Safety Methods Database

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This document gives an overview of Techniques, Methods, Databases, or Models that can be used during a Safety Assessment. This is a living document. Additions are welcome.

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This document consists of three parts:

Part 1: Overview of Safety Methods
This part, which starts on page 5, contains a table listing all Safety Methods collected, with for each method the following information provided (if available):

- **Method name,** i.e. Acronym and name.
- **Format,** specifies the general format of the method, e.g. whether it is a stepped approach, or a mathematical model, or a combination of various techniques, etc. See Table 1 below for the list of formats defined.
- **Purpose,** specifies the primary purpose of the method, e.g. whether it is for data gathering, for hardware dependability analysis, for human reliability analysis, etc. See Table 2 below for the list of purposes defined.
- **Year**, i.e. year of development of the method. If uncertain, then words like 'about' or 'or older' are added.
- **Aim/description** of the method. This description is very brief; one is referred to the references for a more complete description.
- **Remarks**, such as links to related methods.
- **Safety assessment stage**, which lists the stages of a generic safety assessment process, proposed in [SAP 15], during which the method can be of use. These stages are: **1**) Scope the assessment; **2**) Learning the nominal operation; **3**) Identify hazards; **4**) Combine hazards into risk framework; **5**) Evaluate risk; **6**) Identify potential mitigating measure to reduce risk; **7**) Safety monitoring and verification; **8**) Learning from safety feedback.
- **Domains**, i.e. the domains of application the method has been used in, such as nuclear, chemical, ATM (air traffic management), rail, healthcare. See Table 3 below for the list of domains defined. Methods with a domain that is underlined are found to be exclusive for that domain. For domains between brackets (..), there is an indication that the method is applicable to that domain, but no proof is found yet that the method has been actually used in that domain. See also Table 4 for explanations.
- **Application**, i.e. is the method applicable to hardware, software, human, procedures, or to organisation.
- **References used**. Note that the reference lists are not exhaustive. The codes are explained in Part 3.

Part 2: Statistics
This part, which starts on page 230, gathers some statistics on the number of occurrences of elements in the table of Safety Methods, e.g. number of occurrences of 'aviation' as a Domain, number of occurrences of 'Identify hazards' as a Safety assessment stage.

Part 3: References
This part, which starts on page 239, gives the full list of references used.

Table 1: Classes defined for Format column:

Gen	Generic term or principle or theory, rather than a specific technique
Step	Stepped approach or technique or specific way of working
Tab	Static approach with tabular, checklist or questionnaire support
Stat	Static model or approach with graphical support (e.g. flow charts, trees, graphs)
Dyn	Dynamic model with graphical support, often with mathematical base
Math	Mathematical formalism or expression, with no or limited graphical support
Int	Framework or Integrated method of more than one technique
Dat	Database or data collection tool
Min	Data analysis tool or data mining tool
RTS	Real-time simulation
FTS	Fast-time simulation

Table 2: Classes defined for Purpose column:

Mod	Developing a model (e.g. as input to or as part of analysis)
Par	Parameter value assessment (e.g. human error probabilities, failure frequencies)
HRA	Human Reliability Analysis or Human Error analysis method
HFA	Human Factors Analysis (beyond reliability; e.g. behaviour, situation awareness)
Task	Human Task analysis
Trai	Training technique or method to analyse training
Des	Design technique (about making/ensuring a safe design, rather than about analyzing whether the design is safe)
Dec	Decision-making
SwD	Software dependability analysis or Software testing technique
HwD	Hardware dependability analysis (reliability, maintainability, availability, etc)
OpR	Risk analysis of an operation or of a safety-critical scenario
Org	Organisation, Safety management, or Safety culture assessment
Dat	Data collection and information sharing
Mit	Mitigation of risk
HzI	Identification of hazards /safety concerns /causes /issues
HzA	Identification and analysis of frequency and/or severity of hazards / safety concerns / causes / issues
Col	Collision risk analysis or Conflict risk analysis, typically between aircraft
Val	Validation, Verification, Bias and uncertainty analysis, Documentation/Tracking, and Oversight/Monitoring
Ret	Retrospective accident or event analysis

Table 3: Classes defined for Domain column:

Aviation	Operation of individual aircraft or aircraft fleets, including pilot and crew factors and airline operations
Airport	Airport operations and airport design
ATM	Air traffic management and air traffic control operations and equipment
Aircraft	Aircraft technical systems and airworthiness issues. Also including rotorcraft such as helicopters.
Avionics	Aviation electronics, i.e. electronic systems used on aircraft, satellites, and spacecraft, including communication, navigation, cockpit display.
Defence	Military, on land or in the air, including military aviation, weapon systems and nuclear weapon systems. Excluding military at sea.
Navy	Navy, military at sea, including sub-marines
Space	Space safety, including spacecraft, satellites, space missions. Excluding aircraft, excluding avionics.
Rail	Rail transport and operation of trains, including railway design. Excluding manufacturing of trains.
Road	Road transport and operation of cars, including road design, tunnels. Excluding manufacturing of cars.
Maritime	Marine, maritime or inland water transport, e.g. ships, vessels, ferry's, and coast guard search and rescue. Excluding navy, sea pollution, oil spills.
Nuclear	Nuclear power industry. Excluding nuclear weapon systems.
Energy	Energy or electricity-generating plants, solar energy, windturbines, thermal power plants. Excluding nuclear power.
Chemical	Chemical industry and processes, including production of medicine, biochemical industry. Excluding oil&gas, petrochemical, food and beverages.
Oil&gas	Oil and/or gas industry, including offshore oil&gas industry, petrochemical industry
Manufacturing	Manufacturing plants, including automotive or automobile manufacturing, construction of buildings, ship building, and process industry (i.e. processing of bulk resources into other products). Excluding food, chemical or petrochemical industry.
Healthcare	Health care, hospitals, nursing, medical operations, biomedical issues. Excluding production of medicine and other chemicals, and excluding ergonomics.
Environment	Environment safety, e.g. air pollution, sea pollution, fuel and oil spills, wastewater treatment plants, fish and wildlife reserves, biology, earthquakes, water management
Food	Food and beverages, including public water supply systems, agriculture
Mining	Mining industry
Social	Psychology, psychometrics, behavioural sciences, social sciences, education, safety culture studies.
Ergonomics	Ergonomics, i.e. workplace equipment design, intending to reduce operator fatigue and discomfort. Also including household safety
Finance	Finance, banking, insurance, economics
Management	Management and organisation, including project management, information management, product management, marketing, operations research, logistics
Security	Security, i.e. dealing with protection from harm due to intentional criminal acts such as assault, burglary or vandalism. Excluding police and fire fighting
Leisure	Leisure and amusement industry, amusement parks, games, video games, media (e.g. tv advertisements), leisure-related search and rescue
Police	Police and Fire fighting, Search and rescue, including forensics and law.
Electronics	Electronics, electronic equipment, telecommunications, digital forensics
Software	Method has been applied to software design or analysis, but the industry sector in which the software is actually used is unclear or unspecified.
No-domain-found	No applications were found (yet) for this method, not even in an example illustration, so that the domain is currently unclear.
All	There are a few approaches that are very generic and that have been used in virtually all domains.

Table 4: Codes regarding Domain column:

domain	Found proof or strong indication that method has in fact been applied in this domain (note that this proof is not necessarily provided in this document)
<u>domain</u>	Ditto; method appears to be for use in this domain exclusively
(domain)	Found indication that the method is intended for application in this domain, but found no strong indication (yet) that the method has in fact been applied. For instance, the method name refers to a domain, the method is mentioned in a domain-specific document, or an application of the method is a theoretical example.
<u>(domain)</u>	Ditto; method appears to be for use in this domain exclusively

Document control sheet

Version	Date	Main changes	Number of methods in database
1.2	3 November 2020	Descriptions of 19 new methods added plus 2 alternative names to already listed methods.	866 methods (plus 177 links or alternative names to methods)
1.1	31 August 2016	Rigorous re-classification and update of Format and Purpose of all methods. Rigorous re-classification and update of Domain of all methods, now also distinguishing between method being applicable in domain versus actually applied in domain. Addition of several new methods. Some similar methods are combined. Update of some details in other columns. Some references added.	847 methods (plus 175 links or alternative names to methods)
1.0	4 March 2013	Description and classification of many methods improved. Many new methods added, primarily identified as part of a project on safety methods conducted by NLR for the U.S. Federal Aviation Administration in 2011-2012.	807 methods (plus 162 links or alternative names to methods)
0.9	7 December 2010	Description and classification of many methods improved. 69 new methods added. 66 methods added without number but with reference to other methods. 15 methods removed with reference to other methods. For 32 methods, number and description removed, with reference to other methods. Update of statistics. Verification and update of all URLs in list of references and many references added. Introduction of a new classification type (in column Purpose) which collects Design (D) techniques, which are aimed at designing rather than analysing with respect to safety.	726 methods (plus 150 links or alternative names to methods)
0.8	31 January 2008	Descriptions of 19 new methods added plus 3 alternative names to already listed methods. New classification type introduced (in column Purpose), which collects (O) Organisation techniques. This class now includes about 20 methods, most of which were previously classified as (H) Human performance analysis technique, five were previously (R) Risk assessment techniques; two were (M) hazard Mitigating techniques.	701 methods (plus 53 links or alternative names to methods)
0.7	20 February 2007	Descriptions of 31 new methods added. Alternative names or links to 49 methods included as separate entries in the table, with link to the original method, and without additional details provided. Details for one method removed and replaced by link to same method by alternative name. Minor details for many other methods updated.	682 methods (plus 50 links or alternative names to methods)
0.6	28 November 2006	One method added. Update of statistics and minor details of other methods.	652
0.5	28 August 2006	One method added. Update of statistics and minor details of other methods.	651
0.4	27 April 2006	24 methods added from various sources. Textual changes and updates of other methods. Insert of statistics on database attributes.	650
0.3	31 March 2005	Update, supported by the project CAATS [CAATS SKE II, 2006]. Ninety-nine methods added, mainly from references [GAIN ATM, 2003] and [GAIN AFSA, 2003]. Textual changes and updates of all methods.	626
0.2	26 November 2004	Update, supported by the project CAATS [CAATS SKE II, 2006]. Seven methods added, and for all methods an assessment provided of the applicable Safety Assessment Stages.	527
0.1	24 September 2004	Initiation of database, with 520 methods gathered during the EEC funded and supported project [Review SAM Techniques, 2004].	520

Part 1: Overview of Safety Methods

(For explanation of table headers, see first pages of this document.)

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
1.	@RISK	FTS	Dec	1991	@RISK uses the techniques of Monte Carlo simulation for Bias and Uncertainty assessment in a spreadsheet-based model. Four steps: (1) Developing a Model – by defining a problem or situation in Excel spreadsheet, (2) Identifying Uncertainty – in variables in Excel spreadsheets and specifying their possible values with probability distributions, and identifying the uncertain spreadsheet results that are to be analyzed, (3) Analyzing the Model with Simulation – to determine the range and probabilities of all possible outcomes for the results of the worksheet, and (4) Making a Decision – based on the results provided and personal preferences.	Developed by Palisade. @RISK evolved from PRISM (this is another than the PRISM elsewhere in this database), released by Palisade in 1984, which also allowed users to quantify risk using Monte Carlo simulation. See also Monte Carlo Simulation.					5				finance, oil&gas, manufacturing, healthcare, environment, defence, aircraft, electronics, management				x		• [GAIN ATM, 2003] • [GAIN AFSA, 2003] • [FAA HFW]
2.	3CA (Control Change Cause Analysis)	Step	Ret	2000	In 3CA, accidents and incidents are treated as a sequence of events, beginning with the moment that control is reduced and ending with the moment that control is restored. Some of the events in the sequence are 'significant', i.e. they increase risks or reduce control, so allow further unwanted changes to occur. Steps are: 1) identify these significant events, making explicit who/what is acting, the action and who/what is acted upon. 2) identify what measures could have prevented the events or limited their effects, and in what ways prevention was ineffective. Here, the focus is on tangible barriers and controls, those at the operational level. 3) identify the differences between what was expected (based on norms such as standards and procedures) and what was true in the actual situation. 4) Explain these differences in terms of organisational and cultural factors that influenced the situation and in terms of the systems and management arrangements that caused or allowed the difference to exist.	3CA was developed by Humber Chemical Focus and the UK Health &Safety Executive (HSE) in 2000. This original version is sometimes referred to as 3CA Form-A. Later versions, by Noordwijk Risk Initiative Foundation, are referred to as Form-B (developed in 2007) and Form C (developed in 2009); the latter includes a graphical worksheet. 3CA is based on a generalised form of energy trace and barrier analysis (ETBA).								8	road, police, chemical, manufacturing, food, (nuclear)					x	• [Ziedelis & Noel, 2011] • [Kingston, 2002] • [Wu & Zongxiao & Lei, 2016]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
3.	3-D Collision Risk Model	Math	Col	1999 from	The Eurocontrol 3-D collision risk model aims at providing a means for assessing the Level of Safety in (European) en route airspace, where controllers monitor air traffic by means of radar and provide tactical instructions to aircraft. A supporting prototype software tool analyzes recorded aircraft tracks from Radar Data Processing systems within a time span and a given volume of airspace, in order to identify all proximate events (conflicts, potential conflicts, and potential collisions), classifies them according to various criteria, estimates the frequency of occurrence of these events, and determines the different parameters needed to estimate the probability of aircraft being on a collision course and the probability of air traffic control-loop resolution failure.	The work to develop the 3-D collision risk model has been accomplished under several Eurocontrol contracts since 1999.					5				ATM				x		• [Burt, 1999] • [Burt, 2000] • [INECO, 2006] • [Garcia et al, 2007] • [Mehadhebi, 2007] • [Saez et al, 2010]
	3D-SART (3D-Situation Awareness Rating Technique)					See SART. Applicable to aircrew.															
4.	5M Model or 5-M Factors	Stat	Mod	1949 - 1976	The 5M Model is aimed at describing or examining a proposed change, a system, or a particular accident in a structured way. It assists in deconstructing the proposed change (or system or accident) elements that are later input to the structured identification of the sources, causes, hazards, and current and proposed hazard mitigation strategies related to the proposed change (or system or accident). The five Ms are: 1) Mission: the purpose or central function of the system, the reason that all the other elements are brought together; 2) Man: the human element of a system. 3) Machine: the hardware and software (including firmware) element of a system. 4) Management: includes the procedures, policy, and regulations involved in operating, maintaining, installing, and decommissioning a system. 5) Media: the environment in which a system will be operated, maintained, and installed, it includes operational and ambient conditions.	The 5M Model of System Engineering is commonly depicted as three circles, one each for Man, Machine and Media, which partially overlap. Mission is in the area in which all three circles overlap. Surrounding the combination of three circles is another circle for Management. In FAA references, the locations of Management and Media are interchanged (making Media the surrounding circle). The first triple of M's (Man, Machine, Media) was proposed by T.P. Wright of Cornell University in the late 1940s. Management was introduced in 1965 at University of Southern California. Mission was introduced in 1976 by E.A. Jerome, Flight Safety Foundation.	1	2							aviation, ATM, oil&gas, defence, finance	x	x	x	x	x	• [FAA00] • [ATO SMS Manual v3.0] • [Wells & Rodrigues, 2001] • [DotAF, 5M Model] • [CAPGORM] • [AFP 90-902, 2000]
5.	ABMS (Agent Based Modelling and Simulation)	Gen	Mod	1949	Agent-based modeling is a simulation modeling technique in which a system is modeled as a collection of interacting autonomous decision-making entities called agents. Each agent individually assesses its situation and makes decisions on the basis of a set of rules. Agents may execute various behaviours appropriate for the system they represent. Since the models typically feature repetitive complex behaviour patterns and competitive interactions between agents, their evaluation cannot be done analytically but is done by means of computer simulation.	In safety analysis, ABMS is referred to as MA-DRM.				4					ATM, environment, social, management, road, finance, energy, healthcare, chemical, security	x		x	x	x	• [Bonabeau, 2002] • [Macal & North, 2006] • [Stroeve et al, 2013]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
6.	ABRM (Analytic Blunder Risk Model)	Math	Col	1985	ABRM is a computational model to evaluate the probability of a collision, given a particular blunder (controller error, pilot error, equipment malfunction) between one aircraft involved in the error (the "blunderer") and another aircraft (the "evader"). ABRM considers both the probability of a collision assuming no intervention, and the probability of timely intervention by pilots or controllers. It uses empirical probability distributions for reaction times and a closed form probability equation to compute the probability that a collision will occur. This permits it to consider combinations of events with small probabilities efficiently and accurately.	ABRM is programmed in Excel (with macros). Developed by Ken Geisinger (FAA) in 1985.					5				ATM				x		• [Geisinger, 1985] • [GAIN ATM, 2003]
7.	Absorbing boundary model	Math	Col	1964	Collision risk model. Reich-based collision risk models assume that after a collision, both aircraft keep on flying. This one does not. A collision is counted if a process state (usually given by a differential equation) hits the boundary of a collision area. After this, the process state is "absorbed", i.e. does not change any more.	Mainly of theoretical use only, since it requires a parabolic partial differential equation to have a unique solution.					5				(ATM)				x		• [Bakker & Blom, 1993] • [MUFTIS3.2-II, 1996]
8.	ACAT (Air Carrier Assessment Tool)	Tab	HzI	1999 or older	ACAT is used to assess an air carrier's or applicant's systems and operating environment for indications of hazards or conditions that may create hazards. This process helps to highlight any area on which to focus special oversight attention, and is used to prioritize the elements. The tool has 28 risk indicators, which let principal inspectors document concerns derived from information obtained through the Voluntary Disclosure Reporting Program (VDRP), Aviation Safety Action Program (ASAP) and Flight Operational Quality Assurance program (FOQA). These concerns are converted to a numerical score that is used to prioritize work assignments and re-target inspections.	Risk indicators are groupings of safety- and/or performance-related data that reflect areas of potential hazards and prioritize air carrier oversight plans. The two major categories for risk indicators (System Stability and Operational Risks) reflect the notion that internal and external events affect air carrier systems. Two subject areas further subdivide the categories. These subject areas focus the indicators on the operational, performance, and environmental risks most likely to impact an air carrier's systems.							7	8	aviation	x			x		• [AV Glossary - ATOS] • [GAO, 1999] • [FAA FSIMS, 2009]
9.	ACCC (Air Carrier Configuration Checklist)	Dat, Tab	Val	2007 or older	The Air Carrier Configuration Checklist is a series of questions that helps Certification Project Teams (CPT) and Certificate Management Teams (CMT) to document the air carrier's or applicant's scope of operation including factors such as type of operations, aircraft, facilities, personnel, equipment and operations specifications. This information is used for automated filtering of the oversight profile.	For the checklist, see [FAA FSIMS, 2009], Page 29.	1	2						8	aviation	x		x	x	x	• [FAA FSIMS, 2009]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
10.	Accident Analysis	Gen	OpR	1992 or older	The purpose of the Accident Analysis is to evaluate the effect of scenarios that develop into credible and incredible accidents. Those that do not develop into credible accidents are documented and recorded to verify their consideration and validate the results. The process generally builds a database of factors such as Activity at the time of the accident; Distribution of incidents among personnel; Accident locations; Distribution of incidents by sub-unit; Patterns of unsafe acts or conditions. This database then serves as the basis to identify the risk drivers.	Many methods and techniques are applied. E.g. PHA, Subsystem HA.			3	4	5				nuclear, aviation, chemical, ATM, space, rail, road, oil&gas, mining, healthcare, social	x	x	x	x	x	• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]
	Accident Triangle					See Heinrich's Pyramid															•
	Accident-Concentration Analysis					See Black Spot Analysis															
11.	AcciMapping	Stat	Ret	1997	Retrospective accident analysis technique that is used to identify and graphically represent the causal flow of events and the planning, management and regulatory bodies that may have contributed to a particular accident scenario. It also identifies decision makers who have the power to improve safety, and identifies relevant cross-disciplinary co-operation in research and design.	Developed by Svedung & Rasmussen. A typical AcciMap comprises the following main levels: government policy and budgeting; regulatory bodies and associations; local area government planning and budgeting; company management, technical and operational management, physical processes and actor activities, equipment and surroundings.			3	4		6		8	road, maritime, rail, oil&gas, ATM, police, healthcare, space, aviation	x		x	x	x	• [Rasmussen & Svedung, 2000] • [Salmon et al, 2005] • [Qureshi, 2007]
12.	ACOP (Air Carrier Oversight Profile)	Dat, Tab	HzI	2008 or older	This technique is a tailored list of elements, DCT (Data Collection Tool) questions, and job task items that are based on the specific regulatory requirements (SRR) that apply to the air carrier or applicant. Technique allows the principal inspector (PI) or certification project manager (CPM) to plan and conduct oversight activities that are specific to the air carrier's or applicant's system configuration. The PI or CPM can manually modify the profile in the event the air carrier has a unique situation that results in differences from the standard profile, such as a deviation or exemption. The PI or CPM must provide an explanation for all manual adjustments to the air carrier oversight profile.	Technique is applied early in the safety assessment process, during system description.	1	2						8	aviation	x		x	x	x	• [FAA FSIMS, 2009]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
13.	ACS (Airworthiness Concern Sheet)	Dat	Dat, Mit	2000 about	An ACS is intended as a means for FAA Aviation Safety Engineers to coordinate airworthiness concerns with aircraft owner/operators. When informed of a safety or airworthiness concern, the FAA engineer will complete an ACS detailing the available information, and send the ACS to the appropriate associations and type clubs, who disseminate the ACS to their members. Feedback information on technical and cost impact is compiled and submitted back to FAA, who develops appropriate corrective action. This action could involve an Airworthiness Directive (AD) or a Special Airworthiness Bulletin (SAIB), or the FAA could determine that no action is needed at that time.								8	aircraft	x					• [SADAD Manual]
	ACSE (Applied Cognitive Systems Engineering)					See ACWA (Applied Cognitive Work Analysis)															
14.	ACT (Activity Catalog Tool)	Dat	Dat	1993	ACT provides instant, real-time statistical analysis of an observed sequence, including such measures as frequency of occurrence, duration of activity, time between occurrences and probabilities of transitions between activities. ACT automatically creates a data-log file that provides a detailed description of all observations, as well as a further important statistical description of the concurrence of events and activities. To allow for multiple observers and/or multiple observations of a given video tape, data-log files can be merged and/or appended using simple post processing functions.	ACT was designed by two human factors experts (L. Segal and A. Andre, co-founders of Interface Analysis Associates (IAA)), who designed this tool for use for analysing pilot performance in the cockpit, analysis of computer workstations, evaluation of consumer products and graphical user interfaces.		2	3		5				(ergonomics), (aviation)			x			• [FAA HFW] • [ACT web]
15.	ACTA (Applied Cognitive Task Analysis)	Tab	Task	1997	ACTA aims at identifying cognitive demands and skills required for a task, which can then be used to improve training or provide interface design recommendations. It consists of three interview methods: 1. Task Diagram Interview - provides a broad overview of the task and highlights the difficult cognitive portions of the task. 2. Knowledge Audit - surveys the aspects of expertise required for a specific task or subtask. 3. Simulation Interview - allows to probe the cognitive processes of the subject matter expert within the context of a specific scenario. The interviews are followed by the creation of a cognitive demands table to consolidate and synthesize the data.	Development of ACTA was funded by the Navy Personnel Research and Development Center. Aims to be less resource-intensive than CTA.		2							defence, police			x			• [Militello&Hutton, 1998] • [Alley, 2005]
16.	Action Information Requirements	Stat	Task	1986 or older	Helps in defining those specific actions necessary to perform a function and, in turn, those specific information elements that must be provided to perform the action. It breaks up the references function requirement into useful groupings of action requirements and information requirements.	Procedure for developing or completing action/information requirements forms is much more informal than that for most analysis methods.		2							aviation, defence			x	x	x	• [MIL-HDBK, 1999] • [HEAT overview]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
17.	Activity Sampling	Dat	Task	1950	Method of data collection which provides information about the proportion of time that is spent on different activities. By sampling an operator's behaviour at intervals, a picture of the type and frequency of activities making up a task can be developed.	Cannot be used for cognitive activities.					5				manufacturing, healthcare, management			x			• [Kirwan & Ainsworth, 1992] • [FAA HFW]
18.	ACT-R (Adaptive Control of Thought - Rational)	FTS	HFA	1993	Simulates human cognition, using Fitts's (1964) three-step skill acquisition model of how people organise knowledge and produce intelligent behaviour. ACT-R aims to define the basic and irreducible cognitive and perceptual operations that enable the human mind. In theory, each task that humans can perform should consist of a series of these discrete operations. The three steps of this model are (1) the conversion of declarative input, (2) knowledge compilation and procedurisation, and (3) the result of both procedurisation and compilation. Procedure**:** Researchers create models by writing them in ACT-R, thus adopting ACT-R's way of viewing human cognition. Researchers write their own assumptions in the model and test the model by comparing its results to results of people actually performing the task.	The original ACT was developed by J.R. Anderson in 1982. In 1993, Anderson presented ACT-R. There exist several University research groups on ACT-R. Typical for ACT-R is that it allows researchers to collect quantitative measures that can be compared with the quantitative results of people doing the same tasks. See also MoFL. See also HPM.		2		4					social, navy			x	x		• [FAA HFW] • [Anderson, 1982] • [Anderson, 1993] • [Fitts, 1964] • [Koubek, 1997] • [Leiden & Best, 2005] • Many other refs at [Refs on ACT-R]
19.	ACWA (Applied Cognitive Work Analysis)	Step	HFA	2001	ACWA systematically transforms the analysis of the cognitive demands of a domain into supporting visualisations and decision-aiding concepts. The first three (analysis) steps in this process relate to the analysis of the work domain: 1. Use a Functional Abstraction Network model to capture the essential domain concepts and relationships that define the problem-space; 2. Overlay Cognitive Work Requirements on the functional model as a way of identifying the cognitive demands / tasks / decisions that arise in the domain and require support; 3. Identify the Information / Relationship Requirements for successful execution of these cognitive work requirements. Subsequently, there are two design steps: 1. Specifying the Representation Design Requirements (RDR) to define the shaping and processing for how the information / relationships should be represented to practitioner(s); and 2. Developing Presentation Design Concepts (PDC) to explore techniques to implement the RDRs. PDCs provide the syntax and dynamics of presentation forms, in order to produce the information transfer to the practitioner(s).	Developed by W.C. Elm et al, Aegis Research Corporation. Sucessor to ACWA is referred to as ACSE (Applied Cognitive Systems Engineering).		2				6			defence, nuclear, leisure, social			x			• [Elm et al, 2004] • [Gualtieri, 2005]
	Ad Hoc Function Allocation					See Function Allocation Trades															
20.	Adaptive User Model	Gen	HFA	1985	Captures the human's preference structure by observing the information available to the human as well as the decisions made by the human on the basis of that information.	Link with THERP.				4					healthcare, social			x			• [FAA HFW] • [Freedy, 1985]
	Adaptive Voting					See N out of M vote															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
21.	ADI (Assessment Determination and Implementation Tool)	Dat	Dat, Mit	2008 or older	ADI is designed to permit a principal inspector or management official to collect and analyze inspection data in order to make decisions to mitigate risks found during inspections of air carriers' operating programs. The inspector certification program manager uses this tool to document the bottom-line design or performance assessment and the appropriate course of action for implementation.									8	(aviation)	x				x	• [FAA FSIMS, 2009]
22.	ADMIRA (Analytical Dynamic Methodology for Integrated Risk Assessment)	Dyn	OpR	1991	ADMIRA is based on a Decision Tree approach. It utilises event conditional probabilities, which allows for the development of event trajectories without the requirement for detailed boolean evaluation. In this way, ADMIRA allows for the dynamic evaluation of systems as opposed to the conventionally available static approaches. Through a systematic design interrogation procedure it develops a complete series of logically linked event scenarios, which allows for the direct evaluation of the scenario probabilities and their associated consequences. Due to its interactive nature, ADMIRA makes possible the real time updating of the model of the plant/system under examination.	See also DTA (Decision Tree Analysis).				4	5				(nuclear)	x					• [Senni et al, 1991]
23.	ADREP (Accident Data REPorting system)	Dat	Dat	1975	The ADREP system receives, stores and provides Contracting States with aircraft accident and incident data that will assist them in validating safety. The database includes worldwide accident/incident data from 1970 of aircraft (fixed wing and helicopter) heavier than 2250 kg. The data are submitted in a common reporting taxonomy.	The ADREP system is operated and maintained by ICAO. Since 2004, it runs on the ECCAIRS software platform, which makes ADREP and ECCAIRS compatible.								8	aviation, ATM	x			x		• [ATSB, 2004]
24.	ADSA (Accident Dynamic Sequence Analysis)	RTS ?	HRA	1994	Cognitive simulation which builds on CREWSIM. Designed to identify a range of diagnosis and decision-making error modes such as fallacy, the taking of procedural short-cuts, and delayed response. Performance Shaping Factors (PSF) in the model are linked to particular Psychological Error Mechanisms (PEMs), e.g. PSF time pressure leading to the PEM of taking a short-cut. With this, the simulation approaches become (apparently) more able to generate realistic cognitive External Error Modes (EEMs) that have been observed to occur in real events and incidents.				3	4					(nuclear)			x	x		• [Kirwan, 1995] • [Kirwan, Part 1, 1998]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
25.	AEA (Action Error Analysis)	Tab	HRA, Task	1978	Action Error Analysis analyses interactions between machine and humans. Is used to study the consequences of potential human errors in task execution related to directing automated functions. Very similar to FMEA, but is applied to the steps in human procedures rather than to hardware components or parts. The AEA worksheet contains the following columns: Task step; Cue; Action feedback / Effect feedback; Action error; Cause; Consequences; Risk; Suggested risk reduction actions and remarks.	Developed at Risø National Laboratory in Denmark. Any automated interface between a human and automated process can be evaluated, such as pilot / cockpit controls, or controller / display, maintainer / equipment interactions. AEA can be executed for critical procedures during the detail design phase, but can also be executed for established procedures. AEA consists of AEMA and AECA, see also AEMA.			3		5				oil&gas	x		x	x		• [FAA00] • [Leveson, 1995] • [MUFTIS3.2-I, 1996] • [ΣΣ93, ΣΣ97] • [Andersen, 2011] • [Taylor, 2013]
26.	AEB (Accident Evolution and Barrier function)	Stat	Ret	1991	The AEB method models the interaction between human and technical systems. It consists of the narrative of the accident, the flow chart model of human and systems malfunctions, errors and failures, and barrier function analysis. The evolution leading to an accident evolution is modelled as a chain or sequence of malfunctions, failures, and errors in human and technical systems. Barrier functions represent functions which can arrest the accident evolution so that the next event in the chain is never realised.	Developed by O. Svenson (Lund & Stockholm University). Method derived from HPES (human performance enhancement system). It is particularly focused on failures and errors. It can be used in predictive safety analyses as well as in post hoc incident analyses. In general, application of the model will indicate where and how safety can be improved, and it also raises questions about issues such as the cost, feasibility, and effectiveness of different ways of increasing safety.						6		8	nuclear	x		x		x	• [Svenson, 1991] • [Ziedelis & Noel, 2011]
27.	AEMA (Action Error Mode Analysis)	Tab	HRA, Task	1994 or older	Human errors for each task are identified using guidewords such as ‘omitted’, ‘too late’, etc. Abnormal system states are identified in order to consider consequences of carrying out the task steps during abnormal system states. Consequences of erroneous actions and abnormal system states are identified, as well as possibilities for recovery.	Resembles Human HAZOP or FMECA. AEMA can be complemented by an Action Error Cause Analysis (AECA), which addresses identification of causes and contributing factors, and which can help to identify further error reduction measures for critical action error modes. AEMA plus AECA is called AEA. See also AEA.			3			6			oil&gas, (rail), (energy)			x			• [Oien & Rosness, 1998] • [Vinnem, 2000]
28.	AERO (Aeronautical Events Reports Organizer)	Dat	Dat	2003 or older	Aim is to organise and manage incidents and irregularities in a reporting system, to provide graphs and reports, and to share information with other users. AERO is a FileMaker database developed to support the management of the safety department of aviation operators. AERO was created to enhance communication between the safety department and all employees, reduce paper handling, and produce reports. The Data Sharing program allows all AERO Certified Users to benefit from the experience of the other users. AERO users review their monthly events and decide which ones to share with the rest of the companies using AERO.	Safety Report Management and Analysis System								8	(aviation)	x		x	x		• [GAIN AFSA, 2003] • http://www.aerocan.com

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
29.	AET Method (Arbeitswissenschaftliches Erhebungsverfahren zur Tätigkeitsanalyse Methode) (Ergonomic Job Analysis)	Step	Task	1978	Job evaluation with a regard for stress and strain considerations. Assesses the relevant aspects of the work object, resources, tasks and requirements as well as the working environment. Focus is on components and combinations of a one-person job. AET is structured in three parts: tasks, conditions for carrying out these tasks, and the resulting demands upon the worker.	Developed by K. Landau, and W. Rohmert, TU Darmstadt (Germany).		2	3						ergonomics			x			• [FAA HFW] • [Rohmert & Landau, 1983] • [AET, 2009]
	Affinity Diagrams					See Card Sorting															
	AGS (Analysis Ground Station)					See Flight Data Monitoring Analysis and Visualisation															
30.	AHP (Analytic Hierarchy Process)	Stat	Dec	1975	Decision-making theory designed to reflect the way people actually think. Aims to quantify allocation decisions. The decision is first structured as a value tree, then each of the attributes is compared in terms of importance in a pairwise rating process. When entering the ratings the decision-makers can enter numerical ratios. The program then calculates a normalised eigenvector assigning importance or preference weights to each attribute. Each alternative is then compared on the separate attributes. This results in another eigenvector describing how well each alternative satisfies each attribute. These two sets of eigenvectors are then combined into a single vector that orders alternatives in terms of preference.	AHP was developed in the 1970's by Dr. Thomas Saaty, while he was a professor at the Wharton School of Business. Software support available (e.g. Expert Choice (EC)).		2		4	5				healthcare, nuclear, defence, oil&gas, chemical, environment, social, management, ATM			x			• [FAA HFW] • [Lehto, 1997] • [Maurino & Luxhøj, 2002] • [Saaty, 1987] • [AHP tutorial]
31.	AHRA (All Hazards Risk Assessment)	Int	OpR	2011	The purpose of the AHRA process is to assess and view risks in a standardized fashion using a common set of principles and steps. Steps are: 1. Setting the Context – Articulating an institution's objectives and defining its external and internal parameters to be taken into consideration when managing risks. 2. Risk Identification – Finding, recognizing, and recording risks. 3. Risk Analysis – Understanding the nature and level of risk, in terms of its impacts and likelihood. 4. Risk Evaluation – Comparing with risk criteria to determine whether a risk and/or its magnitude is acceptable or tolerable. 5. Risk Treatment – Identifying and recommending risk control or Risk Treatment options.	Scope is safety risks to the Canadian people requiring emergency planning by federal institutions, including thunderstorms, earthquakes, internet disruptions, disease outbreaks, train derailments, national security threats. For each step, the guidelines suggest various techniques that may be used.	1		3	4	5	6			environment, security					x	• [PSC, 2012]
32.	AHRQ approach (Agency for Healthcare Research and Quality approach)	Tab	Org	2004	Survey on hospital patient safety culture. Measures seven unit-level aspects: Supervisor/ manager expectations and actions promoting safety; Organizational learning - continuous improvement; Teamwork within units; Communication openness; Feedback and communication about error; Non-punitive response to error; Staffing. In addition, the survey measures three hospital-level aspects of safety culture: Hospital management support for patient safety; Teamwork across hospital units; Hospital handoffs and transitions.	Has been used in hospitals in and outside the US.								8	healthcare					x	• [Mkrtchyan & Turcanu, 2012]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
33.	AIDS (Accident Incident Data System)	Dat	Dat	1978	The FAA AIDS database contains incident data records for all categories of civil aviation in the US. Incidents are events that do not meet the aircraft damage or personal injury thresholds contained in the National Transportation Safety Board (NTSB) definition of an accident. The information contained in AIDS is gathered from several sources including incident reports on FAA Form 8020-5. The data are presented in a report format divided into the following categories: Location Information, Aircraft Information, Operator Information, Narrative, Findings, Weather/Environmental Information, and Pilot Information and other data fields.	The FAA AIDS database contains incidents that occurred between 1978 and the present.								8	aviation, airport	x			x		• [AIDS]
	AIM (Accident Incident Model)					See IRP (Integrated Risk Picture)															
34.	AIMS (Australian Incident Monitoring Study)	Dat	Dat, Ret	1996	Anonymous voluntary incident reporting system for intensive care. Aims to improve the quality of intensive care. AIMS allows the reporter to provide a narrative of the incident, and then uses check boxes to gather information regarding the patient and personnel involved, when and where the incident happened, contributing factors, and factors limiting the effects of the incident. Using a knowledge, skill and rule-based error taxonomy, it allows the reporter to classify any errors that contributed to the incident.									8	(healthcare)			x	x	x	• [Salmon et al., 2005]
35.	AIPA (Accident Initiation and Progression Analysis)	Stat	HRA	1975	Models the impact of human errors. Uses event trees and fault trees to define the explicit human interactions that can change the course of a given accident sequence and to define the time allowed for corrective action in that sequence. A time-dependent operator response model relates the time available for correct or corrective action in an accident sequence to the probability of successful operator action. A time-dependent repair model accounts for the likelihood of recovery actions for a sequence, with these recovery actions being highly dependent on the system failure modes.	Is reported to be no longer in use.				4					nuclear			x			• [Fleming, 1975]
36.	Air Safety Database	Dat	Dat	1998	This database consists of accident data from a large number of sources including, for instance, official international reporting systems (e.g. ICAO ADREP), Accident Investigation Agencies, and insurance companies. These sources provide data for virtually all reported ATM related accidents. The database also contains exposure data (e.g. number of flights) and arrival and departure data of commercial aircraft at airports worldwide.	Maintained at NLR. Currently, the database includes almost 500,000 records of incidents, serious incidents en accidents.			3					8	aviation, ATM	x	x	x	x	x	• [Van Es, 2001]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
37.	Air Traffic Control Training Tools	RTS	Trai	1980 from	Air Traffic Control Training Tools provide human-in-the-loop simulation environments for air traffic control operators. Examples of tools are: • ARTT (Aviation Research and Training Tools) (Adacel, 2002) - aviation research and training, simulating Tower, Radar, Driver, and Coms. Provides visual display on computer screen or large screen displays. • AT Coach (UFA Inc., 1995) - products supporting standalone training, ATC Automation system based training and testing, airspace modelling, and voice recognition based simulation control. There are two simulation systems: the AT Coach Standalone Simulation and the AT Coach Embedded Simulator. • AWSIM (Warrior Preparation Center, early 1980s) - real-time, interactive, entity-level air simulation system. Provides capability for training, mission rehearsal, doctrine and procedures development, experimentation and operational plans assessment.			2				7		ATM, defence			x			• [GAIN ATM, 2003] • [FAA HFW] • [MaraTech]
	AirFASE (Aircraft Flight Analysis & Safety Explorer)					See Flight Data Monitoring Analysis and Visualisation															
38.	Air-MIDAS (Air- Man-Machine Integrated Design and Analysis System)	Int	HRA	1998 about	Predictive model of human operator performance (flight crew and ATC) to evaluate the impact of automation developments in flight management and air traffic control. The model is used to predict the performance of flight crews and ATC operators interacting with automated systems in a dynamic airspace environment. The purpose of the modelling is to support evaluation and design of automated aids for flight management and airspace management and to predict required changes in both domains.	Augmented version of MIDAS. Air-MIDAS was developed by members of the HAIL (Human Automation Integration Laboratory) at SJSU (San Jose State University). It is currently being used for the examination of advanced air traffic management concepts in projects sponsored by NASA ARC (Ames Research Center) and Eurocontrol. See also HPM. See also MIDAS.				4	5				ATM	x		x	x	x	• [Air-MIDAS web] • [Gore & Corker, 2000] • [HAIL] • [Leiden & Best, 2005]
39.	AIRS (Area Information Records System)	Dat	Dat	1967	The AIRS is a group of integrated, regional systems for the storage, analysis, and retrieval of information by public safety and justice agencies through the efficient and effective use of electronic data processing.	Developed by Environmental Systems Corporation.							7	8	police	x					• [AIRS]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
40.	AIRS (Aircrew Incident Reporting System)	Dat	Dat, HRA	1996	AIRS is a confidential human factors reporting system that provides airlines with the necessary tools to set up an in-house human performance analysis system. It was established to obtain feedback from operators on how well Airbus aircraft operate to identify the significant operational and technical human performance events that occur within the fleet; develop a better understanding of how the events occur; develop and implement design changes, if appropriate, and inform other operators of the "lessons learned" from the events. AIRS aims to provide an answer to "what" happened as well as to "why" a certain incident and event occurred. The analysis is essentially based on a causal factor analysis, structured around the incorporated taxonomy. The taxonomy is similar to the SHEL model that includes environmental, informational, personal, and organisational factors that may have had an influence on crew actions.	AIRS is part of the Airbus Flight Operations Monitoring package. Over 20 airlines are using the system and several more are considering it. Based on BASIS software.			3				7	8	aviation, aircraft			x	x	x	• [AIRS example] • [GAIN AFSA, 2003] • [Benoist]
41.	Analysable Programs	Gen	Des	1984	Aim is to design a program in a way that program analysis is easily feasible. The program behaviour must be testable completely on the basis of the analysis.	Necessary if the verification process makes use of statistical program analysis techniques. Complementary to program analysis and program proving. Tools available. Software design & development phase.						6			software		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]
42.	Analysis of field data	Dat	HwD	1984 or older	In-service reliability and performance data is analysed to determine the observed reliability figures and the impacts of failures. It feeds back into redesign of the current system and the estimation processes for new, but similar, systems. Scoped to the analysis of performance data of technical equipment.	Variants are Stochastic analysis of field data and Statistical analysis of field data. See also Field study.						6		8	security, environment, healthcare, aircraft, rail, oil&gas	x					• [DeGroot & Baecher, 1993]
	Animation					See Prototype Development or Prototyping or Animation															
43.	AoA (Analysis of Alternatives)	Step	Dec	1975	Alternatives for a particular system or procedure are analysed, including no-action alternative. The AoA attempts to arrive at the best value for a set of proposals received from the private sector or other sources.	AoA is the new name for Cost and Operational Effectiveness Analysis (COEA) or Production Readiness Analysis.						6			defence, management, nuclear, road	x			x		• [MIL-HDBK, 1999]
44.	Apex (Architecture for Procedure Execution)	Dyn	Mod	1998	Apex is an agent-based modelling approach comprising two major components: 1) an action selection system, in which knowledge is represented as tasks (or procedures) organized into a goal hierarchy; 2) a resource allocation architecture, which represents the individual elements in the information-processing system, such as perception, cognition, and motor elements.	Agent based modelling. Developed by Michael Freed for NASA Ames. Is intended to be used by people without a great deal of expertise in cognitive modelling.				4					ATM			x			• [Morrison, 2003] • [FAA HFW]
45.	APHAZ (Aircraft Proximity HAZards)	Dat	Dat, Col	1989	APHAZ reporting has been introduced by the UK CAA in 1989. In these reports air traffic controllers describe conflicts between aircraft, mostly in terminal manoeuvring areas.	One should note that the APHAZ reporting rate seemed to increase significantly after the introduction of Safety Monitoring Function.								8	ATM	x		x	x		• [CAA9095]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
46.	APJ (Absolute Probability Judgement)	Step	Par	1983	Estimates human error probabilities. For this, experts are asked their judgement on the likelihood of specific human error, and the information is collated mathematically for inter-judge consistency. Two forms: Groups APJ and Single expert APJ. For the former, there are four major methods: Aggregated individual method. Delphi method, Nominal group technique, consensus group method. Does not restrict to human error only.	Can be used together with PC. Other name for APJ is Direct Numerical Estimation. See also SLIM. See also Delphi method.					5				nuclear, ATM, (oil&gas)	x		x			• [Humphreys, 1988] • [Kirwan, 1994] • [MUFTIS3.2-I, 1996] • [Seaver & Stillwell, 1983]
	APMS (Aviation Performance Measuring System)					See Flight Data Monitoring Analysis and Visualisation															
47.	APRECIH (Analyse PREliminaire des Conséquences de l'Infiabilité Humaine)	Tab	HRA	1999	Preliminary Analysis of Consequences of Human Unreliability. Focuses on the consequence assessment of human behavioural deviations independently of the probabilities of the occurrence of human errors. APRECIH classifies scenarios of unreliability using a three-dimensional cognitive model that includes: acquisition-based unreliability, problem solving-based unreliability and action-based unreliability. It consists of four consecutive steps: 1) Functional analysis of human-machine system; 2) Procedural and contextual analysis; 3) Identification of task characteristics; 4) (Qualitative) Consequence analysis.	Design phase. In [Vanderhaegen, 2000], APRECIH has been integrated with a retrospective analysis step into a method named ACIH (a French acronym for Analysis of Consequences of Human Unreliability).			3	4	5				rail			x			• [PROMAI5, 2001] • [Vanderhaegen & Telle, 1998] • [Vanderhaegen, 2000]
48.	AQD (Aviation Quality Database)	Dat	Dat, Org	1998	AQD is a comprehensive and integrated set of tools to support Safety Management and Quality Assurance. Provides tools for data gathering, analysis and planning for effective risk management. AQD can be used in applications ranging from a single-user database to include operations with corporate databases over wide-area networks. AQD gathers Incident, Accident and Occurrence Reports together with internal and external quality and safety audits for joint analysis. It also offers tools for creating internal audit programs, assisting with audits for all airline departments, tracking corrective and preventive actions, integrating external audit requirements and analysing and reporting trends in quality indicators.	In [RAW, 2004], AQD is referred to as one of the big three Safety Event and Reporting Tools, along with BASIS and AVSiS. Ref. [GAIN GST03] refers to AQD as a clone of ASMS and states that AQD and ASMS are compatible in the sense that external organisations are able to gather their own occurrence data, track their own audit corrective actions, analyse the data and report their safety performance to CAA via an electronic interface. In practice, AQD is only used by larger organisations. Version 5 was released in 2005.								8	aviation, ATM, airport, aircraft	x		x	x	x	• [GAIN AFSA, 2003] • [Glyde, 2004] • [RAW, 2004] • [GAIN GST03]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
49.	ARCA (Apollo Root Cause Analysis)	Stat	Ret	2007	ARCA is a root cause analysis method that does not aim to find the root cause, but to identify the most effective solution to prevent the primary effect. It is based on 4 basic characteristics: 1. Cause and effect are the same thing; 2. Causes and effects are part of an infinite continuum. 3. Every effect has at least two causes in the form of actions and conditions; 4. An effect exists only if its causes exist at the same point in time and space. Part of the method is creating a RealityChart, which looks for causes of primary effects in actions and conditions, and looks for causes of these causes until a stopping criterion applies. Next, effective solutions are identified by challenging each cause in the Realitychart and checking possible solutions against the best solution criteria.	Supported by software						6			manufacturing, mining, road, rail	x		x	x		• [Ziedelis & Noel, 2011] • [Gano, 2007] • [ARCA web]
	Architectural Design Analysis					See SADA (Safety Architectural Design Analysis)															
50.	ARIA (Aerodrome Runway Incursion Assessment Tool)	Tab	Col	2006	ARIA is a computer based assessment that assists in assessing the possibility of runway incursions occurring at an airport, and showing which remedial actions may help to reduce this possibility. The user is presented a list of about 40 characteristics for airports (related to e.g. runway layout, traffic volume, pilot-controller communication, ground vehicles, weather, and potential risk reduction factors such as signs and signals at runway entrance), and selects which of these characteristics apply to the airport under study. Next, the model translates all selected characteristics into a numeric score and weighs and combines them in a formula to generate a runway incursion vulnerability index for the airport.	The model has been validated against data from 18 European civil airports, which covered a wide range of characteristics.					5	6			(airport)				x		• [ICAO 9870/AN463] • [ARIA, 2007] • [Van Es, 2006]
51.	ARMS (Aviation Risk Management Solutions)	Int	OpR	2010	ARMS defines an overall process for Operational Risk Assessment. This starts with Event Risk Classification (ERC), which is the first review of events in terms of urgency and the need for further investigation. This step also attaches a risk value to each event - which is necessary for creating safety statistics reflecting risk. The next step is data analysis in order to identify current Safety Issues. These Safety Issues are then risk assessed in detail through the Safety Issue Risk Assessment (SIRA). The whole process ensures that any necessary safety actions are identified, creates a Register for following up risks and actions and provides a Safety Performance Monitoring function. SIRA can also be used to make Safety Assessments, which is a requirement of the “Management of Change” element of the SMS.	Developed by the ARMS Working Group. Primary focus is on operational Flight Safety risks, i.e. any risks that could harm the occupants of an aircraft (passengers and crew)				3		5	6			aviation	x		x	x	x	• [ARMS, 2010]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
52.	ARP 4761 and ARP 4754 (Aerospace Recommended Practice documents 4761 and 4754)	Int	SwD, HwD	1994 and 2010	Guidelines and methods for conducting safety assessment on civil airborne systems and equipment, including hardware as well as software. The methodology consists of the steps Functional Hazard Assessment (FHA), Preliminary System Safety Assessment (PSSA), System Safety Assessment (SSA). In addition, CCA is performed throughout the other steps. CCA, FHA, PSSA and SSA are described separately in this database list.	ARP 4754 is the higher level document dealing with general certification. ARP 4761 gives a more detailed definition of the safety process. It is a refinement and extension of the JAR-25 and was developed by the Society of Automotive Engineers (SAE). In principle, the guidelines in the ARP documents are written for electronic systems, but may also be considered for other aircraft systems. Update (2010) of ARP 4754 is referred to as ARP 4754A.		2	3	4	5	6	7		aircraft, avionics	x	x				• [ARP 4754] • [ARP 4761] • [Klompstra & Everdij, 1997] • [Lawrence, 1999]
53.	Artificial Intelligence Fault Correction	Gen	SwD, Mit	1986 or older	Aim is to react to possible hazards in a very flexible way by introducing a mix (combination) of process models and on-line safety and reliability analysis. The methods are selected such that faults may be corrected and the effects of failures be minimised, in order to meet the desired safety integrity.	Software architecture phase.						6			(software)		x				• [EN 50128, 1996] • [Rakowsky] • [IEC61508 Part 7, 1997]
	Artificial Neural Networks					See Neural Networks															
54.	ART-SCENE (Analysing Requirements Trade-offs - Scenario Evaluation)	Step	SwD, HwD	2002	ART-SCENE is a process with Web-enabled tool support that organisations can use to generate and walk through scenarios, and thus discover the complete and correct requirements for new computer systems. It enhances current Rational Unified Processes and Use Case approaches to systems development.	ART-SCENE was developed by City University's Centre for HCI Design in London. Its origins were in the EU-funded Framework IV 21903 'CREWS' long-term research project. Since then ART-SCENE has been evaluated and extended in the UK EPSRC-funded SIMP project and bi-lateral projects, primarily with Eurocontrol and the UK's National Air Traffic Services. See also CREWS approach.						6			(ATM)	x	x				• [ART-SCENE web] • [ART-SCENE slides]
	ARTT (Aviation Research and Training Tools)					See Air Traffic Control Training Tools															
55.	A-SA Model (Attention - Situation Awareness Model)	Stat	HFA	2003	This model aims to predict pilot situation awareness (SA) and assessment. It is composed of two modules: The attention module describes the allocation of attention to events and flight deck displays within the aircraft environment. The belief updating module describes SA in terms of understanding the current and future state of the aircraft.	A-SA does not attempt to model complete human performance				4					aviation			x			• [Leiden & Best, 2005]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
56.	ASAP (Aviation Safety / Accident Prevention)	Dat	Dat	1984	ASAP is a collection of searchable databases, including airworthiness directives, accident/incidents, daily alerts, NTSB recommendations, safety analysis, service difficulty reports (SDRs), and significant SDRs. ASAP comes with software to enhance the tracking, analysis, and reporting of safety related issues and warnings. If an SDR is rated Hazardous or Catastrophic, the responsible engineer investigates the problem, the investigation is tracked in the significant SDR ASAP database, and the investigation is closed with a recommendation.	ASAP was developed by the FAA Rotorcraft Certification Directorate of the Aircraft Certification Service.			3			6		8	aviation	x			x		• [ATN Briefing 2004] • [FAA CFGA] • [SAT-01.1, 1997] (p. 112)
57.	ASAP (Aviation Safety Action Program)	Dat	Dat	1997	ASAP promotes voluntary reporting of safety issues and events that come to the attention of airline employees, including pilots, flight attendants, repair stations. It includes enforcement-related incentives to encourage employees to voluntarily report safety issues, even though the issues may involve an alleged violation of Title 14 of the FAA Code of Federal Regulations (14 CFR). ASAP safety data, much of which would otherwise be unobtainable, is used to develop corrective actions for identified safety concerns, and to educate the appropriate parties to prevent a reoccurrence of the same type of safety event.	See also ATSAP, which is modelled after ASAP, but which is focused on controllers.						6		8	aviation, aircraft	x			x		• [ATO SMS Manual v3.0] • [ASAP RPC, 2010] • [ASAP P&G] • [FAA AC 120-66B]
58.	ASAT (Airspace Simulation and Analysis for TERPS (Terminal En-route Radar Procedures))	FTS	Col	1998	ASAT is a Monte Carlo simulation tool to estimate e.g. probability of mid-air collision during terminal en route phase. Uses statistical input for Aircraft (flight dynamics, propulsion/performance, wake turbulence, on board avionics), Geographical/Geodetic (digital terrain elevation data, obstacles), Environmental (standards atmosphere, non-standards atmosphere, measured wind and temperature gradients data), Navigation ground systems, Surveillance (PRM, ASR-9, ARSR, TCAS, ADS-B), Human factors (pilot, air traffic control). ASAT can provide answers either in a deterministic or a probabilistic way.	Developed by ATSI (Air Traffic Simulation, Inc.). PRM = precision runway monitor; ASR = airport surveillance radar; ARSR = air route surveillance radar; TCAS = traffic collision avoidance system; ADS-B = automatic dependent surveillance - broadcast.			2			5	6			ATM, aviation	x		x	x		• [FAA-AFS-420-86] • [Lankford, 2003]
59.	ASCOT (Assessment of Safety Culture in Organisations Team)	Tab	Org	1992	ASCOT provides organisational self-assessment of safety culture. A review of safety culture involves consideration of all organisations which influence it, including the operating organisation, the regulator and any supporting organisations. For each of these organisations, there are guide questions which should be asked during a review of safety culture and key indicators of an effective safety culture which are used to assess the responses to these questions.	Qualitative. Developed by IAEA (International Atomic Energy Agency).							7	8	nuclear				x		• [Kennedy & Kirwan, 1998]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
60.	ASEP (Accident Sequence Evaluation Programme)	Tab	HRA	1987	Abbreviated and slightly modified version of THERP. ASEP comprises pre-accident screening with nominal human reliability analysis, and post-accident screening and nominal human reliability analysis facilities. Consists of four procedures: Pre-accident tasks, Post-accident tasks, Screening human reliability analysis, Nominal human reliability analysis.	Nuclear specific tool, developed by A.D. Swain. ASEP provides a shorter route to human reliability analysis than THERP by requiring less training to use the tool, less expertise for screening estimates, and less time to complete the analysis. Is often used as screening method to identify human actions that have to be assessed in more detail using THERP. However, is more conservative.					5				nuclear			x			• [HIFA Data] • [Kirwan, 1994] • [Kirwan & Kennedy & Hamblen] • [Straeter, 2000] • [Straeter, 2001]
61.	ASHRAM (Aviation Safety Human Reliability Analysis Method)	Step	HRA, Ret	2000	ASHRAM allows aviation researchers to analyze aviation accidents and incidents that involve human errors in ways that account for the operational context, crew expectations, training, airframe-related human-system interfaces, crew resource management, and generic human-error mechanisms. It examines the airframe and airspace situational factors, pilot performance-shaping factors, and error mechanisms identified by cognitive psychology to explain and model the overt and covert events leading up to an unsafe act. The ASHRAM cognitive model uses three cognitive functions: environmental perception, reasoning and decision-making, and action.	ASHRAM is a second-generation human reliability analysis developed by the Nuclear Regulatory Commission's Sandia National Laboratories. Based on ATHEANA, but adapted for aviation purposes.								8	(aviation)			x			• [Fitzgerald, 2007]
62.	ASIAS (Aviation Safety Information Analysis and Sharing)	Dat	Dat	2007	Primary objective is to provide a U.S. national resource for use in discovering common, systemic safety problems that span multiple airlines, fleets and regions of the global air transportation system. ASIAS leverages internal FAA data, de-identified airline safety data and other government and publicly available data sources. It fuses these data sources in order to proactively identify trends in the National Airspace System (NAS) and to assess the impact of changes in the aviation operating environment. Safety information discovered through ASIAS analytic activities is used across the industry to drive improvements and support Safety Management Systems.	Created by FAA. ASIAS gathers data from over 73 U.S. commercial operators. Its focus is currently on the integration of commercial aviation data, but future plans include the expansion of ASIAS to other sectors of the air transportation system. Former name is NASDAC Database (National Aviation Safety Data Analysis Center Database).			3		5			8	aviation, ATM, airport	x	x	x	x	x	• [ASIAS portal] • [Randolph, 2009] • [ASIAS refs] • [Hadjimichael et al] • [Basehore, 2011]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
63.	ASMS (Aviation Safety Monitoring System)	Dat	Dat, Val	1991	ASMS is a relational database that links information on aviation document holders with safety failures (occurrences and non-compliances) and tracks corrective actions. It is fully integrated with CAA's management information system and contains tools for creating and maintaining a database, customising and creating occurrence reports, tracking safety investigations, analysing data, and tracking corrective actions. Risk management is facilitated though the use of severity and likelihood codes. Automated Occurrence Report forms provide assistance in entering data and provide an audit trail of changes made. Investigation reports support full multimedia, including pictures.	Purpose: to provide the New Zealand aviation community with safety information as determined from accidents and incidents. It is also used to track corrective actions against non-compliances that are detected during proactive surveillance. It was commissioned in 1991. Ref. [GAIN GST03] refers to AQD as a clone of ASMS and states that AQD and ASMS are compatible in the sense that external organisations are able to gather their own occurrence data, track their own audit corrective actions, analyse the data and report their safety performance to CAA via an electronic interface.								8	aviation	x		x	x		• [GAIN ATM, 2003] • [GAIN GST03]
64.	ASMT (Automatic Safety Monitoring Tool)	Dat	Dat, HzI	2000	ASMT provides an automatic monitoring facility for safety related occurrences based on operational data. It detects and categorises each occurrence for assessment by trained operational experts. The tool will help determine causes and assist in the evolution of local procedures, airspace design, equipment and techniques. ASMT collects proximity-related occurrences. It will begin collecting ACAS occurrences through Mode-S stations, altitude deviations, runway incursions, airspace penetrations, and route deviations.	ASMT was developed by the Eurocontrol Experimental Centre (EEC), in co-operation with the Maastricht Upper Airspace Centre, for pilot operational use in 2000. It is also being used as part of the real time ATM simulation facilities at the EEC.							7		ATM				x		• [GAIN ATM, 2003]
	ASOR (Allocation of Safety Objectives and Requirements)					See ED-78A (RTCA/EUROCAE ED-78A DO-264)															
65.	ASP (Accident Sequence Precursor)	Stat	OpR	1979	ASP is a program containing several models for risk assessment. It identifies nuclear power plant events that are considered precursors to accidents with the potential for severe core damage and uses risk assessment methodologies to determine the quantitative significance of the events. ASP models contain event trees that model the plant response to a selected set of initiating events. When a precursor to be analysed involves one of these initiating events, an initiating event assessment is performed.	Established by the NRC (Nuclear Regulatory Commission) in 1979 in response to the Risk Assessment Review Group report. In 1994, INEEL (Idaho National Engineering and Environmental Laboratory) started the development for US NRC of a Human Reliability Analysis methodology as part of ASP.				4	5				nuclear	x		x			• [HRA Washington, 2001] • [NRC-status, 1999] • [NSC-ANSTO, 2002]
66.	AsPeCSS (Assessment methodology for forward looking integrated Pedestrian, and further extension to Cyclists Safety Systems)	Step	HzA	2014	AsPeCSS aims at assessing impact and cost of pedestrian injury due to collisions with road vehicles equipped with safety systems, such as automated emergency braking systems, pedestrian forward collision warning systems. The method includes various test scenarios of pedestrian dummies crossing the road in front of vehicles, measuring speed reduction, and converting dummy pedestrian responses into injury risk and casualty cost. Driver models can also be included.					4	5				road	x	x				• [Lubbe & Kullgren, 2015]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
67.	ASRM (Aviation Safety Risk Model)	Stat	OpR	1999	The ASRM is a decision support system aimed to predict the impacts of new safety technologies/ interventions upon aviation accident rate. First the interactions of causal factors are modelled. Next, Bayesian probability and decision theory are used to quantify the accident causal models and to evaluate the possible impacts of new interventions. Each such model is a BBN, and the models are combined into a Hierarchical BBN, i.e. a HBN. The entire process is largely based on expert judgments. ASRM uncertainty and sensitivity analyses is supported by a tool named BN-USA (Bayesian Network-Uncertainty and Sensitivity Analyses).	ASRM was originally developed for use by US Naval Aviation, but has since been used more widely within the aviation industry. It makes use of HFACS. ASRM is being enhanced and further developed by the NASA Aviation Safety Program Office to evaluate the projected impact upon system risk reduction of multiple new technology insertions/ interventions into the National Airspace System.				4	5				aviation	x					• [Luxhøj, 2002] • [Cranfield, 2005] • [Luxhøj, 2005] • [Luxhøj & Coit, 2005] • [Luxhøj & Oztekin, 2005]
68.	ASRS (Aviation Safety Reporting System)	Dat	Dat	1975	The ASRS receives, processes and analyses voluntarily submitted incident reports from pilots, air traffic controllers, and others. Reports submitted to ASRS describe both unsafe occurrences and hazardous situations. ASRS's particular concern is the quality of human performance in the aviation system. Individuals involved in aviation operations (pilots, crew members, ground personnel, etc.) can submit reports to the ASRS when they are involved in or observe a situation that they believe compromised safety. These reports are voluntary and submitted at the discretion of the individual. Teams of experienced pilots and air traffic controllers analyse each report and identify any aviation hazards.	The ASRS was established in 1975 under a memorandum of agreement between FAA and NASA. Datamining tool: QUORUM Perilog			3					8	aviation, ATM	x		x	x	x	• [ASRS web] • [GAIN ATM, 2003] • [FAA HFW]
69.	Assertions and plausibility checks	Step	SwD	1976 or older	Software Testing technique. Aim is to produce code whose intermediate results are continuously checked during execution. An assertion is a predicate (a true–false statement) placed in a program to indicate that the developer thinks that the predicate is always true at that place. When an assertion failure occurs, the programmer is notified of the problem. In case of incorrect results a safety measure is taken.	Applicable if no complete test or analysis is feasible. Related to self-testing and capability checking. Tools available. See also Software Testing.							7		software		x				• [Bishop, 1990]
70.	ASSET (Assessment of Safety Significant Event Team)	Stat	Ret	1991	In ASSET analysis, the event is broken up into logically connected occurrences which can be attributed to a single failure of either people, procedures or equipment, and the direct cause and root causes of each occurrence are identified to determine the corrective actions which will eliminate the direct cause and root causes. From a narrative of the event, the chronological order of occurrences is identified, which are represented by a logic tree in chronological order. For each occurrence analysed, corrective actions are suggested to eliminate the latent weakness identified, with special attention to prevention of repeated failures.	Developed by IAEA for investigating events of high significance with related managerial and organisational issues. Root cause analysis. No longer supported by IAEA, replaced by PROSPER (2000).						6		8	nuclear	x		x	x	x	• [Ziedelis & Noel, 2011]
	AT Coach					See Air Traffic Control Training Tools															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
71.	ATCS PMD (Air Traffic Control Specialist Performance Measurement Database)	Dat	Dat	1999	This database aims at selecting appropriate performance measures that can be used for evaluation of FAA NAS (National Airspace System) operations concepts, procedures, and new equipment. This database is intended to facilitate measurement of the impact of new concepts on controller performance. Using standard database techniques, a researcher can search the database to select measures appropriate to the experimental questions under study. With the selection of a particular measure(s), the database also provides citations for the primary source of the measure and additional references for further information. Having a set of measures with standardised parameters will increase the reliability of results across experiments, and enable comparisons of results across evaluations.	Provides a compilation of techniques that have been proven effective for use in human factor research related to air traffic control. Developed by FAA in 1999.		2					7		(ATM)			x	x		• [FAA HFW] • [ATCSPMD] • [Hadley, 1999]
72.	ATHEANA (A Technique for Human Error ANAlysis)	Step	HRA, Ret	1996	Aim is to analyse operational experience and understand the contextual causes of errors, and then to identify significant errors not typically included in PSAs for nuclear power plants, e.g. errors of commission. Key human failure events and associated procedures etc. are identified from the PSA, and unsafe acts are then identified that could affect or cause these events. Associated error-forcing conditions are then identified that could explain why such unsafe acts could occur. The important point is that these forcing conditions are based on the system being assessed, i.e. the real context that is the focus of the assessment.	Developed by NRC (Nuclear Regulatory Commission). Currently the method relies on operational experience and expert judgement. It is the intention of the authors to produce guidance material on the technical basis of the model. Such material could reduce the reliance on expert judgement and increase the auditability of the technique. Goes beyond THERP in its capability to account for and predict human errors, by examining cognitive processes. See also ASHRAM.								8	nuclear			x			• [Kirwan, Part 1, 1998] • [Ziedelis & Noel, 2011]
73.	ATLAS	Int	Task	1996	ATLAS is a performance modelling software package designed to support Human Factors Integration studies from an early stage in system development. It can be applied to predict and assess operator performance in critical operating scenarios. It combines a graphically-based task analysis with a database, aiming at maximizing the value of task analysis data. The analysis data structure was based on GOMS. The task data can be viewed and exported in various ways.	Developed by Human Engineering Limited (UK). Supports a variety of conventional task analysis methods (including hierarchical task analysis (HTA), timeline analysis (TLA) and tabular task analysis (TTA)) and incorporates more than 60 human performance, workload, and human reliability algorithms.			2						8	ATM, rail, oil&gas			x			• [Hamilton, 2000] • [FAA HFW]
	Atmospheric Dispersion Modelling					See Dispersion Modelling or Atmospheric Dispersion Modelling															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
74.	ATOS Random Inspections (Air Transportation Oversight System Random Inspections)	Dat	Val, HzI	2009	ATOS random inspections are unplanned cockpit en route inspections, cabin en route inspections, ramp inspections, or spot inspections. With management approval, ATOS-qualified part 121 air carrier inspectors may perform these inspections on any part 121 air carrier at any location, at any time. ATOS random inspections are not included in Comprehensive Assessment Plans or the National Flight Standards Work Program Guidelines. The results of ATOS random inspections are documented in the ATOS database.	ATOS job aids have been developed for cockpit en route, cabin en route, ramp, and spot inspections. These job aids supplement current guidance on these types of inspections (and in some cases replace existing job aids). The ATOS job aids can be accessed and printed from ATOS automation.							7		aviation	x		x	x	x	• [Notice 8900.81]
75.	ATQA (Air Traffic Quality Assurance)	Dat	Dat	1985	ATQA is a collection of subject specific databases (NMACS, PDS, VPDS, and OEDS). The Near Midair Collision System (NMACS) database contains reports of in flight incidents where two aircraft have closed to an unsafe distance and avoided an actual collision. The Pilot Deviation System (PDS) database contains incident reports in which the actions of the pilot violate a Federal Aviation Regulation (FAR) or a North American Aerospace Defense Command (NORAD), Air Defense Identification Zone (ADIZ) tolerance. The Vehicle/Pedestrian Deviation System (VPDS) contains incident reports of pedestrians, vehicles, or other objects interfering with aircraft operations on runways or taxiways. The Operational Error/Deviation System (OEDS) is used for reporting and monitoring certain kinds of situations that do not actually result in a collision but meet specific criteria as posing a potential danger or violating operational guidelines. Runway incursions are derived from OED, PD and VPD systems.	Formerly known as National Airspace Incidents Monitoring System (NAIMS). The OEDS system is not currently available on-line. Reference [FAA FY 2014] states that the ATQA reporting database has been replaced by Comprehensive Electronic Data Analysis and Reporting (CEDAR) (as of January 2012).								8	aviation, ATM	x		x	x	x	• [ATO SMS Manual v3.0] • [FAA FY 2014]
76.	ATSAP (Air Traffic Safety Action Program)	Dat	Dat, HzI	2008	ATSAP is a non-punitive, voluntary reporting program for air traffic controllers and other employees modeled after ASAP (Aviation Safety Action Program), which is used in the aviation industry. The collected information is reviewed and analyzed to facilitate early detection and improved awareness of operational deficiencies and adverse trends. The primary purpose of ATSAP is to identify safety events and implement skill enhancements and system-wide corrective actions to reduce the opportunity for safety to be compromised. Information obtained from ATSAP will provide stakeholders with a mechanism to identify actual and potential risks throughout the National Airspace System.	ATSAP has been established by FAA ATO (air traffic organization). It is 'genetically linked to' the NASA Aviation Safety Reporting System (ASRS), and is modelled after the ASAP (Aviation safety Action Program).			3			6		8	ATM	x			x		• [ATO SMS Manual v3.0] • [Notice JO 7210.772] • [ATSAP MoU] • [ATSAP Home]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
77.	ATSAT (Aviation Topics Speech Acts Taxonomy)	Tab	HRA	1995	ATSAT is a tool for categorizing pilot/controller communications according to their purpose, for classifying communication errors, and to develop time based performance metrics. ATSAT supports the encoding and hierarchical arrangement of operator and task performance. The encoded messages can be entered in a spreadsheet and be imported for statistical analysis.	ATSAT uses the phraseology standard contained in FAA Order 7119.65 Handbook of Air Traffic Control. It is supported by a Windows-based application ATSATpc, which is designed to facilitate posting of voice communications data into a predefined electronic spreadsheet, and which consists of 5 main menus: File Information; Transmission Identification; Speech Act Category; Aviation Topic; Communication Error.		2	3						(ATM)			x			• [FAA HFW] • [Prinzo, 1995] • [Prinzo, 2002] • [GAIN ATM, 2003] • [Prinzo & Maclin, 1996]
78.	ATWIT (Air Traffic Workload Input Technique)	RTS	HFA	1985	ATWIT aims to measure mental workload in "real-time" by presenting auditory and visual cues that prompt an air traffic controller to press one of seven buttons on the workload assessment keypad (WAK) within a specified amount of time to indicate the amount of mental workload experienced at that moment.	The ATWIT tool has been developed and has been in use at the FAA Technical Center.							7		ATM			x			• [FAA HFW] • [Stein, 1985]
79.	Avalanche/Stress Testing	Step	SwD	1995 or older	Software Testing technique. Helps to demonstrate robustness to overload. There are a variety of test conditions that can be applied. Under these test conditions, the time behaviour of the test object is evaluated. The influence of load changes is observed.	See also Software Testing.							7		software		x				• [EN 50128, 1996] • [Jones et al, 2001] • [Rakowsky]
	Aviation Safety Data Mining Workbench					See Data Mining															
80.	Avoidance of Complexity	Gen	Des	1987	To minimise the chance of error by making the system as simple as possible.	See also Measurement of Complexity.						6			software	x	x				• [Bishop, 1990]
81.	AVSiS (Aviation Safety Information System)	Dat	Dat, Mit	2003	AVSiS is a safety event logging, management and analysis tool. Events are divided into two groups: happenings (which are noteworthy but not actual incidents), and incidents. The Flight Safety Officer (FSO) on receipt of an event report consolidates the information into the AVSiS system, either electronically or manually. The FSO may then request follow up reports from either internal or external departments, and may assign human factors(s). Severity and likelihood are assessed. Finally, the FSO may record recommendations for actions to rectify any safety system weaknesses identified, and may record whether or not they have been accepted and then implemented.	AVSiS was developed by AvSoft and runs on Windows PCs (95, 98, NT, 2000 or XP). In [RAW, 2004], AVSiS is referred to as one of the big three Safety Event and Reporting Tools, along with BASIS and AQD. AVSiS Version 2.0p was released in 2003.								8	aviation	x		x	x		• [GAIN AFSA, 2003] • [RAW, 2004]
	AWSIM (Air Warfare Simulation)					See Air Traffic Control Training Tool															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
82.	B&UA (Bias and Uncertainty Assessment)	Math	Val	2002	Aim is to get detailed insight into the effect of all differences between a model (that is used in a safety risk assessment) and reality. The technique aims to assess all differences on their bias and uncertainty effect on safety risk, and to combine the results to get an estimate of 'true risk' and a credibility interval for 'true risk'. In addition, it aims to identify directions for model improvement as well as directions for safety design improvement and safety design requirements, based on those differences that have the highest effect on bias and/or uncertainty.	Two categories of uncertainty are: aleatory (reflecting the inherent randomness of processes) and epistemic uncertainty (reflecting restrictions in the state-of-knowledge used for the development of the model). B&UA is an important step in Verification and Validation of model-based safety risk assessment.					5	6			ATM	x	x	x	x	x	• [Everdij et al, 2006a] • [Everdij & Blom, 2002] • [Everdij & Blom, 2004] • [Nurdin, 2002]
83.	Back-to-back testing	Step	SwD	1986 or older	Software Testing technique. Aim is to detect failures by comparing the output of two or more programs implemented to the same specification. Also known as Comparison Testing.	Useful if two or more programs are to be produced as part of the normal development process. See also Software Testing.							7		software		x				• [Bishop, 1990]
84.	Backward Recovery or Backward Error Recovery	Step	Des	1989 or older	Back-up to a previous state that was known to be correct; then no (or little) knowledge of the error is needed. The Backward Recovery approach tends to be more generally applicable than the forward recovery approach - errors are often unpredictable, as are their effects.	Software architecture phase. See also Forward Recovery.						6			software		x				• [EN 50128, 1996] • [Rakowsky] • [SSCS]
85.	Barrier Analysis	Stat	Mit	1973	Barrier analysis is a structured way to consider the events related to a system failure. It suggests that an incident is likely preceded by an uncontrolled transfer of energy and therefore for an incident to occur there needs to be: 1. A person present 2. A source of energy 3. A failed barrier between the two. Barriers are developed and integrated into a system or work process to protect personnel and equipment from unwanted energy flows. Is implemented by identifying energy flow(s) that may be hazardous and then identifying or developing the barriers that must be in place to form damaging equipment, and/or causing system damage, and/or injury. Can also be used to identify unimaginable hazards.	Similar to ETBA (Energy Trace and Barrier Analysis). Barrier analysis is a qualitative tool for systems analysis, safety reviews, and accident analysis. Combines with MORT. Not to be confused with the Barrier Analysis developed by T. Davis (1990), which is used to study behaviour change in e.g. children.			3			6			chemical, nuclear, police, road, (rail)	x					• [FAA00] • [Kirwan & Ainsworth, 1992] • [ΣΣ93, ΣΣ97] • [FAA HFW]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
86.	BASIS (British Airways Safety Information System)	Dat	Dat	1992	Database based on voluntary reporting. BASIS Air Safety Reporting is used to process and analyse flight crew generated reports of any safety related incident. It has been regularly updated since its inception and has become the world's most popular aviation safety management tool (according to British Airways). The following modules are available: Air Safety Reporting (ASR); Safety Information Exchange (SIE); Ground and Cabin Safety modules.	Supporting tools available, e.g. BASIS Flight Data Tools, purpose of which is to gather and analyse digital data derived from onboard flight data recorders in support of an airline's Flight Data Monitoring (FDM) Programme - known in the U.S. as Flight Operations Quality Assurance (FOQA). The following modules are available: Flight Data Traces (FDT); Flight Data Events (FDE); Flight Data Measurements (FDM); Flight Data Simulation (FDS); Flight Data Home (FDH). In [RAW, 2004], BASIS is referred to as one of the big three Safety Event and Reporting Tools, along with AQD and AVSiS.			3					8	aviation	x	x	x	x	x	• [GAIN AFSA, 2003] • [RAW, 2004]
	Bayes Networks					See BBN (Bayesian Belief Networks)															
	Bayesian Networks					See BBN (Bayesian Belief Networks)															
87.	BBN (Bayesian Belief Networks)	Stat	Mod	1950	BBN (also known as Bayesian networks, Bayes networks, Probabilistic cause-effect models and Causal probabilistic networks), are probabilistic networks derived from Bayes theorem, which allows the inference of a future event based on prior evidence. A BBN consists of a graphical structure, encoding a domain's variables, the qualitative relationships between them, and a quantitative part, encoding probabilities over the variable. A BBN can be extended to include decisions as well as value or utility functions, which describe the preferences of the decision-maker. BBN provide a method to represent relationships between propositions or variables, even if the relationships involve uncertainty, unpredictability or imprecision. By adding decision variables (things that can be controlled), and utility variables (things we want to optimise) to the relationships of a belief network, a decision network (also known as an influence diagram) is formed. This can be used to find optimal decisions, control systems, or plans.	Bayesian belief networks are based on the work of the mathematician and theologian Rev. Thomas Bayes (1702-1761), who worked with conditional probability theory in the late 1700s to discover a basic law of probability, which was then called Bayes' rule: p(A | B) = (p(A) * p(B | A)) / p(B). The term Bayesian came in use around 1950. The term "Bayesian networks" was coined by Judea Pearl (1985). Tools available, e.g. SERENE (SafEty and Risk Evaluation using bayesian NEts), see [GAIN ATM, 2003]; HUGIN. See also ASRM, BBN, DBN, HBN.				4	5				healthcare, environment, finance, ATM, aviation, rail, maritime, chemical,oil&gas, nuclear, defence	x	x	x	x	x	• [Adusei-Poku, 2005] • [Belief networks] • [BBN04] • [GAIN ATM, 2003] • [Pearl, 1985] • [FAA HFW]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
88.	BDD (Binary Decision Diagram)	Stat	Mod	1959	Represents a Boolean function, by means of a rooted, directed, acyclic, binary graph, which consists of decision nodes and two terminal nodes called 0-terminal and 1-terminal. Such a BDD is called 'ordered' if different variables appear in the same order on all paths from the root. It is called 'reduced' if the graph is reduced according to two rules: 1) Merge any isomorphic subgraphs. 2) Eliminate any node whose two children are isomorphic.	Introduced by C.Y. Lee, and further developed by others. In literature the term BDD generally refers to ROBDD (Reduced Ordered BDD), the advantage which is that it is unique for a particular functionality. See also DTA and Decision Tables. See also CCDM or CCA.				4					electronics, avionics	x	x				• [Lee, 1959]
	Bedford Workload Scale					See Rating Scales															
	Behaviorally Based Performance Rating Scale					See Rating Scales															
89.	Behaviour Graphs	Dyn	HwD	1985	Behaviour graphs are combined control and information flow graphs for describing system behaviour within the requirements driven development systems engineering methodology. The graphs show system behaviour explicitly as a function of time. The data flow is shown on the horizontal axis, and time on the vertical axis. The graphs are used for function analysis at the system level, and for scenario modelling. Behaviour graphs model the communication and coordination between components and operators in a system. Thus details of the system architecture must be available. The input and output item sequences between the system and its environment must also be available.					4					defence, ATM, social	x					• [HEAT overview] • [Beevis, 1992]
90.	Beta-factor method	Math	Par	1967	A method for the quantitative approximation of the probability of common cause failures (CCF). A beta factor is estimated (if possible by using historical data) such that beta% of the failure rate is attributed to the CCF and (1- beta)% is attributed to the random failure rate of the component.	Developed by Marshall and Olkin. See also Multiple Greek Letters method.					5				aircraft, nuclear, chemical	x					• [Guey, 1984] • [MUFTIS3.2-I, 1996] • [Charpentier, 2000] • [Mauri, 2000] • [Pozsgai & Neher & Bertsche, 2002]
	Bias and Uncertainty Assessment					See B&UA (Bias and Uncertainty Assessment)															
91.	Black Spot Analysis	Step	Mit	1980 or older	Black Spot analysis is a strategic framework for long term systematic and cost efficient occupational injury prevention. The philosophy underlying Black Spot analysis is to allocate resources where they will lead to the greatest reduction in the most severe injuries. Based principally on workers' compensation statutory claims data, Black Spot analysis will identify priority areas for action to prevent severe occupational trauma	Also referred to as Accident-Concentration Analysis						6			road				x		• [Kjellen, 2000] • [QWHSS, 2005]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
92.	Bond-Graphs	Dyn	Mod	1961	A Bond graph is a modelling approach using graphical representation of a physical dynamic system. The "bonds" link together "single port", "double port" and "multi port" elements. Each bond represents the instantaneous bi-directional flow of physical energy (dE/dt) or power. The energy exchange includes mechanical, electrical, hydraulic energy. The flow in each bond is denoted by a pair of variables called 'power variables' whose product is the instantaneous power of the bond. The power variables are broken into two types: "effort" and "flow". Effort multiplied by flow produces power.	Developed by Henry Paynter, MIT. The term "bond graph" comes from the notion that many of these graphs look like the bonds in chemistry. If the dynamics of the physical system to be modelled operate on widely varying time scales, fast continuous-time behaviours can be modelled as instantaneous phenomena by using a hybrid bond graph.		2		4					manufacturing, electronics, finance	x					• [Broenink, 1999] • [Gero & Tsai, 2004]
93.	Boundary value analysis	Step	SwD	1992 probably older	Software Testing technique. Boundary value analysis is a software testing technique in which tests are designed to include representatives of boundary values, which are values on the edge of an equivalence partition or at the smallest value on either side of an edge. The values could be either input or output ranges of a software component. Since these boundaries are common locations for errors that result in software faults they are frequently exercised in test cases.	Boundary-value testing of individual software components or entire software systems is an accepted technique in the software industry. See also Software Testing.							7		software		x				• [EN 50128, 1996] • [Jones et al, 2001] • [Rakowsky] • [Sparkman, 1992]
94.	Bow-Tie Analysis	Stat	Mit	1999	Aim is to enhance communication between safety experts (who construct a Bow-Tie diagram) and operational experts (who identify hazard mitigating measures using the Bow-Tie diagram). The knot of the Bow-Tie represents a releasing event or a hazard. The left-hand side wing shows threats and Pro-active measures, which improve the chances to avoid entering the hazard; the right-hand side wing shows consequences and Re-active measures to improve the chances to escape from the hazard prior to its escalation.	Developed by Royal Dutch Shell. The Bow-Tie Diagram has evolved over the past decades from the Cause Consequence Diagram of the 1970s and the Barrier Diagram of the mid 1980s. It has been most often used in chemical and petro-chemical industries. The approach has been popularised at EU Safety Case Conference, 1999, as a structured approach for risk analysis within safety cases where quantification is not possible or desirable. See also CCDM or CCA.						6			oil&gas, chemical, healthcare, defence, nuclear, finance, manufacturing	x		x	x		• [Bishop, 1990] • [Villemeur, 1991] • [Rademakers et al, 1992] • [EN 50128, 1996] • [Edwards, 1999] • [Zuijderduijn, 1999] • [Trbojevic & Carr, 1999] • [Blom & Everdij & Daams, 1999] • [DNV-HSE, 2001] • [Petrolekas & Haritopoulos, 2001] • [FAA HFW]
95.	Bow-Tie Analysis using Fault Tree and Event Tree	Stat	HzA	2002	A method for cause-consequence analysis of a hazard or critical event. The left-hand-side of the Bow-Tie is formed by a Fault Tree, which models how the hazard is caused by combinations of primary events. The right-hand-side of the Bow-Tie is formed by an Event Tree, which models the consequences of the hazard.	This type of bow-tie is also known as Cause-Consequence Diagram (CCD). See also CCDM or CCA.				4					ATM	x		x			• [EN 50128, 1996] • [EHQ-PSSA, 2002] • [Harms-Ringdahl, 2013]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
96.	BPA (Bent Pin Analysis)	Step	HwD	1965	BPA is an analysis technique for identifying hazards caused by bent pins within cable connectors. It evaluates the effects should connectors short as a result of bent pins and mating or demating of connectors. BPA generally only considers and evaluates the effect of a single bent pin contacting another pin within its radius or with the connector case. BPA does not consider two pins bending and making contact with each other or with a third pin, except in the case of high-consequence circuits.	Developed by The Boeing Company circa 1965, on the Minuteman program. Any connector has the potential for bent pins to occur. Connector shorts can cause system malfunctions, anomalous operations, and other risks. Combines with and is similar to CFMA. Applicable during maintenance operations. Sometimes referred to as a subset of FMEA.			3		5				defence	x					• [ΣΣ93, ΣΣ97] • [FAA00] • [Ericson, 2005]
97.	Brahms (Business Redesign Agent-based Holistic Modelling System)	Dyn	Mod	1997	Agent-based simulation tool for modelling the activities of groups in different locations. The typical simulation can be organized into 7 component models: 1. Agent model: the groups of people, individuals (agents), and their interrelation-ships; 2. Activity model: the activities that can be performed by agents and objects; 3. Communic-ation model: the communication among agents and between agents and objects; 4. Timing model: the temporal constraints and relationships between activities; 5. Knowledge model: the initial beliefs and thought frames of agents and objects; 6. Object model: the objects in the world used as resources by agents or used to track information flow; 7. Geography model: the specification of geographical areas and potential paths in which agents and objects perform their activities.	Developed 1992-1997 by B. Clancey, D. Torok, M. Sierhuis, and R. van Hoof, at NYNEX Science and Technology; after 1997 development was continued by NASA ARC. Can be used qualitatively or quantitatively.				4	5				management, healthcare, space			x	x	x	• [Morrison, 2003]
98.	Brainstorming	Gen	Dat	1953 or older	A group of experts sit together and produce ideas. Several approaches are known, e.g. at one side of the spectrum the experts write down ideas privately, and then gather these ideas, and at the other side of the spectrum, the expert openly generate ideas in a group.	The term Brainstorming was popularised by A.F. Osborn in 1953. See also Table Top Analysis.			3			6			all	x	x	x	x	x	• [FAA HFW] • [Rakowsky]
	BREAM (Bridge Reliability And Error Analysis Method)					See CREAM (Cognitive Reliability and Error Analysis Method)															
	Brio Intelligence 6					See Data Mining. See FDM Analysis and Visualisation Tools.															
99.	Brown-Gibson model	Math	Dec	1972	Addresses multi-objective decision making. The model integrates both objective and subjective measures (weights) for decision risk factors to obtain preference measures for each alternative identified. Makes repeated use of Paired Comparisons (PC).	Developed in 1972 by P. Brown and D. Gibson. Used many times for decision-making on facility location. Link with AHP and PC. See also MCDM.					5				management	x					• [Feridun et al, 2005] • [Maurino & Luxhøj, 2002]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
100.	BTS Databases (Bureau of Transportation Statistics Databases)	Dat	Dat	1992	The BTS maintains databases, including ones related to safety statistics, such as Aviation Accident Statistics, Aviation Safety Reporting System, Data on Occupational Injuries, Road Safety Data, Marine Casualty and Polution (e.g. Oil spills), Pipeline Safety Data, Railroad Accident/Incident Reporting, Recreational Boating Accident Reporting, Crime Statistics, Search and Rescue Management Information, Hazardous Material Incident Reporting System.									8	aviation, ergonomics, healthcare, oil&gas, road, maritime, leisure, police, management, rail	x			x		• [Data Library Safety] • [Data Library Aviation]
101.	Bug-counting model	Step	SwD	1983 or older	Model that tends to estimate the number of remaining errors in a software product, and hence the minimum time to correct these bugs.	Not considered very reliable, but can be used for general opinion and for comparison of software modules. See also Musa Models. See also Jelinski-Moranda models.			3						software		x				• [Bishop, 1990]
102.	C3TRACE (Command, Control, and Communication-Techniques for Reliable Assessment of Concept Execution)	Step	Org, Task	2003	C3TRACE provides an environment that can be used to evaluate the effects of different personnel configurations and information technology on human performance as well as on overall system performance. This tool provides the capability to represent any organisation, the people assigned to that organisation, the tasks and functions they will perform, and a communications pattern within and outside the organisation, all as a function of information flow and information quality.					4				8	defence			x		x	• [Kilduff et al, 2005] • [FAA HFW] • [Alley, 2005]
103.	CAAM (Continued Airworthiness Assessment Methodologies)	Step	HwD	2002	CAAM is an aircraft engine reliability and failure data analysis tool used to identify and prioritize unsafe conditions. Steps are: a) Identify potential unsafe condition; b) Estimate the number of aircraft exposed; c) Estimate the uncorrected risk factor (i.e. the expected number of events if no action is taken to address the condition) and risk per flight, by means of analytical techniques such as root cause problem assessments; d) Estimate effects (potential risk reduction) of candidate mitigating actions; e) Implement and monitor corrective action plan. Five CAAM hazard levels are used, ranging from level 5 (catastrophic consequences) to level 1 (minor consequences). Levels 3, 4 and 5 represent the greatest area of safety concern, and a hazard ratio is established for these occurrences, i.e. the conditional probability that a particular powerplant installation failure mode will result in an event of such hazard level.	The CAAM process was developed by FAA in 1994-2002, and was based on a 1993 study by AIA (Aerospace Industries Association) aimed at addressing safety related problems occurring on commercial aircraft engines. CAAM is reactive to incidents, in the sense that it depends on data from incidents and other reported problems, and it cannot react to situations for which operational data are not available. In addition, CAAM is proactive to accidents, in the sense that it uses data from minor abnormalities to predict more serious problems.		2	3	4	5	6	7		aircraft	x					• [FAA AC 39-8, 2003] • [FAA AC 33.4-2, 2001]
104.	CADA (Critical Action and Decision Approach)	Tab	HRA, Task	1988	CADA is a technique for systematic examination of decision-making tasks. It utilizes checklists to classify and examine decision errors and to assess their likelihood. Psychologically-based tool. Model-based incident analysis / HRA.	Apparently not in current use or else used rarely. Developed from Murphy diagrams and SRK.					5				nuclear			x			• [Kirwan, Part 1, 1998]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
105.	CADORS (Civil Aviation Daily Occurrence Reporting System)	Dat	Dat	1996	CADORS is a Canadian national data reporting system that is used to collect timely information concerning operational occurrences within the Canadian National Civil Air Transportation System and is used in the early identification of potential aviation hazards and system deficiencies. Under the Aeronautics Act, there is a mandatory requirement for ATS certificate holders to report items listed in the CADORS Manual. CADORS reports are collected from a number of sources, but NAV CANADA supplies close to 80% of all reports. Other information providers include Transportation Safety Board, airports, police forces, public, etc. CADORS captures a wide scope of safety related events including ATC operating irregularities; communication, navigation, surveillance, and other air traffic systems failures; controlled airspace violations; etc. Included in the collection are occurrences related to aircraft, aerodromes, security (e.g. bomb threats, strike actions) and environment (e.g. fuel spills)	In 2001, CADORS consisted of 36,000 safety reports of aviation occurrences.			3					8	aviation, ATM, aircraft, airport, security, environment	x		x	x		• [GAIN ATM, 2003]
106.	CAE Diagrams (Conclusion, Analysis, Evidence Diagrams or Claims-Argument-Evidence Diagrams)	Stat	Ret	1996	CAE Diagrams are used to structure a safety case of an accident. They provide a road-map of the evidence and analysis of an accident and encourage analysts to consider the evidence that supports particular lines of argument. CAE diagrams are graphs. The roots represent individual conclusions/claims from an accident report. Lines of analysis/arguments that are connected to items of evidence support these. Each item of evidence either weakens or strengthens a line of analysis/argument. Lines of analysis/argument may also strengthen or weaken the conclusion/claim at the root of the tree.	Conclusion Analysis Evidence diagrams were developed by Chris Johnson (Univ. Glasgow). The consultancy firm Adelard developed a version named Claims-Argument-Evidence diagrams. Link with GSN. CAE is different to GSN; it uses different shapes and approach, but similar concepts. It is an approach to 'graphical argumentation'.				4					maritime, healthcare, management, aircraft	x			x		• [Johnson, 1999] • [Johnson, 2003] • [Johnson, 2003a] • [UK CAA SRG, 2010] • [Bishop & Bloomfield, 1998] • [Bloomfield & Wetherilt, 2012] • [Greenwell, 2005]
107.	CAHR (Connectionism Assessment of Human Reliability)	Tab	HRA, Ret	1992 - 1998	The Database-System CAHR is a twofold tool aiming at retrospective event analysis and prospective assessment of human actions. It is implemented as a tool for analysing operational disturbances, which are caused by inadequate human actions or organisational factors using Microsoft ACCESS. Retrospectively, CAHR contains a generic framework for the event analysis supprted by a knowledge base of taxonomies and causes that is extendable by the description of further events. The knowledge-base contains information about the system-state and the tasks as well as for error opportunities and influencing factors (Performance Shaping Factors). Prospectively it aims to provide qualitative and quantitative data for assessing human reliability.	The term Connectionism was coined by modelling human cognition on the basis of artificial intelligence models. It refers to the idea that human performance is affected by the interrelation of multiple conditions and factors rather than singular ones that may be treated isolated. Developed 1992-1998. See also CAHR-VA.					5				nuclear, maritime, manufacturing, rail			x	x	x	• [HRA Washington, 2001] • [Straeter et al, 1999] • [Apostolakis et al, 2004] • [Straeter, 2006a] • [Straeter, 2000] • [Ghamdi & Straeter, 2011] • [Loer et al, 2011]
108.	CAHR-VA (Connectionism Assessment of Human Reliability - Virtual Advisor)	Tab	HRA	2007	This is CAHR tailored to the support of human reliability assessment workshops with qualitative and quantitative data of human reliability helping air traffic management experts to generate appropriate judgements.	Uses MUAC (Maastricht Upper Area Control) incident database.					5				(ATM)			x	x	x	• [Blanchard, 2006] • [Leva et al, 2006] • [Kirwan, 2007]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
109.	CAIR (Confidential Aviation Incident Reporting)	Dat	Dat	1988	CAIR aims to gather data that would not be reported under a mandatory system. It covers flight crews, maintenance workers, passengers, and air traffic service officers. The program is designed to capture information, no matter how minor the incident. While confidentiality is maintained, the report must not be anonymous or contain unverifiable information. The ATSB supplement in the 'Flight Safety Australia' magazine is the primary method of publishing a report and obtaining feedback on CAIR issues. Publication of selected CAIR reports on the Internet is planned. Air safety investigations are performed by ATSB independent of the Civil Aviation Safety Authority (CASA) (the regulator) and AirServices Australia (the air traffic service provider). The ATSB has no power to implement its recommendations.	CAIR was instituted by the Australian Transport Safety Bureau (ATSB) in 1988 as a supplement to their mandatory reporting system, the Air Safety Incident Report (ASIR). The program's focus is on systems, procedures and equipment, rather than on individuals. In 2004, CAIR was replaced by the Aviation Self Reporting (ASR) system, which was introduced in 1988. Several other countries have an analogue to CAIR, such as Singapore (SINCAIR), Samoa (SACAIR), Korea (KAIRS), UK (CHIRP), USA (ASRS). The Australian CAIR was modelled directly on ASRS.								8	aviation, ATM, aircraft, airport, security	x		x	x		• [GAIN ATM, 2003] • [Salmon et al., 2005]
110.	CAMEO/TAT (Cognitive Action Modelling of Erring Operator/Task Analysis Tool)	RTS	Task	1991	Simulation approach acting as a task analysis tool, primarily to evaluating task design, but also for potential use in Human Reliability Assessment. It allows designers to ensure that operators can carry out tasks. Performance Shaping Factors used in the approach include task load, complexity, time pressure, opportunistic change of task order, multiple task environments, negative feedback from previously made decisions or actions, operator's policies and traits, etc.	This approach is relatively rare in Human Error Identification, where more usually either an 'average' operator is considered, or a conservatively worse than average one is conceptualised.		2	3						(nuclear)			x	x		• [Fujita, 1994] • [Kirwan, Part 1, 1998]
111.	CANSO Common Safety Method	Int	OpR	2014	This standard aims to be a common framework on safety risk evaluation and assessment for air navigation service providers, applying to ground-based functional changes to air traffic management. Steps are: a. functional system definition (objective, elements, boundary, environment, safety measures); b. risk analysis (hazard identification and risk acceptability); c. risk evaluation (i.e. comparison with risk acceptance criteria); and d. safety requirements (i.e. safety measures to be implemented to reduce risk, and demonstration of compliance). For the risk acceptability step, three methods can be used: 1) application of codes of practice; 2) comparison with similar reference functional system; 3) explicit estimation of frequency and severity of hazardous scenarios.	Framework; the practitioner has the freedom to choose how to conduct all steps. CANSO is the Civil Air Navigation Services Organisation, which has 80 full members and 79 associate members (as of 2014).	1	2	3	4	5	6			(ATM)	x		x	x		• [CANSO, 2014]
112.	CAP (Comprehensive Assessment Plan)	Tab	Val	1988 or older	The CAP is a tool for planning, documenting, and tracking Design Assessments (DA) and Performance Assessments (PA). The CAP is developed during initial certification or at an annual planning meeting. The CAP documents the planned assessments at the system element level. The principal inspector uses the CAP to adjust priorities and due dates of assessments, and to record the reasons for making adjustments.	Widely applied in education domain.							7		social, healthcare, environment, aviation	x			x	x	• [FAA FSIMS, 2009]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
113.	CARA (Controller Action Reliability Assessment)	Step	Par	2007	This is HEART tailored to the air traffic controller. CARA quantifies human errors in controller tasks.	Uses the CORE-DATA human error database					5				ATM			x			• [Kirwan, 2007] • [Kirwan & Gibson]
114.	Card Sorting	Min	HzA	1960	Card Sorting is a technique for discovering the latent structure in an unsorted list of statements or ideas. The investigator writes each statement on a small index card and requests six or more subject matter experts to individually sort these cards into groups or clusters. The results of the individual sorts are then combined and if necessary analyzed statistically. Related techniques are: • Affinity Diagrams, which is a brainstorming method that helps to first generate, then organize ideas or concerns into logical groupings. It is used to sort large amounts of complex, or not easily organized data. Existing items and/or new items identified by individuals are written on sticky notes which are sorted into categories as a workshop activity. Can incorporate the represent-ation of the flow of time, in order to describe the conditions under which a task is performed. • Cluster analysis is a collection of statistical methods that is used to organize observed data into meaningful structures or clusters. The measure of the relationship between any two items is that pair's similarity score. Cluster analysis programs can display output in the form of tree diagrams, in which the relationship between each pair of cards is represented graphically by the distance between the origin and the branching of the lines leading to the two clusters. Cluster members share certain properties and thus the resultant classification will provide some insight into a research topic. • Content analysis (1969) is a research tool that uses a set of categorisation procedures for making valid and replicable inferences from data to their context. It is analogous to Card Sorting. Researchers quantify and analyze the presence, meanings and relationships of words and concepts, then make inferences about the messages within the texts. CA is usually carried out as part of an analysis of a large body of data such as user suggestions. Content analysis is conducted in five steps: 1. Coding. 2. Categoriz-ing. 3. Classifying. 4. Comparing. 5. Concluding. • P Sort is a sorting technique where the expert is asked to sort a limited number of domain concepts into a fixed number of categories. • Q Sort is a process whereby a subject models his or her point of view by rank-ordering items into 'piles' along a continuum defined by a certain instruction.	The affinity diagram was devised by Jiro Kawakita in the 1960s and is sometimes referred to as the Kawakito Jiro (KJ) Method.		2			5				manufacturing	x			x	x	• [Affinity Diagram] • [Cluster Analysis] • [Anderberg, 1973]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
115.	CASE (Controlled Airspace Synthetic Environment)	RTS	Trai	1998	CASE is a training system that models the complete airspace system from gate-to-gate. The CASE simulator is capable of recording every single event that occurs within the scenario that has been defined. In addition to modelling the performance/profiles of any number of aircraft and ground vehicles, CASE is also able to evaluate and analyse events such as congestion, sector loading, the number of times a separation threshold has been violated the number of aircraft controlled by each control station, etc. The core elements are: 1) a Central Processing Suite, 2) up to thirty-five Pilot, Controller (and Supervisor) Operator Workstations, 3) an Exercise Preparation System, and 4) Voice and data communications networks.	Developed by AMS (Alenia Marconi Systems).		2							ATM, defence	x		x	x	x	• [GAIN ATM, 2003]
116.	CAS-HEAR (Computer-Aided System for Human Error Analysis & Reduction)	Stat	Ret	2008	Method aims at a systematic and thorough analysis of human error in an accident. Steps are: 1) Select critical human errors from the accident sequence. 2) For each of the human subjects who committed the errors, analyse the operator-, task-, environment-, and organisation-related contexts. Rate the degree of influence on the accident on a five-level scale (very low-very high). 3) Identify the error types. 4) Identify error causes. This uses a classification scheme that contains causally linked factors. Causal factors linked to contextual factors rated 'Very high' in Step 2 are selected, and influences are identified by following the causal links. Repeat this process until the root causes of the error are found. 5) Analyse error handling processes, including error detection and recovery 6) Analyse barriers. These can be physical administrative or procedural barriers. 7) Review causal analysis and determine the key causes of the accident. 8) Develop corrective actions. 9) Evaluate corrective actions.	Based on managerial error analysis system HEAR (Human Error Analysis & Reduction), which was developed for use in the Korean railway industry. CAS-HEAR was designed to increase the quality and efficiency of human error analysis using HEAR. Although CAS-HEAR was developed specifically for the railway industry, it is said to be applicable to other industries with minor modifications.				4		6		8	rail			x			• [Ziedelis & Noel, 2011] • [Kim et al, 2008]
117.	CASS (Commercial Aviation Safety Survey)	Tab	Org	2003	The CASS questionnaire-based survey was designed to measure five organisational indicators of safety culture within an airline: Organisational Commitment to Safety; Managerial Involvement in Safety; Employee Empowerment; Accountability System; Reporting System.	Developed at the University of Illinois. Ref. [Von Thaden, 2006] addresses a translation to a Chinese context. CASS exists in two versions: one for flight operations personnel (pilots, chief pilots, and operations management) and one for aviation maintenance personnel (technicians, inspectors, lead technicians, supervisors, and maintenance management).								8	aviation, aircraft					x	• [Gibbons et al, 2006] • [Von Thaden, 2006] • [Wiegman et al, 2003]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
118.	CAST (Causal Analysis based on STAMP)	Step	Ret	2011	CAST is STAMP-based retrospective analysis of actual accidents and incidents. It takes as input a comprehensive accident report, and proceeds to thoroughly explain why the accident occurred, rather than who is to blame. The CAST methodology follows these steps: 1. Define the system and hazards in the accident. 2. Identify system safety constraints and associated safety requirements. 3. Define system control structure. 4. Estimate the events leading up to the accident. 5. Analyze loss at the physical system level. 6. By ascending and descending throughout the system control, determine the how and why each successive higher level allowed the inadequate control to continue to be erroneous. 7. Evaluate overall coordination and communication contributors to the accident. 8. Determine dynamic changes in the system and the safety control structure relating to the loss and any weakening of the safety over time. 9. Generate Recommendations.	CAST is based on STAMP and was developed by Nancy Leveson and co-authors. Following STAMP principles, safety is treated as a control problem, rather than as a failure problem; accidents are viewed as the result of inadequate enforcement of constraints on system behavior.								8	aviation, finance, food, rail, healthcare	x	x	x	x	x	• [Leveson, 2011]
119.	CAT (Cognitive Analysis Tool)	Dat	Mod	1992	CAT is a computerized GOMS technique for soliciting information from experts. CAT allows the user to describe his or her knowledge in an area of expertise by listing the goals, subgoals, and one or more methods for achieving these goals, along with selection rules. These production rules form the basis of GOMS models that can be used to generate detailed predictions of task execution time using a proposed interface. Cognitive aspects of the task may be derived from this method, but the technique itself does not guarantee it.	Developed by Dr. Kent Williams in 1992. A development based on lessons learned from CAT is referred to as CAT-HCI (CAT for Human Computer Interaction). Link with GOMS.		2							(navy), (social)			x	x		• [FAA HFW] • [Williams et al., 1998]
120.	CATS (Causal model for Air Transport safety)	Stat	Dat	2005	A causal model represents the causes of commercial air transport accidents and the safeguards that are in place to prevent them. The primary process is further subdivided into several flight phases: take-off, en-route and approach and landing. Events occurring between an aircraft's landing and its next flight are not modelled. The numerical estimates derived in the model apply to western-built aircraft, heavier than 5700 kg, maximum take-off weight. The model apportions the probability per flight of an accident over the various scenarios and causes that can lead to the top event. The CATS model architecture includes Event Sequence Diagrams (ESDs), Fault Trees (FTs) and Bayesian Belief Nets (BBNs). ESDs represent the main event sequences that might occur in a typical flight operation and the potential deviations from normal. FTs resolve the events in an ESD into base events. The base events relating to human error are further resolved into causal events, which relate to the base events via probabilistic influence, as captured in a BBN.	CATS arose from the need for a thorough understanding of the causal factors underlying the risks implied by the air transport, so that improvements in safety can be made as effectively as possible. It was developed for the Netherlands Ministry of Transport and Water Management by a consortium including Delft University of Technology, National Aerospace Laboratory NLR, White Queen Safety Strategies, the National Institute for Physical Safety (NIVF), Det Norske Veritas (DNV) and JPSC. The model currently consists of 1365 nodes, 532 functional nodes, representing ESDs and FTs, and 833 probabilistic nodes.								8	aviation	x					• [Ale et al, 2006] • [Ale et al, 2008]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
121.	CATT (Corrective Action Tracking Tool)	Tab	Mit	2009	CATT is a tool used by certificate management team (CMT) managers and principal inspectors (PIs) to ensure that certificate holders meet schedules for completing corrective actions that result from design assessments (DA), performance assessments (PA), or other oversight functions. The CATT documents immediate and long-term CMT-initiated corrective actions required of certificate holders, including specific follow-up actions that may be required by guidance.							7	8	(aviation)	x			x	x	• [FAA FSIMS, 2009]
122.	Causal Networks	Stat	Mod	1940 or older	Graph of random quantities, which can be in different states. The nodes are connected by directed arcs which model that one node has influence on another node.	The idea of using networks to represent interdependencies of events seems to have developed with the systematisation of manufacturing in the early 1900s and has been popular since at least the 1940s. Early applications included switching circuits, logistics planning, decision analysis and general flow charting. In the last few decades causal networks have been widely used in system specification methods such as Petri nets, as well as in schemes for medical and other diagnosis. Since at least the 1960s, causal networks have also been discussed as representations of connections between events in spacetime, particularly in quantum mechanics.				4					manufacturing, healthcare	x	x				• [Loeve & Moek & Arsenis, 1996] • [Wolfram, 2002]
	Causal probabilistic networks					See BBN (Bayesian Belief Networks)															
123.	CbC or CbyC (Correctness-by-Construction)	Gen	Des	1992 about	In contrast to 'construction by correction' (i.e., build and debug), CbC seeks to produce a product that is inherently correct. Aim of CbC is to employ constructive means that preclude defects. It is a process for developing high integrity software, aiming at removing defects at the earliest stages. The process almost always uses formal methods to specify behavioural, security and safety properties of the software. The seven key principles of Correctness-by-Construction are: Expect requirements to change; Know why you're testing (debug + verification); Eliminate errors before testing; Write software that is easy to verify; Develop incrementally; Some aspects of software development are just plain hard; Software is not useful by itself.	Developed by Praxis Critical Systems. Correctness-by-Construction is one of the few secure SDLC processes that incorporate formal methods into many development activities. Requirements are specified using Z, and verified. Code is checked by verification software, and is written in Spark, a subset of Ada which can be statically assured.					5	6			software		x				• [Amey, 2006] • [Leveson, 1995] • [IEC 61508-6, 1998] • [CbC lecture]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
124.	CBFTA (Condition-Based Fault Tree Analysis)	Stat	HwD	2007	CBFTA is a tool for updating reliability values of a specific system and for calculating the residual life according to the system's monitored conditions. It starts with a known FTA. Condition monitoring methods applied to systems are used to determine updated failure rate values of sensitive components, which are then applied to the FTA. CBFTA recalculates periodically the top event failure rate, thus determining the probability of system failure and the probability of successful system operation.	CBFTA is for use during the systems operational phase, including maintenance, not just during design.							7		manufacturing	x					• [ShalevTiran, 2007]
125.	CBR (Case-Based Reasoning)	Min	Dat, Mit	1980	Case-based reasoning aims at using old specific experiences to understand and solve new problems (new cases). A CBR application uses a previous situation similar to the current one to: solve a new problem, meet new demands, explain new situations, critique new solutions, interpret a new situation, or to create an equitable solution to a new problem. CBR generally follows the following process: 1) Retrieve the most similar case (or cases) by comparing the case to a collection or library of previous cases; 2) Reuse the information and knowledge in the retrieved case to propose a solution to the current problem; 3) Revise and adapt the proposed solution if necessary; 4) Retain the parts of this experience likely to be useful for future problem solving.	CBR was developed in the early 1980s at Yale University. A specific approach to CBR applied to the aviation domain has been developed in [Luxhøj, 2005], [Luxhøj & Oztekin, 2005], and is aimed at accident scenario knowledge management. Given an accident scenario, the user answers a given set of questions. These answers are used to retrieve from an accident case library a list of candidate cases (i.e., solution possibilities) with certain relevance factors attached to them. The retrieved cases are ranked with respect to their similarity to the current accident scenario.			3		5	6			aviation, healthcare, ATM, manufacturing, navy, nuclear, food, finance, oil&gas, road, rail, management	x	x	x	x	x	• [Luxhøj, 2005] • [Luxhøj & Oztekin, 2005] • [Kolodner 1992] • [Aamodt, 1994] • [Bergman, 1998] • [Harrison, 1997]
126.	CCA (Common Cause Analysis)	Int	HzA	1974	Common Cause Analysis will identify common failures or common events that eliminate redundancy in a system, operation, or procedure. Is used to identify sources of common cause failures and effects of components on their neighbours. Is subdivided into three areas of study: Zonal Analysis, Particular Risks Assessment, and Common Mode Analysis.	Common causes are present in almost any system where there is any commonality, such as human interface, common task, and common designs, anything that has a redundancy, from a part, component, sub-system or system. Related to Root Cause Analysis. CCA is a term mainly used within the aerospace industry. In the nuclear industry, CCA is referred to as Dependent Failure Analysis. According to [Mauri, 2000], common cause failures and cascade failures are specific types of dependent failures; common mode failures are specific types of common cause failures.			3		5				aircraft, nuclear, energy	x	x				• [ARP 4754] • [EN 50128, 1996] • [FAA AC431] • [FAA00] • [Mauri, 2000] • [MUFTIS3.2-I, 1996] • [Rakowsky] • [ΣΣ93, ΣΣ97] • [Amberkar et al, 2001] • [DS-00-56, 1999] • [Mauri, 2000] • [Lawrence, 1999] • [Sparkman, 1992] • [Mosley, 1991] • [Browne et al, 2008]
	CCCMT (Continuous Cell-to-Cell Mapping Technique)					See CCMT (Cell-to-Cell Mapping Technique).															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
127.	CCDM (Cause Consequence Diagram Method) or CCA (Cause Consequence Analysis)	Stat	Mod	1971	Aim is to model, in diagrammatical form, the sequence of events that can develop in a system as a consequence of combinations of basic events. Cause-Consequence Analysis combines bottom-up and top-down analysis techniques of Binary Decision Diagrams (BDD) and Fault Trees. The result is the development of potential accident scenarios.	Developed at Risø laboratories (Denmark) in the 1970's to aid in the reliability analysis of nuclear power plants in Scandinavian countries. For assessment of hardware systems; more difficult to use in software systems. Related to BDD, ETA, FTA and Common Cause Analysis. Tools available. No task analysis allowed. See also Bow-Tie Analysis using Fault Tree and Event Tree.				4	5				nuclear, (aircraft)	x	x				• [Bishop, 1990] • [EN 50128, 1996] • [FAA00] • [Leveson, 1995] • [MUFTIS3.2-I, 1996] • [Rakowsky] • [Ridley & Andrews, 2001] • [ΣΣ93, ΣΣ97] • [Andrews & Ridley, 2002]
128.	CCFA (Common Cause Failure Analysis)	Gen, Stat	HzA	1975	Common Cause Failure Analysis is a generic term for an approach which aims at analysing common cause failures (CCF). Here, a CCF refers to a subset of dependent failures in which two or more component fault states exist at the same time, or within a short interval, as a result of a shared cause. The shared cause is not another component state because such cascading of component states, due to functional couplings, are already usually modelled explicitly in system models. In [FAA00], the procedural steps for a CCFA are: (1) Establish "Critical Tree Groups". This is often accomplished utilizing FMECAs, FTA, and Sneak Circuit Analyses (SCA) to limit the scope of analysis to the critical components or functions or "hidden" interrelationships. (2) Identify common components within the groups of "(1)" above. (3). Identify credible failure modes. (4) Identify common cause credible failure modes. This requires understanding of the system/hardware involved, the use of "lessons learned", and historical data. (5) Summarize analysis results including identification of corrective action.	CCFA is one of the techniques that can be used in a Probabilistic Risk Assessment (PRA). Techniques typically used for CCFA are fault tree analysis, augmented with e.g. the Beta Factor method or the Multiple Greek Letters method, the Alpha Factor method or the Binomial Failure Rate method. In [FAA00], CCFA is referred to as an extension of FTA to identify "coupling factors" that can cause component failures to be potentially interdependent.			3	4	5	6			aircraft, nuclear, space, healthcare, rail, oil&gas	x	x				• [FAA00] • [Rasmuson & Mosley, 2007] • [Wierman et al., 1999] • [Kelly & Rasmuson, 2008]
129.	CCMT (Cell-to-Cell Mapping Technique)	Math, Dyn	Mod	1987	CCMT is a numerical technique for the global analysis of non-linear dynamic systems. It models system evolution in terms of probability of transitions within a user-specified time interval (e.g., data-sampling interval) between sets of user-defined parameter/state variable magnitude intervals (cells). The cell-to-cell transition probabilities are obtained from the given linear or nonlinear plant model. CCMT uses Matrix solvers as solution method.	It is particularly useful if the system has a strange attractor. A variation of CCMT is CCCMT (Continuous Cell-to-Cell Mapping Technique) where the Solution method is ODE (ordinary differential equation) solvers rather than Matrix solvers.				4					nuclear	x					• [Hsu, 1987]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
130.	CCS (Calculus of Communicating Systems)	Math	SwD	1980	CCS is an algebra for specifying and reasoning about concurrent systems. As an algebra, CCS provides a set of terms, operators and axioms that can be used to write and manipulate algebraic expressions. The expressions define the elements of a concurrent system and the manipulations of these expressions reveal how the system behaves. CCS is useful for evaluating the qualitative correctness of properties of a system such as deadlock or livelock.	Introduced by Robin Milner. Formal Method. Descriptive tool in cases where a system must consist of more than one process. Software requirements specification phase and design & development phase.		2							software		x				• [Bishop, 1990] • [CCS] • [EN 50128, 1996] • [Rakowsky]
131.	CDA (Code Data Analysis)	Step	SwD	1996 or older	Code data analysis concentrates on data structure and usage in the software code. The analysis aims at ensuring that the data items are defined and used properly, and that safety critical data is not being inadvertently altered or overwritten. This is accomplished by comparing the usage and value of all data items in the code with the descriptions provided in the design materials. In addition, there are checks to see if interrupt processing is interfering with safety critical data, and checks of the “typing” of safety critical declared variables.				3						healthcare, (avionics), (space)		x				• [NASA-GB-1740.13-96] • [Rakowsky] • [FAA00]
132.	CDM (Critical Decision Method)	Dat	Task, Ret	1989	The CDM is a semi-structured interview technique developed to obtain information about decisions made by practitioners when performing their tasks. A subject-matter expert is asked to recount a particularly challenging or critical incident in which his/her skills were needed. The operator is asked to provide a general description of the incident followed by a more detailed account of the sequence of events. The interviewer and the operator then establish a timeline and identify the critical points in the incident. The interviewer then uses a number of probes to elicit more detailed information about the problem solving processes at each of the critical points in the incident. The interviewer probes to identify decision points, shifts in situation assessment, critical cues leading to a specific assessment, cognitive strategies, and potential errors.	CDM is a variant of CIT, extended to include probes that elicit aspects of expertise such as the basis for making perceptual discriminations, conceptual discriminations, typicality judgments, and critical cues. Output can be represented in various ways, e.g. through narrative accounts, or in the form of a cognitive requirements table that lists the specific cognitive demands of the task, as well as contextual information needed to develop relevant training or system design recommendations.							8	navy, healthcare			x	x		• [Klein et al, 1989] • [FAA HFW]
133.	CDR (Critical Design Review)	Step	HwD	1989 or older	The CDR demonstrates that the maturity of the design is appropriate to support proceeding with full-scale fabrication, assembly, integration, and test. A CDR is conducted a) to verify that the detailed design of one or more configuration items satisfy specified requirements, b) to establish the compatibility among the configuration items and other items of equipment, facilities, software, and personnel, c) to assess risk areas for each configuration item, and, as applicable, d) to assess the results of productibility analyses, review preliminary hardware product specifications, evaluate preliminary test planning, and evaluate the adequacy of preliminary operation and support documents. Checklists may be used to guide the review process.	A CDR is held when a major product deliverable has reached a point in design and prototyping work where "viability" of the design can be judged, and by extension, the project can be considered to have reached a state of significantly reduced risk. CDRs are intended to show that a design is complete to a certain level of elaboration. Unlike formal inspections, these reviews are focused more on explaining a design than identifying defects.					5			8	space, aircraft, defence	x					• [FAA00] • [CDR Template] • [CDR Report] • [CDR Assessments]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
134.	CED (Cause and Effect Diagram) or Ishikawa diagram or Fishbone diagram	Stat	Mod	1943	The Cause And Effect Diagram is a Logic Diagram with a significant variation. It provides more structure than the Logic Diagram through the branches that give it one of its alternate names, the fishbone diagram. The user can tailor the basic "bones" based upon special characteristics of the operation being analyzed. Either a positive or negative outcome block is designated at the right side of the diagram. Using the structure of the diagram, the user completes the diagram by adding causal factors. Causes are usually grouped into major categories to identify sources of variation. The categories are often categorized as "The 6 Ms" (used in manufacturing, and including Machine, Method, Material, Man power, etc), "The 8 Ps (used in service industry and including Product, Price, Place, etc) and "The 5 Ss (used in service industry and including Surroundings, Suppliers, Skills, etc). Using branches off the basic entries, additional hazards can be added.	Also called the Ishikawa diagram (after its creator, Kaoru Ishikawa of Japan, who pioneered quality management processes in the Kawasaki shipyards, and in the process became one of the founding fathers of modern management), or the Fishbone Diagram (due to its shape) or herringbone diagram. See also 5M model.				4					management, manufacturing	x					• [FAA00]
135.	CEDAR (Comprehensive Electronic Data Analysis and Reporting)	Dat	Dat	2010 or older	CEDAR provides air traffic management with an electronic support in assessing air traffic employee performance, managing resources, and capturing safety-related information and metrics. The tool provides a standard interface for the collection, retrieval, and reporting of data from multiple sources. It also automates the creation, management, and storage of facility activities and events; briefing items; Quality Assurance Reviews; technical training discussions; and FAA forms.									8	ATM			x		x	• [ATO SMS Manual v3.0]
	CEFA (Cockpit Emulator for Flight Analysis)					See Flight Data Monitoring Analysis and Visualisation															
136.	CELLO method	Tab	Mit	1998 or older	CELLO is similar to heuristic or expert evaluation except it is collaborative in that multiple experts, guided by a defined list of design criteria, work together to evaluate the system in question. The criteria may be principles, heuristics or recommendations which define good practice in design and are likely to lead to high quality in use. The criteria represent compiled knowledge derived from psychology and ergonomics theory, experimental results, practical experience and organisational or personal belief. At the conclusion of the inspection an evaluation report is created that details how specific functions or features of the system contravene the inspection criteria and may provide recommendations as to how the design should be changed in order to meet a criterion or criteria. The results of the inspection are reported in a standard form related to the criteria used and the objectives of the inspection. The usual severity grading used is: 1. Show stopper. 2. Inconvenient. 3. Annoyance.	Developed by Nigel Claridge et al at Nomos AB, Sweden. Is largely derived from the expert-based heuristic method promoted by Jacob Neilsen. CELLO can be used throughout the lifecycle but it is most useful when applied early in the development cycle as a check that the user and usability repuirements for the system in question are being observed. See also Heuristic Evaluation.			2			6			(ergonomics)	x		x			• [FAA HFW] • [CELLO web]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
137.	Certificated Hardware Components or Hardware certification	Gen	Des	1949 or older	Aim is to assure that all hardware components that are used will not reveal inherent weaknesses after their use within the system by screening and segregating the positively certified components.	In some fields (e.g. military, space, avionics) mandatory. Tools available. Used as part of product certification.						6			aircraft, avionics, defence, space, nuclear, chemical, manufacturing, healthcare, electronics	x					• [Bishop, 1990] • [DO-254] • [ICAO Annex 8]
138.	Certified Software Components	Gen	Des	1990 or older	Aim is to minimise the development of new software through the use of existing components of known level of confidence or quality.	Additional validation and verification may be necessary. Tools available.						6			avionics		x				• [Bishop, 1990]
139.	Certified Tools or Certified Tools and Certified Translators	Gen	Des	1990 or older	Tools are necessary to help developers in the different phases of software development. Certification ensures that some level of confidence can be assumed regarding the correctness of software.	Software design & development phase. Note that certified tools and certified translators are usually certified against their respective language or process standards, rather than with respect to safety.							7		electronics		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]
140.	CES (Cognitive Environment Simulation)	RTS	HRA	1987	Human performance assessment. Dynamic. Was developed for simulating how people form intentions to act in nuclear power plant personnel emergencies. CES can be used to provide an objective means of distinguishing which event scenarios are likely to be straightforward to diagnose and which scenarios are likely to be cognitively challenging, requiring longer to diagnose and which can lead to human error. Can also be used to predict human errors by estimating the mismatch between cognitive resources and demands of the particular problem-solving task.	See also CREATE.				4	5				nuclear			x			• [MUFTIS3.2-I, 1996] • [Kirwan, Part 1, 1998]
141.	CESA (Commission Errors Search and Assessment)	Step	HzA, HRA	2001	CESA aims to identify and analyse error of commission (EOC) events, and to prioritize them regarding their potential risk-relevance. Module CESA-Q addresses the quantification, by using Bayesian Belief Networks to analyse EOCs in terms of plant- and scenario-specific situational and adjustment factors that may motivate inappropriate decisions.	Developed at Paul Scherrer Institute, Switzerland, in 2001. The CESA-Q module was added in 2009-2013.			3	4	5				nuclear			x			• [Reer, 2008] • [Podofillini et al, 2010] • [HRA Washington, 2001] • [Dang et al, 2002] • [Podofillini et al., 2014]
142.	CFA (Cognitive Function Analysis)	Step	Task	1998	Cognitive Function Analysis (CFA) is a methodology that enables a design team to understand better the right balance between cognitive functions that need to be allocated to human(s) and cognitive functions that can be transferred to machine(s). Cognitive functions are described by eliciting the following inputs: task requirements; users, background (skills and knowledge to cope with the complexity of the artifact to be controlled); users' own goals (intentional actions); and external events (reactive actions).	Developed by Guy A. Boy, Florida Institite of Technology.		2							aviation			x			• [FAA HFW] • [Boy, 2014]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
143.	CFMA (Cable Failure Matrix Analysis)	Step	HwD	1979	Cable Failure Matrix Analysis identifies the risks associated with any failure condition related to cable design, routing, protection, and securing. The CFMA is a shorthand method used to concisely represent the possible combinations of failures that can occur within a cable assembly.	Should cables become damaged system malfunctions can occur. Less than adequate design of cables can result in faults, failures and anomalies, which can result in contributory hazards and accidents. Similar to Bent Pin analysis.			3						(defence)	x					• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]
144.	CGHDS (Controlled General Hybrid Dynamical System)	Math	Mod	1996	Interaction collection of dynamical (mathematical) systems, each evolving on continuous valued state spaces, and each controlled by continuous controls. Considers switching as a general case of impulses; the general term is jump. Each jump goes to a new dynamical system.					4					(electronics), (manufacturing), (avionics)	x	x	x	x	x	• [Branicky & Borkar& Mitter, 1998]
	Chain of Multiple Events					See Domino Theory															
145.	Change Analysis	Step	HzA	1965 ?	Change Analysis examines the effects of modifications from a starting point or baseline. It is a technique designed to identify hazards that arise from planned or unplanned change. Four steps: 1) review previous operation / current practice; 2) Review operational analysis of planned operation; 3) For each step / phase of the operation, identify differences ("changes") between the two; 4) Determine impact on risk of the operation. The change analysis systematically hypothesises worst-case effects from each modification from the baseline.	Cause-Consequence analysis is also used during accident/ incident investigation.		2	3		5				healthcare, management, aviation	x			x	x	• [FAA AC431] • [FAA00] • [ORM] • [ΣΣ93, ΣΣ97] • [FAA HFW]
	Change Impact Analysis					See IA (Impact Analysis)															
	Characterisation Analysis					See Trend Analysis															
146.	CHASE (Complete Health And Safety Evaluation)	Tab	Org	1987	CHASE is a general management health and safety audit method for general industry. There are two versions: CHASE-I is for small and medium sized organisations, CHASE-II is for large organisations (100+ employees). CHASE is comprised of sections (4 in CHASE-I; 12 in CHASE-II) which include a number of short questions. Answering Yes gives 2-6 points depending on the activity assessed; answering No gives zero points. The scores on the sub-sets of safety performance areas are weighted and then translated into an overall index rating.	Qualitative. Developed by HASTAM Ltd., UK. Designed for both monitoring by line managers and auditing by safety professionals. The questions consider the management of e.g. legal requirements and resources, machinery and plant, chemicals and substances, vehicles, energy, health, tasks, people, change, emergencies, etc.							7	8	(manufacturing), (police), (social)			x			• [Kennedy & Kirwan, 1998] • [Kuusisto, 2001]
	CHAZOP (Computer HAZOP)					See SHARD (Software Hazard Analysis and Resolution in Design)															
	China Lake Situational Awareness Rating Scale					See Rating Scales															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
147.	CHIRP (Confidential Human Factors Incident Reporting Programme)	Dat	Dat	1982	The aim of CHIRP is to contribute to the enhancement of flight safety in the UK commercial and general aviation industries, by providing a totally independent confidential (not anonymous) reporting system for all individuals employed in or associated with the industries. Reporters' identities are kept confidential. Important information gained through reports, after being disidentified, is made available as widely as possible. CHIRP provides a means by which individuals are able to raise issues of concern without being identified to their peer group, management, or the Regulatory Authority. Anonymous reports are not normally acted upon, as they cannot be validated.	CHIRP has been in operation since 1982 and is currently available to flight crew members, air traffic control officers, licensed aircraft maintenance engineers, cabin crew and the GA (General Aviation) community. Example issues are those related to work hours, rest periods, and fatigue. Since 2003, there is also a CHIRP for maritime (shipping industry, fishing industry, leisure users), named Confidential Hazardous Incident Reporting Programme.								8	aviation, ATM, aircraft, maritime			x	x	x	• [CHIRP web] • For other systems like this, see [EUCARE web] • [GAIN ATM, 2003]
148.	CI (Contextual Inquiry)	Dat	Dat	1988	Contextual Inquiry is both a form of field study, semi-structured interview method and a data analysis technique. Experimenters observe users in their normal working environment and record both how the users work and the experimenters' interaction with the users. This recording can be hand-written notes or, if possible, through the use of video or audiotape recordings. The aim is to gather details of work, discovering parameters, criteria, features, or process flows for design or redesign.	The notes may be organised in an Affinity Diagram. See also Plant walkdowns/ surveys. See also Field Study. See also Interview.		2							electronics, healthcare			x			• [FAA HFW] • [Fouskas et al., 2002]
149.	CIA (Cross Impact Analysis)	Int	OpR	1966	CIA is a family of techniques that aims to connect relationships between events and variables. These relationships are then categorized as positive or negative to each other, and are used to determine which events or scenarios are most probable or likely to occur within a given time frame. In its original form ('The Futures Forecasting Style'), CIA follows five steps: 1) Identify the number and type of events to be considered in the analysis and create an event set. Typically, 10 to 40 events are used. 2) Identify the initial probability of each individual event, independent from other events. 3) Generate, for each possible interaction between events, conditional probabilities that events have on each other. 4) Test the initial conditional probabilities to ensure that there are no mathematical errors. This is usually done by running simulations in a computer several times. 5) Run the analysis to determine future scenarios, or determine how significant other events are to specific events.	Developed by Theodore Gordon and Olaf Helmer in 1966. Later expanded by other researchers. The outcome of applying a cross-impact model is a production of scenarios. Each run of the model produces a synthetic future history, or scenario, which includes the occurrence of some events and the non-occurrence of others. The primary focus of this process is to generate forecasting studies of the iterations of the probability of one event affecting another so interactions are definitely considered and possible futures.					5				finance, nuclear, road, aviation	x	x	x	x	x	• [Gordon, 1994]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
150.	CIA (Code Interface Analysis)	Step	SwD	1996 or older	Code interface analysis verifies the compatibility of internal and external interfaces of a software component and is intended to verify that the interfaces have been implemented properly. A software component is composed of a number of code segments working together to perform required tasks. These code segments must communicate with each other, with hardware, other software components, and human operators to accomplish their tasks. The analysis includes a check that parameters are properly passed across interfaces, since each of these interfaces is a source of potential problems.				3						software, (avionics), (space)		x				• [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky]
151.	CIRS (Critical Incident Reporting System)	Dat	Dat, Ret	1997	Collects anonymous critical anaesthesia incident reports to gain insight into the nature of critical events. CIRS defines a critical incident as any deviation from an expected course with potential for an adverse outcome.									8	(healthcare)			x	x	x	• [Salmon et al., 2005]
152.	CIT (Critical Incident Technique)	Step	HzA, Task	1954	This is a method of identifying errors and unsafe conditions that contribute to both potential and actual accidents or incidents within a given population by means of a stratified random sample of participant-observers selected from within the population. Operational personnel can collect information on potential or past errors or unsafe conditions. Hazard controls are then developed to minimise the potential error or unsafe condition.	This technique can be applied in any operational environment. Generally, the technique is most useful in the early stages of a larger task or activity.							7	8	aviation, ATM, nuclear, healthcare, manufacturing, defence, social, management	x		x		x	• [Flanagan, 1954] • [FAA00] • [Infopolis2] • [Kirwan, 1994] • [Kirwan & Ainsworth, 1992] • [ΣΣ93, ΣΣ97] • [MIL-HDBK 46855A] • [FAA HFW]
153.	CLA (Check List Analysis or Checklist Analysis)	Tab	HzI	1974	Checklist Analysis is a comparison to criteria, or a device to be used as a memory jogger. The analyst uses a list to identify items such as hazards, design or operational deficiencies. Checklists enable a systematic, step by step process. They can provide formal documentation, instruction, and guidance.	Checklist Analysis can be used in any type of safety analysis, safety review, inspection, survey, or observation. Combines with What-if analysis. See also Ergonomics Checklists. See also CTC.			3						chemical, oil&gas, rail, security	x	x	x	x	x	• [EN 50128, 1996] • [FAA00] • [Leveson, 1995] • [ΣΣ93, ΣΣ97] • [RBDMG]
154.	CLA (Code Logic Analysis)	Step	SwD	1996 or older	Code Logic Analysis aims to detect logic errors in a given software code. This analysis is conducted by performing logic reconstruction (which entails the preparation of flow charts from the code and comparing them to the design material descriptions and flow charts), equation reconstruction (which is accomplished by comparing the equations in the code to the ones provided with the design materials) and memory coding (which identifies critical instruction sequences even when they may be disguised as data).				3						software, (avionics), (space)		x				• [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky]
	Clocked Logic					See Dynamic Logic															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
155.	ClusterGroup	Int	Dec?	2002	ClusterGroup uses cluster analysis techniques to facilitate the priorisation of the importance of aviation safety risk factors by groups of experts. Aims to gain an understanding of the rationale behind decisions made in situations involving risk. It uses various clustering algorithms to aggregate similar opinions of groups of experts into "majority" and "minority" clusters. The underlying methodology eliminates the necessity of performing numerous pairwise comparisons.	Up to 80% reduction in the number of computations is reported possible, yet results are said to compare favorably with more traditional methods, such as the AHP.					5				(aviation)			x			• [Luxhøj, 2002] • [Maurino & Luxhøj, 2002] • [Ammarapala, 2002]
156.	CM (Configuration Management)	Gen	Des	1950	Configuration management is a field of management that focuses on establishing and maintaining consistency of a system's or product's performance and its functional and physical attributes with its requirements, design, and operational information throughout its life. Aim is to ensure the consistency of groups of development deliverables as those deliverables change.	Tools available. Configuration management was first developed by the United States Air Force for the Department of Defense in the 1950s as a technical management discipline of hardware. It is now being used in many domains. Its application to software is referred to as SCM; see also SCM.						6			defence, aircraft, manufacturing	x					• [Bishop, 1990]
157.	CMA (Confusion Matrix Analysis)	Tab	HRA	1981	Determines human reliability. Is aimed specifically at two of the diagnostic error-forms, namely misdiagnoses and premature diagnoses. A confusion matrix is an array showing relationships between true and predicted classes. Typically the variables are an observation and a prediction. Each row in the confusion matrix represents an observed class, each column represents a predicted class, and each cell counts the number of samples in the intersection of those two classes. Probabilities can be derived experimentally or using expert judgments.	Is sometimes followed after an FSMA.					5				environment, healthcare, finance, social, chemical			x			• [Kirwan, 1994] • [Kirwan, Part 1, 1998] • [MUFTIS3.2-I, 1996] • [GAIN ATM, 2003] • [FAA HFW] • [CM] • [Potash, 1981] • [Volpe, 1998]
158.	CMA (Common Mode Analysis)	Step	HwD	1987	CMA provides evidence that the failures assumed to be independent are truly independent in the actual implementation. It covers the effect of design, manufacturing and maintenance errors and the effects of common component errors. A common mode failure has the potential to fail more than one safety function and to possibly cause an initiating event or other abnormal event simultaneously. The analysis is complex due to the large number of common mode failures that may be related to the different common mode types such as design, operation, manufacturing, installation and others.	CMA is the third step in a Common Cause Analysis (CCA). Particular Risks Assessment is the second, and provides input to the CMA.			3						aircraft	x	x				• [ARP 4761] • [Mauri, 2000]
159.	CMFA (Common Mode Failure Analysis)	Step	HwD	1972	Aim is to identify potential failures in redundant systems or redundant sub-systems that would undermine the benefits of redundancy because of the appearance of the same failures in the redundant parts at the same time.	The technique is not well developed but is necessary to apply, because without consideration of common mode failures, the reliability of redundant systems would be over-estimated. Related methods: ETA, CCA, FMEA.			3						road, nuclear	x	x				• [Bishop, 1990]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
160.	CMMI (Capability Maturity Model Integration)	Tab	Mit	2002	CMMI aims to rate processes (e.g. software processes, projects, organisational processes) according to their maturity levels, which are defined as: Initial, Managed, Defined, Quantitatively Managed, Optimizing.	CMMI is the successor of the capability maturity model (CMM) or Software CMM, which was developed from 1987 until 1997. CMMI is administered by Carnegie Mellon University. Sometimes abbreviated as iCMM (integrated Capability Maturity Model). There is a link with SPC (Statistical Process Control).					5				defence, (ATM)		x			x	• [FAA HFW] • [FAA TM]
	CMN-GOMS (Card, Moran and Newell GOMS)					See GOMS															
161.	COCOM (COntextual COntrol Model)	Stat	HFA	1993	COCOM models human performance as a set of control modes - strategic (based on long-term planning), tactical (based on procedures), opportunistic (based on present context), and scrambled (random) - and proposes a model of how transitions between these control modes occur. This model of control mode transition consists of a number of factors, including the human operator's estimate of the outcome of the action (success or failure), the time remaining to accomplish the action (adequate or inadequate), and the number of simultaneous goals of the human operator at that time.	Developed by Erik Hollnagel. Also used within TOPAZ.				4					ATM			x			• [Hollnagel, 1993] • [Cacciabue, 1998] • [Kirwan, Part 1, 1998] • [COCOM web] • [Hollnagel & Nabo & Lau, 2003] • [Daams & Blom & Nijhuis, 2000]
162.	CODA (Conclusions from Occurrences by Descriptions of Actions)	Step	Ret	1997	Method for analysing human-related occurrences (i.e., incorrect human responses) from event cases retrospectively. The CODA method uses an open list of guidelines based on insights from previous retrospective analyses. It is recommended in this method to compile a short story that includes all unusual occurrences and their essential context without excessive technical details. Then the analysis should envisage major occurrences first. For their description, the method presents a list of criteria which are easy to obtain and which have been proved to be useful for causal analysis. For their causal analysis, various guidelines are provided. They are mainly of holistic, comparative and generalising nature. It is demonstrated by various event cases that CODA is able to identify cognitive tendencies (CTs) as typical attitudes or habits in human decision-making.	Quantification may be done with expert judgement or THERP.			3		5				(nuclear)			x			• [Reer, 1997] • [Straeter et al, 1999]
163.	Code Analysis	Step	SwD	1995 about ?	Code analysis verifies that the coded program correctly implements the verified design and does not violate safety requirements. The techniques used in the performance of code analysis mirror those used in design analysis.								7		software, (avionics), (space)		x				• [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
164.	Code Coverage	Step	Val	1963	This is a check if all lines in the software code are used when running the program. Unused lines can be removed. Alternatively, code coverage describes the degree to which the source code of a program has been tested. It is a form of testing that inspects the code directly and is therefore a form of 'white box testing'. In time, the use of code coverage has been extended to the field of digital hardware.	Code coverage techniques were amongst the first techniques invented for systematic software testing. The first published reference was by Miller and Maloney in Communications of the ACM in 1963. See also Unused Code Analysis.							7		avionics, manufacturing, finance, electronics, healthcare, nuclear, rail, mining, oil&gas, defence		x				• NLR expert
165.	Code Inspection Checklists	Tab	SwD	1992 or older	Checklists are developed during formal inspections to facilitate inspection of the code to demonstrate conformance to the coding standards. The checklist aims to make the code easier to read and understand, more reliable, and easier to maintain. Bug databases are also good sources to use when creating checklists for code inspections.	See also Design and Coding Standards. See also Formal Inspections. See also Software Testing. Appendix H of [NASA-GB-1740.13-96] provides a collection of checklists.						6			software, (avionics), (space)		x				• [EN 50128, 1996] • [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky]
	Co-discovery					See Think Aloud Protocol															
	COEA (Cost and Operational Effectiveness Analysis)					See AoA (Analysis of Alternatives)															
166.	COGENT (COGnitive objects with a Graphical Environment)	Stat	HFA	1998	COGENT permits psychologists to construct and test information-processing models of cognition based on traditional box/arrow diagrams. COGENT provides a graphical model editor together with a set of standard types of cognitive module based on theoretical constructs from psychological theory. Models are constructed by selecting appropriate box types and connecting them with appropriate communication links. Once a model has been constructed it may be executed to examine and analyze its behaviour.	Developed by R. Cooper and J. Fox, School of Psychology, Birbeck College London. COGENT is divided into five basic components: Memory buffers, Rule-based processes, Connectionist networks, Input sources/output sinks, Inter-module communication links.				4					healthcare, social			x			• [COGENT web] • [Morrison, 2003]
167.	COGENT (COGnitive EveNt Tree)	Stat	HRA	1993	Extension of the THERP event tree modelling system, dealing particularly with cognitive errors, although the approach appears to deal with other errors as well. The aim is to bring current more cognitively-based approaches into the Human Error Identification process. This has led to a hybrid taxonomy with terms such as Skill-based slip, rule-based lapse, and knowledge-based lapses or mistakes. The approach thereafter is for the analyst to develop cognitive event trees.	It requires significant analytical judgement. At present, it appears to be a relatively simple step forward in modelling (representation), rather than in Human Error Identification.				4					nuclear			x			• [Kirwan, Part 1, 1998] • [Gertman, 1993]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
168.	COGNET (Cognition as a Network of Tasks)	Stat	Task	1989	COGNET is a framework for creating and exercising models of human operators engaged in primarily cognitive (as opposed to psychomotor) tasks. Its purpose is to develop user models for intelligent interfaces. It has been used to model surrogate operators (and opponents) in submarine warfare simulations. The most important assumption behind COGNET is that humans perform multiple tasks in parallel. These tasks compete for the human's attention, but ultimately combine to solve an overall information-processing problem. COGNET is based on a theory of weak task concurrence, in which there are at any one time several tasks in various states of completion, though only one of these tasks is executing. That is, COGNET assumes serial processing with rapid attention switching, which gives the overall appearance of true parallelism.	Development of COGNET was led by Dr. W. Zachary, CHI Systems. The basis for the management of multiple, competing tasks in COGNET is a pandemonium metaphor of cognitive processes composed of "shrieking demons", proposed by Selfridge (1959). In this metaphor, a task competing for attention is a demon whose shrieks vary in loudness depending on the problem context. The louder a demon shrieks, the more likely it is to get attention. At any given time, the demon shrieking loudest is the focus of attention and is permitted to execute.		2			5				navy, ATM, electronics			x			• [GAIN ATM, 2003] • [Zachary, 1996] • [FAA HFW] • [Morrison, 2003]
	Cognitive Walkthrough					See Inspections and Walkthroughs															
169.	COMET (COMmission Event Trees)	Stat	HRA	1991	Modified event trees that deal with errors of commission and cascading errors whose source is either erroneous intention or a latent error. COMETs are developed e.g., using SNEAK, and are basically event trees, their results feeding into fault trees. The main significance of this approach appears to be as a means of integrating errors of commission into PSA and quantifying them. It does not help too much in terms of actually identifying errors of commission.	Relation with SNEAK and ETA.				4					nuclear			x			• [Kirwan, Part 1, 1998]
170.	Comparison Risk Analysis	Step	OpR	1995	Is used during the design of new plants (and modifications) in order to predict the occupational accident-frequency rate for the plant during operation. Results are expressed as relative changes in the accident-frequency rate in relation to the experienced rate of a reference plant that has been in operation for some years. Method follows four steps: 1) Establishment of a database for the reference installation; 2) Grouping of the accidents with respect to area and activity; 3) Establishment of a simulated database for the analysis object; 4) Estimation of the injury-frequency rate for the analysis object.	Method was originally developed to meet the Norwegian risk-analysis regulations for the offshore industry. See also Severity Distribution Analysis.					5				(oil&gas)	x					• [Kjellen, 2000]
171.	Complexity Models	Gen	SwD	1971	Aim is to predict the reliability of programs from properties of the software itself (e.g. number of program steps) rather than from its development or test history.	Can be used at the design, coding and testing phase to improve quality of software by the early identification of over-complex modules and by indicating the level of testing required for different modules. Tools available.			3						software		x				• [Bishop, 1990]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
172.	Computer Modelling and Simulation	RTS, FTS	Mod	1978 or older	Involves the use of computer programs to represent e.g. operators and/or system activities or features. Human performance data that have been previously collected, or estimates of task components, error probabilities, etc., are entered into the computer program. The program either can then simulate graphically the environment and workspace or can dynamically run the task in real or fast time as a way of estimating complete cycle times and error likelihoods, etc.	Four well-known variants are often referred to as Real-Time Simulation (simulator clock runs with speed according to real clocks), Fast Time Simulation (simulator clock does not run with speed according to real clocks, and can even make jumps), Discrete Event Simulation, and Monte Carlo simulation.				4	5				chemical, social, finance, ATM, aviation, nuclear, rail, road, ergonomics, leisure, security	x		x	x	x	• [Kirwan & Ainsworth, 1992]
173.	Conceptual Graph Analysis	Stat	HFA	1976	Conceptual graph analysis is a method of visually depicting internal knowledge structures during a cognitive task analysis. These graphs consist of nodes connected via arcs. The nodes contain either single concepts or single statements. Constructing a conceptual graph is similar to concept mapping, but it includes a formal and detailed collection of nodes, relations, and questions. The nodes can include more than just concepts. Nodes can be goals, actions, or events. There are specific relations for each type of node, and a set of formal, probing questions is developed for each node type.	Conceptual Graphs were first used by John Sowa in 1976.				4					road, aviation, environment, social			x			• [Jonassen et al, 1999] • [FAA HFW] • [Dieng, 1997]
174.	ConDOR (Constructed Dynamic Observation Report)	Dat	HzI	2006 or older	ConDOR is used for focused, special inspections, and for identification of more specific information about a hazard or risk. It allows data collection activities to be requested or assigned with instructions to inspect and report on specific areas of immediate concern outside of the normal assessment schedule. ConDOR may be appropriate in the following instances: A). To evaluate program, policy, or regulatory changes. B). To address focused or unique situations in response to local, regional, or national requirements. C). To collect targeted data for specific areas of immediate concern. D). As an action item in the risk management process action plan. E). To document minor changes to the air carrier's system (e.g., changes to the individual identified by the certificate holder as having responsibility and/or authority over the process). F). If the air carrier presents a revision to a manual that only changes a reference, a DA may not be necessary.				3				7		aircraft	x				x	• [FAA FSIMS, 2009]
	Consequence Tree Method					See ETA (Event Tree Analysis)															
175.	Contingency Analysis	Step	Mit	1972 ?	Contingency Analysis is a method of minimising risk in the event of an emergency. Potential accidents are identified and the adequacies of emergency measures are evaluated. Contingency Analysis lists the potential accident scenario and the steps taken to minimise the situation.	Contingency Analysis can be conducted for any system, procedure, task or operation where there is the potential for harm. It is an excellent formal training and reference tool.			3			6			nuclear, electronics, oil&gas, chemical, ATM, aviation, airport, navy, healthcare	x		x	x		• [FAA00] • [ΣΣ93, ΣΣ97]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
176.	Control Flow Checks or Control Flow Analysis	Stat	HzI	1981	Control flow analysis is a static code analysis technique for determining at compile time which functions may be applied at run time, i.e. it determines the control flow of a program. For many languages, the control flow of a program is explicit in a program's source code. As a result, control-flow analysis implicitly usually refers to a static analysis technique for determining the receiver(s) of function or method calls in computer programs written in a higher-order programming language. For both functional programming languages and object-oriented programming languages, the term CFA refers to an algorithm that computes control flow. Aim is to detect computer mal-operation by detecting deviations from the intended control flow.	Not necessary if the basic hardware is fully proven or self-checking. Otherwise, it is valuable technique for systems that can fail to a safe state where there is no hardware redundancy or no software diversity in the program or support tools. Tools available. See also Data Flow Analysis.		2							software		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]
	Cooper Harper Rating Scale					See Rating Scales															
	Cooperative Evaluation					See Think Aloud Protocol															
177.	CORE (Controlled Requirements Expression)	Step	Mod	1979	Aim is to ensure that all the requirements are identified and expressed. Intended to bridge the gap between the customer/end user and the analyst. Is designed for requirements expression rather than specification. Seven steps: 1) Viewpoint identification (e.g. through brainstorming); 2) Viewpoint structuring; 3) Tabular collection (Table with source, input, output, action, destination); 4) Data structuring (data dictionary); 5,6) Single viewpoint modelling and combined viewpoint modelling (model viewpoints as action diagrams, similar as in SADT); 7) Constraint analysis.	Developed for British Aerospace in the late 1970s to address the need for improved requirements expression and analysis. Despite its age, CORE is still used today on many projects within the aerospace sector. Is frequently used with MASCOT. Tools available.			3						avionics		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky] • [Mullery, 1979] • [Shekhar et al, 2014]
178.	CORE-DATA (Computerised Human Error Database for Human Reliability Support)	Dat	Dat, HRA	1992 from	Database on human errors and incidents, for human reliability support. According to 2004 data, it contains about 1500 data points.	Originally collated from nuclear power industry, recently extended to other sectors, such as offshore lifeboat evacuation, manufact-uring, offshore drilling, permit-to-work, electricity transmission, nuclear power plant emergency scenarios, calculator errors, and a small number of ATM-related human error probabilities have been developed. Initially developed at the University of Birmingham, UK.					5				(ATM), (nuclear), (oil&gas), (maritime), (manufacturing), (energy)			x			• [Kirwan & Basra & Taylor] • [Kirwan & Kennedy & Hamblen]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
179.	COSIMO (Cognitive Simulation Model)	RTS ?	HFA	1992	A parallel to CES in that it is a simulation of the human operator and his/her thought processes, using a computerised blackboard architecture. The simulated operator comprises a set of properties and attributes associated with particular incident scenarios, and 'packets' of process knowledge and heuristics rules of thumb. When diagnosing, each scenario and its associated attributes are contrasted to 'similarity-match' to the symptom set being displayed to the 'operator', and the simulated operator will either determine unequivocally which scenario matches the symptoms, or, if there is ambiguity, will 'frequency- gamble'. Once hypotheses are formulated, they are evaluated according to a confidence threshold, and may be accepted or rejected.			2			5				nuclear			x			• [Kirwan, 1995] • [Kirwan, Part 1, 1998] • [MUFTIS3.2-I, 1996]
180.	CPA (Critical Path Analysis)	Stat	HzI, Task	1957	Critical Path Analysis is an algorithm for scheduling a set of project activities. The technique is to construct a model of the project that includes a list of all activities required to complete the project (typically categorized within a work breakdown structure), the time (duration) that each activity will take to completion, and the dependencies between the activities. Next, CPA calculates the longest path of planned activities to the end of the project, and the earliest and latest that each activity can start and finish without making the project longer. This process determines which activities are "critical" (i.e., on the longest path) and which have "total float" (i.e., can be delayed without making the project longer). Any delay of an activity on the critical path directly impacts the planned project completion date.	Project modeling technique developed in the late 1950s by Morgan R. Walker of DuPont and James E. Kelley, Jr. of Remington Rand. This technique is applied in support of large system safety programs, when extensive system safety-related tasks are required. Combines with PERT. Tools available. See also Gantt Charts.		2							management, chemical,manufacturing, rail, defence	x			x		• [FAA AC431] • [FAA00] • [Kirwan & Ainsworth, 1992] • [ΣΣ93, ΣΣ97]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
181.	CPIT (Cabin Procedural Investigation Tool)	Int	Ret	2002	The CPIT process focuses on a cognitive approach to understand how and why the event occurred, not who was responsible. CPIT depends on an investigative philosophy, which acknowledges that professional cabin crews very rarely fail to comply with a procedure intentionally, especially if it is likely to result in an increased safety risk. It also requires the airline to explicitly adopt a non-jeopardy approach to incident investigation. CPIT contains more than 100 analysis elements that enable the user to conduct an in-depth investigation, summarise findings and integrate them across various events. The CPIT data organisation enables operators to track their progress in addressing the issues revealed by the analyses. CPIT is made up of two components: the interview process and contributing analysis. It provides an in-depth structured analytic process that consists of a sequence of steps that identify key contributing factors to cabin crew errors and the development of effective recommendations aimed at the elimination of similar errors in the future.	The CPIT approach, developed by Boeing, has benefited from lessons learned by its sister program, Procedural Event Analysis Tool (PEAT), which Boeing has provided to airlines since 1999. CPIT is a stand-alone service, but is normally offered with PEAT training.								8	aviation			x			• [GAIN AFSA, 2003]
	CPM (Critical Path Method)					See CPA (Critical Path Analysis) or CPM (Critical Path Method)															
182.	CPM-GOMS (Cognitive-Perceptual-Motor GOMS)	Stat	Task	1988	CPM-GOMS builds on previous GOMS models by assuming that perceptual, cognitive and motor operators can be performed in parallel. Where other GOMS techniques assume that humans do one thing at a time, CPM-GOMS assumes as many operations as possible will happen at any given time subject to constraints of the cognitive, perceptual, and motor processes. Models are developed using PERT charts and execution time is derived from the critical path. CPM-GOMS generally estimates unit-tasks serial executions to be faster than the other version of GOMS. This happens because the model assumes that the users are expert and are executing the operations as fast as the Model Human Processor can perform.	CPM-GOMS is a variation of the GOMS technique in human computer interaction. CPM stands for two things: Cognitive, Perceptual, and Motor and the project planning technique Critical Path Method (from which it borrows some elements). CPM-GOMS was developed in 1988 by Bonnie John, a former student of Allen Newell. Unlike the other GOMS variations, CPM-GOMS does not assume that the user's interaction is a serial process, and hence can model multitasking behavior that can be exhibited by experienced users. The technique is also based directly on the model human processor - a simplified model of human responses. See also CAT, CTA, GOMS, KLM-GOMS, NGOMSL.		2							electronics			x	x		• [FAA HFW] • [John & Kieras, 1996]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
183.	CPQRA (Chemical Process Quantitative Risk Analysis)	Step	OpR	1989	Quantitative risk assessment within chemical process industry. Stands for the process of hazard identification, followed by numerical evaluation of incident consequences and frequencies, and their combination into an overall measure of risk when applied to the chemical process industry. Ordinarily applied to episodic events.	Processes of all types. Is related to Probabilistic Risk Assessment (PRA) used in the nuclear industry.			3	4	5				chemical	x			x		• [ΣΣ93, ΣΣ97] • [CPQRA] • [CPQRA2]
184.	CRC (Control Rating Code Method)	Tab	Mit	1980 ?	Control Rating Code aims to prioritise hazard control options that are found during risk analysis or accident analysis. A number of candidate strategies to control hazards is assessed regarding various control types, i.e. Design change (engineering type controls that potentially eliminate the hazard); Passive control (controls that are in place that do not require human intervention); Active control (controls that are in place that require humans to activate them); Warning device (alarms or monitoring that indicate a hazardous situation); Procedure (documented standard operating procedures that control the hazardous situation). The assessments are then used to determine a ranking of strategies.	Control Rating Code can be applied when there are many hazard control options available.						6			defence, mining	x					• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97] • [White Benner, 2005] • [Henderson, 2009] • [Benner, 2008]
185.	CREAM (Cognitive Reliability and Error Analysis Method)	Step	HRA, Ret	1998	Cognitive modelling approach. Applies cognitive systems engineering to provide a more thoroughly argued and theory supported approach to reliability studies. The approach can be applied retrospectively or prospectively, although further development is required for the latter. The 'meat' of CREAM is the distinction between phenotypes (failure modes) and genotypes (possible causes or explanations).	Developed by Erik Hollnagel. Related to SHERPA, SRK and COCOM. A version of traffic safety has been implemented (DREAM - Driver Reliability And Error Analysis Method). Later, a version was developed for use in maritime accident analysis (BREAM - B for the ship's Bridge).				4					nuclear, rail, manufacturing, healthcare, chemical			x			• [Kirwan, Part 1, 1998] • [CREAM web] • [FAA HFW]
186.	CREATE (Cognitive Reliability Assessment Technique)	Step	HRA	1987	Human error reliability assessment. Describes how Cognitive Environment Simulation (CES) can be used to provide input to human reliability analyses (HRA) in probabilistic risk assessment (PRA) studies.						5				nuclear			x			• [Woods et al, 1992]
187.	CREWPRO (CREW PROblem solving simulation)	RTS ?	HFA	1994	Cognitive simulation which builds on CREWSIM. Intends to be able to model communication and confidence in other crew members. These represent ambitious but significant enhancements of the external validity or realism of modelling.	Developed by Mosley et al. The name CREWPRO was proposed by B. Kirwan.			3	4					(nuclear)			x	x		• [Kirwan, 1995] • [Kirwan, Part 1, 1998]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
188.	CREWS approach (Cooperative Requirements Engineering With Scenarios)	Step	OpR, Mit	1998	The ESPRIT CREWS approach focuses more on goal definition and the linking of goals to stakeholders' actual needs by linking goals and scenarios. It uses a bi-directional coupling allowing movement from goals to scenarios and vice-versa. The complete solution is in two parts: when a goal is discovered, a scenario can be authored for it and once a scenario has been authored, it is analysed to yield goals. By exploiting the goal-scenario relationship in the reverse direction, i.e. from scenario to goals, the approach pro-actively guides the requirements elicitation process. In this process, goal discovery and scenario authoring are complementary steps and goals are incrementally discovered by repeating the goal-discovery, scenario-authoring cycle. The steps are: 1. Initial Goal Identification; 2. Goal Analysis; 3. Scenario Authoring; 4. Goal Elicitation through Scenario Analysis. Steps 2 - 4 are repeated until all goals have been elicited	CREWS has been developed as part of ESPRIT, a European Strategic Program on Research in Information Technology and ran from 1983 to 1998. ESPRIT was succeeded by the Information Society Technologies (IST) programme in 1999. See also ART-SCENE.						6			no-domain-found					x	• [Rolland et al. 1998] • [CREWS] • [Chocolaad, 2006]
189.	CREWSIM (CREW SIMulation)	RTS	HFA	1993	Simulation model that models the response of an operating team in a dynamically evolving scenario. The model simulates operator interactions within a three-person crew, as well as the cognitive processes of the crewmembers, and the crew-plant dynamic interaction. Although the model has a knowledge base as other simulations do (e.g. COSIMO and CES), CREWSIM differs by using a set of prioritised lists that reflect the priorities of different concerns. Some other interesting aspects are 1) attentional resources control is simulated, such that diagnosis will be suspended while the operator is communicating or carrying out some other task. 2) the model's usage focuses particularly on transitions between procedures, and hence is looking in particular for premature, delayed, and inappropriate transfer within the emergency procedures system. 3) several error mechanisms are treated by the model: memory lapse; jumping to conclusions; communication failures; incorrect rules; and improper prioritisation.	Has been particularly developed to date to focus on a particular nuclear power plant scenario.			3	4					(nuclear)			x	x		• [Kirwan, Part 1, 1998]
190.	CRIOP (CRisis Intervention in Offshore Production)	Tab	HzA	1989 and 2004	CRIOP is a structured method for assessing offshore control rooms. The main focus is to uncover potential weaknesses in accident/incident response. CRIOP assesses the interface between operators and technical systems within the control room. The assessment is comprised of two main parts: (1) a design assessment in the form of a checklist; and (2) a scenario based assessment intended to assess the adequacy of response to critical situations.	Developed by the Norwegian Oil & Gas industry. It underwent a significant revision in 2004.							7	8	oil&gas	x			x		• [CRIOP History] • [Kjellen, 2000] • [SAFETEC web]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
191.	Criticality Analysis or Criticality Matrix	Tab	HwD	1967	The purpose of the Criticality Analysis is to rank each failure mode identified in a Failure Modes and Effect Analysis. Once critical failures are identified they can be equated to hazards and risks. Designs can then be applied to eliminate the critical failure, thereby eliminating the hazard and associated accident risk.	The technique is applicable to all systems, processes, procedures, and their elements. Combines with FMEA to become FMECA. See also Nuclear Criticality Analysis.					5				defence, space	x	x		x		• [FAA00] • [ΣΣ93, ΣΣ97]
	Criticality Matrix					See Criticality Analysis or Criticality Matrix															
192.	CRM (Crew Resource Management)	Int	HRA, Trai	1979	CRM is a procedure and training system for operations where human error can have devastating effects. It examines the implications of human factors and limitations, and the effect they have on performance. It introduces the concept of the 'Error Chain', the application of which can lead to recognition of incipient error situations, and develops tools for error intervention and avoidance. CRM is concerned not so much with the technical knowledge and skills required to operate equipment but rather with the cognitive and interpersonal skills needed to manage resources within an organised system.	Cognitive skills are defined as the mental processes used for gaining and maintaining situation awareness, for solving problems and for making decisions. Interpersonal skills are regarded as communications and a range of behavioral activities associated with teamwork. In aviation, CRM is sometimes referred to as Cockpit Resource Management. In the maritime industry, it is referred to as BRM (Bridge Resource Management). For aircraft maintenance, and for maritime, the term MRM is in use.						6			aviation, oil&gas, healthcare, defence, police, leisure, ATM, aircraft, maritime, nuclear, rail			x	x		• [TRM web] • [Salmon et al, 2005]
193.	CRM (Collision Risk Model of the ICAO Obstacle Clearance Panel)	Math	Col	1980	This is a method to calculate the probability of a collision with obstacles by an aircraft on an ILS (Instrument Landing System) approach and possible subsequent missed approach. It is assumed that aircraft are distributed around a nominal path due to factors such as wind conditions, instrument performance and flight technical error. The risk presented by an obstacle depends on the location of the obstacle relative to the nominal approach path of the aircraft and on the extent to which the aircraft are likely to spread the nominal path at the range of the obstacle. Visual flight conditions are assumed to be such that pilots are not able to see and avoid the obstacles. In the event that the calculated collision probability is unacceptable, the procedures specialist may use the CRM to study the relative effects of changes in any of the parameters involved. Examples include removing an obstacle or raising the glide path angle.						5	6			airport				x		• [ICAO Doc 9274] • [Smith, 1988] • [ACRP 51, 2011]
194.	CRT (Current Reality Tree)	Stat	Mod	1984	A CRT is a statement of an underlying core problem and the symptoms that arise from it. It maps out a sequence of cause and effect from the core problem to the symptoms. Most of the symptoms will arise from the one core problem or a core conflict. Remove the core problem and we may well be able to remove each of the symptoms as well. Operationally one works backwards from the apparent undesirable effects or symptoms to uncover or discover the underlying core cause.	Developed by Eliyahu M. Goldratt in his theory of constraints that guides an investigator to identify and relate all root causes using a cause-effect tree whose elements are bound by rules of logic (Categories of Legitimate Reservation). See also Root Cause Analysis.				4					management, manufacturing					x	• [Dettmer, 1997]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
195.	CSA (Comparative Safety Assessment)	Tab	Mit	2000 or older	Each safety hazard is investigated in the context of investment alternatives. The result is a ranking of alternative solutions by reduction in safety risk or other benefits. Steps are to: • Define the alternative solutions under study in system engineering terms (mission, human, machine, media and management); • Develop a set of hierarchical functions that each solution must perform; • Develop a Preliminary Hazard List (PHL) for each alternative solution; • List and evaluate the risk of each hazard for the viable alternative solutions; • Evaluate the risk; • Document the assumptions and justifications for how the severity and probability of each hazard condition was determined.	The input hazards for CSA are identified in an Operational Safety Assessment (OSA, see ED-78A), which is conducted during Mission Analysis in accordance with the NAS Modernisation System Safety Management Plan (SSMP). A different version of CSA, applicable to food safety (e.g. genetic modifications), was developed in 2003 by Kok & Kuiper.					5	6			aviation, healthcare, food	x		x	x		• [FAA00] (App B) • [FAA tools] • [Kok & Kuiper, 2003]
196.	CSE (Cognitive Systems Engineering)	Gen	HFA	1983	CSE aims at description and analysis of human-machine systems or sociotechnical systems. In CSE the focus is not on human cognition as an internal function or as a mental process, but rather on how cognition is necessary to accomplish effectively the tasks by which specific objectives related to activities can be achieved. CSE proposes that composite operational systems can be looked at as joint cognitive systems. The approach is to observe the field practice and represent the knowledge thus acquired in some form that facilitates the design of appropriate cognitive support systems. Those design solutions are then evaluated via computer modelling or human-in-the-loop simulation. The tools used for knowledge acquisition, knowledge representation and cognitive modelling have been developed specifically to deal with the complex and nonlinear nature of human cognition; its hidden interdependencies and those of its processes that are beyond the conscious awareness of the operational expert.	Formulated by Erik Hollnagel and David Woods. CSE emerged as a research direction in the early 1980s, and has since then grown to become a recognized discipline. CSE addresses the problems of people working with complex systems. Sometimes referred to as Cognitive Engineering.				4					healthcare, (navy), (nuclear), (aviation), (defence), (ATM)			x			• [CSE web] • [Gualtieri, 2005] • [Hollnagel & Woods, 1983] • [Hollnagel & Woods, 2005] • [Lintern]
197.	CSM (Common Safety Method on risk evaluation and assessment)	Int	OpR	2009	This is a framework process for assessing the risk associated with changes to the railway system, including technical, operational and organisational changes. It follows generic steps, including scope and system definition, hazard identification, identification of scenarios, risk assessment, comparison to criteria, identification of safety measures to mitigate or control the risk, demonstration of compliance. The framework does not prescribe specific techniques to be used for each step.	The CSM method for risk evaluation and risk assessment makes part of a set of Common Safety Methods (CSMs) established in accordance with Article 6 of European Union Directive 2016/798. The CSMs describe how the safety levels, the achievement of safety targets and compliance with other safety requirements should be fulfilled. Depending on their scope, they are applied by authorities and/or by specific actors of the railway system (e.g. railway undertakings, infrastructure managers, entities in charge of maintenance).	1	2	3	4	5	6	7		rail	x	x	x	x	x	• [ERA CSM web] • [Jovicic, 2009a] • [Jovicic, 2009b]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
198.	CSP (Communicating Sequential Processes)	Gen	Des	1978; update in 1985	Formal language for the specification of concurrent software systems, i.e. systems of communicating processes operating concurrently. Allows one to describe systems as a number of components (processes) which operate independently and communicate with each other over well-defined channels.	First version was described by C.A.R. Hoare. Descriptive tool in cases where a system must consist of more than one process. Related to CCS. The restriction that the component processes must be sequential was removed between 1978 and 1985, but the name was already established. Software requirements specification phase and design & development phase.			3						electronics, avionics, space, security		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]
199.	CSS (Confined Space Safety)	Step	HzA	1992	The purpose of this analysis technique is to provide a systematic examination of confined space risks. A confined space is defined to be an area that 1) has limited or restricted means of entry or exit; 2) is large enough for a person to enter to perform tasks; 3) and is not designed or configured for continuous occupancy. The analysis includes investigation of hazardous atmospheres, e.g. insufficient ventilation to remove dangerous air contamination and/or oxygen deficiency, or hazardous configuations of the walls of the space.	Any confined areas where there may be a hazardous atmosphere, toxic fume, or gas, the lack of oxygen, could present risks. Confined Space Safety is applicable to tank farms, fuel storage areas, manholes, transformer vaults, confined electrical spaces, race-ways.			3						chemical, oil&gas, police, energy, mining, environment, leisure	x					• [FAA00] • [ΣΣ93, ΣΣ97] • [OSHA CSS]
200.	CSSA (Cryogenic Systems Safety Analysis)	Step	Mit	1982	The purpose is to specifically examine cryogenic systems from a safety standpoint in order to eliminate or to mitigate the hazardous effects of potentially hazardous materials at extremely low temperatures.	Use with PHA or SSHA. Cryogenic is a term applied to low-temperature substances and apparatus.			3			6			(chemical)	x					• [FAA AC431] • [ΣΣ93, ΣΣ97]
201.	CSSM (Continuous Safety Sampling Methodology)	Stat	HzA, Mit	1997	This is a form of hazard analysis that uses observation and sampling techniques to determine and maintain a pre-set level of the operator's physical safety within constraints of cost, time, and operational effectiveness. Sampling is performed to observe the occurrence of conditions that may become hazardous in a given system and could result in an accident or occupational disease. The collected data are then used to generate a control chart. Based on the pattern of the control chart, a system "under control" is not disturbed whereas a system "out of control" is investigated for potential conditions becoming hazardous. Appropriate steps are then taken to eliminate or control these conditions to maintain a desired safe system.	Developed by R. Quintana and A. Nair, University of Texas.			3	4		6			manufacturing, healthcare	x		x			• [HIFA Data] • [FAA HFW] • [Quintana & Nair, 1997]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
202.	CTA (Cognitive Task Analysis)	Gen	Task	1983	CTA thoroughly describes some aspect of human operation and cognitive processing within a work domain. CTA is used to design human-system interaction and displays, assess job requirements, develop training, or evaluate teamwork. A CTA is an analysis of the knowledge and skills required for a proper performance of a particular task. The framework consists of three elements: (a) an analysis of the task that has to be carried out to accomplish particular goals; (b) an analysis of the knowledge and skills required to accomplish these tasks; and (c) an analysis of the cognitive (thought) processes of experienced and less experienced persons.	[MIL-HDBK, 1999] describes three examples for conducting CTA: 1) The Precursor, Action, Results and Interpretation method (PARI); 2) Conceptual Graph Analysis (CGA); 3) Critical Decision Method. Tools: GOMS, DNA Method (Decompose, Network, and Assess Method)		2							defence, aviation, nuclear, ATM, navy, leisure			x			• [Davison] • [MIL-HDBK, 1999] • [Mislevy et al, 1998] • [Klein, 2004] • [Kieras, 1988] • [Johnson, 1992] • [Schaaftal & Schraagen, 2000] • [FAA HFW]
203.	CTA (Critical Task Analysis)	Tab	Task	1979 or older	A Critical Task Analysis aims to describe the results of analyses of critical tasks performed to provide a basis for evaluation of the design of the system, equipment, or facility, verifying that human engineering technical risks have been minimised and solutions are in hand.	Developed by FAA. Critical tasks are elemental actions required to perform the task. 'Critical' is usually defined as being necessary for mission success.		2							defence, navy			x			• [FAA HFW] • [HEAT overview] • [Beevis, 1992]
204.	CTC (Comparison-To-Criteria)	Tab	HzA	1993	The purpose of CTC is to provide a formal and structured format that identifies safety requirements. Any deviations between the existing design requirements and those required are identified in a systematic manner, and the effect of such deviations on the safety of the process or facility is evaluated. The deviations with respect to system upsets are those caused by operational, external, and natural events. Operational events include, among others, individual component failures, human error interactions with the system (to include operation, maintenance, and testing), and support system failures. For systems that do not meet current design requirements, an upgrade is not done automatically until an assessment of their importance to safety is made.	Comparison-To-Criteria is a listing of pertinent safety criteria. This technique can be considered in a Requirements Cross-Check Analysis. Applicable safety-related requirements such as OSHA (Occupational Safety and Health Administration), NFPA (National Fire Protection Association), ANSI (American National Standards Institute), are reviewed against an existing system or facility.						6	7		chemical, environment, energy, (aviation)	x	x	x			• [FAA00] • [McClure & Restrepo, 1999] • [ΣΣ93, ΣΣ97]
205.	CTD (Cognitive Task Design)	Gen	Task	1995 or older	The aim of Cognitive Task Design is to focus on the consequences that artefacts have for how they are used, and how this use changes the way we think about them and work with them – on the individual as well as organisational level. The ambition is to ensure that Cognitive Task Design is an explicit part of the design activity, rather than something that is done fortuitously and in an unsystematic manner.	In some references, e.g. [Sutcliffe, 2003], CTD is presented as a generic term rather than a specific technique. CTD has the same roots as Cognitive Task Analysis (CTA), but the focus is on macro-cognition rather than micro-cognition, i.e., the requisite variety of the joint system, rather than the knowledge, thought processes, and goal structures of the humans in the system. CTD goes beyond CTA, as the emphasis is on the potential (future) rather than the actual (past and present) performance.				4					nuclear, aviation			x			• [CTD web] • [Hollnagel, 2003] • [Sutcliffe, 2003] • [Worden & Schneider, 1995]
	CTM (Cause Tree Method)					See FTA (Fault Tree Analysis)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
206.	CWA (Cognitive Work Analysis)	Int	Task	1975	CWA analyzes the work people do, the tasks they perform, the decisions they make, their information behavior, and the context in which they perform their work - for the purpose of systems design. It offers a mechanism to transfer results from an in-depth analysis of human-information work interaction directly to design requirements. CWA focuses on identifying the constraints that shape behavior rather than trying to predict behavior itself. It consists of five layers of analysis: 1. Work Domain - The functional structure of the work domain in which behavior takes place. 2. Control Tasks - The generic tasks that are to be accomplished. 3. Strategies - The set of strategies that can be used to carry out those tasks. 4. Social-Organisational - The organisation structure. 5. Worker Competencies - The competencies required of operators to deal with these demands.	Cognitive Work Analysis was developed in the 1970s at the Risø National Laboratory in Denmark, to facilitate human-centered design. It complements traditional task analysis by adding the capability of designing for the unanticipated by describing the constraints on behavior rather than behavior per se. Can be used in Cognitive Task design (CTD).		2							nuclear, navy, aviation, ATM, road, rail, healthcare			x			• [FAA HFW] • [CWA portal] • [Naikar, 2006]
207.	DAD (Decision Action Diagram)	Stat	Task	1950	Aim is to show how to navigate a system, based on decisions and actions. Actions are drawn as rectangles, decisions as diamonds, and possible decision outcomes are labelled on arrows from decision diamonds. Decisions can be phrased as yes/no or as multiple choice questions.	Developed by Dunlap & Associates in the 1950s. Similar in appearance and logic to the mechanical handling diagrams which are used in mechanical HAZOPs. Also known as Information Flow Charts or Decision-Action-Information Diagrams. Also similar to functional flow diagrams except that decision points are added.		2							oil&gas, defence, navy, nuclear			x			• [HEAT overview] • [Kennedy & Kirwan, 1998] • [Kirwan, 1994] • [Kirwan & Ainsworth, 1992] • [MIL-HDBK, 1999] • [Silva et al, 1999] • [FAA HFW] • [Beevis, 1992]
208.	Data Flow Analysis	Stat	SwD	1973	Data flow analysis is a static analysis technique that is performed both at procedure level and also as part of the system wide analysis, which is one aspect of integration testing. It identifies data flow anomalies in the program, e.g. the use of uninitialised variables. It gathers information about the possible set of values calculated at various points in a computer program. A program's control flow graph is used to determine those parts of a program to which a particular value assigned to a variable might propagate. The information gathered is often used by compilers when optimizing a program.	A simple way to perform dataflow analysis of programs is to set up dataflow equations for each node of the control flow graph and solve them by repeatedly calculating the output from the input locally at each node until the whole system stabilizes, i.e., it reaches a fixpoint. See also Control Flow Analysis.			3						software		x				• [EN 50128, 1996] • [Rakowsky] • [SPARK web]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
209.	Data Mining	Min	Dat	1750	Data Mining is defined as the systematic and automised searching of a database in order to extract information and patterns. Data mining commonly involves four classes of tasks: • Clustering - is the task of discovering groups and structures in the data that are "similar", without using known structures in the data. • Classification - is the task of generalizing known structure to apply to new data. Common algorithms include decision tree learning, nearest neighbour, naive Bayesian classification, neural networks and support vector machines. • Regression - attempts to find a function which models the data with the least error. • Association rule learning - searches for relationships between variables.	Early methods of identifying patterns in data include Bayes' theorem (1700s) and regression analysis (1800s). Some tools are: • Aviation Safety Data Mining Workbench (MITRE, 2001) - three data mining techniques for application to aviation safety data • Brio Intelligence 6 (Brio Software Japan (1999); Hyperion (2003)) • IMS (Inductive Monitoring System) (NASA Ames, 2003) – Health monitoring • QUORUM Perilog (NASA, 1995) – four data mining techniques; supports FAA's Aviation Safety Reporting System (ASRS) Other tools related to Data Mining are: Mariana, ReADS (Recurring Anomaly Detection System). See also SequenceMiner.			3		5		7	8	ATM, aviationmanagement, manufacturing, finance, electronics, healthcare, energy, social, environment, security	x	x	x	x		• [Fayyad et al, 1996] • [GAIN AFSA, 2003] • [Halim et al, 2007] • [GAIN ATM, 2003] • [Nazeri, 2003] • [FAA HFW] • [ASDMW application]
	Data Recording and Analysis					See Self-Reporting Logs															
210.	Data Security	Gen	Des	1975 or older	Data security is the means of ensuring that data is kept safe from corruption and that access to it is suitably controlled. Thus data security helps to ensure privacy. It also helps in protecting personal data. Aim is to guard against external and internal threats which can either accidentally or deliberately endanger the objectives of design and may lead to unsafe operation.	Tools available.						6			finance, electronics, security, defence, social		x				• [Bishop, 1990]
211.	DBN (Dynamic Bayesian Network)	Dyn	Mod	1997 or older	Dynamic Bayesian Networks (or Dynamic Bayseian Belief Networks) are a method for studying state-transition systems with stochastic behaviour. A DBN is a Bayesian network that represents sequences of variables. These sequences are often time-series (for example, in speech recognition) or sequences of symbols (for example, protein sequences). DBNs comprise a large number of probabilistic graphical models, which can be used as a graphical representation of dynamic systems. With this, they provide a unified probabilistic framework in integrating multi-modalities.	A Dynamic Bayesian Network extends the static Bayesian Belief Network (BBN) by modelling changes of stochastic variables over time. The hidden Markov model and the Kalman filter can be considered as the simplest dynamic Bayesian network.				4	5				healthcare, leisure, road, security	x	x	x	x	x	• [Goransson & Koski, 2002] • [Murphy, 2002]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
212.	DCA (Design Constraint Analysis)	Step	SwD	1996 or older	Evaluates restrictions imposed by requirements, the real world and environmental limitations, as well as by the design solution. The design materials should describe all known or anticipated restrictions on a software component. These restrictions may include: update timing and sizing constraints; equations and algorithms limitations; input and output data limitations (e.g., range, resolution, accuracy); design solution limitations; sensor/actuator accuracy and calibration; noise; quantization/roundoff noise/errors; actuator power / energy capability; capability of energy storage devices; human factors, human capabilities and limitations; physical time constraints and response times; off nominal environments; friction, inertia, backlash in mechanical systems; validity of models and control laws versus actual system behavior; accommodations for changes of system behavior over time: wear-in, hardware wear-out, end of life performance versus beginning of life performance degraded system behavior and performance. Design constraint analysis evaluates the ability of the software to operate within these constraints.	A constraint is a design target that must be met for the design to be successful. (In contrast, an objective is a design target where more (or less) is better.)					6			software, (avionics), (space)		x				• [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky]
213.	DCPN (Dynamically Coloured Petri Nets)	Dyn	Mod	1997	Extension of Petri Nets to include dynamic colours, i.e. variables attached to Petri net tokens that can take on real values and that can change through time according to the solutions of (ordinary) differential equations. There are 3 types of transitions: immediate transitions (zero delay), delay transitions (exponential delay) or guard transitions (colours of input tokens reaching certain values).	DCPN are mathematically equivalent to PDP (Piecewise Deterministic Markov Processes). A DCPN extension to include stochastic differential equations is referred to as SDCPN. DCPN and SDCPN are the main modelling formats used for MA-DRM. See also MA-DRM, see also TOPAZ, see also SDCPN.				4	5				ATM	x	x	x	x	x	• [Everdij & Blom & Klompstra, 1997] • [Everdij & Blom, 2003] • [Everdij & Blom, 2005] • [Everdij et al, 2004] • [Everdij, 2010]
214.	DD (Dependence Diagrams)	Stat	Mod	1994 or older	Structured, deductive, top-down analysis that identifies the conditions, failures, and events that would cause each defined failure condition. Graphical method of identifying the logical relationship between each particular failure condition and the primary element or component failures, other events, or combinations of these that can cause the failure condition. Similar to FTA, except that a Fault Tree Analysis is failure-oriented and is conducted from the perspective of which failures must occur to cause a defined failure condition. A Dependence Diagram Analysis is success-oriented and is conducted from the perspective of which failures must not occur to preclude a defined failure condition.	In some references stated to be equivalent to Reliability Block Diagrams (RBD). Also equivalent to Success Trees.				4					aircraft	x					• [ARP 4761] • [FAA memo02]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
215.	DDA (Design Data Analysis)	Step	SwD	1996 or older	Design data analysis evaluates the description and intended use of each data item in the software design. Data analysis ensures that the structure and intended use of data will not violate a safety requirement. A technique used in performing design data analysis is to compare description-to-use of each data item in the design logic. Interrupts and their effect on data must receive special attention in safety-critical areas. Analysis should verify that interrupts and interrupt handling routines do not alter critical data items used by other routines. The integrity of each data item should be evaluated with respect to its environment and host. Shared memory, and dynamic memory allocation can affect data integrity. Data items should also be protected from being overwritten by unauthorized applications.						6				software, (avionics), (space)		x				• [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky]
216.	DDET (Discrete Dynamic Event Tree)	Dyn	Mod	1988	DDET is a simulation method implemented by forward branching event trees; the branch points are restricted at discrete times only. The knowledge of the physical system under study is contained in a numerical simulation, written by the analyst. The components of the system are modelled in terms of discrete states. All possible branches of the system evolution are tracked. The events (branches) can only happen at predefined discrete time intervals. It is assumed that if the appropriate time step is chosen, DDETs would investigate all possible scenarios. The systematic branching would easily lead to such a huge number of sequences that the management of the output Event Tree becomes awkward. Measures have been taken to eliminate the explosion.	DDET is an extension of the classical event trees, by removing the binary logic restriction. The construction of the DDET can be computerized. In order to better manage the multiple generated scenarios by the DDET, methods as DYLAM and DETAM were developed.				4					nuclear	x					• [Amendola, 1988] • [Hu, 2005]
	Decision Analysis					See DTA (Decision Tree Analysis) or Decision Analysis. See Risk-Based Decision Analysis.															
217.	Decision Matrix	Tab	Dec	1982	Used to form an initial allocation hypothesis. The "goodness" in response to some performance demand is scaled from unsatisfactory (*U)* to excellent for both the human (*h*) and automation (*a*). Demands that fall into an U_{ah} region indicate the need for system redesign; those falling into U_h or U_a regions are biased toward static allocation design perspectives favouring the machine or human, respectively; and demands in the P_a, P_h, and P_{ha} (where both human and machine can perform the function reasonably well) regions will offer the most design options, including the potential for dynamic function allocation.	Is used to describe a MCDA (multi-criteria decision analysis) problem.					6				management, social, nuclear, healthcare, aviation	x		x			• [FAA HFW] • [Price, 1982] • [Sharit, 1997]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
218.	Decision Tables	Tab	Dec	1962	A Decision table is a decision support that involves considering a variety of combinations of conditions and their interrelationships, particular for complex interrelationships. In a decision table, logic is divided into conditions (relevant to a decision), actions (resulting from a given combination of conditions) and rules (which specify which actions are to be followed for a given set of conditions).	Widely used. Can be seen as a generalisation of FMEA. Is also used for software testing. Also referred to as Truth Tables and several other names.			3	4					finance, management	x	x				• [Moreno & Verhelle & Vanthienen, 2000] • [EN 50128, 1996] • [Genesereth, 2005] • [HEAT overview] • [MUFTIS3.2-I, 1996] • [Rakowsky] • [Sparkman, 1992] • [Beevis, 1992]
	Decision-Action-Information Diagram					See DAD (Decision Action Diagram)															
219.	Defensive Programming	Gen	Des	1988 or older	Defensive programming is an approach to improve software and source code, in terms of: General quality - Reducing the number of software bugs and problems; Making the source code comprehensible - the source code should be readable and understandable so it is approved in a code audit; Making the software behave in a predictable manner despite unexpected inputs or user actions. Aim is to produce programs which detect anomalous control flow, data flow or data values during their execution and react to these in a predetermined and acceptable manner.	Useful where there is insufficient confidence in the environment or the software. Tools available. Similar to Failure assertion programming. Software architecture phase.			3			6			software		x				• [Bishop, 1990] • [EN 50128, 1996]
220.	Delphi Knowledge Elicitation Method or Delphi Method	Dat, Tab	Dat	1959	The Delphi method allows experts to deal systematically with a complex problem or task. The technique comprises a series of questionnaires sent either by mail or via computerised systems, to a pre-selected group of geographically dispersed experts. These questionnaires are designed to elicit and develop individual responses to the problems posed and to enable the experts to refine their views as the group's work progresses in accordance with the assigned task. The group interaction in Delphi is anonymous; comments, forecasts, and the like are not identified as to their originator but are presented to the group in such a way as to suppress any identification.	Developed by Olaf Helmer, Norman Dalkey, and Nicholas Rescher to forecast the impact of technology on warfare. The name "Delphi" derives from the Oracle of Delphi (Greece), due to its use for forecasting. The main point behind the Delphi method is to overcome the disadvantages of conventional committee action. Anonymity, controlled feedback, and statistical response characterise Delphi.			3		5				defence, finance, healthcare, social, management, aviation, ATM	x		x			• [Delphi] • [Rakowsky] • [Cuhls, 2003]
221.	Delta-X Monte Carlo Method	FTS	Par	2007	Delta-X deals with quantifying the error made when low probability cut sets of large fault trees are truncated. Truncation errors are defined by the difference between the actual structure function of a fault tree and the equivalent binary function to the union of all the identified minimal cut sets. For the assessment, Monte Carlo simulation and Importance sampling is used to evaluate the binary functions related to the truncation errors.	See also HPLV, Monte Carlo Simulation, and Importance Sampling.					5				(nuclear)	x					• [ChoiCho, 2007]
	Dependent failure analysis					See CCA (Common Cause Analysis)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
222.	DES (Discrete Event Simulation)	FTS	Mod	1955	An event calendar is constructed which indicates what events are scheduled to occur and when. The simulation executes the first event on the calendar, which may lead to a state change, and next updates the calendar.	See also at Computer Modelling and Simulation. Can be seen as special case of Monte Carlo Simulation, but statements vice versa occur as well.				4	5				healthcare, finance, defence, oil&gas, electronics, manufacturing, management, aviation, airport, nuclear, chemical	x	x				• [MUFTIS3.2-I, 1996] • [Nance, 1993]
223.	Design and Coding Standards	Gen	Des	1994 or older	A Coding Standard aims to avoid potential problems with a programming language before the design is actually implemented in code. The standard can indicate what software constructs, library functions, and other language-specific information must or must not be used. As such, it produces, in practice, a “safe” subset of the programming language. Coding standards may be developed by the software designer, based on the software and hardware system to be used, or may be general standards for a “safer” version of a particular language.	Software design and development phase. See also Code Inspection Checklists. See also Safe Language Subsets or Safe Subsets of Programming Languages.						6			software		x				• [EN 50128, 1996] • [Rakowsky]
224.	Design for Testability (Software)	Gen	Des	1980 or older	Design for testability aims to include ways that internals of a component can be adequately tested to verify that they are working properly. An example is to limit the number and size of parameters passed to routines.	Tools available. See also DFT, on which this method was based.						6			electronics		x				• [Bishop, 1990] • [NASA-GB-1740.13-96]
225.	DESIREE (Distributed Environment for Simulation, Rapid Engineering and Experimentation)	RTS	Des	2001	DESIREE is a simulation platform for Air Traffic Control (ATC) ground systems. Its principal use is for rapid prototyping and human factors experimentation. It provides realistic Terminal and En-route ATC simulations simultaneously. The Desiree user interface is programmable. It uses an internal messaging scheme, which allows data to be recorded for later analysis and also permits to use scripted events. It emulates multiple en route and terminal sectors with automatic handoff and transfer of control features.	DESIREE was developed by, and is wholly owned and operated by, the FAA Research, Development, and Human Factors Laboratory (RDHFL).							7		ATM			x			• [Zingale et al, 2008] • [FAA HFW]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
226.	DETAM (Dynamic Event Tree Analysis Method)	Dyn	Mod	1991	DETAM is a generalisation of DYLAM to allow scenario branching based on stochastic variations in operator state. It treats time-dependent evolution of plant hardware states, process variable values, and operator states over the course of a scenario. A dynamic event tree is an event tree in which branchings are allowed at different points in time. This approach is defined by: (a) branching set, (b) set of variables defining the system state, (c) branching rules, (d) sequence expansion rule and (e) quantification tools. The branching set refers to the set of variables that determine the space of possible branches at any node in the tree. Branching rules refer to rules used to determine when a branching should take place (a constant time step). The sequence expansion rules are used to limit the number of sequences.	Developed by Acosta & Siu (MIT Nuclear Engineering Department). This approach can be used to represent operator behaviours, model the consequences of operator actions and also serve as a framework for the analyst to employ a causal model for errors of commission. Thus it allows the testing of emergency procedures and identify where and how changes can be made to improve their effectiveness.				4	5				nuclear	x		x	x		• [MUFTIS3.2-I, 1996]
227.	Development Standards	Gen	Des	1990 or older	To enhance software quality by using standard approaches to the software development process.	Essential for safety critical systems. Necessary for implementing in a quality assurance program. Tools available. See also Design and Coding standards.						6			avionics, defence, security		x				• [Bishop, 1990]
228.	DFD (Data Flow Diagrams)	Stat	Mod	1979	Data flow diagrams illustrate how data is processed by a system in terms of inputs and outputs. Different nodes and arrows exist: Processes, Datastores, Dataflows, External entities. DFD can be drawn in several nested layers.	Developed by Gane and Sarson. The purpose and value of the data flow diagram is primarily data discovery, not process mapping. Several tools exist.		2							finance, management, social		x			x	• [AIS-DFD] • [EN 50128, 1996] • [Rakowsky] • [Smartdraw]
229.	DFM (Double Failure Matrix)	Tab	HzA	1981	Inductive approach that considers the effects of double failures. All possible failures are placed on the vertical and the horizontal axis of a matrix, and all combinations are considered and put into severity classes.	Its use is feasible only for relatively noncomplex systems.				4	5				space, (nuclear), (defence), (electronics)	x					• [FT handbook, 2002] • [MUFTIS3.2-I, 1996]
230.	DFM (Dynamic Flowgraph Methodology)	Int	SwD	1990	Is an integrated, methodical approach to modelling and analysing the behaviour of software-driven embedded systems for the purpose of dependability assessment and verification. DFM has two fundamental goals: 1) to identify how events can occur in a system; 2) to identify an appropriate testing strategy based on an analysis of system functional behaviour. To achieve these goals, DFM employs a modelling framework in which models expressing the logic of the system being analysed are developed in terms of causal relationships between physical variables and temporal characteristics of the execution of software modules.	Combines the benefits of conventional SFTA and Petri nets.			3	4					nuclear, space, (aircraft)	x	x				• [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky] • [Al-Dabbagh, 2009]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
231.	DFS Safety Assessment Methodology	Int	OpR	2001	Methodology that consists of three major phases: FHA (Functional Hazard Assessment); PSSA (Preliminary System Safety Assessment); SSA (System Safety Assessment). During the FHA, a system's functional structure is analysed, all relevant hazards are identified and assessed according to the severity and conditional probability of their effects. Safety Objectives are defined (quantitative values for the maximum acceptable frequency of a hazard), based on the maximum acceptable frequency of each of the identified effects and the conditional probabilities of the causal links between the hazards and the effects. The PSSA is carried out in order to create Safety Requirements suitable to reach the Safety Objectives. Safety Requirements are concrete specifications for the architecture, the implementation or the operation of the future system. They are derived from the Safety Criticality of a system component, which in turn can be derived from a conditional probabilities assessment. The SSA is performed after the system has been developed and before it goes operational and aims at providing Safety Evidence, i.e. at ensuring that the system is free from unacceptable risks. Besides verifying that all Safety Requirements have been met, the Hazard Analysis performed during FHA and PSSA is refined to reflect new insights and perceptions. All hazards found are classified according to the frequency (or rate) of their occurrence, the actual frequency and the severity of their effects. For every non-acceptable risk found, suitable additional measures or safeguards have to be taken to mitigate that risk.	Developed by DFS (Deutsche FlugSicherung). Main modelling technique used is Bayesian Belief Networks. DFS SAM and EATMP SAM both have further evolved from an old version of EATMP SAM, and by now they are rather different.		2	3	4	5	6	7		ATM	x		x	x		• [DFS Method Handbook, 2004]
232.	DFT (Design for Testability) (Hardware)	Gen	Des	1948	DFT is a name for design techniques that add certain testability features to a microelectronic hardware product design. The premise of the added features is that they make it easier to develop and apply manufacturing tests for the designed hardware. The purpose of manufacturing tests is to validate that the product hardware contains no defects that could, otherwise, adversely affect the product's correct functioning. Aim is to enable all hardware components to be fully tested both on and off line.	Used wherever fault tolerance and redundancy is applied. Tools available.						6			manufacturing, electronics	x					• [Bishop, 1990]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
233.	DIA (Design Interface Analysis)	Step	SwD	1996 or older	Verifies the proper design of a software component's interfaces with other components of the system. This analysis will verify that the software component's interfaces as well as the control and data linkages between interfacing components have been properly designed. Interface characteristics to be addressed should include data encoding, error checking and synchronization. The analysis should consider the validity and effectiveness of checksums and CRCs (cyclic redundancy checks). The sophistication of error checking implemented should be appropriate for the predicted bit error rate of the interface. An overall system error rate should be defined, and budgeted to each interface.	Interface requirements specifications are the sources against which the interfaces are evaluated. A checksum is a fixed-size datum computed from an arbitrary block of digital data for the purpose of detecting accidental errors that may have been introduced during its transmission or storage.			3						software, (avionics), (space)		x				• [FAA00] • [NASA-GB-1740.13-96]
	Diary Method					See Self-Reporting Logs															
	Digital Logic					See Dynamic Logic															
234.	Digraphs	Stat	Mod	1965 or older	A Digraph or Directed Graph consists of vertices (or 'nodes'), connected by directed arcs (arrows). It differs from an ordinary or undirected graph, in that the latter is defined in terms of unordered pairs of vertices, which are usually called edges. Sometimes a digraph is called a simple digraph to distinguish it from a directed multigraph, in which the arcs constitute a multiset, rather than a set, of ordered pairs of vertices. Also, in a simple digraph loops are disallowed. (A loop is an arc that pairs a vertex to itself.) On the other hand, some texts allow loops, multiple arcs, or both in a digraph.					4					aircraft, nuclear, chemical	x					• [FAA AC431] • [ΣΣ93, ΣΣ97] • [Bang-Jensen & Gutin, 2007]
	Direct Numerical Estimation					See APJ (Absolute Probability Judgement)															
235.	Dispersion Modelling or Atmospheric Dispersion Modelling	FTS, Math	HzI	1930	Dispersion modelling is the mathematical simulation of how air pollutants disperse in the ambient atmosphere. It is performed with computer programs that solve the mathematical equations and algorithms which simulate the pollutant dispersion. The dispersion models are used to estimate or to predict the downwind concentration of air pollutants or toxins emitted from sources such as industrial plants, vehicular traffic or accidental chemical releases.	Quantitative tool for environmental and system safety engineering. Used in chemical process plants, can determine seriousness of chemical release.		2							chemical, airport, oil&gas, environment, road	x					• [Dispersion]
236.	Diverse Programming or NVP (N-Version Programming)	Step	Des	1977	Diverse Programming (also referred to as N-version programming) involves a variety of routines satisfying the same specification being written in isolation from one another. When a result is sought, voting takes place and the routine giving the most satisfactory answer wins. Aim is to detect and mask residual software design faults during execution of a program in order to prevent safety critical failures of the system, and to continue operation for high reliability.	Developed by Liming Chen and Algirdas Avizienis. Software architecture phase. Also known as multiversion programing or multiple-version dissimilar software. Useful for safety relevant fault compensating systems.			3						avionics, rail, electronics, security, nuclear		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky] • [SSCS] • [Storey, 1996]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
237.	DLA (Design Logic Analysis)	Step	SwD	1996 or older	DLA evaluates the equations, algorithms and control logic of a software design. Each function performed by a software component is examined. If a function responds to, or has the potential to violate one of the safety requirements, it should be considered critical and undergo logic analysis. In such logic analysis, the safety-critical areas of a software component are examined, design descriptions and logic flows are analysed, and discrepancies are identified.	An ultimate fully rigorous DLA uses the application of Formal Methods. If this is too costly, then less formal alternative may be used, such as manual tracing of the logic.			3							software, (avionics), (space)		x				• [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky]
238.	DMEA (Damage Mode and Effects Analysis)	Tab	HzA	1977	Damage Mode and Effects Analysis evaluates the damage potential as a result of an accident caused by hazards and related failures. DMEA expands a FMEA to include data required for vulnerability assessments. Information extracted from an existing FMEA includes: Item identification number; item nomenclature; function; failure modes and causes; mission phase/operation; severity class. DMEA then identifies all possible damage modes which could result from exposure to the specified threat mechanism(s), as well as the consequences of each assumed damage mode on item operation, function and status. Since the damage mode under consideration can affect several indenture levels, the analysis is carried out for local, next higher level and end effects.damage modes, local effects and end effects.	DMEA is primarily applicable to new or weapon system acquisitions or existing weapon systems. Risks can be minimised and their associated hazards eliminated by evaluating damage progression and severity. Related to and combines with FMEA.			3		5					aircraft, defence	x					• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]
239.	DO-178B (RTCA/EUROCAE ED-12B DO-178B)	Int	SwD	1981 and 2011	International standard on software considerations in airborne systems and equipment certification. Describes issues like systems aspects relating to software development, software lifecycle, software planning, etc, until aircraft and engine certification. The Design Assurance Level (DAL) is determined from the safety assessment process and hazard analysis by examining the effects of a failure condition in the system. The failure conditions are categorized by their effects on the aircraft, crew, and passengers. The categories are: Catastrophic; Hazardous; Major; Minor; No Effect. This software level determines the number of objectives to be satisfied (eventually with independence). The phrase "with independence" refers to a separation of responsibilities where the objectivity of the verification and validation processes is ensured by virtue of their "independence" from the software development team.	Jointly developed by RTCA, Inc. and EUROCAE. First version was released in 1981. Relates to civil aircraft and represents agreement between Europe and US. Updated version (2011) is referred to as DO-178C. See also DO-278.		2	3		5	6			aircraft, avionics		x				• [DO-178B, 1992] • [DO-178C, 2011] • [Storey, 1996]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
240.	DO-278 (RTCA DO-278/EUROCAE ED-109)	Int	SwD	2002	RTCA/DO-278 provides guidelines for the assurance of software contained in non-airborne CNS/ATM systems (e.g., surveillance radars, weather radars, navigation systems, surface management systems, air traffic management systems, etc.). The assignment of assurance levels for software is based on the severity and likelihood of system hazards. Design mitigation allows for flexibility in managing system risk that may be influenced by software. Therefore, by translating a specified assurance level from the initial System Risk via the SwAL assignment matrix, an acceptable level of assurance can be specified for the system's software.	DO-278 is the ground based complement to the DO-178B airborne standard. DO-278 was first published in 2002.		2	3		5	6			avionics, ATM		x				• [SRM Guidance, 2007] • [DO-278A, 2011]
241.	DODT (Design Option Decision Trees)	Stat	HwD, HFA	1971	DODT are a means of formally reviewing design options for the human factors implications of design choices. The technique requires a comprehensive understanding of the human factors issues and costs associated with the class of system being developed, together with information on possible technological choices. This requires the equivalent of a "state-of-the-art" review of human factors issues for the particular class of system. The analysis produces a tree of design decisions which have significant human factors costs, and detailed descriptions of the human engineering issues associated with each decision.	The original DODT approach was developed by Askren & Korkan (1971) to locate points in the design process for the input of human factors data.				4	5				manufacturing, (aircraft), (defence)	x		x			• [HEAT overview] • [Beevis, 1992]
	D-OMAR (Distributed Operator Model Architecture)					See OMAR (Operator Model Architecture)															
242.	Domino Theory	Gen	Mit	1932	According to this theory, there are five factors in the accident sequence: 1) the social environment and ancestry; 2) the fault of the person; 3) the unsafe act and/or mechanical or physical hazard; 4) the accident; 5) the injury. These five factors are arranged in a domino fashion such that the fall of the first domino results in the fall of the entire row. This illustrates that each factor leads to the next with the end result being the injury. It also illustrates that if one of the factors (dominos) is removed, the sequence is unable to progress and the injury will not occur.	Developed by H.W. Heinrich in 1932. Originally used to explain the spread of political ideas through nations around the world. Also referred to as Chain of Multiple Events. See also Swiss Cheese Model.						6			defence, management	x		x	x		• [Kjellen, 2000] • [Storbakken, 2002]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
243.	DOR (Dynamic Observation Report)	Dat	Val, Dat	2001	This tool allows inspectors to record on-the-spot safety observations outside the planned oversight process. DORs are not intended for routine use as a substitute for planned assessments but are used only in the following situations: a) Single-activity observations unrelated to the FAA ATOS (Air Transportation Oversight System) element being assessed. b) Unplanned observations when there is not an ATOS element or question that addresses the unique situation. c) Unplanned observations about a certificate holder the inspector is not assigned to inspect. d) Observations directed by a handbook bulletin or other national directive.	See also ConDOR.							7		(aviation)	x				x	• [FAA FSIMS, 2009] • [Sabatini, 2002]
244.	DORA (Dynamic Operational Risk Assessment)	Dyn	OpR	2009	DORA aims at operational risk analysis in oil/gas and chemical industries, guiding the process design and further optimisation. The probabilistic modelling part of DORA integrates stochastic modelling and process dynamics modelling to evaluate operational risk. The stochastic system-state trajectory is modeled according to the abnormal behavior or failure of each component. For each of the possible system-state trajectories, a process dynamics evaluation is carried out to check whether process variables, e.g., level, flow rate, temperature, pressure, or chemical concentration, remain in their desirable regions. Component testing/inspection intervals and repair times are critical parameters to define the system-state configuration, and play an important role for evaluating the probability of operational failure.					4	5				oil&gas, chemical	x			x		• [Yanga&Mannan, 2010]
	DREAM (Driver Reliability And Error Analysis Method)					See CREAM (Cognitive Reliability and Error Analysis Method)															
245.	DREAMS (Dynamic Reliability technique for Error Assessment in Man-machine Systems)	Dyn	HRA	1993	DREAMS is a DYLAM-related technique for human reliability analysis, which identifies the origin of human errors in the dynamic interaction of the operator and the plant control system. The human behaviour depends on the working environment in which the operator acts ("external world"), and on the "internal world", i.e. his psychological conditions, which are related to stress, emotional factors, fixations, lack of intrinsic knowledge. As a logical consequence of the dynamic interaction of the human with the plant under control, either the error tendency or the ability to recover from a critical situation may be enhanced. Output is an overall probability measure of plant safety related to human erroneous actions.	Developed by Pietro Cacciabue and others.			3	4	5				nuclear			x			• [MUFTIS3.2-I, 1996]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
246.	DSA (Deactivation Safety Analysis)	Step	HzA, Mit	1997 or older	This analysis identifies safety and health (S&H) concerns associated with facilities that are decommissioned/closed. The S&H practices are applicable to all deactivation activities, particularly those involving systems or facilities that have used, been used for, or have contained hazardous or toxic materials. The deactivation process involves placing the system or facility into a safe and stable condition that can be economically monitored over an extended period of time while awaiting final disposition for reuse or disposal. The deactivation methodology emphasises specification of end-points for cleanup and stabilisation based upon whether the system or facility will be deactivated for reuse or in preparation for disposal.	Deactivation may include removal of hazardous materials, chemical contamination, spill cleanup.			3				7		chemical, nuclear	x					• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]
247.	DTA (Decision Tree Analysis) or Decision Analysis	Stat	Dec	1997	A decision tree is a decision support tool that uses a tree-like graph or model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility. Decision Trees are tools for helping one to choose between several courses of action. They provide a structure within which one can lay out options and investigate the possible outcomes of choosing those options. They also help to form a balanced picture of the risks and rewards associated with each possible course of action.	Looks similar to Fault Trees, including the quantification part of FTA. A decision tree can be represented more compactly as an influence diagram, focusing attention on the issues and relationships between events.				4	5				nuclear, healthcare, finance, food, security	x		x			• [MindTools-DTA] • [Straeter, 2001] • [FAA HFW]
248.	DYLAM (Dynamic Logical Analytical Methodology)	Dyn	Mod	1985	Implementation of concept of Dynamic Event Tree Analysis. A physical model for the system is constructed which predicts the response of system process variables to changes in component status. Next, the undesired system states are defined in terms of process variable levels. At the end of the first time interval all possible combinations of component states are identified and their likelihoods are calculated. These states are then used as boundary conditions for the next round of process variable updating. This is continued until an absorbing state is reached.					4	5				nuclear, chemical	x		x	x		• [Cacciabue & Amendola & Cojazzi8, 1996] • [Cacciabue & Carpignano& V ivalda, 1992] • [Cojazzi & Cacciabue, 1992] • [Kirwan, Part 1, 1998] • [MUFTIS3.2-I, 1996]
249.	Dynamic Event Tree Analysis	Dyn	Mod	1985	Couples the probabilistic and physical behaviour of a dynamic process, for more detailed reliability analysis. Presents tree-based representation of an accident scenario.	See also DYLAM. See also DETAM.				4					nuclear, chemical	x		x	x		• [MUFTIS3.2-I, 1996]
250.	Dynamic Logic	Dyn	Des, Mod	1973 or older	Dynamic logic uses a clock signal in its implementation of combinational logic circuits, i.e. logic circuits in which the output is a function of only the current input. The usual use of a clock signal is to synchronize transitions in sequential logic circuits, and for most implementations of combinational logic, a clock signal is not even needed. Aim is to provide self-supervision by the use of a continuously changing signal.	Desirable in redundant systems as a means of distinguishing faulty channels. Sometimes referred to as Digital Logic or Clocked Logic			3						electronics		x				• [Bishop, 1990]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
251.	Dynamic Reconfiguration	Dyn	Des	1971 or older	Dynamic Reconfiguration (DR) is a software mechanism that allows resources to be attached (logically added) or detached (logically removed) from the operating environment control without incurring any system downtime. Aim is to maintain system functionality despite an internal fault.	Valuable where high fault tolerance and high availability are both required, but costly and difficult to validate. Software architecture phase.						6			electronics	x	x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky] • [Vargas, 1999]
	Dynamic Workload Scale					See Rating Scales															
252.	EASA CS25.1309, formerly known as JAR-25 (Joint Aviation Requirements Advisory Material Joint (AMJ) 25.1309)	Int	HwD	1974	JAR-25 provides Joint Aviation Requirements for large (turbine-powered) airplanes. Its Advisory Material Joint (AMJ 25.1309) includes a safety assessment methodology for large airplanes that runs in parallel with the large aeroplane lifecycle stages. The steps are: 1) Define the system and its interfaces, and identify the functions which the system is to perform. Determine whether or not the system is complex, similar to systems used on other aeroplanes, and conventional; 2) Identify and classify the significant failure conditions. This identification and classification may be done by conducting a Functional Hazard Assessment. The procedure depends on whether or not the system is complex; 3) Choose the means to be used to determine compliance with JAR-25.1309 b., c. and d. The depth and scope of the analysis depend on the types of function performed by the system, on the severity of systems failure conditions, and on whether or not the system is complex; 4) Implement the design and produce the data which are agreed with the Certification Authority as being acceptable to show compliance.	First issue was published in 1974. In 1983, the first aircraft was certified to JAR-25. AMJ 25.1309 is used as basis for several other safety assessment methodologies, e.g. ARP 4761, EATMP SAM. ARP 4754 is called up in AMJ 25.1309. Following the establishment of the European Aviation Safety Agency in September 2003 and the adoption of EASA Implementing Rules (IR), Certification Specifications (CS), and Acceptable Means of Compliance and Guidance Material (AMC), the JAA Committee made the decision that in future the JAA would publish amendments to the airworthiness JARs by incorporation of reference to EASA IR, AMC and CS. USA version of JAR-25 is FAR-25, which was issued before JAR-25 as a derivation of older regulations, and does not limit to turbine-powered aeroplanes.		2	3	4	5	6	7		aircraft	x					• [JAR 25.1309] • [Klompstra & Everdij, 1997] • [EASA CS-25, 2012]
253.	EASp EME 1.1 Method (European Aviation Safety plan Method to Assess Future Risks)	Int	OpR	2012	This method aims at prospective analysis of aviation safety risks. Steps are: 1) Scope the system and the assessment; 2) Describe/model the system and nominal operations; 3) Identify hazards; 4) Combine hazards into a risk framework; 5) Assess and evaluate risks; 6) Identify potential risk controls and reassess residual risk until acceptable; 7) Safety monitoring and verification; 8) Organisational learning and process improvement.	The eight steps are taken from [SAP 15], enriched with elements from FAST Method, such as use of Areas of Change (AoC), and a selection of methods from this Safety Methods Database.	1	2	3	4	5	6	7	8	(aviation), (ATM)	x			x		• [EASp EME1.1, 2012]
254.	EATMP SAM (European Air Traffic Management Programme Safety Assessment Methodology)	Int	OpR	2000 from	Safety Assessment Methodology supported by EATMP. Consists of three steps: FHA (Functional Hazard Assessment), PSSA (Preliminary System Safety Assessment) and SSA (System Safety Assessment) which run parallel to all development stages of a lifecycle of an Air Navigation System. Each step consists of several substeps.	Developed by a SAM Task Force chaired by Eurocontrol. Is used widely throughout Europe by Air Navigation Service Providers. The steps FHA, PSSA and SSA are described separately in this database. Version 2.1 was released in 2008.	1	2	3	4	5	6	7		ATM	x	x	x	x		• [EHQ-SAM, 2002] • [Review of SAM techniques, 2004]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
255.	EBSCA (Event-based Safety Culture Assessment)	Tab	Org	2004	Safety culture assessment for nuclear industry. Aimed at identifying organizational and management factors concerning the failure causes. Steps are: Cause complexes are classified and quantified due to their frequencies; Events are assigned weights related to cause complexes; Events are given relevance weights in relation with plant safety; The final score is decided by multiplying the two weights scores.									8	nuclear						x	• [Mkrtchyan & Turcanu, 2012]
256.	ECCAIRS (European Co-Ordination Centre for Aviation Incident Reporting Systems)	Dat	Dat	2004	ECCAIRS is a European Union initiative to harmonise the reporting of aviation occurrences by Member States so that the Member States can pool and share data on a peer-to-peer basis. The proposed data sharing has not yet been implemented. Each Member State will enforce the procedures for collecting and processing the reports. The reports will be placed in an electronic database together with safety relevant information derived from confidential reporting. An electronic network will allow any CAA or AAIB in the EU to have access to the integrated information. It will facilitate independent analyses and plans include having tools for trend and other analysis tools built-in.	Developed by the JRC in Italy. In use in ICAO since 1 January 2004.								8	aviation	x	x	x	x		• [GAIN ATM, 2003] • [JRC ECCAIRS]
257.	ECFC (Event and Causal Factor Charting)	Stat	Ret	1995 or older	Event and Causal Factor Charting utilises a block diagram to graphically display an entire event. The heart of the ECFC is the sequence-of events line. It provides a means to organise the data, provides a summary of what is known and unknown about the event, and results in a detailed sequence of facts and activities. Elements in the charts are: Condition (Ovals), Event (Blocks), Accident, Primary event line, Primary events and conditions, Secondary event lines, Secondary events and conditions, Causal factors, Items of note.	The technique aims at understanding the sequence of contributing events that lead to an accident.				4					nuclear, chemical, oil&gas, environment	x					• [FAA00] • [ΣΣ93, ΣΣ97] • [OSHAcademy] • [PPI, 2006]
258.	ECOM (Extended Control Model)	Stat	Mod	2003	ECOM acknowledges that the performance of the joint system can be described as involving different but simultaneous layers of control (or concurrent control loops). Some of these are of a closed-loop type or reactive, some are of an open-loop type or proactive, and some are mixed. Additionally, it is acknowledged that the overall level of control can vary, and this variability is an essential factor with regard to the efficiency and reliability of performance. Four layers are defined: Tracking, Regulating, Monitoring, Targeting. The ECOM describes the performance of the joint system by means of four interacting and simultaneous control loops, one for each layer.	Link with COCOM, which can be seen as an elaboration of the basic cyclical model with emphasis on the different control modes, i.e., how control can be lost and regained, and how the control modes affect the quality of performance. ECOM adds a modelling layer. The degree of control can still be considered relative to the levels of the ECOM.				4					(nuclear), (road)			x			• [ECOM web] • [Hollnagel & Nabo & Lau, 2003] • [Engstrom, 2006]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
259.	ED-78A (RTCA/EUROCAE ED-78A DO-264)	Int	OpR	2000	Guidelines for approval of the provision and use of Air Traffic Services supported by data communications. It provides a Safety assessment methodology with steps OSED (Operational Service and Environment Definition), OHA (Operational Hazard Analysis), ASOR (Allocation of Safety Objectives and Requirements), together also named Operational Safety Assessment (OSA).	EUROCAE ED-78A is equivalent to RTCA DO-264; the guidance was developed by a joint group: EUROCAE WG53/ RTCA SC189. OSA is a requirement development tool based on the assessment of hazard severity. The OSA is normally completed during the Mission Analysis (MA) phase. Development of the OSA should begin as soon as possible in the MA process.		2	3		5	6			ATM	x		x			• [FAA00] chap 4 • [FAA tools]
260.	EDAM (Effects-Based Decision Analysis Methodology)	Int	Dec, HFA	2005	EDAM is a hybrid approach that aims at the requirements analysis and design of revolutionary command and control systems and domains. It uses knowledge elicitation and representation techniques from several current cognitive engineering methodologies, such as GDTA and CTA. The techniques were chosen to allow for decision analysis in the absence of an existing similar system or domain. EDAM focuses on the likely system or domain constraints and the decisions required within that structure independent of technology, existing or planned. It is intended to be used throughout the design and development of a prototype. Information gathered with EDAM can also be used throughout a project to evaluate human performance in the proposed system.			2				6			(defence)	x		x			• [Ockerman et al, 2005]
261.	EEA (External Events Analysis)	Step	OpR	1983 or older	The purpose of External Events Analysis is to focus attention on those adverse events that are outside of the system under study. It is to further hypothesise the range of events that may have an effect on the system being examined. The occurrence of an external event such as an earthquake is evaluated and effects on structures, systems, and components in a facility are analysed.				3		5				nuclear, chemical	x					• [FAA00] • [Region I LEPC] • [ΣΣ93, ΣΣ97] • [DOE 1023-95, 2002] • [NEA, 1998]
262.	Egoless programming	Gen	Des	1971	A way of software programming that does not create an environment in which programmers consider the code as their own property, but are willing to share.	Developed by Jerry Weinberg in his book The Psychology of Computer Programming.						6			software		x				• NLR expert • [Weinberg, 1971
263.	Electromagnetic Protection	Gen	Des	1990 or older	Aim is to minimise the effects of electromagnetic interference (EMI) of the system by using defensive methods and strategies.	Tools available.						6			electronics	x					• [Bishop, 1990]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
264.	EMC (Electromagnetic Compatibility Analysis and Testing)	Step	Mit	1975	The analysis is conducted to minimise/prevent accidental or unauthorised operation of safety-critical functions within a system. The output of radio frequency (RF) emitters can be coupled into and interfere with electrical systems which process or monitor critical safety functions. Electrical disturbances may also be generated within an electrical system from transients accompanying the sudden operation of electrical devices. Design precautions must be taken to prevent electromagnetic interference (EMI) and electrical disturbances. Human exposure to electromagnetic radiation is also a concern.	Adverse electromagnetic environmental effects can occur when there is any electromagnetic field. Electrical disturbances may also be generated within an electrical system from transients accompanying the sudden operations of solenoids, switches, choppers, and other electrical devices, Radar, Radio Transmission, transformers.			3			6			avionics, defence, manufacturing, electronics, healthcare	x					• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]
265.	Emergency Exercises	Gen	Trai		Practising the events in an emergency, e.g. leave building in case of fire alarm.								7	8	nuclear, chemical, aviation, space, oil&gas, manufacturing, healthcare, mining, police				x	x	• [NEA, 2001]
266.	EMS (Event Measurement System)	Min	Dat	1998	EMS is designed to ease the large-scale implementation of flight-data analysis in support of the Flight Operational Quality Assurance (FOQA) Programs and Advanced Qualifications Programs (AQP). The EMS is a configurable and adaptable Windows 2000 based flight data analysis system. It is capable of managing large bodies of flight data, and can expand with fleet size and changing analysis needs. As the operations grow, EMS has the capacity to continue to extract maximum analysed value from the flight data.	Developed by Austin Digital.							7		aviation	x	x				• [GAIN AFSA, 2003]
267.	ENEL approach (Entity for Electricity approach)	Tab	Org	2006	Safety culture self-assessment within a nuclear facility, using a questionnaire based on the following principles: Everyone is personally responsible for nuclear safety, Leaders demonstrate commitment to safety, Trust permeates the organization, Decision-making reflects safety first, Nuclear technology is recognized as special and unique, A questioning attitude is cultivated, Organizational learning is embraced, Nuclear safety undergoes constant examination.									8	nuclear					x	• [Mkrtchyan & Turcanu, 2012]
268.	Energy Analysis	Step	HzA	1972 or older	The energy analysis is a means of conducting a system safety evaluation of a system that looks at the “energetics” of the system.	The technique can be applied to all systems, which contain, make use of, or which store energy in any form or forms, (e.g. potential, kinetic mechanical energy, electrical energy, ionising or non-ionising radiation, chemical, and thermal.) This technique is usually conducted in conjunction with Barrier Analysis and is similar to the Energy Trace part of ETBA.			3						chemical, nuclear, police, road, (rail)	x					• [FAA00] • [ΣΣ93, ΣΣ97]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
269.	Energy Trace Checklist	Tab	HzI	1972 or older	The analysis aids in the identification of hazards associated with energetics within a system, by use of a specifically designed checklist. The use of a checklist can provide a systematic way of collecting information on many similar exposures.	Similar to ETBA (Energy Trace and Barrier Analysis), to Energy Analysis and to Barrier Analysis. The analysis could be used when conducting evaluation and surveys for hazard identification associated with all forms of energy.			3						(chemical), (defence)	x					• [FAA00] • [ΣΣ93, ΣΣ97]
270.	Environment Analysis	Gen	HzI	1997	Describes the environment in which the activities or basic tasks are performed, with the purpose to identify environment specific factors impacting the task(s).			2							no-domain-found	x		x			• [FAA HFW] • [Wickens et al, 1997]
271.	EOCA (Error of Commission Analysis)	Tab	HRA	1995	HAZOP-based approach whereby experienced operators consider procedures in detail, and what actions could occur other than those desired. Particular task formats, error mode keywords, and PSF (Performance Shaping Factors) are utilised to structure the assessment process and to prompt the assessors. Identified significant errors are then utilised in the PSA fault and/or event trees.				3						road, social, (nuclear), (healthcare)	x	x	x	x	x	• [Kirwan, 1994] • [Kirwan, Part 1, 1998]
272.	E-OCVM (European Operational Concept Validation Methodology)	Int	Val	2007	E-OCVM includes three aspects of validation that, when viewed together, help provide structure to an iterative and incremental approach to concept development and concept validation: (1) The Concept Lifecycle Model facilitates the setting of appropriate validation objectives and the choice of evaluation techniques, shows how concept validation interfaces with product development and indicates where requirements should be determined; (2) The Structured Planning Framework facilitates programme planning and transparency of the whole process; (3) The Case-Based Approach integrates many evaluation exercise results into key 'cases' (safety case, business case, environment case, human factors case) that address stakeholder issues about air traffic management (ATM) performance and behaviours. These three aspects fit together to form a process. This process is focused on developing a concept towards an application while demonstrating to key stakeholders how to achieve an end system that is fit for purpose.	Developed by Eurocontrol, building on several European Validation project results. See also SARD.	1	2	3	4	5	6	7	8	ATM	x	x	x	x	x	• [E-OCVM]
273.	EPA Methods (Environmental Protection Agency Collection of Methods)	Gen	HzA	1991 ?	Collection of methods for measuring the presence and concentration of chemical pollutants; evaluating properties, such as toxic properties, of chemical substances; or measuring the effects of substances under various conditions. The methods are organised in categories: Air and Radiation; Water; Prevention, Pesticides, and Toxic Substances; Research and Development; Solid Waste and Emergency Response.	Maintained by Environmental Protection Agency, U.S.A.			3	4					environment					x	• [EPA Methods]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
274.	EPI DCT (Element Performance Inspection Data Collection Tool)	Dat	Val. HzI	1999 or older	This tool is for Performance Assessments (PA). It is designed to collect data to help the certification project manager (CPM) or principal inspector (PI) determine if an air carrier adheres to its written procedures and controls for each system element, and if the established performance measures for each system element are met. The PI or CPM needs to determine how many EPI DCTs to complete to obtain the data needed to assess air carrier performance for each element. Typically, an inspector has only one EPI assigned for a specific PA. He or she may complete multiple activities as part of that single EPI. PIs or CPMs may assign EPIs to more than one inspector in a PA. For example, PIs or CPMs may want to assign EPIs to different inspectors for each aircraft fleet, for certain geographic areas, or for different training programs.							7		aviation	x				x	• [FAA FSIMS, 2009] • [GAO, 1999]
275.	EPIC (Executive Process Interactive Control)	RTS	HFA, Task	1994	EPIC is a cognitive architecture model of human information processing that accounts for the detailed timing of human perceptual, cognitive, and motor activity. EPIC provides a framework for constructing and synthesising models of human-system interaction that are accurate and detailed enough to be useful for practical design purposes. Human performance in a task is simulated by programming the cognitive processor with production rules organized as methods for accomplishing task goals. The EPIC model then is run in interaction with a simulation of the external system and performs the same task as the human operator would. The model generates events (e.g. eye movements, key strokes, vocal utterances) whose timing is accurately predictive of human performance.	Developed by David E. Kieras and David E. Meyer at the University of Michigan. Takes into account the age of the individual.		2							social, (navy)			x			• [Kieras & Meyer, 1997] • [FAA HFW] • [Leiden et al., 2001] • [Morrison, 2003]
276.	EPOQUES	Int	Mit	2002	EPOQUES is a collection of methods and tools to treat safety occurrences at air traffic service providers. Participatory design and iterative prototyping are being used to define a set of investigative tools. Two complementary methods are being conducted in parallel. One is to study the existing work practices so that the initial prototype is grounded in current every day use. The second is to involve participants and designers to work together to iterate, refine, and extend the design, using rapid prototyping and collective brainstorming.	Developed at CENA, France.					6				(ATM)	x		x	x		• [GAIN ATM, 2003] • [Gaspard, 2002]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
277.	Equivalence Partitioning and Input Partition Testing	Step	SwD	1995 or older	Software Testing technique. Aim is to test the software adequately using a minimum of test data. The test data is obtained by selecting the partitions of the input domain required to exercise the software. This testing strategy is based on the equivalence relation of the inputs, which determines a partition of the input domain. Test cases are selected with the aim of covering all the partitions previously identified. At least one test case is taken from each equivalence class.	Also called Equivalence Class Partitioning (ECP). See also Software testing. See also Partitioning.							7		software		x				• [EN 50128, 1996] • [ISO/IEC 15443, 2002] • [Rakowsky]
278.	ER (External Risk)	Math	OpR	1995	Determination of the third party risk in terms of individual (IR) and societal risk (SR) for the surroundings of airports to individuals induced by air traffic. Quantification of the likelihood to die due to an aircraft accident. Comprises local accident ratio determination, accident location distribution and accident consequences. The latter taking into account consecutive effects such as interaction with dangerous plants and alike. Both traffic level and infrastructure layout form individual scenarios for which IR and SR figures can be computed and graphically displayed. Intended to support procedure design and allow to increase the stakeholder's situational awareness to bottlenecks and to judge new concepts.	Tool used mainly by airport operators					5				(airport)				x		• [GfL web] • [GfL, 2001] • [TUD, 2005]
279.	ERA (Environmental Risk Analysis)	Step	HzA	1975	The analysis is conducted to assess the risk of environmental non-compliance that may result in hazards and associated risks. The analysis may include the following steps: 1) Establish the context for the risk assessment process; 2) Identify environmental risks; 3) Analyse risks; 4) Evaluate risks to determine significant issues.	The analysis is conducted for any system that uses, produces or transports toxic hazardous materials that could cause harm to people and the environment.			3		5				environment	x					• [FAA00] • [ΣΣ93, ΣΣ97] • [Lerche&Paleologos, 2001] • [ERA, 2000]
	ERC (Event Risk Classification)					See ARMS															
280.	ERCS (European Risk Classification Scheme)	Tab	Dec, Ret	2017	Aims to provide a standardised methodology for classifying the risk posed by occurrences in aviation. Looks at which barriers have succeeded in ensuring the occurrence did not result in an actual accident. If the risk is beyond a threshold, a more detailed risk assessment is done. The ERCS is a matrix with 5 rows and 11 columns, where the 5 rows show various severity classes. The cells are coloured green, yellow or red. The size of the aircraft involved in the occurrence and the type of occurrence (e.g. mid-air collision, runway excursion), determines which row to look into: Large aircraft and more potential fatalities => top rows; Small aircraft and few fatalities => bottom rows. Next the failure or success of respective barriers determines which column to look into. If many barriers have failed go further to the right; there is another scheme to assist in this process.	Development was mandated by EU Regulation 376/2014 and was tasked to EASA from the European Commission in late 2014. See also RCS	1								aviation	x					• [EU 376/2014] • [EU 2020/2034]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
281.	Ergonomics Checklists	Tab	Task	1949 or older	These are checklists, which an analyst can use to ascertain whether particular ergonomics are being met within a task, or whether the facilities that are provided for that task are adequate.	See also Checklist Analysis, AET.							7		nuclear, ergonomics, oil&gas, healthcare, manufacturing	x					• [Kirwan & Ainsworth, 1992]
282.	ERPN (Efficient Risk Priority Number)	Step	HzA	2013	ERPN aims to enhance FMECA by calculating for each hazard ERPN = S x O x D x P x E / C, with S: Severity (severity of consequences); O: Occurrence (probability of occurrence); D: Detection (probability of detection); P: Prevention (extent to which prevention action is possible); E: Effectiveness (extent to which the preventive actions are effective); C: Cost (cost of preventive actions). Hazards with the highest ESPN are addressed first.						5				(manufacturing)	x					• [Falcon etal., 2013]
283.	Error Detection and Correction	Step	Des	150 AD	Aim is to detect and correct errors in sensitive information. Describes how to transit bits over a possibly noisy communication channel. This channel may introduce a variety of errors, such as inverted bits and lost bits.	Method has been used for many centuries, e.g. for precise copying of the bible. May be useful in systems where availability and response times are critical factors.						6			electronics, security		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]
284.	Error Guessing	Step	HzI	1995 or older	Error Guessing is the process of using intuition and past experience to fill in gaps in the test data set. There are no rules to follow. The tester must review the test records with an eye towards recognising missing conditions. Two familiar examples of error prone situations are division by zero and calculating the square root of a negative number. Either of these will result in system errors and garbled output.	Said to be not repeatable.			3						software		x				• [EN 50128, 1996] • [Rakowsky]
285.	Error Message Guidelines	Gen	Des	1992	The rules are: Be as specific and precise as possible; Be positive: Avoid Condemnation; Be constructive: Tell user what needs to be done; Be consistent in grammar, terminology, and abbreviations; Use user-centred phrasing; Use consistent display format; Test the usability of error messages; Try to reduce or eliminate the need for error messages.							6			software		x	x			• [EMG] • [FAA HFW] • [Liu, 1997] • [Schneiderman, 1992]
286.	Error Seeding	Step	SwD	1989 or older	Technique that can be used to evaluate the ability of language processors to detect and report errors in source programs. Typical faults are inserted (seeded) into the software. If during testing, K of the N inserted faults are found, then this method assumes that the same percentage of the actual faults are found as well.	See also Software testing.							7		software		x				• [EN 50128, 1996] • [Meek & Siu, 1989] • [Rakowsky]
287.	ESA (Explosives Safety Analysis)	Step	HzA	1970	This method enables the safety professional to identify and evaluate explosive hazards associated with facilities or operations. The purpose is to provide an assessment of the hazards and potential explosive effects of the storage, handling or operations with various types of explosives from gram to ton quantities and to determine the damage potential. Explosives Safety Analysis can be used to identify hazards and risks related to any explosive potential, i.e. fuel storage, compressed gases, transformers, batteries.	See also SAFER. See also Process Hazard Analysis.			3		5				chemical, defence	x					• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97] • [DDESB, 2000]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
288.	ESAT (Expertensystem zur Aufgaben-Taxonomie (Expert-System for Task Taxonomy))	Int	Task	1992	Artificial intelligence concepts are used to describe the human tasks. Quantification of PSF (Performance Shaping Factors) for any task. Determination of a dependability class (from 1-10) by ratings of default PSFs. The functional context between HEP and dependability class is partly given by expert judgement (based on generic cognition of human performance) and partly by measurement of performance.	Method established in the aviation field (e.g. design of cockpit displays).		2			5				(aviation)			x			• [Straeter, 2001]
289.	ESCAPE (Eurocontrol Simulation Capability Platform for Experimentation)	RTS	Trai	1996	ESCAPE is an ATC real-time simulator platform. It uses the Raptor 2500 FPS display technology, using LCD flat panel displays, each with a 170-degree viewing angle. ESCAPE has the capability to simulate a host of different en route scenarios.	ESCAPE has been developed by EEC and was launched in 1996.							7		(ATM)			x	x		• [GAIN ATM, 2003]
290.	ESD (Event Sequence Diagrams)	Stat	Mod	1983	An event-sequence diagram is a schematic representation of the sequence of events leading up until failure. In other words, it is a flow chart with a number of paths showing the 'big picture' of what happened - a holistic view. ESD can be used to identify pivotal events or defenses to prevent the progression of accident scenarios to undesired end states. It is a variation of Cause Consequence Diagram and generalisation of ETA, not restricted to representation of event sequences, repairable systems can be modelled.	First used by Pickard, Lowe and Garrick in 1983; extended and mathematically formulated by Swaminathan and Smidts in 1999.				4					nuclear, aviation, space	x		x	x		• [MUFTIS3.2-I, 1996] • [Swaminathan & Smidts, 1999]
291.	ESSAI (Enhanced Safety through Situation Awareness Integration in training)	Int	Trai	2000 - 2002	The ESSAI project developed a training approach for problems that occur in cockpits when pilots are confronted with extreme situations (a Crisis) for which they do not have appropriate procedures. These extreme situations may be the result of a rare chain of events, but may also occur because of lack of Situation Awareness of the crew. The project plans to develop training tools and techniques and their implementation in training programmes.							6			(aviation)			x	x	x	• [ESSAI web] • [Hörmann et al, 2003]
292.	ETA (Event Tree Analysis)	Stat	Mod	1968	An Event Tree models the sequence of events that results from a single initiating event and thereby describes how serious consequences can occur. Can be used for developing counter measures to reduce the consequences. The tool can be used to organise, characterise, and quantify potential accidents in a methodical manner. The analysis is accomplished by selecting initiating events, both desired and undesired, and develop their consequences through consideration of system/ component failure-and-success alternatives.	Former name is CTM (Consequence Tree Method). Useful in conjunction with fault tree analysis as an alternative to cause-consequence diagrams. Mainly for technical systems; human error may also be modelled. Tools available, e.g. Fault Tree+, RISKMAN, see [GAIN AFSA, 2003]. A variation developed for error of commission analysis is GASET (Generic Accident Sequence Event Tree.				4	5				nuclear, healthcare, aircraft, ATM, oil&gas, space, chemical	x		x	x		• [Leveson, 1995] • [MUFTIS3.2-I, 1996] • [Rakowsky] claims this one does handle software • [ΣΣ93, ΣΣ97] • [Baybutt, 1989] • [DNV-HSE, 2001] • [Rademakers et al, 1992] • [Rakowsky] • [Reason, 1990] • [Siu, 1994] • [Smith, 1996 and 1997] • [Storey, 1996] • [Terpstra, 1984] • [Villemeur, 1991]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
293.	ETBA (Energy Trace and Barrier Analysis)	Step	HzA	1973	The analysis aims to produce a consistent, detailed understanding of the sources and nature of energy flows that can or did produce accidental harm. The ETBA method is a system safety-based analysis process developed to aid in the methodical discovery and definition of hazards and risks of loss in systems by producing a consistent, detailed understanding of the sources and nature of energy flows that can or did produce accidental harm. Outputs support estimation of risk levels, and the identification and assessment of specific options for eliminating or controlling risk. These analyses are routinely started in conjunction with the System Hazard Analysis and may be initiated when critical changes or modifications are made.	ETBA is similar to Energy Analysis and to Barrier Analysis. The technique can be applied to all systems, which contain, make use of, or which store energy in any form or forms, (e.g. potential, kinetic mechanical energy, electrical energy, ionising or non-ionising radiation, chemical, and thermal.) Developed as part of MORT.			3		5	6			chemical, nuclear, police, road, (rail)	x					• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]
294.	ETTO (Efficiency-Thoroughness Trade-Off)	Gen	Mod	2002	ETTO is a principle that concludes that both normal performance and failures are emergent phenomena, hence that neither can be attributed to or explained by specific components or parts. For the humans in the system this means in particular that the reason why the outcome of their actions differs from what was intended or required, is due to the variability of the context and conditions rather than to the failures of actions. The adaptability and flexibility of human work is the reason for its efficiency. At the same time it is also the reason for the failures that occur, although it is never the cause of the failures. Herein lies the paradox of optimal performance at the individual level. If anything is unreasonable, it is the requirement to be both efficient and thorough at the same time – or rather to be thorough when with hindsight it was wrong to be efficient.					4					(healthcare), (nuclear)			x			• [Hollnagel-ETTO] • [Hollnagel, 2004]
295.	European Air Navigation Service Providers (ANSPs) Safety Culture Tool	Tab	Org	2006	Aim is to assess the safety culture of an air traffic management organization. Uses questionnaires, interviews and workshops to discuss: Commitment to safety; Resources for safety; Responsibility for safety; Involving air traffic controllers in safety; Management involvement in safety; Teaming for safety; Reporting incidents/communicating problems; Learning from incidents; Blame and error tolerance/discipline and Punishment; Communication about procedural/system changes; Trust within the organization; Real working practices; Regulatory effectiveness.									8	ATM					x	• [Mkrtchyan & Turcanu, 2012]
	Execution Flow Check					See Memorizing Executed Cases.															
	Expert Evaluation					See Heuristic Evaluation															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
296.	Expert Judgement	Gen	Par		Generic term for using human expert judgement for providing qualitative or quantitative information in safety assessments. Several expert judgement techniques exist, such as APJ or PC.	Expert judgement is often used, especially where statistical data is scarce, but needs to be treated with special care. There are well-proven protocols for maximising and testing its validity.					5				all	x	x	x	x		• [Ayyub, 2001] • [Humphreys, 1988] • [Kirwan, 1994] • [Kirwan & Kennedy & Hamblen] • [Nijstad, 2001] • [Williams, 1985] • [Basra & Kirwan, 1998] • [Foot, 1994] • [MUFTIS3.2-I, 1996] • [FAA HFW]
297.	Ex-Post Facto Analysis	Min	Ret	1980 or older	Is employed to study whether a causal relationship may exist. Statistics on accidents are compared with similar statistics for accident-free situations. The aim is to identify factors which are more common in the accident material than what is expected because of pure chance. In the next step, physical, physiological and psychological theories are brought in to explain the actual causal relationships.				3	4					social, environment, police, aircraft	x		x			• [Kjellen, 2000]
298.	FACE (Framework for Analysing Commission Errors)	Int	HRA	1999	Framework for analysing errors of commission. The framework consists of five generic phases: I) Target selection, II) identification of potential commission opportunities, III) screening commission opportunities, IV) modelling important commission opportunities, V) probability assessment.				3	4	5				nuclear			x			• [HRA Washington, 2001] • [Straeter, 2001]
299.	FACET (Future ATM (Air Traffic Management) Concepts Evaluation Tool)	FTS	OpR	2000 or older	FACET is an air traffic management (ATM) modelling and simulation capability. Its purpose is to provide an environment for the development and evaluation of advanced ATM concepts. FACET can model system-wide airspace operations over the entire US. It uses flight plan data to determine aircraft routing. As options, the routes can be automatically modified to direct routes or windoptimal routes. FACET then uses aircraft performance characteristics, winds aloft, and kinematic equations to compute flight trajectories. It then computes sector loading and airspace complexity. As an option, FACET can compute and simulate advanced concepts such as: aircraft self-separation and National Playbook rerouting. FACET also models the en-route impact of ground delay programs and miles-in-trail restrictions.	Developed at NASA Ames Research Center. FACET is capable of operating in one of the following four modes: Simulation, Playback, Hybrid, and Live.		2			5				ATM, aviation				x		• [GAIN ATM, 2003] • [Bilimoria00] • [FACET User manual, 2006] • [Sridhar et al, 2002]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
300.	Factor Analysis	Math	Mod ?	1900	The purpose of factor analysis is to discover simple patterns in the pattern of relationships among the variables. In particular, it seeks to discover if the observed variables can be explained largely or entirely in terms of a much smaller number of variables called factors. Statistical method.	Factor analysis was invented 100 years ago by psychologist Charles Spearman, who hypothesized that the enormous variety of tests of mental ability--measures of mathematical skill, vocabulary, other verbal skills, artistic skills, logical reasoning ability, etc.--could all be explained by one underlying "factor" of general intelligence. Method is used in fields that deal with large quantities of data.					5				social, manufacturing, healthcare			x			• [Darlington] • [Rakowsky]
301.	Fail safety	Gen	Des	1987 or older	A fail-safe design is a design that enables a system to continue operation, possibly at a reduced level (also known as graceful degradation), rather than failing completely, when some part of the system fails. That is, the system as a whole is not stopped due to problems either in the hardware or the software. Aim is to design a system such that failures will drive the system to a safe state.	Useful for systems where there are safe plant states. Also referred to as fault tolerance. See also Memorizing Executed Cases. See also Vital Coded Processor.						6			aircraft, manufacturing, rail, space, electronics, avionics, road, nuclear	x	x				• [Bishop, 1990]
302.	Failure Assertion Programming	Step	SwD	1995 or older	Detects residual software design faults during execution of a program, in order to prevent safety critical failures of the system and to continue operation for high reliability. Follows the idea of checking a pre-condition (before a sequence of statements is executed, the initial conditions are checked for validity) and a post-condition (results are checked after the execution of a sequence of statements). If either the pre-condition or the post-condition is not fulfilled, the processing reports the error.	Software architecture phase. Similar to Defensive programming. See also Software Testing.							7		software		x				• [EN 50128, 1996] • [Heisel, 2007] • [Rakowsky]
303.	Failure Tracking	Dat	HwD, Dat	1983 or older	Failure tracking is used to compile and store data upon which benchmarking can be performed. Failure tracking ensures the collection of quality data that reflects the system as a whole. Aim is to minimise the consequences of detected failures in the hardware and software.	Desirable for safety-related applications. Tools available. See also HTRR and SRMTS.						6			electronics	x	x				• [Bishop, 1990]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
304.	Fallible machine Human Error	Gen	HRA	1990	A model of human information processing that accounts for a variety of empirical findings. The important feature of the model is that items in a long term “Knowledge base” (such as task knowledge) are “activated” and recalled into working memory by processes that depend in the current contents of the working memory and sensory inputs. Items that are recalled will ultimately be used in making decisions that result in motor outputs. Central to the operation of this ‘machine’ are the processes by which long term memory items are ‘activated’ in a way that allows them to be selected for use. According to the model, two processes govern the activation of long term memory items: *similarity matching* and *frequency gambling*. Briefly stated, similarity matching means that items are activated on the basis of how closely they match environmental and task dependent cues, and frequency gambling means that items receive greater activation if they have been activated more frequently in the past.	The concept of fallible machine was proposed by James Reason (1990).			3						no-domain-found			x			• [Fields, 2001] • [Reason, 1990]
305.	FANOMOS (Flight track and Aircraft Noise Monitoring System)	Min	Dat	1982	FANOMOS aims to monitor and control the impact of aircraft noise on built-up areas around airports. It has the following main functions: Flight track reconstruction, Monitoring violation of prescribed flight routes, Correlation between noise measurements and flights, Correlation between complaint data and flights, Calculation and monitoring of actual noise exposure, Statistical processing of flight data. FANOMOS is also used to collect statistical data of aircraft trajectories for safety studies. It includes a database of aircraft trajectories in the Netherlands since 2001.	Developed by NLR. Experience with FANOMOS includes the monitoring of flight tracks and/or noise in the vicinity of Amsterdam Airport Schiphol, Rotterdam Airport, Maastricht/Aachen Airport, Manchester, Zürich and all major airports in Germany (this is referred to as STANLY_Track). FANOMOS software has been made available for integration in the Global Environment System (GEMS) offered by Lochard Pty., Melbourne, Australia. Lochard GEMS systems, including FANOMOS software, are installed world-wide at over 25 airports.							7		airport				x		• [FANOMOS] • [KleinObbink & Smit, 2004]
	FAR-25 (Federal Aviation Requirements -25)					See EASA CS25.1309 and JAR-25 (Joint Aviation Requirements Advisory Material Joint (AMJ) 25.1309)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
306.	FAST (Functional Analysis System Technique)	Stat	Mod, Task	1965	Visually displays the interrelationships between all functions that must be performed to achieve the basic function. The goal is to provide an understanding of how the system works and how cost-effective modifications can be incorporated. Steps are: 1 Define all of the functions using the verb-noun pairs. Write these noun-verb pairs on cards or sticky notes so that they can be easily manipulated; 2 Select the two-word pairs that best describe the basic function; 3 Use the basic function to create a branching tree structure from the cards described in 2 above; 4 Verify the logic structure; 5 Delineate the limits of responsibility of the study so that the analysis does not go on to functions outside of the scope.	FAST was first introduced in 1965 by the Society of American Value Engineers. This tool is used in the early stages of design to investigate system functions in a hierarchical format and to analyse and structure problems (e.g., in allocation of function). It asks 'how' a sub-task links to tasks higher up the task hierarchy, and 'why' the super-ordinate tasks are dependent on the sub-tasks.		2							management, defence	x					• [HIFA Data] • [Kirwan & Ainsworth, 1992] • [FAA HFW] • [Sharit, 1997] • [DeMarle, 1992] • [Roussot, 2003]
307.	FAST Method (Future Aviation Safety Team Method)	Step	HzI	2005 and 2010	The FAST Method is aimed at identifying future hazards due to future changes within the aviation system. Ten steps: 1: Define suites of proposed changes, anticipated timeframe for deployment, and their associated developer communities; 2: Define enablers required to implement changes; 3:Identify elements of the FAST description of the future state of aviation relevant to the set of system-wide changes and domain-specific "inter-actions"; 4: Collect hazards and degradation/failure scenarios previously identified by developers of proposed concepts of operation (if available); 5: Identify new, emergent hazards by contrasting the results of step 4 against the results of step 3; 6: Group hazards into themes and architectures; 7: Formulate novel system-wide failure scenarios by conducting interaction analysis among emergent hazards and existing hazards and by examining the hazard themes and architectures; 8: Identify watch items for the detection of system-wide emergent hazards, specific vulnerabilities or possible failure scenarios; 9: Perform hazard analysis and risk assessment considering existing and planned mitigations according to best practices and existing organizational procedures; 10: Record concerns/ recommendations and disseminate results.	The first version of the FAST method was published in 2005. The 2010 version (presented in the previous column) was developed at the behest of the CAST/JIMDAT following re-activation of the Future Aviation Safety Team in 2009, and incorporates an update of all steps. One key element of the FAST Method is a list of AoC (Areas of Change), which are generic descriptions of the major changes affecting the aviation system in the years to come. This list is regularly updated.	1	2	3	4					aviation, ATM	x		x	x	x	• [FAST method, 2005]
	Fast-Time Simulation					See Computer modelling and simulation															
308.	Fault Injection	Step	SwD	1970 s	Faults are injected into the code to see how the software reacts. When executed, a fault may cause an error, which is an invalid state within a system boundary. An error may cause further errors within the system boundary, therefore each new error acts as a fault, or it may propagate to the system boundary and be observable.	See also Software Testing.							7		software		x				• [FaultInjection] • [Voas, 1997a] • [Voas, 1997b]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
309.	Fault Isolation Methodology	Step	HzI	1985	The method is used to determine and locate faults in large-scale ground based systems. Examples of specific methods applied are: Half-Step Search, Sequential Removal/ Replacement, Mass replacement, Lambda Search, and Point of Maximum Signal Concentration.	Determines faults in any large-scale ground based system that is computer controlled. Sometimes referred to as Fault Detection and Isolation (FDI). See also FDD.			3						avionics, space, electronics, defence, manufacturing	x	x				• [FAA00] • [Rakowsky] • [ΣΣ93, ΣΣ97]
310.	Fault Schedule and Bounding Faults	Stat	Mit	2004 or older	The purpose of a fault schedule is to identify hazards to operators and to propose engineered, administrative and contingency controls to result in acceptable risks. Bounding refers to the maximum and minimum of test criteria.				3			6			nuclear			x			• [Kirwan & Kennedy & Hamblen]
311.	FDD (Fault Detection and Diagnosis)	Step	HzI	1995 or older	Process of checking a system for erroneous states caused by a fault. A fault is evaluated by means of a classification into non-hazard and hazard classes that are represented by fuzzy sets. Through the use of diagnostic programs, the software checks itself and hardware for incorrect results.	Software architecture phase. See also Safety Bag.			3						chemical, rail, manufacturing, aircraft, nuclear, space, energy, oil&gas	x	x				• [EN 50128, 1996] • [Rakowsky] • [Schram & Verbruggen, 1998] • [Sparkman, 1992]
	FDI (Fault Detection and Isolation)					See Fault Isolation Methodology															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
312.	FDM Analysis and Visualisation Tools (Flight Data Monitoring Analysis and Visualisation Tools)	Min	Dat	1990 from	FDM tools capture flight data, transform these into an appropriate format for analysis, and visualise them to assist analysis. Examples of tools are: • AirFASE (Airbus and Teledyne Controls, 2004) - measurement, analysis and reporting dealing with in-flight operational performance of commercial aircraft • AGS (Analysis Ground Station) (SAGEM, 1992) - provide report generation from automatic and manual data selection, import/export functions, advanced analysis, and database management • APMS (Aviation Performance Measuring System) (NASA Ames, 1993) - flight-data analyses and interpretation; enables airline carriers to analyse the flight data to identify safety trends and increase flight reliability • CEFA (Cockpit emulator for Flight Analysis) (CEFA Aviation) - restores universal flight synthesis extracted from flight data. Emulates a view of the cockpit, and a 3D outside view of the aircraft moving in flight environment. • FlightAnalyst (SimAuthor, Inc.) - analyse routine and special events, categorical events, exceedances, negative safety trends, and other flight training, operational or tactical issues • FlightTracer (Stransim Aeronautics Corporation) - 3D-visualisation tool for flight investigations, training, and monitoring programs • FlightViz (SimAuthor, Inc.) - facilitates analysts to visually recreate a flight in 3D, using actual aircraft or simulator flight data • FltMaster (Sight, Sound & Motion) - 3D animation and flight data replay using a suite of visualisation tools able to accept data from simulations, manned-motion simulators, and recorded flight data • LOMS (Line Operations Monitoring System) (Airbus) – creates database of flight data recorded in the digital flight data recorder media, compares flight data, identifies exceedances, and monitors events to propose: menu-driven reporting, identification of risk scenario, and trend analysis. • RAPS & Insight (Recovery, Analysis, & Presentation System & Insight) (Flightscape, 1990) - ground data replay and analysis station including flight animation as well as aircraft accident and incident investigations • SAFE (Software Analysis for Flight Exceedance) (Veesem Raytech Aerospace) - analyse FDR data of flights, to indicate adverse trends creeping in, which can be monitored and preventive action can be taken before a chronic breakdown of vital systems occurs.	These tools assist in the routine analysis of flight data generated during line operations, to reveal situations that require corrective action before problems occur, and identify operational trends. Other examples of tools for visual display of data are • Brio Intelligence 6 (Brio Software Japan, 1999) • Spotfire (TIBCO Spotfire, Inc) - a tool for visual display of data in many dimensions, allowing to spot multi-dimensional relationships that might not be detectable through looking at raw numbers or more limited presentations. • Starlight (Battelle Memorial Institute) - an R&D platform that uses visual metaphors to depict the contents of large datasets. This makes relationships that exit among the items visible, enabling new forms of information access, exploitation and control.			3				7	8	aviation	x	x	x	x		• [GAIN AFSA, 2003] • [AirFASE web] • [AGS example, 2004] • [AGS slides] • [CEFA example] • [APMS example, 2004] • [APMS guide, 2004] • [Statler, 2004] • [GAIN ATM, 2003] • [FAA HFW]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
313.	FEA (Front-End Analysis)	Int	Trai	1993	Comprises four analyses: (1) Performance analysis: Determine if it is a training/ incentive/ organisational problem. I.e., identify who has the performance problem (management/ workers, faculty/learners), the cause of the problem, and appropriate solutions. (2) Environmental analysis: Accommodate organisational climate, physical factors, and socio-cultural climate to determine how these factors affect the problem. (3) Learner analysis: Identify learner/ trainee/ employee characteristics and individual differences that may impact on learning / performance, such as prior knowledge, personality variables, aptitude variables, and cognitive styles. (4) Needs assessment: Determine if an instructional need exists by using some combination of methods and techniques.	Also referred to as Training Systems Requirements Analysis.			3		5				social			x	x	x	• [FEA web] • [IDKB]
314.	FEMo (Functional Energy Model)	Stat	Mod	2001	Model that can be used to study the circulation of energy flows in a technical system, localise the links with the operators and thus identify potentially hazardous phenomena. The model consists of 4 elements: a) frontiers that delimit a component in relation to its external environment; b) functional surfaces that designate the interfaces between a component and its environment. c) links that associate two functional surfaces that do not belong to the same component. d) internal links that associate two functional surfaces belonging to the same component.	Elements c) and d) can be classed into three types: conductive (C), semi-conductive (SC) or insulating (I). See also Barrier Analysis, and see ETBA.		2	3						(manufacturing)	x					• [DeGalvez et al., 2016]
315.	FFC (Future Flight Central)	RTS	Des	1999	Full-scale high fidelity interactive Air Traffic Control Tower simulator that aims to use human-in-the-loop simulation to study improvements to airport safety and capacity. It is designed to allow virtual reality tests of new tower procedures, airport designs and technologies.	Opened December 13, 1999 at NASA Ames Research Center, Moffett Field, California. Its design and development was a joint NASA and FAA supported project. NASA maintains and operates the simulator.			3				7		ATM, airport			x	x		• [FFC guide 2004] • [FFC web] • [GAIN ATM, 2003] • [SAP15]
316.	FFD (Functional Flow Diagram)	Stat	Mod	1955	Block diagram that illustrates the relationship between different functions. It is constructed by identifying the functions to be performed in the system, and then arranging these as a sequence of rectangular blocks, which represent the interrelationships between the functions. AND and OR gates are used to represent necessary sequences of functions or alternative courses of action.	Is called the most popular systems method for the determination of functional requirements. FFDs are sometimes called Function Flow Block Diagrams. Tool: FAST		2							defence, space, chemical, nuclear, road, aviation	x					• [HEAT overview] • [Kirwan & Ainsworth, 1992] • [MIL-HDBK, 1999] • [FAA HFW] • [Beevis, 1992]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
317.	FHA (Functional Hazard Assessment) according to JAR-25	Step	HzA	1992 or older	In FHA according to JAR-25, all system functions are systematically examined in order to identify potential failure conditions which the system can cause or contribute to; not only if it malfunctions, but also in its normal response to unusual or abnormal external factors. Each failure condition is classified according to its severity. If the system is not complex and similar to systems used on other aeroplanes, this identification and classification may be derived from design and installation appraisals and the service experience of the comparable, previously-approved, systems. If the system is complex it is necessary to systematically postulate the effects on the safety of the aeroplane and its occupants resulting from any possible failure, considered both individually and in combination with other failures or events.	FHA was developed by the aerospace industry to bridge between hardware and software, since functions are generally identified without specific implementations.			3						aircraft	x					• [JAR 25.1309] • [Klompstra & Everdij, 1997] • [Mauri, 2000] • [MUFTIS3.2-I, 1996]
318.	FHA (Functional Hazard Assessment) according to ARP 4761	Step	HzA	1994	FHA according to ARP 4761 examines aircraft and system functions to identify potential functional failures and classifies the hazards associated with specific failure conditions. The FHA is developed early in the development process and is updated as new functions or failure conditions are identified. FHA is applied at two different levels: an aircraft level and a system level. The former is a qualitative assessment of the basic known aircraft functions, the latter examines each system which integrates multiple aircraft functions. An aircraft level FHA, which is a high level FHA, is applied during an activity to determine functional failure consequences and applications; i.e. to determine the classification of the failure conditions associated with each function. This classification is based on hazard severity. A system level FHA is applied during an activity in which functions are allocated to systems and people; this stage consists of establishing the appropriate grouping of aircraft functions and the allocation of the related requirements to people or systems. The allocation should define inputs, processes performed and outputs. From the function allocations and the associated failure consequences, further specific system requirements necessary to achieve the safety objectives are determined. The output is a set of requirements for each human activity and aircraft system together with associated interfaces.	This FHA is a refinement and extension of the FHA according to JAR-25. It covers software as well as hardware.			3						aircraft, avionics	x	x				• [ARP 4754] • [ARP 4761] • [Klompstra & Everdij, 1997] • [Lawrence, 1999] • [Mauri, 2000]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
319.	FHA (Functional Hazard Assessment) according to EATMP SAM	Step	HzA	2000	The FHA according to EATMP SAM analyses the potential consequences on safety resulting from the loss or degradation of system functions. Using service experience, engineering and operational judgement, the severity of each hazard effect is determined qualitatively and is placed in a class 1, 2, 3, 4 or 5 (with class 1 referring the most severe effect, and class 5 referring to no effect). Safety Objectives determine the maximum tolerable probability of occurrence of a hazard, in order to achieve a tolerable risk level. Five substeps are identified: 1) FHA initiation; 2) FHA planning; 3) Safety objectives specification; 4a) FHA validation; 4b) FHA verification; 4c) FHA assurance process; 5) FHA completion. Most of these steps consist of substeps.	The FHA according to EATMP SAM is a refinement and extension of the FHA according to JAR-25 and of the FHA according to ARP 4761, but its scope is extended to Air Navigation Systems, covering AIS (Aeronautical Information Services), SAR (Search and Rescue) and ATM (Air Traffic Management).	1		3	4					ATM	x					• [EHQ-SAM, 2002] • [Review of SAM techniques, 2004]
320.	FHA or FaHA (Fault Hazard Analysis)	Tab	HzA	1965	A system safety technique that is an offshoot from FMEA. It is similar to FMEA however failures that could present hazards are evaluated rather than hazards themselves. A typical FHA form contains the following columns: 1) Component identification; 2) Failure probability; 3) Failure modes; 4) Percent failures by mode; 5) Effect of failure (traced up to some relevant interface); 6) Identification of upstream component that could command or initiate the fault; 7) Factors that could cause secondary failures; 8) Remarks. The FHA is generally like an FMEA or FMECA with the addition of the extra information in columns 6 and 7.	Developed by Boeing for the Minuteman program. FHA was developed as a special purpose tool for use on projects involving many organisations. It is valuable for detecting faults that cross organisational interfaces. Any electrical, electronics, avionics, or hardware system, sub-system can be analysed to identify failures, malfunctions, anomalies, and faults, that can result in hazards. Hazard analysis during system definition and development phase. Emphasis on the cause. Inductive. FHA is very similar to PHA and is a subset of FMEA. Weakness is that it does not discover hazards caused by multiple faults. It also tends to overlook hazards that do not result entirely from failure modes, such as poor design, timing errors, etc.			3						defence	x					• [FAA00] • [FT handbook, 1981] • [FT handbook, 2002] • [Leveson, 1995] • [ΣΣ93, ΣΣ97] • [GAIN AFSA, 2003] • [Ericson, 2005]
321.	FHERAM (Fuzzy Human Error Risk Assessment Methodology)	Math	HRA	2010	Fuzzy logic-based evaluation of Human Error Risk Importance (HERI) as a function of Human Error Probability (HEP), Error-Effect Probability (EEP) and Error Consequence Severity (ECS).	Is implemented on fuzzy logic toolbox of MATLAB using Mamdani techniques.				4	5				nuclear			x			• [Li et al., 2010]
322.	Field Study	Gen	Dat		A systematic observation of events as they occur in their natural environment with the purpose to identify structural and process characteristics of a system, to identify ways to maintain system performance, to improve the system or to correct the system.	Alternative names: Systematic observation; Naturalistic observation. See also Plant walkdowns/ surveys. See also Contextual Inquiry. See also Analysis of field data. See also Observational Techniques.			3						environment, social, finance, healthcare, management	x					• [FAA HFW]
323.	Finite State semi-Markov processes	Stat	Mod	1967 or older	These are Markov processes having a finite state space, that also allow non-exponential distributions.					4					environment	x	x				• [Markov process]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
324.	Fire Hazards Analysis	Gen	HzA		Fire Hazards Analysis is applied to evaluate the risks associated with fire exposures. There are several fire-hazard analysis techniques, i.e. load analysis, hazard inventory, fire spread, scenario method. Subtechniques are: Preliminary Fire Hazard Analysis, Barrier Analysis, Fuel Load Analysis, National Fire Protection Association Decision Tree Analysis.	Any fire risk can be evaluated.			3		5				nuclear, rail	x			x		• [FAA AC431] • [FAA00] • [Peacock et al, 2001] • [ΣΣ93, ΣΣ97]
325.	FIs (Fagan Inspections)	Step	Val	1976	Fagan Inspection is a group review method used to evaluate output of a given activity with a pre-specified entry and exit criteria. In every activity or operation for which entry and exit criteria are specified Fagan Inspections can be used to validate if the output of the activity complies with the exit criteria specified. The inspection process involves the following steps - 1) Identify Deliverable To Inspect 2) Choose Moderator and Author 3) Run Deliverable Through Code Validator 4) Identify Concerns (Create Inspection Checklist) 5) Choose Reviewers and Scribe 6) Hold Initial Briefing Meeting 7) Perform the Inspection Itself 8) Hold the Inspection Meeting 9) Generate Issues Report 10) Follow-up on Issues And the following people - a) Author b) Moderator c) Reviewer d) Scribe.	Fagan Inspections is a Formal inspection method to evaluate the quality of code modules and program sets. Sometimes referred to as Fagan Defect-Free Process. Named after Michael Fagan who is credited with being the inventor of formal software inspections. See also Code Inspection Checklists.			3		5	6			avionics, electronics, defence		x				• [EN 50128, 1996] • [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky] • [Fagan, 2002]
	Fishbone Diagram					See Cause and Effect Diagram															
326.	Fitts Lists	Gen	Des	1951	These lists summarise the advantages of humans and machines with regards to a variety of functions. They list characteristics of tasks that humans are most suited for (such as Ability to perceive patterns of light or sound; Ability to improvise and use flexible procedures) and characteristics of tasks that machines are most suited for (such as Ability to respond quickly to control signals, and to apply great force smoothly and precisely).	Static allocation of functions. Broader organisational and cultural issues as well as psychological and financial issues are not taken into account. Named after Paul M. Fitts, who developed a model of human movement, Fitts's law. Also referred to as MABA-MABA: 'Men are better at, Machines are better at'.		2				6			defence aviation, nuclear, maritime, ATM	x		x			• [FAA HFW] • [Fitts, 1951] • [Winter & Dodou, 2011] • [HEAT overview] • [Beevis, 1992]
327.	Five Star Audit or Five Star Occupational Health and Safety Audit	Tab	Org	1988	The Five Star Occupational Health and Safety Audit is an independent evaluation of an organisation's health and safety management system. Its aim is to give an independent perspective to support systems and reassure companies that they are working towards best practice and to resolve poor practice. The audit is based upon a Business Excellence Model and aims to cover eight areas of the management systems: Best practice, Continuous improvement, Safety organisation, Management control systems, Fire control systems, Measurement and control systems, Workplace implementation, Verification.	Qualitative. Adopted by British Safety Council.								8	manufacturing, oil&gas, social, leisure, management, nuclear					x	• [HE, 2005] • [Kennedy & Kirwan, 1998]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
328.	FLASH (Failure Logic Analysis for System Hierarchies)	Tab	HzA	1998	FLASH enables the assessment of a hierarchically described system by identifying potential functional failures of the system at the application level and then to systematically determine the causes of those failures in progressively lower levels of the design. The result of the assessment is a consistent collection of safety analyses (a hierarchy of tables) which provides a picture of how low-level failures are stopped at intermediate levels of the design, or propagate and give rise to hazardous malfunctions.				3	4	5	6			(manufacturing)	x	x				• [Mauri, 2000]
	FlightAnalyst					See Flight Data Monitoring Analysis and Visualisation															
	FlightTracer					See Flight Data Monitoring Analysis and Visualisation															
	FlightViz					See Flight Data Monitoring Analysis and Visualisation															
329.	Flow Analysis	Stat	HzI	1973 or older	The analysis evaluates confined or unconfined flow of fluids or energy, intentional or unintentional, from one component/sub-system/ system to another. In software engineering, the term refers to a method used to detect poor and potentially incorrect software program structures. In the latter case, there are two versions: Data FA and Control FA. Data FA derives information about the dynamic behaviour of a program by only examining the static code, thus collecting information about the way the variables are used. Control FA is a static code analysis technique for determining the control flow of a program; the control flow is expressed as a control flow graph.	The technique is applicable to all systems which transport or which control the flow of fluids or energy. Complementary to inspection methods. Useful especially if there is suitable tool support. Tools available.			3						chemical, food, environment, nuclear, electronics	x	x				• [Bishop, 1990] • [FAA00] • [ΣΣ93, ΣΣ97]
	FltMaster					See Flight Data Monitoring Analysis and Visualisation															
330.	FMEA (Failure Mode and Effect Analysis)	Tab	HzA	1949	FMEA is a reliability analysis that is a bottom up approach to evaluate failures within a system. It provides check and balance of completeness of overall safety assessment. It systematically analyses the components of the target system with respect to certain attributes relevant to safety assessment.	Any electrical, electronics, avionics, or hardware system, sub-system can be analysed to identify failures and failure modes. Useful in system reliability analyses. Tools available. Not suitable for humans and software. Sometimes referred to as SFMEA (Systems Failure Mode and Effect Analysis). See also AEA, CMFA, Decision Tables, DMEA, FHA, FMECA, FMES, GFCM, HESRA, HF PFMEA, PHA, PRA, SEEA, SHERPA, SFMEA, SPFA.			3						aircraft, defence, manufacturing, oil&gas, environment, food, space, healthcare, maritime, rail, chemical, energy	x					• [Bishop, 1990] • [Cichocki & Gorski, 1999] • [FAA00] • [Kirwan & Ainsworth, 1992] • [Leveson, 1995] • [MUFTIS3.2-I, 1996] • [ΣΣ93, ΣΣ97] • [Storey, 1996] • [GAIN AFSA, 2003] • [ARP4761]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
331.	FMECA (Failure Mode Effect and Criticality Analysis)	Tab	HzA	1949	Is FMEA completed with a measure for criticality (i.e. probability of occurrence and gravity of consequences) of each failure mode. Aim is to rank the criticality of components that could result in injury, damage or system degradation through single-point failures in order to identify those components that might need special attention and control measures during design or operation.	Useful for safety critical hardware systems where reliability data of the components is available. See also Criticality Analysis.			3		5				defence, space, aircraft, manufacturing, food, chemical, oil&gas, energy, rail	x					• [Bishop, 1990] • [FAA00] • [Leveson, 1995] • [MUFTIS3.2-I, 1996] • [ΣΣ93, ΣΣ97] • [Pentti & Atte, 2002] • [DNV-HSE, 2001] • [Hoegen, 1997] • [Kumamoto & Henley, 1996] • [Matra-HSIA, 1999] • [Page et al, 1992] • [Parker et al, 1991], • [Rademakers et al, 1992] • [Richardson, 1992] • [Amberkar et al, 2001] • [Storey, 1996] • [Villemeur, 1991] • [GAIN AFSA, 2003]
332.	FMES (Failure Modes and Effects Summary)	Tab	HzA	1994 or older	Groups failure modes with like effects. FMES failure rate is sum of failure rates coming from each FMEA. Is used as an aid to quantify primary FTA events.	Is used as an interface between FMEA/FMECA and FTA.					5				aircraft	x					• [ARP 4761]
333.	FOQA (Flight Operations Quality Assurance)	Dat	Dat	1995	The objective of the FOQA database is to identify and correct safety deficiencies in flight operations using information about trends and safety risks. This information can be used to identify trends in the aviation system. The air carriers own the FOQA data and use the data to identify possible safety trends or problems.	Currently, 13 air carriers participate in FOQA by equipping aircraft with data collection devices that monitor the aircraft engines, flight paths, and other variables.								8	aviation, aircraft	x		x	x		• [Hansen et al., 2006]
334.	FORAS (Flight Operations Risk Assessment System)	Math	OpR	2004	FORAS gives a quantitative assessment of accident / incident risk for a flight operation, broken down into a variety of subgroups: by fleet, region, route, or individual flight. This assessment is performed using a mathematical model which synthesizes a variety of inputs, including information on crew, weather, management policy and procedures, airports, traffic flow, aircraft, and dispatch operations. The system aims to identify those elements that contribute most significantly to the calculated risk, and in some cases to suggest possible interventions.						5	6			aviation	x		x	x		• [NRLMMD, 2006] • [Cranfield, 2005]
335.	Formal Inspections	Tab	Val	1996 or older	A safety checklist, based on safety requirements, is created to follow when reviewing the requirements. After inspection, the safety representative reviews the official findings of the inspection and translates any that require safety follow-up on to a worksheet.								7		aircraft, avionics, nuclear, chemical		x				• [NASA-GB-1740.13-96]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
336.	Formal Methods	Math	Val		Formal Methods refer to techniques and tools based on mathematical modelling and formal logic that are used to specify and verify requirements and designs for computer systems and software.	Generation of code is the ultimate output of formal methods. In a pure formal methods system, analysis of code is not required. In practice, however, attempts are often made to apply formal methods to existing code after the fact.				4		6			electronics, security, aircraft, rail, avionics, space, nuclear		x				• [DO-178B, 1992] • [EN 50128, 1996] • [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky] • [Storey, 1996]
337.	Formal Proof	Step	Val	1969 or older	A number of assertions are stated at various locations in the program and they are used as pre and post conditions to various paths in the program. The proof consists of showing that the program transfers the preconditions into the post conditions according to a set of logical rules and that the program terminates.	Software verification and testing phase.						6			software		x				• [EN 50128, 1996] • [Rakowsky]
338.	Formally Designed Hardware or Formal Design (Hardware)	Gen	Des	1988 or older	Aim of formally designed hardware is to prove that the hardware design meets its specification. A formal specification is a mathematical description of the hardware that may be used to develop an implementation. It describes what the system should do, not (necessarily) how the system should do it. Provably correct refinement steps can be used to transform a specification into a design, and ultimately into an actual implementation, that is correct by construction.	Best applied in context where all components are formally proven. Can be used in combination with N out of M voting. Tools available. See also Formal Methods.						6			electronics, road, aircraft	x					• [Bishop, 1990]
339.	Forward Recovery	Stat	Mit	1989 or older	The aim of forward recovery is to apply corrections to a damaged state in a 'bottom-up' fashion. This starts at the lowest levels, up to a failure within the broader system. For this approach to work, some understanding of errors that have occurred is needed. If errors are very well understood, the Forward Recovery approach can give rise to efficient and effective solutions.	Software architecture phase. See also Backward Recovery.						6			software		x				• [EN 50128, 1996] • [Rakowsky] • [SSCS]
340.	FOSA (Flight Operational Safety Assessment)	Step	OpR	2009	FOSA is a safety assessment methodology aimed at operations considering aircraft on approach to an airport, for which they require authorization related to their navigation performance. FOSA combines quantitative and qualitative analyses and evaluations of the navigation systems, aircraft systems, operational procedures, hazards, failure mitigations, normal, rare-normal and non-normal conditions, and the operational environment.		1	2	3	4	5	6	7		aviation				x		• [Smith, 2010]
341.	FPC (Flow Process Chart)	Stat	Task	1921	A Flow Process Chart is a graph with arrows and six types of nodes: Operation, Move, Delay, Store, Inspect process, and Decision. It allows a closer examination of the overall process charts for material and/or worker flow and includes transportation, storage and delays.	Developed by American Society of Mechanical Engineers (ASME). Used for physical processes. Similarities with Operations Analysis in [FAA00]. FPC were a precursor to Operational Sequence Diagram (OSD). See also PFD (Process Flow Diagram), which is used for chemical processes.		2							manufacturing, management, defence, navy, nuclear	x			x	x	• [FAA00] • [HEAT overview] • [MIL-HDBK, 1999] • [Kirwan & Ainsworth, 1992] • [Beevis, 1992]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
342.	FPTN (Failure Propagation and Transformation Notation)	Stat	HzA	1993	Hierarchical graphical notation that represents system failure behaviour. Is linked to design notation and is both an inductive and deductive analysis. FPTN makes consistency checks and is designed to be used at all stages of the life cycle. FPTN represents a system as a set of interconnected modules; these might represent anything from a complete system to a few lines of program code. The connections between these modules are failure modes, which propagate between them.	Developed by Fenelon & McDermid. Originated from HAZOP				4					manufacturing		x				• [Mauri, 2000]
343.	FRAM (Functional Resonance Accident Method)	Stat	Mod, Ret	2004	FRAM is a qualitative accident model that describes how functions of (sub)systems may under unfavourable conditions resonate and create situations that are running out of control (incidents / accidents). It can be used in the search for function (process) variations and conditions that influence each other and then may resonate in the case of risk analysis, or have resonated in the case of accident analysis. The model syntax consists of multiple hexagons that are coupled. Each hexagon represents an activity or function. The corners of each hexagon are labelled (T): Time available: This can be a constraint but can also be considered as a special kind of resource; (C): Control, i.e. that which supervises or adjusts a function. Can be plans, procedures, guidelines or other functions; (O): Output, i.e. that which is produced by function. Constitute links to subsequent functions; (R): Resource, i.e. that which is needed or consumed by function to process input (e.g., matter, energy, hardware, software, manpower); (P): Precondition, i.e. system conditions that must be fulfilled before a function can be carried out; and (I): Input, i.e. that which is used or transformed to produce the output. Constitutes the link to previous functions.	Developed by Erik Hollnagel. FRAM is based on the premise that performance variability, internal variability and external variability are normal, in the sense that performance is never stable in a complex system as aviation. Performance variability is required to be sufficiently flexible in a complex environment and it is desired to allow learning from high and low performance events. FRAM means 'forward' in Norwegian and Swedish.				4					aviation, ATM, healthcare, nuclear, aircraft, maritime			x	x		• [Hollnagel & Goteman, 2004] • [Hollnagel, 2004] • [Hollnagel, 2006]
344.	FSAS (Facility Safety Assessment System)	Dat	Dat	2005	FSAS is a database and web-based tool that contains information related to the safety assessment process of a facility. This information includes evaluation checklists, reports, facility information, tracking information, and response data, including mitigation plans. FSAS is used for air traffic facilities conducting internal evaluations and for conducting audits. It is a central collection point for both the evaluation and the audit data as it is completed. It provides a means for internal facility communication on the status of the evaluation and on identified areas not meeting requirements yet.	Maintained by FAA ATO Safety for U.S.A. In fiscal year (FY) 2005, the first use of FSAS occurred and in FY 2006 all ATC facilities became responsible for performing facility self-assessments.	1						7		ATM	x					• [ATO SMS Manual v3.0] • [Notice JO 7010.21] • [FSAS User Guide 2005]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
345.	FSM (Finite State Machines)	Stat	Mod	1955	An FSM is a behaviour model composed of a finite number of states, transitions between those states, and actions, similar to a flow graph in which one can inspect the way logic runs when certain conditions are met. Aim is to model and analyse the control structure of a purely discrete state system.	A simple yet powerful technique for event driven systems. Two variants are a Mealy machine (1955), which is an FSM that generates an output based on its current state and input, and a Moore machine (1956), which is an FSM where the outputs are determined by the current state alone and do not depend directly on the input. Tools available. Similar to State Transition Diagrams. Sometimes referred to as (Finite State) Automaton.				4					electronics, environment, social, defence, navy, ATM, healthcare, software	x	x				• [Bishop, 1990] • [EN 50128, 1996] • [HEAT overview] • [Rakowsky] • [Beevis, 1992]
346.	FSMA (Fault-Symptom Matrix Analysis)	Tab	HzA	1981	A Fault-Symptom Matrix is a matrix with vertically the faults of a system and horizontally the possible symptoms. The cells contain probabilities of occurrence.	Linked to Confusion Matrix Approach.			3		5				nuclear	x					• [Kirwan, 1994] • [Qiu&al]
347.	FSSA (Facility System Safety Analysis)	Tab	HzA	1992 or older	A Facility Systems Safety Analysis (FSSA) is a systematic approach toward: Identifying credible hazards associated with the operation of a facility; Defining the hazards in terms of severity and probability; Assessing the controls for those hazards; Making recommendations toward reduction of the severity and/or probability of occurrence; and Identifying documentation to place under configuration control. A FSSA is performed on new facilities, or on existing facilities that have undergone a construction modification. Aim is to document the safety bases for and commitments to the control of subsequent operations. This includes staffing and qualification of operating crews; the development, testing, validation, and inservice refinement of procedures and personnel training materials; and the safety analysis of the person-machine interface for operations and maintenance. Considerations of reliable operations, surveillance, and maintenance and the associated human factors safety analysis are developed in parallel and integrated with hardware safety design and analysis.	Facilities are analysed to identify hazards and potential accidents associated with the facility and systems, components, equipment, or structures. The results of the FSSA are documented in a SAR (Safety Analysis report). Standard Operating Procedures (SOP's) and Checklists, Configuration Control Documentation (CCD), and Other special items identified by the Facility Team ensure that hazard controls (e.g., procedures, interlocks, etc.) have been documented and placed under configuration control.			3			6			space, aircraft, (nuclear), (chemical)	x		x	x		• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97] • [NASA, 2006-FSSA]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
348.	FTA (Fault Tree Analysis)	Stat	HzA, Mod	1961	The objectives of FTA are to determine how a higher-level failure may be caused by lower-level failures, and to quantify the probability of occurrence of such higher-level failure. The analyst starts from a top-level undesired event, which becomes the top of the Fault Tree. Next, the analyst determines all credible single faults and combinations of failures at the next lower level of design that could cause this top event, and interconnects them with appropriate symbols to extend each fault event to the next lower level. The symbols predominantly used are for AND and OR relations, but other symbols are available (e.g., 'exclusive or', 'priority and', 'external event'). The analysis proceeds down through successively more detailed (lower) levels of design, until either the top-level requirement can be satisfied, or an event is uncovered that is not further developed. A common approach to analyze a fault tree is to determine its minimal cut sets, i.e. minimal sets of primary failures, such that if all these simultaneously exist, the top event exists. Quantification of the fault tree is usually done through quantification of its minimal cut sets.	Former name is CTM (Cause Tree Method). Developed in 1961 by Bell Telephone Laboratories for US ICBM (Intercontinental Ballistic Missile system) program; guide published in 1981. Tools are available, e.g. Fault Tree+, FaultrEASE, RISKMAN. The logical operations are covered within IEC (International Electrotechnical Commission) 1025 international standard. FTA is intended to be used for analysis of complex technical systems, primarily hardware systems. Applications to software failures and to human error exist, but for these, quantification is much more challenging regarding the Analysis part of FTA. See also CBFTA, CCDM or CCA, DD, DTA, KTT, Logic Diagram, PRA, RBD, SFTA.				4	5				aircraft, space, oil&gas, nuclear, healthcare, defence, rail energy, ATM	x					• [EN 50128, 1996] • [FAA00] • [FT Handbook, 2002] • [GAIN ATM, 2003] • [GAIN AFSA, 2003] • [Leveson, 1995] • [Mauri, 2000] • [MUFTIS3.2-I, 1996] • [ΣΣ93, ΣΣ97] • [Storey, 1996] • [Henley & Kumamoto, 1992] • [DNV-HSE, 2001] • [Howat, 2002] • [Kumamoto & Henley, 1996] • [Villemeur, 1991] • [Ericson, 1999]
	Function Allocation Evaluation Matrix					See Function Allocation Trades and See Decision Matrix															
349.	Function Allocation Trades	Stat	Mod	1986 or older	Working in conjunction with project subsystem designers and using functional flows and other human error methods, plus past experience with similar systems, the practitioner makes a preliminary allocation of the actions, decisions, or functions shown in the previously used charts and diagrams to operators, equipment or software.	Several techniques are proposed to work out the details in this method. Also referred to as Function Allocation Evaluation Matrix, or as Ad Hoc Function Allocation.		2		4					defence	x	x	x			• [HEAT overview] • [MIL-HDBK, 1999] • [Beevis, 1992]
350.	Functional Safety Assessment Method for Cooperative Automotive Architecture	Step	Mit	2021	The method aims to ensure that an automotive architecture is functionally safe to operate in given scenarios. The proposed method derives functional safety requirements (FSR) for a cooperative driving scenario and checks whether they are fulfilled in the technical software architecture of a vehicle. Cooperative driving refers to the collective optimization of the traffic participants' behaviour by sharing information using wireless communication.	Functional safety in this context is defined as "an absence of unreasonable risk due to hazards caused by malfunctioning behaviour of electrical and/or electronic systems". Method follows ISO 26262 guidelines.		2	3			6			manufacturing, road		x				• [Kochanthara et al, 2021]
351.	Fuzzy Logic	Math	Mod	1925	Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth: truth values between "completely true" and "completely false".	The term fuzzy logic was introduced in 1965 by Dr. Lotfi Zadeh of University of California, but the approach has been studied since the 1920s. Software design & development phase.				4					rail, electronics, manufacturing, environment, nuclear, aircraft		x				• [EN 50128, 1996] • [FuzzyLogic] • [Rakowsky]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
352.	Gain Scheduling	Math	Mod	1968 about	Gain scheduling is an approach to control of non-linear systems that uses a family of linear controllers, each of which provides satisfactory control for a different operating point of the system. One or more observable variables, called the scheduling variables, are used to determine what operating region the system is currently in and to enable the appropriate linear controller. Aim is to achieve fault tolerance by storing pre-computed gain parameters. It requires an accurate FDD (Fault Detection and Diagnosis scheme) that monitors the status of the system.	Popular methodology. See also FDD.						6			aviation, manufacturing, energy, nuclear, oil&gas, aircraft	x					• [Schram & Verbruggen, 1998] • [Leith & Leithead, 2000]
353.	Gantt Charts	Stat	Mod	1915	Graphically illustrates time courses of functions and tasks. The functions and tasks may be used in flow-charting methods to address potential workload problems that may have implications for function allocation. May be applied to functions that are temporal (e.g., scheduling).	Developed by Henry Laurence Gantt (1861-1919).		2							management			x	x		• [FAA HFW] • [Gantt, 2003]
354.	Gas Model	Math	Col	1971	Analytical accident risk model to determine probability of collision between aircraft or to assess air traffic controller workload. Based on the physical model of gas molecules in a heated chamber to estimate the number of conflicts between aircraft occupying some part of airspace. The model assumes that aircraft are uniformly and independently distributed within an area, i.e. a horizontal plane, or a volume. It is further assumed that aircraft travel in straight lines in directions which are independently and uniformly distributed between 0 and 360^{o} and with speeds that are independent of the direction of travel and are drawn, independently for each aircraft, from a probability distribution.	This simple representation may be only suited to an uncontrolled part of airspace occupied by pleasure fliers who may indeed be flying in random directions.					5				(ATM)				x		• [MUFTIS1.2, 1996] • [Alexander, 1970] • [Marks, 1963] • [Flanagan & Willis, 1969] • [Graham & Orr, 1969] • [Graham & Orr, 1970] • [Endoh, 1982]
	GASET (Generic Accident Sequence Event Tree)					See ETA (Event Tree Analysis)															
355.	GBRAM (Goal-Based Requirements Analysis Method) and GBRAT (Goal-Based Requirements Analysis Tool)	Int	Mod	1995	GBRAT is designed to support goal-based requirements analysis. The tool provides procedural support for the identication, elaboration, refinement and organisation of goals to specify the requirements for software based information systems. GBRAT employs interactive Web browser technology to support the collaborative nature of requirements engineering. GBRAM defines a top-down analysis method refining goals and attributing them to agents starting from inputs such as corporate mission statements, policy statements, interview transcripts etc.			2				6			social		x			x	• [Anton, 1996] • [Anton, 1997]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
356.	GDTA (Goal-Directed Task Analysis)	Int	Task	1993	GDTA is a cognitive task analysis technique that is concerned with the situation awareness (SA) requirements necessary to complete a task. It focuses on the basic goals for each team role (which may change dynamically), the major decisions that should be made to accomplish these goals, and the SA requirements for each decision. GDTA attempts to determine what operators would ideally like to know to meet each goal. Structured interviews, observations of operators performing their tasks, as well as detailed analysis of documentation on users' tasks are used to complete the analysis process. GDTA aims to reveal information needs for complex decision making in environments such as air traffic control.	Developed by Mica R. Endsley.		2							ATM, defence, environment, ergonomics, healthcare			x			• [FAA HFW] • [Endsley, 1993] • [Bolstad et al, 2002]
357.	GEMS (Generic Error Modelling System)	Tab	HRA	1987	GEMS is an error classification model that is designed to provide insight as to why an operator may move between skill-based or automatic rule based behaviour and rule or knowledge-based diagnosis. Errors are categorised as slips/lapses and mistakes. The result of GEMS is a taxonomy of error types that can be used to identify cognitive determinants in error sensitive environments. GEMS relies on the analyst either having insight to the tasks under scrutiny or the collaboration of a subject matter expert, and an appreciation of the psychological determinants of error.	Proposed by James Reason. Based on variation of Step Ladder Model (SLM). Also referred to as extension of SRK (Skill, Rule, Knowledge). Rarely used as tool on its own.					5				healthcare, rail, (nuclear)			x			• [Kirwan, 1994] • [Kirwan, Part 1, 1998]
358.	Generalised Gas Model	Math	Col	1982 or older	Analytical model. Based on the gas model, but the aircraft do not always fly in random directions. Aim is to determine probability of collision between aircraft or to assess air traffic controller workload.						5				(ATM)				x		• [MUFTIS1.2, 1996] • [Endoh, 1982] • [Endoh & Odoni, 1983]
359.	Generalised Reich Collision Risk Model	Math	Col	1993	The Generalized Reich collision risk model aims at evaluating collision risk between aircraft in an arbitrary network of lane segments incorporating hazards and human behavior. All types of aircraft collisions are considered, including airborne collisions and collisions between taxiing aircraft and aircraft landing or taking off. Since the model does not assume steady state distributions like the Reich model does, the pdfs for aircraft position and velocity may be time-dependent.	To apply the Generalized Reich collision risk model, the pdfs have to be determined by means of Monte Carlo simulations of a stochastic dynamic model that includes pilot and controller behavior, technical and operational hazards, collision detection and avoidance maneuvers, weather influences, etc., including all interactions between these entities. See also TOPAZ.					5				ATM				x		• [Bakker & Blom, 1993] • [Blom & Bakker, 2002] • [MUFTIS3.2-II, 1996]
360.	GFCM (Gathered Fault Combination Method)	Stat	HzA	1991 or older	Extension and generalisation of FMEA. A FMECA is made for all components of the system. Next, failure modes (or their combinations), which have the same effect are gathered in a tree.	Qualitative and quantitative.			3	4	5				no-domain-found	x	x				• [MUFTIS3.2-I, 1996] • [Villemeur, 1991]
361.	GO Charts (Graphics Oriented Charts)	Stat	HwD	1975	A GO chart is graphical organizer to organise and summarise a text. Is used for reliability analysis of complex systems (including components with two or more failure modes), mainly during the design stage.	Useful for a qualitative analysis during the design stage. Related techniques: FTA, Markov analysis. Tools available.				4					social, healthcare, management	x				x	• [Bishop, 1990]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
362.	Goal-Obstacle Analysis	Stat	Mit	2000	A goal defines a set of desired behaviors, where a behavior is a temporal sequence of states. Goal obstruction yields sufficient obstacles for the goal not to be reachable; the negation of such obstacles yields necessary preconditions for the goal to be achieved.	During Goal-Obstacle Analysis, scalability is of special concern. See also KAOS.			3			6			(finance)	x	x				• [Lamsweerde & Letier, 2000] • [Letier, 2001] • http://lamswww.epfl.ch/reference/goal
363.	GOMS (Goals, Operators, Methods and Selection rules)	Stat	Task	1983	GOMS is a task modelling method to describe how operators interact with their systems. Goals and sub-goals are described in a hierarchy. Operations describe the perceptual, motor and cognitive acts required to complete the tasks. The methods describe the procedures expected to complete the tasks. The selection rules predict which method will be selected by the operator in completing the task in a given environment.	GOMS is mainly used in addressing human-computer interaction and considers only sequential tasks. The original version of GOMS is referred to as CMN-GOMS, which takes the name after its creators Stuart Card, Thomas P. Moran and Allen Newell who first described GOMS in their 1983 book The Psychology of Human Computer Interaction. See also CAT, CPM-GOMS, CTA, KLM-GOMS, NGOMSL.		2							defence			x	x		• [HIFA Data] • [Kirwan & Ainsworth, 1992] • [Card, 1983] • [Eberts, 1997] • [Hochstein, 2002] • [FAA HFW] • [Parasuraman & Rovira, 2005] • [John & Kieras, 1996]
	Graphic Mission Profile					See Mission Profile															
	GRMS (Generalised Rate Monotonic Scheduling)					See RMA (Rate Monotonic Scheduling)															
364.	GSN (Goal Structuring Notation)	Stat	Mod	1997	GSN shows how goals are broken into sub-goals, and eventually supported by evidence (solutions) whilst making clear the strategies adopted, the rationale for the approach (assumptions, justifications) and the context in which goals are stated. GSN explicitly represents the individual elements of a safety argument (requirements, claims, evidence and context) and the relationships that exist between these elements (i.e. how individual requirements are supported by specific claims, how claims are supported by evidence and the assumed context that is defined for the argument).	Tools available. Developed by Tim Kelly and John McDermid (University of York).								8	nuclear, defence, manufacturing space, rail	x	x	x	x	x	• [Kelly, 1998] • [Pygott et al, 1999] • [Wilson et al, 1996]
365.	HACCP (Hazard Analysis and Critical Control Points)	Step	HzA, Mit	1960	HACCP aims at identifying, evaluating and controlling safety hazards in a food process, at the earliest possible point in the food chain. It is used to develop and maintain a system, which minimises the risk of contaminants. It identifies who is to be protected, from what, and how. Risks are identified and a corrective or preventative risk management option is selected and implemented to control the risk within the limits of acceptable risk standards. Steps are: 1. Identify hazards; 2. Determine the critical control points; 3. Determine the critical limits for each control point; 4. Monitor the critical limits; 5. Identify corrective action procedures (corrective action requests or CARs); 6. Establish records and control sheets; 7. Verify the HACCP plan	Developed by NASA in the 1960's to help prevent food poisoning in astronauts. A critical control point is defined as any point or procedure in a specific food system where loss of control may result in an unacceptable health risk. Whereas a control point is a point where loss of control may result in failure to meet (non-critical) quality specifications. Food safety risk can be divided into the following three categories: Microbiological Risks, Chemical Risks, and Physical Risks.			3		5	6			food				x		• [McGonicle]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
	Hardware/Software Safety Analysis					See HSIA (Hardware/Software Interaction Analysis)															
	Hart & Bortolussi Rating Scale					See Rating Scales															
	Hart & Hauser Rating Scale					See Rating Scales															
366.	Hatley notation	Stat	Des	1984	The Hatley notation uses visual notations for modelling systems. Belongs to a class of graphical languages that may be called “embedded behaviour pattern” languages because it embeds a mechanism for describing patterns of behaviour within a flow diagram notation. Behaviour patterns describe different qualitative behaviours or modes, together with the events that cause changes in mode, for the entity being modelled. The flow notation models the movement of information through the system together with processes that use or change this information. Combining these two modelling capabilities makes it possible to model control of processes. A process may, for example, be turned on or off when a change in mode occurs.	Developed by Derek Hatley. A few years later it was extended to Hatley-Pirbhai notation with a complementary approach to high-level design.		2							aircraft, healthcare		x				• [Williams, 1991] • [Hatley & Pirbhai. 1987]
367.	HAW (Hazard Analysis Worksheet)	Tab	HzA	2003 or older	HAW is used to provide an initial overview of the hazards present in the overall flow of an operation. It is commonly presented as a table with column entries, e.g. Hazard ID; Hazard Description; Causes; System State; Existing Controls; Existing Control; Justification/ Supporting Data; Effects; Severity; Severity Rationale; Likelihood; Likelihood Rationale; Initial Risk; Safety Requirements; Organization Responsible for Implementing Safety Requirements; Predicted Residual Risk; Safety Performance Targets.	The HAW is the non-acquisitions (i.e. operational phase) equivalent of the PHA. Can also be used to document hazards that were identified using other methods such as HACCP, SSHA.			3		5	6			food, ATM	x		x	x		• [ATO SMS Manual v3.0]
	Haworth-Newman Avionics Display Readability Scale					See Rating Scales															
368.	Hazard Analysis	Gen	HzI, HzA		Includes generic and specialty techniques to identify hazards. Generally, it is a formal or informal study, evaluation, or analysis to identify hazards.	Multi-use technique to identify hazards within any system, sub-system, operation, task or procedure.			3						all	x		x	x		• [FAA00] • [ΣΣ93, ΣΣ97]
369.	Hazard Coverage Based Modelling	Gen	Mod	1998 from	Safety modelling that checks after each modelling iteration if and how all identified hazards have been modelled. The following modelling iteration will focus on the main hazards that have not been modelled yet. The last iteration ends with a bias and uncertainty assessment of the effect of non-modelled hazards.					4					ATM	x	x	x	x	x	• [Everdij & Blom & Bakker, 2002] • [Stroeve et al, 2011]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
370.	Hazard Crystallisation	Stat	Mod	2006	This technique aims to crystallise a long list of hazards into scenarios. Each scenario aims to bring into account all relevant ways in which a hazardous situation may develop and evolve, under influence of the related operational conditions, and the related hazards. The hazards may include those that create the hazardous situation (root hazards), as well as those that influence the safe resolution of the situation (resolution hazards).	A hazard is defined as anything that may negatively influence safety. An example scenario is the evolution of a conflict between two aircraft. Examples of operational conditions are flight phase and location, number of traffic, environmental conditions.				4					ATM	x	x	x	x	x	• [Blom & Stroeve & DeJong, 2006] • [Stroeve et al, 2009]
371.	Hazard Indices	Step	HzA	1964	Hazard indices measure loss potential due to fire, explosion, and chemical reactivity hazards in the process industries. Can be useful in general hazard identification, in assessing hazard level for certain well-understood hazards, in the selection of hazard reduction design features for the hazards reflected in the index, and in auditing an existing plant.	Originally developed primarily for insurance purposes and to aid in the selection of fire protection methods.			3						chemical, nuclear	x					• [Leveson, 1995]
	Hazard Risk Assessment					See Hazard Analysis.															
372.	HAZid (Hazard Identification)	Tab	HzI	1993 or older	Modification of HAZOP especially to be used for identification of human failures. It has an additional first column with some guidewords to lead the keywords.				3						oil&gas, chemical, ATM			x			• [MUFTIS3.2-I, 1996]
373.	HAZOP (Hazard and Operability study)	Tab	HzA	1974	Group review using structured brainstorming to identify and assess potential hazards. The group of experts starts with a list of tasks or functions, and next uses keywords such as NONE, REVERSE, LESS, LATER THAN, PART OF, MORE. Aim is to discover potential hazards, operability problems and potential deviations from intended operation conditions. Finally, the group of experts establishes the likelihood and the consequences of each hazard and identifies potential mitigating measures.	Began with chemical industry in the 1960s. Analysis covers all stages of project life cycle. In practice, the name HAZOP is sometimes (ab)used for any "brainstorming with experts to fill a table with hazards and their effects". Many variations or extensions of HAZOP have been developed, see e.g. AEMA, EOCA, FPTN, HAZid, Human HAZOP, HzM, MHD, PHEA, PHECA, SHARD (or CHAZOP), SCHAZOP, SUSI, WSA.			3			6			chemical, nuclear, healthcare, ATM, rail, oil&gas	x	x	x			• [Kirwan & Ainsworth, 1992] • [Kirwan, Part 1, 1998] • [Leveson, 1995] • [MUFTIS3.2-I, 1996] • [Reese & Leveson, 1997] • [ΣΣ93, ΣΣ97] • [Storey, 1996] • [CAA-RMC93-1] • [CAA-RMC93-2] • [Foot, 1994] • [Kennedy & Kirwan, 1998] • [Kletz, 1974] • [Villemeur, 1991]
374.	HBN (Hierarchical Bayesian Network)	Stat	Mod	2002	HBN is an extension of BBN and consists of two parts. The structural part contains the variables of the network and describes the 'part-of relationships' and the probabilistic dependencies between them. The part-of relationships in a structural part may be illustrated either as nested nodes or as a tree hierarchy. The second part of a HBN, the probabilistic part, contains the conditional probability tables that quantify the links introduced at the structural part.					4	5				aviation, electronics	x	x	x	x	x	• [FlachGyftodimos, 2002] • [Gyftodimos & Flach, 2002] • [Kardes, 2005]
375.	HCA (Human Centred Automation)	Gen	Des	1991	Design and development concept. Can be used to study whether explicit information on the actions of the plant automation system improves operator performance when handling plant disturbances caused by malfunctions in the automation system.								7		nuclear, defence			x			• [Kirwan et al, 1997] • [Kirwan_HCA] • [Skjerve HCA]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
376.	HCAS (Hazard Classification and Analysis System)	Dat	Dat	2006	HCAS is a taxonomy for the identification and communication of hazard sources and sub-sources for UAS (Unmanned Aircraft Systems) operations. The system-level taxonomy comprises the four main hazard sources of UAS, Airmen, Operations and Environment and their interactions as well as the constituent sub-sources. There are approximately 100 elements in the HCAS taxonomy.	HCAS was developed for the U.S. National Airspace System (NAS) by researchers at Rutgers University through a cooperative agreement with the Federal Aviation Administration (FAA). The HCAS taxonomy may serve as a link between the RCFF and actual event analysis. Whereas the RCFF represents a top-down safety analysis, the HCAS represents a "bottom-up" safety analysis.			3						(aviation)	x		x	x		• [FAA UAS SMS] • [Luxhoj, 2009] • [Oztekin & Luxhoj, 2008]
377.	HCR (Human Cognitive Reliability model)	Math	HRA	1984	Method for determining probabilities for human errors after trouble has occurred in the time window considered. Probability of erroneous action is considered to be a function of a normalised time period, which represents the ration between the total available time and the time required to perform the correct action. Different time-reliability curves are drawn for skill-based, rule-based and knowledge-based performance.	Developed in nuclear industry by G.W. Hannaman et al. Not considered as very accurate. See also SRK.					5				nuclear, chemical			x			• [Humphreys, 1988] • [Kirwan, 1994] • [MUFTIS3.2-I, 1996] • [Hannaman et al., 1984]
378.	HEA (Human Error Analysis)	Gen	HRA, Task		Method to evaluate the human interface and error potential within the human /system and to determine human-error- related hazards. Many techniques can be applied in this human factors evaluation. Contributory hazards are the result of unsafe acts such as errors in design, procedures, and tasks. This analysis is used to identify the systems and the procedures of a process where the probability of human error is of concern. The concept is to define and organise the data collection effort such that it accounts for all the information that is directly or indirectly related to an identified or suspected problem area. This analysis recognises that there are, for practical purposes, two parallel paradigms operating simultaneously in any human/machine interactive system: one comprising the human performance and the other, the machine performance. The focus of this method is to isolate and identify, in an operational context, human performance errors that contribute to output anomalies and to provide information that will help quantify their consequences.	Human Error Analysis is appropriate to evaluate any human/machine interface.			3		5				all	x		x	x		• [FAA AC431] • [FAA00] • [HEA practice] • [HEA-theory] • [ΣΣ93, ΣΣ97]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
379.	HEART (Human Error Assessment and Reduction Technique)	Step	Par, HRA	1985	Quantifies human errors in operator tasks. Considers particular ergonomic and other task and environmental factors that can negatively affect performance. The extent to which each factor independently affects performance is quantified, and the human error probability is then calculated as a function of the product of those factors identified for a particular task.	Developed by Jerry C. Williams. Popular technique. See also CARA (which is HEART tailored to ATM), NARA (which is HEART tailored to nuclear).					5				nuclear, chemical, oil&gas, healthcare, navy			x			• [Humphreys, 1988] • [Kennedy] • [Kirwan, 1994] • [MUFTIS3.2-I, 1996] • [Williams, 1988] • [CAA-RMC93-1] • [CAA-RMC93-2] • [Foot, 1994] • [Kirwan & Kennedy & Hamblen] • [Kirwan, Part I, 1996] • [Kirwan et al, Part II, 1997] • [Kirwan, Part III, 1997] • [FAA HFW] • [GAIN ATM, 2003]
380.	HECA (Human Error Criticality Analysis)	Stat, Tab	HRA, Task	1999	HECA aims to identify the potentially critical problems caused by human error in the human operation system. It performs task analysis on the basis of operation procedure, analyzes the human error probability (HEP) for each human operation step, and assesses its error effects to the whole system. The results of the analysis show the interrelationship between critical human tasks, critical human error modes, and human reliability information of the human operation system.	Based on FMECA. Human tasks are modelled using event trees.			3	4	5				manufacturing, (healthcare)			x			• [Yu et al, 1999] • [Das et al, 2000]
381.	HEDAD (Human Engineering Design Approach Document)	Dat	Des	1992 or older	HEDAD-M (Maintainer) provides a source of data to evaluate the extent to which equipment having an interface with maintainers meets human performance requirements and human engineering criteria. HEDAD-O (Operator) provides a source of data to evaluate the extent to which equipment having an interface with operators meets human performance requirements and human engineering criteria.	Developed by FAA.					5				defence	x		x			• [FAA HFW] • [HEDADM] • [HEDADO]
382.	HEDGE (Human factors Engineering Data Guide for Evaluation)	Gen	Val?	1983	HEDGE is a comprehensive T&E (Test and Evaluation) procedural manual that can be used as a T&E method. It provides the HE (human engineering) practitioner with explanations of methods and sample checklists for evaluating system design and performance. The purpose of the information in HEDGE is to expand test capabilities in considering the human element. It will provide a strategy for viewing an item which is undergoing testing from the standpoint of the soldier who must ultimately operate, maintain, or otherwise utilise it.	Developed by Carlow Associates.						6			defence			x			• [FAA HFW] • [MIL-HDBK, 1999] • [US Army, 1983]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
383.	HEECA (Human Errors, Effects and Criticality Analysis)	Tab	HzA	2015	FMECA-based approach that aims to assess the corrective actions necessary to get a system back to an acceptable state after the occurrence of either a system failure or a human error.	Adapted from FMECA. Makes use of HAMSTERS (Human-centered Assessment and Modelling to Support Task-Engineering for Resilient Systems) notation to represent human activities in a hierarchical way.			3	4	5				space	x		x			• [Fayollas et al, 2015] • [Martinie et al, 2016]
384.	HEERAP (Human Engineering and Ergonomics Risk Analysis Process)	Tab	HzA, Mit	2008	HEERAP is a process that aims at identifying and assessing human injury risks, and at providing guidance on design solutions to mitigate the risks. The process includes determining human interface design requirements, followed by risk analysis, and development of risk mitigation strategies. The risk results are visualised in a Human Injury Risk Matrix.	Developed by L. Avery et. al.		2			5	6			(defence), (navy)			x			• [Geiger et al, 2008]
385.	Heinrich's Pyramid	Stat	Par	1931	Heinrich's Pyramid is a depiction of Heinrich's Law that says: for every accident that causes a major injury, there are 29 accidents that cause minor injuries and 300 accidents that cause no injuries. This is then used to estimate accident frequencies based on incident frequencies.	Also called The Accident Triangle. See also Domino Theory.					5				ATM, chemical, nuclear, healthcare					x	• [Heinrich, 1931]
386.	HEIST (Human Error Identification in Systems Tool)	Tab	HRA	1994	HEIST can be used to identify external error modes by using tables that contain various error prompt questions. There are eight tables in total, under the headings of Activation/Detection; Observation/Data collection; Identification of system state; Interpretation; Evaluation; Goal selection/Task definition; Procedure selection and Procedure execution. The analyst applies each table to each task step from an HTA and determines whether any errors are credible. For each credible error, the analyst then records the system cause or psychological error mechanism and error reduction guidelines (which are all provided in the HEIST tables) and also the error consequence.	HEIST was developed by Barry Kirwan as a component of HERA. According to [Stanton et al., 2006] it is nuclear domain specific.			3						nuclear			x			• [Kirwan, 1994] • [Stanton et al, 2006]
387.	HEMECA (Human Error Mode, Effect and Criticality Analysis)	Tab	HRA	1989	A FMECA-type approach to Human Error Analysis. It uses a HTA (Hierarchical Task Analysis) followed by error identification and error reduction. The PSF (Performance Shaping Factors) used by the analyst are primarily man-machine interface related, e.g. workplace layout, information presentation, etc. Typically, an FMEA approach identifies many errors, primarily through detailed consideration of these PSF in the context of the system design, in relation to the capabilities and limitations of the operator, based on Ergonomics knowledge. Only those errors that are considered to be probable within the lifetime of the plant are considered further.			2	3		5				no-domain-found			x			• [Kirwan, Part 1, 1998]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
388.	HERA or HERA-JANUS (Human Error in ATM Technique)	Step	HRA, Ret	2000	HERA-JANUS is a method of human error identification developed by Eurocontrol for the retrospective diagnosis during ATM system development. It places the air traffic incident in its ATM context by identifying the ATC behaviour, the equipment used and the ATC function being performed. It identifies the root causes of human errors in aviation accidents/ incidents and associated contextual factors by selecting appropriate 'error types' from the literature, and shaping their usage within a conceptual framework. This conceptual framework includes factors to describe the error, such as error modes and mechanisms and factors to describe the context, e.g. when did the error occur, who was involved, where did it occur, what tasks were being performed?	HERA is TRACEr for European use. JANUS is named for the Roman two-headed god of gates and doorways. HERA was renamed HERA-JANUS following harmonisation activities with the FAA. See also HEIST.			3					8	ATM			x			• [Isaac et al, 2003] • [Isaac et al, 1999] • [Isaac & Pounds, 2001] provides pros and cons compared to HFACS • [Kirwan, Part 2, 1998] • [Shorrock, 2001] • [FAA HFW] • [GAIN ATM, 2003]
389.	HERMES (Human Error Reliability Methods for Event Sequences)	Dyn	HFA, Ret	1996	HERMES aims to include human factors in safety assessment studies. It is based on: 1. A cognitive simulation model (COSIMO), which assumes that the operator carries out, dynamically and interactively with the plant, the loop "detection-diagnosis-planning-action"; the cognitive processes are controlled by the effectiveness of the gathered information. 2. A classification scheme of erroneous behaviour, correlated to these theories. 3. A model of the functional response of the plant, based on analytical and numerical treatment of differential equations and on the criteria of FMEA. 4. A method based on DYLAM for structuring the interaction of the models of cognition and of plants and for controlling the dynamic evolution of events.	Can be used for retrospective and prospective studies. See also COSIMO and DYLAM.				4					nuclear			x			• [Cacciabue et al, 1996]
390.	HERTES (Human Error Reduction Technique for the Evaluation of Systems)	Step	HRA	2005	HERTES seeks to establish the hazards and risks associated with human error, and classify these in an order of risk. It includes guidance on how to identify, assess and classify human hazards, and guidance on how different types of hazard are to be addressed in a project setting – by setting human error requirements on the project for elimination, reduction or mitigation – and the ways in which these can be shown to have been achieved.	HERTES is an internally devised approach in NATS, as an answer to needs to include Human Factors assurance in Safety Engineering techniques.					5	6			ATM			x			• [Clark et al., 2008]
391.	HESC (Human Engineering Simulation Concept)	RTS	HRA	2000 or older	HESC aims at using mock-ups and simulators in support of human engineering analysis, design support, and test and evaluation.	May be used by the procuring activity to assist and assess simulation approaches when there is a need to resolve potential human performance problems, particularly where government facilities, models, data or participants are required.		2							(defence)			x			• [FAA HFW]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
392.	HESRA (Human Error and Safety Risk Analysis)	Tab	HRA	2003 about	HESRA is a human error analysis approach that is based on a FMEA. While FMEA focuses on component failures, HESRA focuses on tasks, steps, and the associated human errors that can occur for each task and step. Errors are rated, using ordinal scales, in terms of likelihood of occurrence, severity of the consequences of the error, and the likelihood of detecting and mitigating the error. These ratings are used to calculate a Hazard Index (HI) and a Risk Priority Number (RPN).	Developed by HCR LLC (Human Centric Research). In 2005 HESRA has been adapted to the needs of the FAA, for analysis of risk of human error in ATC maintenance tasks.			3		5				ATM			x			• [HCR-HESRA, 2005] • [Hewitt, 2006]
393.	HET (Human Error Template)	Tab	HRA	2003	HET is designed specifically as a diagnostic tool for the identification of design-induced error on the flight deck. It is a checklist style approach to error prediction that comes in the form of an error proforma containing twelve error modes. The technique requires the analyst to indicate which of the HET error modes are credible (if any) for each task step, based upon their judgement. For each credible error the analyst 1) provides a description of the error; 2) Determines the outcome or consequence associated with the error; and 3) Estimates the likelihood of the error (low, medium or high) and the criticality of the error (low, medium or high). If the error is given a high rating for both likelihood and criticality, the aspect of the interface involved in the task step is then rated as a 'fail', meaning that it is not suitable for certification.	HET can be applied to each bottom level task step in a HTA. The HET error taxonomy consists of 12 basic error modes that were selected based upon a study of actual pilot error incidence and existing error modes used in contemporary HEI methods. Has been benchmarked against SHERPA, HAZOP, and HEIST, and was found to outperform these when comparing predicted errors to actual errors reported during an approach and landing task in a modern, highly automated commercial aircraft.			3			6			aviation			x			• [Li et al, 2009] • [Stanton et al, 2006]
394.	Heuristic Evaluation	Step	HzA	1990	Usability heuristic evaluation is an inspection method for finding the usability problems in a human-computer interface design so that they can be attended to as part of an iterative design process. Heuristic evaluation involves having a small set of evaluators examine the interface and judge its compliance with recognised usability principles (the "heuristics").	Developed by Jakob Nielsen and Rolf Molich. Heuristic evaluation is the most popular of the usability methods, particularly as it is quick, easy and cheap. See also CELLO method.						6			electronics	x					• [HIFA Data]
395.	HF PFMEA (Human Factors Process Failure Mode and Effects Analysis)	Tab	HRA, Mit	2002 or older	HF PFMEA provides a systematic means for assessing human errors in any process. It is based on Process Failure Mode and Effects Analysis (PFMEA). The analysis includes six steps: 1) Breakdown the process into discrete steps 2) Determine potential human errors 3) Identify positive and negative contributing factors 4) Define barriers and controls 5) Assess the error 6) Employ risk reduction strategies	Alternative name is Relex Human Factors Risk Analysis. Applicable to management risk.			3		5	6			manufacturing			x			• [FAA HFW] • [Soguilon, 2009]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
396.	HFA (Human Factors Analysis)	Gen	HFA, Task		Human Factors Analysis represents an entire discipline that considers the human engineering aspects of design. There are many methods and techniques to formally and informally consider the human engineering interface of the system. There are specialty considerations such as ergonomics, bio-machines, anthropometrics. The Human Factors concept is the allocation of functions, tasks, and resources among humans and machines. The most effective application of the human factors perspective presupposes an active involvement in all phases of system development from design to training, operation and, ultimately, the most overlooked element, disposal. Its focus ranges from overall system considerations (including operational management) to the interaction of a single individual at the lowest operational level. However, it is most commonly applied and implemented, from a systems engineering perspective, to the system being designed and as part of the SHA.	Human Factors Analysis is appropriate for all situations were the human interfaces with the system and human-related hazards and risks are present. The human is considered a main sub-system.			3		5	6			all	x		x	x		• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]
397.	HFACS (Human Factors Analysis and Classification System)	Tab	HRA	1997	Human factors taxonomy. HFACS examines instances of human error as part of a complex productive system that includes management and organisational vulnerabilities. HFACS distinguishes between the "active failures" of unsafe acts, and "latent failures" of preconditions for unsafe acts, unsafe supervision, and organisational influences.	It is based on James Reason's Swiss cheese model of human error in complex systems. Developed by Scott Shappell (Civil Aviation Medical Institute) and Doug Wiegmann (University of Illinois). Originally developed for the US navy for investigation of military aviation incidents; a Maintenance Extension is referred to as HFACS-ME and is similar to MEDA. Is currently being used by FAA to investigate civil aviation incidents. A version adapted for the railroad industry is HFACS-RR.			3					8	defence, navy, aviation, rail			x		x	• [Isaac & Pounds, 2001] provides pro-s and con's compared to HERA • [FAA HFW] • [Shappell & Wiegman, 2000] • [Wiegman et al, 2000] • [GAIN AFSA, 2003] • [GAIN ATM, 2003]
398.	HFAM (Human Factors Analysis Methodology)	Step	Org, HRA	1993	HFAM is comprised of 20 groups of factors that are subdivided into three broad categories: 1) management level factors; 2) operational level generic factors; 3) operational level job specific factors. HFAM first invokes a screening process to identify the major areas vulnerable to human error; the generic and appropriate job-specific factors are then applied to these areas. The problems that are identified ultimately reflect failures at the management control level. Corresponding management-level factors would then be evaluated to identify the nature of the management-based error (latent errors).	Management-level factors fall into various categories, including 1) those that can be specifically linked to operational-level factors; 2) those that are indicators of the quality of safety culture and therefore can affect the potential for both errors and violations; 3) those that reflect communication of information throughout the organisation, incl the capability for learning lessons from operational experience based on various forms of feedback channels.			3		5				(nuclear), (chemical)			x		x	• [Pennycook & Embrey, 1993]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
399.	HF-Assessment Method (Human Factors Assessment Method)	Tab	HFA	2003	HF-Assessment Method can be used for systematically reviewing both the process of how Human Factors have been integrated into the design and operation of control rooms and for evaluating the results of this process. The method can be used under the development of new control rooms, modifications, upgrades or evaluation of existing control rooms. It consists of seven revision checklists: One checklist of Questions and references that cover minimum requirements to documentation; One checklist of Questions and references that cover minimum requirements to all phases; and Five checklists of Questions and references that cover minimum requirements to each phase.	Was developed by HFS (Human Factors Solutions) for the PSA to allow them to assess how well operating companies comply with the Health, Safety and Environment (HSE) Regulations. The tool is for use by the Norwegian Petroleum Directorate (NPD) and the petroleum industry.		2			5				oil&gas			x			• [HFS, 2003]
400.	HFC (Human Factors Case)	Int	HFA	2002	A Human Factors Case is a framework for human factors integration, similar to a Safety Case for Safety Management. The approach has been developed to provide a comprehensive and integrated approach that the human factors aspects are taken into account in order to ensure that the system can safely deliver desired performance. Human Factors issues are classified according to six categories: 1. Working Environment; 2. Organisation and Staffing; 3. Training and Development; 4. Procedures, Roles and Responsibilities; 5. Teams and Communication; 6. Human and System. Subsequently, an Action Plan is made to address these issues.	Developed by Eurocontrol.		2	3		5	6			ATM			x			• [HFC, 2004] • [Barbarino, 2001] • [Barbarino, 2002]
401.	HHA (Health Hazard Assessment)	Step	HzI	1981	The method is used to identify health hazards and risks associated within any system, sub-system, operation, task or procedure. The method evaluates routine, planned, or unplanned use and releases of hazardous materials or physical agents.	The technique is applicable to all systems which transport, handle, transfer, use, or dispose of hazardous materials of physical agents.			3						defence, navy, healthcare	x			x		• [FAA00] • [FAA tools] • [ΣΣ93, ΣΣ97]
	High-Fidelity Prototyping					See Prototyping															
402.	HIP Model (Human Information Processing Model)	Int	HFA	1984	This is a framework for modelling human cognitive process through a series of mental operations beginning with sensory stimuli and ending with response execution. Consists of: 1) Sensory store, which converts physical phenomena into neural manifestations. 2) Pattern recognition, which maps the physical codes of the sensory stores into meaningful elements. 3) Decision/ response selection, which depends on the options available. 4) Response execution, which is initiated by the response selection. 5) Attention Resources, which can be viewed as a limiting factor for the last three stages.	Developed by C.D. Wickens.				4					food, management, road, ATM, electronics			x			• [Wickens & Flach, 1988] • [Wickens & Hollands, 1999] • [Leiden et al, 2001]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
403.	HITLINE (Human Interaction Timeline)	Stat	HRA	1994	Incorporates operator errors of commission in probabilistic assessments. It is based on a cognitive model for operator errors of omission and commission. The result of the methodology is similar to a human event tree, with as initiating event an error of commission. The generic events that determine the branch splittings are called performance influencing factors. The quantification part is performed using mapping tables.	Developed by Macwan & Mosley. Tool available.				4	5				nuclear			x			• [Macwan & Mosley, 1994] • [MUFTIS3.2-I, 1996]
	HLMSC (High Level Message Sequence Chart)					See MSC (Message Sequence Chart).															
404.	HMEA (Hazard Mode Effects Analysis)	Tab	HzA	1997 or older	Method of establishing and comparing potential effects of hazards with applicable design criteria. Introductory technique.	See also FMEA.					5				(aircraft)	x					• [FAA00] • [ΣΣ93, ΣΣ97]
405.	HMRI approach (Her Majesty's Railway Inspectorate approach)	Tab	Org	2005	Aims to assess safety culture of a railway-related organisation. Focuses on the psychological aspects of safety culture and aims to capture what happens in the company, rather than focusing on the perceptions of staff. Evaluates against five indicators: Leadership, Two-Way Communication, Employee Involvement, Learning Culture, Attitude Towards Blame.	Has been used in UK railways.								8	rail					x	• [Mkrtchyan & Turcanu, 2012]
406.	HOL (Higher Order Logic)	Stat	Des	1991 or older	Formal Method. Refers to a particular logic notation and its machine support system. The logic notation is mostly taken from Church's Simple Theory of Types. Higher order logic proofs are sequences of function calls. HOL consists of 1) two theories, called 'min' and 'bool'; 2) eight primitive inference rules, and 3) three rules of definition.	Software requirements specification phase and design & development phase.		2							software		x				• [EN 50128, 1996] • [Melham & Norrish, 2001] • [Rakowsky]
407.	HOS (Human Operator Simulator)	FTS	HFA	1970 - 1989	HOS is a computer simulation for modelling the effects of human performance on system performance. Can be used to estimate effects of human performance on a system before development/ modification.	Originally conceived in 1970 by Robert Wherry Jr. (Navy at Point Magu), but has undergone a series of major upgrades. Version IV became available in 1989.				4					defence, navy			x			• [FAA HFW] • [HOS user's guide, 1989] • [Morrison, 2003]
408.	How-How Diagram	Stat	Mit	1973	A How-How Diagram is a Tree Diagram where each child is determined by asking 'how' the parent can be achieved. It is thus useful for creating solutions to problems. Steps: 1) Place the solution to the left side of a paper; 2) Identify the initial steps needed to implement the solution and write them in the appropriate blanks to the right of the solution; 3) Consider each step individually, breaking it down into its detailed constituent stages by repeatedly asking how it might be achieved; 4) The process continues until each step has been drawn out until its logical limit; 5) examing the complete diagram for recurring elements, which tend to indicate the most crucial stages in the process of implementation.	Also referred to as Relevance Tree. See also Why-Why diagram.				4					food, management	x					• [IE, How-How] • [Futures Group, 1994] • [Switalski, 2003]
409.	HPED (Human Performance Events Database)	Dat	Dat, HzI	1992	Database of events related to human performance that can be used to identify safety significant events in which human performance was a major contributor to risk.				3						nuclear			x			• [NUREG CR6753]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
410.	HPES (Human Performance Enhancement System)	Stat	Ret	1990	The HPES method is a systematic process for understanding how the event happened, why the behaviour occurred and what additional factors contributed to the event. HPES uses event and causal factor charting, in which the tools of barrier analysis, change analysis and cause and effect analysis have been graphically incorporated into the same chart. The integrated chart shows the direct causes, the root causes, the contributing causes, and the failed barriers, with their interconnections and dependencies.	HPES was developed by Institute of Nuclear Power Operations (INPO) in 1990. The method aims at identification of human performance issues. Methods derived from HPES include: K-HPES (Korean version), J-HPES (Japanese version), UK-HPES (UK version), Man-Technology-Organisation Investigation (MTO) (Swedish version), CAS-HPES (computer-aided system for K-HPES), HPIP, AEB, PRCAP, CERCA.								8	nuclear			x			• [Ziedelis & Noel, 2011]
411.	HPIP (Human Performance Investigation Process)	Int	HRA, Ret	1994	HPIP aims at investigation of events that involve human performance issues at nuclear facilities. It is a suite of six tools: 1) Events and Causal Factors Charting: - Helps to plan an accident Investigation. 2) SORTM - A guide to HPIP Modules used to assist investigation planning and fact collection. 3) Barrier Analysis – To identify human performance difficulties for root cause analysis 4) HPIP Modules - Identifies important trends or programmatic system weaknesses. 5) Change Analysis – Allows understanding of the event and ensures complete investigation and accuracy of perceptions. 6) Critical Human Actions Profile (CHAP) - Similar to change analysis, CHAP provides an understanding of the event and ensures complete investigation and accuracy of perceptions	HPIP was developed for the US Nuclear Regulatory Commission and the safety management factors in the Management Oversight & Risk Tree (MORT) of the US Department of Energy.		2	3	4	5				nuclear			x			• [FAA HFW] • [Ziedelis & Noel, 2011]
412.	HPLV (Human Performance Limiting Values)	Math ?	Val	1990	HPLVs are used as dependency 'bounding probabilities' for human error outsets. They represent a quantitative statement of the analyst's uncertainty as to whether all significant human error events have been adequately modelled in the fault tree. Special attention to (in)dependence of human errors. It is important to note that HPLVs are not HEPs (Human Error Probabilities); they can only be used to limit already modelled HEPs once direct dependence has been considered.	Developed by Kirwan et al. Relation with Fault Trees. JHEDI applies HPLV to fault trees. See also Bias and Uncertainty assessment. See also Uncertainty Analysis.					5				nuclear			x			• [Kirwan, 1994]
413.	HPM (Human Performance Modelling)	Gen	HRA	1940 or older	Human performance models are abstractions, usually mathematical or computational, that attempt to explain or predict human behaviour in a particular domain or task. They can be used, e.g., to examine latent design flaws that induce human error, to compare development options, to define procurement needs or strategies, to examine human interactions with existing and proposed technical systems, to examine aspects of the task environment, equipment and procedures. The model mechanisms can be anything from a simple mathematical formula, to complex computerised 3-D graphics simulations.	Human performance is defined as the accomplishment of a task in accordance with agreed upon standards of accuracy, completeness, and efficiency. Many specific techniques and tools are available.				4					all			x			• [Leiden & Best, 2005] • [Foyle et al, 2005] • [Pew, 2008] • [Corker et al, 2005] • [Blom & Stroeve et al, 2002] • [Blom & Stroeve & Daams & Nijhuis, 2001]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
414.	HPRA (Human Performance Reliability Analysis)	Gen	HRA		Consists of an analysis of the factors that determine how reliably a person will perform within a system or process. General analytical methods include probability compounding, simulation, stochastic methods, expert judgement methods, and design synthesis methods.	Among published HPRA methods are THERP, REHMS-D, SLIM-MAUD, MAPPS.				4	5				all			x			• [MIL-HDBK, 1999]
415.	HRA (Human Reliability Analysis)	Gen	HRA	1952	Human Reliability Analysis is is a generic name for methods to assess factors that may impact human reliability in a probabilistic risk analysis for the operation of a socio-technical system.				3		5				all			x			• [FAA00] • [Kirwan, 1994] • [Hollnagel, 1993] • [Pyy, 2000] • [NEA, 1998] • [ΣΣ93, ΣΣ97]
416.	HRAET (Human Reliability Analysis Event Tree)	Stat	HRA	1983	Tool used for THERP. Is a simpler form of event tree, usually with diagonal line representing success, and individual branches leading diagonally off the success diagonal representing failure at each point in the task step.	Can also be used for maintenance errors. See also THERP.				4	5				nuclear, maritime			x			• [Kirwan & Ainsworth, 1992] • [Kirwan & Kennedy & Hamblen] • [MUFTIS3.2-I, 1996]
417.	HRMS (Human Reliability Management System)	Int	HRA	1989	The HRMS is a fully computerized system dealing with all aspects of the process. It is a quantification module based on actual data, which is completed by the author's own judgments on the data extrapolation to the new scenario/tasks. A PSF (Performance Shaping Factors)-based sensitivity analysis can be carried out in order to provide error-reduction techniques, thus reducing the error likelihood.	Developed by Kirwan et al. Apparently not in current use or else used rarely. JHEDI is a derivative of HRMS and provides a faster screening technique.								8	nuclear			x			• [DiBenedetto, 2002] • [Kirwan, 1994] • [Kirwan, Part 1, 1998] • [Seignette, 2002]
418.	HSIA (Hardware/Software Interaction Analysis)	Tab	SwD, HwD	1991 or older	The objective of HSIA is to systematically examine the hardware/ software interface of a design to ensure that hardware failure modes are being taken into account in the software requirements. Further, it is to ensure that the hardware characteristics of the design will not cause the software to over-stress the hardware, or adversely change failure severity when hardware failures occur. HSIA is conducted through checklists, according to which an answer shall be produced for each identified failure case. Checklists are specific to each analysis and have to take into account the specific requirements of the system under analysis. The analysis findings are resolved by changing the hardware and/or software requirements, or by seeking ESA approval for the retention of the existing design.	HSIA is obligatory on ESA (European Space Agency) programmes and is performed for all functions interfacing the spacecraft and / or other units. The HSIA is generally initiated once the development of the hardware is already finished and the development of the software is not started (or it is at the very beginning of the process). See also Interface Testing. See also Interface Analysis, See also LISA.				3			6			space	x	x				• [Hoegen, 1997] • [Parker et al, 1991] • [Rakowsky] • [SW, 2004]
419.	HSMP (Hybrid-State Markov Processes)	Math	Mod	1990 or older	Combines deterministic stochastic evolution with switching of mode processes. The Hybrid Markov state consists of two components, an n-dimensional real-valued component, and a discrete valued component. The HSMP is represented as a solution of a stochastic differential or difference equation on a hybrid state space, driven by Brownian motion and point processes. The evolution of the probability density on the hybrid state space is the solution of a partial integro-differential equation.	Used in e.g. TOPAZ. Numerical evaluation requires elaborated mathematical techniques such as Monte Carlo simulation.				4					ATM	x		x	x		• [Krystul et al, 2012] • [Krystul et al, 2007] • [Blom, 2003] • [Blom, 1990] • [MUFTIS3.2-I, 1996]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
420.	HSYS (Human System Interactions)	Stat	HRA	1990	HSYS provides a systematic process for analyzing Human-System interactions in complex operational settings. It focuses on system interactions from the human's perspective and is built around a linear model (based on Fault Tree principles) of human performance, termed the Input-Action model. According to the model, all human actions involve, to varying degrees, five sequential steps: Input Detection, Input Understanding, Action Selection, Action Planning, and Action ExecutIon. These five steps form branches of the hierarchical tree and have aided in both prospective and retrospective analysis. Based on the Input-Action model, a series of flow charts supported by detailed "topical modules," have been developed to analyze each of the five main components in depth.	HSYS was developed at the Idaho National Engineering Laboratory (INEL). Similar to MORT.				4					oil&gas			x			• [Harbour & Hill, 1990] • [FAA HFW]
421.	HTA (Hierarchical Task Analysis)	Stat	Task	1967	HTA is a method of task analysis that describes tasks in terms of operations that people do to satisfy goals and the conditions under which the operations are performed. The focus is on the actions of the user with the product. This top down decomposition method looks at how a task is split into subtasks and the order in which the subtasks are performed. The task is described in terms of a hierarchy of plans of action.	First paper on the specification for the method dates from 1967 by Annett and Duncan.		2							ATM, nuclear, defence, navy, energy, chemical, oil&gas, ergonomics			x	x		• [Kirwan & Ainsworth, 1992] • [Kirwan, 1994] • [Stanton & Wilson, 2000] • [Shepherd, 2001] • [Kirwan et al, 1997] • [Diaper & Stanton, 2004] • [Shepherd, 1998]
422.	HTLA (Horizontal Timeline Analysis)	Tab	Task, HFA	1987 or older	Investigates workload and crew co-ordination, focusing on task sequencing and overall timing. Is constructed from the information in the VTLA (Vertical Timeline Analysis) to determine the likely time required to complete the task. Usually a graphical format is used, with sub-tasks on the y-axis and time proceeding on the x-axis. The HTLA shows firstly whether the tasks will be achieved in time, and also where certain tasks will be critical, and where bottlenecks can occur. It also highlights where tasks must occur in parallel, identifying crucial areas of co-ordination and teamwork.	See also VTLA. See also Timeline Analysis. VTLA focuses on crew activities and personnel whereas HTLA focuses on task sequencing and overall timing.			3	4					finance, nuclear			x	x		• [Kirwan & Kennedy & Hamblen] • [Kirwan, 1994] • [Task Time]
423.	HTRR (Hazard Tracking and Risk Resolution)	Dat	Dat, Val	1985	Method of documenting and tracking hazards and verifying their controls after the hazards have been identified by analysis or incident. The purpose is to ensure a closed loop process of managing safety hazards and risks. Each program must implement a Hazard Tracking System (HTS) to accomplish HTRR.	HTRR applies mainly to hardware and software-related hazards. However, it should be possible to extend the method to also include human and procedures related hazards, by feeding these hazards from suitable hazard identification techniques.								8	aviation	x	x				• [FAA00] • [FAA tools] • [FAA SSMP] • [MIL-STD 882B] • [NEC, 2002]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
424.	Human Error Data Collection	Gen, Dat	Dat, HRA	1990	Aim is to collect data on human error, in order to support credibility and validation of human reliability analysis and quantification techniques.	An example of a Human Error Data Collection initiative is CORE-DATA. See also CARA.					5				nuclear, ATM			x			• [Kirwan & Basra & Taylor] • [Kirwan, Part I, 1996] • [Kirwan et al, Part II, 1997] • [Kirwan, Part III, 1997] • [Kirwan & Kennedy & Hamblen]
	Human Error Model					See Fallible machine Human Error and see SRK (Skill, Rule and Knowledge-based behaviour model).															
425.	Human Error Recovery	Gen	Mod	1997	Way of modelling that acknowledges that human operators typically introduce and correct errors prior to those errors becoming critical. The error correction frequency is decreasing under stress. The Stages in error recovery are: Error, Detection, Identification, Correction, Resumption.					4					aviation ATM			x			• [Amalberti & Wioland, 1997] • [Leiden et al, 2001]
426.	Human Factors Assessments in Investment Analysis	Gen	HRA	2003	The Human Factors Assessment is a process that is integrated with other processes and provides essential components to the products of the Investment Analysis (IA). Three of these human factors components are: a) the human-system performance contribution to program benefits, b) an assessment of the human-system performance risks, and c) the estimated costs associated with mitigating human factors risks and with conducting the engineering program support. The human factors components related to benefits, risks, and costs are integrated with other program components in the IA products and documentation.	.		2	3	4	5	6			(aviation)			x			• [FAA HFW] • [FAA HFED, 2003]
427.	Human Factors in the Design and Evaluation of Air Traffic Control Systems	Int	Des	1995	This tool provides information about Human Factors related issues that should be raised and addressed during system design and system evaluation. The tool consists of 2 parts; 1. A handbook describes how different Human Factors areas apply to (ATC) Air Traffic Control. This should help the HF practitioner identify relevant HF issues for the system design and evaluation process. 2. An application package allows the construction of checklists to support the system selection and evaluation process.	Developed by FAA.		2				6			(ATM)			x			• [FAA HFW] • [Cardosi & Murphy, 1995]
428.	Human HAZOP or Human Error HAZOP (Human (Error) Hazard and Operability study)	Tab	HRA	1988	Extension of the HAZOP technique to the field of procedures performed by humans. More comprehensive error identification, including the understanding of the causes of error, in order to achieve more robust error reduction.				3	4		6			chemical, rail, nuclear, aviation			x	x		• [Cagno & Acron & Mancini, 2001] • [Kirwan & Ainsworth, 1992] • [Kirwan, 1994]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
429.	Hybrid Automata	Dyn	Mod	1993	A Hybrid Automaton is a mathematical model for describing systems in which computational processes interact with physical processes. The behaviour of a hybrid automaton consists of discrete state transitions and continuous evolution. The latter are usually represented by differential equations.	See also Finite State Machines. Timed Hybrid Automata also include the notion of time.				4					nuclear, chemical, road, ATM, environment, security	x					• [Alur, 1993] • [Lygeros & Pappas & Sastry, 1998] • [Schuppen, 1998] • [Sipser, 1997] • [Tomlin & Lygeros & Sastry, 1998] • [Weinberg & Lynch & Delisle, 1996]
	Hyperion Intelligence					New name of Brio Intelligence, see FDM Analysis and Visualisation Tools, see Data Mining															
430.	HzM (Multilevel HAZOP)	Tab	HzA	2001	HzM maintains the HAZOP approach, but breaks down the analysis in two directions: vertical (hierarchical breakdown of each procedure in an ordered sequence of steps) and horizontal (each step is further broken down into the three logical levels operator, control system and plant/ process). This allows recording how deviations may emerge in different logical levels and establishing specific preventive/ protective measures for each.	Combined use with HEART, THERP and Event trees possible.			3	4		6			chemical	x		x			• [Cagno & Acron & Mancini, 2001]
431.	i* Model Analysis	Stat	Des	1994	i* is an approach originally developed to model information systems composed of heterogeneous actors with different, often-competing goals that nonetheless depend on each other to undertake their tasks and achieve these goals. The i* approach supports the development of 2 types of system model. The first is the Strategic Dependency (SD) model, which provides a network of dependency relationships among actors. The opportunities available to these actors can be explored by matching the depender who is the actor who wants" and the dependee who has the ability". The dependency link indicates that one actor depends on another for something that is essential to the former actor for attaining a goal. The second type of i* model is the Strategic Rationale (SR) model, which provides an intentional description of processes in terms of process elements and the relationships or rationales linking them. A process element is included in the SR model only if it is considered important enough to affect the achievement of some goal. The SR model has four main types of nodes: goals, tasks, resources and softgoals.			2							ATM	x	x				• [Maiden & Kamdar & Bush, 2005] • [Yu, 1994]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
432.	IA (Impact Analysis)	Gen	SwD	1996	Prior to modification or enhancement being performed on the software, an analysis is undertaken to identify the impact of the modification or enhancement on the software and also identify the affected software systems and modules. Two forms are traceability IA and dependency IA. In traceability IA, links between requirements, specifications, design elements, and tests are captured, and these relationships can be analysed to determine the scope of an initiating change. In dependency IA, linkages between parts, variables, logic, modules etc. are assessed to determine the consequences of an initiating change. Dependency IA occurs at a more detailed level than traceability IA.	Defined by S.A. Bohner and R.S. Arnold. Software maintenance phase. Sometimes referred to as Change Impact Analysis or Software Change Impact Analysis.			3							software		x				• [EN 50128, 1996] • [Rakowsky]
433.	IAEA TECDOC 727	Int	HzA	1993	Aim is to classify and prioritise risks due to major industrial accidents. It is a tool to identify and categorise various hazardous activities and hazardous substances. Includes hazard analysis and quantified risk assessment. The categorisation of the effect classes is by means of maximum distance of effect, and affected area.	Applicable to industrial plants and to transport of dangerous goods.			3		5				chemical, management	x			x		• [Babibec et al, 1999] • [IAEA TECDOC 727]
434.	ICAM (Incident Cause Analysis Method)	Step	Ret	1999	Retrospective accident and incident investigation tool. Aims to identify contributory conditions, actions and deficiencies at the levels of people, environment, equipment, procedures and organisation.	Developed by G. Gibb for BHP Billiton. Based on Reason's model of accident causation. Similar to HFACS. Used for root cause analysis.			3			6			manufacturing, aviation, rail, road, mining, oil&gas	x	x	x	x	x	• [Salmon et al., 2005]
	IDA (Influence Diagram Approach)					See STAHR (Socio-Technical Assessment of Human Reliability)															
435.	IDDA (Integrated Dynamic Decision Analysis)	Dyn	Mod, OpR	1994 or older	IDDA develops the sequences of events from the point of view both of the logical construction, and of the probabilistic coherence. The system description has the form of a binary chart, where the real logical and chronological sequence of the events is described; the direction of each branch is characterised by a probability of occurrence that can be modified by the boundary conditions, and in particular by the same development of the events themselves (probabilities conditioned by the events dynamic). At the end of the analysis, the full set of the possible alternatives in which the system could evolve is obtained. These alternatives represent a "partition" since they are mutually exclusive; they are all and the sole possible alternatives, thus allowing the method to guarantee the completeness and the coherence of the analysis.	Developed by R. Galvagni. IDDA is based on an enhanced form of dynamic event tree.				4	5				nuclear, chemical, oil&gas	x					• [Demichela & Piccinini, 2003] • [Galvagni et al, 1994] • [Piccinini et al, 1996]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
436.	IDEF (Integrated Computer-Aided Manufacturing Definition or Integration DEFinition)	Int	Mod	1981	Method of system modelling that enables understanding of system functions and their relationships. Using the decomposition methods of structural analysis, the IDEF modelling languages define a system in terms of its functions and its input, outputs, controls and mechanisms. IDEF covers a wide range of uses, from functional modeling to data, simulation, object-oriented analysis/design and knowledge acquisition.	Developed at US Air Force during the 1970s-1980s. IDEF0 is derived from and is the military equivalent to SADT. Currently, IDEF comprises a suite of methods named IDEF0, (Function modelling), IDEF1 (Information Modelling), IDEF1X (Data Modelling), IDEF2 (Simulation Model Design), etc, up to IDEF14 (Network Design); some of these have not been developed further than their initial definition.		2							defence, management	x					• [HEAT overview] • [MIL-HDBK, 1999] • [Mayer et al., 1992]
437.	ILCI Loss Causation Model (International Loss Control Institute Loss Causation Model)	Stat	Mit	1985	The ILCI model focuses on development of performance standards and enforcement of standards to ensure that employees are performing their work in a safe manner. The ILCI model is based on a sequence of events that leads up to an eventual loss. The events in sequential order are, Lack of Control, Basic Causes, Immediate Causes, Incident/Contact, and Loss. Each event has a role in continuing the loss process to its conclusion, the Loss.	Developed by Mr. Frank E. Bird, Jr. of ILCI in the USA, and based Heinrich's pyramid and his Domino Theory. In 1991, DNV (Det Norske Veritas) bought ILCI rights.						6			food, (oil&gas)	x		x	x		• [Kjellen, 2000] • [Storbakken, 2002]
438.	IMAS (Influence Modelling and Assessment System)	Stat	HRA	1986	Aims to model cognitive behaviour aspects of performance, in terms of relationships between knowledge items relating to symptoms of events (for diagnostic reliability assessment).	Developed by David E. Embrey.		2							nuclear, chemical			x			• [Kirwan, Part 1, 1998]
439.	Importance Sampling	Math	Val	1980	Technique to enable more frequent generation of rare events in Monte Carlo Simulation. Rare events are sampled more often, and this is later compensated for.	Developed by Shanmugan and Balaban. Combine with simulations.					5				ATM, aircraft, finance, road, environment, space, chemical, electronics, management, energy, leisure	x	x	x	x	x	• [MUFTIS3.2-I, 1996] • [Shanmugam&Balaban, 1980]
440.	IMPRINT (Improved Performance Research Integration Tool)	FTS	Task	1994	IMPRINT is a stochastic, discrete event, network modeling tool designed to assist in the evaluation of interactions of human users and system technologies through different phases of the system life cycle. A system mission is decomposed into functions, which are further decomposed into tasks. A branching logic determines how the functions and tasks are connected at their respective levels, indicating whether they are repeated, performed simultaneously, serially, or probabilistically.	Developed by Human Research and Engineering Directorate of ARL (Army Research Laboratory). IMPRINT simulates human performance at a larger level of granularity as compared to the cognitive level of ACT-R. See also HPM (Human Performance Modelling). See also MRT (Multiple Resources Theory).				4					defence, navy			x			• [Leiden & Best, 2005] • [Salvi, 2001] • [Alley, 2005]
	IMS (Inductive Monitoring System)					See Data Mining															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
441.	InCAS (Interactive Collision Avoidance Simulator)	RTS	Col	2000 or older	InCAS is a PC-based interactive simulator for replaying and analysing Airborne Collision Avoidance System (ACAS) during close encounters between aircraft. It is designed for case-by-case incident analysis by investigators. InCAS reads radar data and provides an interface to examine these data in detail, removing any anomalies that may be present. The cleaned data are used to simulate trajectories for each aircraft at one-second intervals and these data are fed into a full version of the logic in the Traffic Alert and Collision Avoidance System, TCAS II (versions 6.04A or 7).	Developed by Eurocontrol.								8	ATM, aviation	x					• [GAIN ATM, 2003]
442.	In-Depth Accident Investigation	Gen	Ret	1995 or older	Aim is to investigate a severe accident or near-accident on-the-scene. Follows eight generic steps: 1) Securing the scene; 2) Appointing an investigation commission; 3) Introductory meeting, planning the commission's work; 4) Collection of information; 5) Evaluations and organising of information; 6) Preparing the commission's report; 7) Follow-up meeting; 8) Follow-up.	This method particularly refers to road traffic accidents, but in a general sense, such investigations are done in other domains as well.								8	road, aviation, ATM, maritime	x			x		• [Kjellen, 2000]
443.	INEL approach (Idaho National Engineering Laboratory)	Tab	Org	1993	Safety culture assessment for nuclear industry. Consists of 19 safety culture categories: Individual responsibility; Safe processes; Safety thinking; Safety management; Priority of safety; Safety values; Safety awareness; Teamwork; Pride and commitment; Excellence; Honesty; Communications; Leadership and supervision; Innovation; Training; Customer relations; Procedure compliance; Safety effectiveness; Facilities.									8	nuclear					x	• [Mkrtchyan & Turcanu, 2012]
	Influence Diagram					See BBN (Bayesian Belief Networks). See RIF diagram (Risk Influencing Factor Diagram). Also called Relevance Diagram.															
	Information Flow Chart					See DAD (Decision Action Diagram)															
444.	Information Hiding or Information Encapsulation	Step, Gen	Des	1972	Aim is to increase the reliability and maintainability of software or hardware. Encapsulation (also information hiding) consists of separating the external aspects of an object, which are accessible to other objects, from the internal implementation details of the object, which are hidden from other objects. If an internal state is encapsulated it cannot be accessed directly, and its representation is invisible from outside the object.	Developed by David Parnas. Closely related to object-oriented programming and design. Tools available. Information Hiding is fundamental to division of labour: the participants do not need to know everything about each other's tasks or component.			3			6			manufacturing, security	x	x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]
	Information Processing Model					See Human Information Processing Model															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
445.	Input-output (block) diagrams	Gen	Mod, Task	1974	The technique involves first selecting the system, task or step of interest and then identifying all the inputs and outputs which are necessary to complete this task or step. The inputs are listed along an incoming arc to a block representing the system, task or step of interest, and the outputs are listed along an outgoing arc.	Developed by W.T. Singleton.		2							energy, nuclear, food, aircraft	x	x	x			• [Kirwan & Ainsworth, 1992]
446.	Inspections and Walkthroughs	Gen	SwD	1972	Aim is to detect errors in some product (mostly a software product) of the development process as soon and as economically as possible. An inspection is the most formal type of group review. Roles (producer, moderator, reader and reviewer, and recorder) are well defined, and the inspection process is prescribed and systematic. During the meeting, participants use a checklist to review the product one portion at a time. Issues and defects are recorded, and a product disposition is determined. When the product needs rework, another inspection might be needed to verify the changes. In a walkthrough, the producer describes the product and asks for comments from the participants. These gatherings generally serve to inform participants about the product rather than correct it.	Effective method of finding errors throughout the software development process. In a Cognitive Walkthrough, a group of evaluators step through tasks, evaluating at each step how difficult it is for the user to identify and operate the system element and how clearly the system provides feedback to that action. Cognitive walkthroughs take into consideration the user's thought processes that contribute to decision making, such as memory load and ability to reason. See also Walk-Through Task Analysis. See also FI (Fagan Inspections).							7		electronics		x				• [Bishop, 1990] • [Inspections]
447.	Integrated NASTEP Application (Integrated National Airspace System Technical Evaluation Program Application)	Dat	Dat, Val	2004 or older	This national database contains reports, findings, and mitigation plans from NASTEP audits and assessments. NASTEP is a program that contributes to the periodic review and maintenance of equipment and procedures. The program offers an independent technical review of how well facilities and services meet their intended objectives; how well the maintenance program is executed; and how well customer needs are being met. Data output includes performance and audit reports.	Maintained by the NAS QA and Performance Group in the Technical Operations Services Management Office.						6	7		ATM	x			x		• [ATO SMS Manual v3.0] • [FAA SMS, 2004]
448.	Integrated Process for Investigating Human Factors	Step	HFA, Ret	1995	This tool provides a step-by-step systematic approach in the investigation of human factors. The tool can be applied to accidents or incidents. The process consists of seven steps 1) collect occurrence data, 2) determine occurrence sequence, 3) identify unsafe actions (decisions) and unsafe conditions, and then for each unsafe act (decision) 4) identify the error type or adaptation, 5) identify the failure mode, 6) identify behavioural antecedents, and 7) identify potential safety problems.	Developed by Transportation Safety Board of Canada. The process is an integration and adaptation of a number of human factors frameworks - SHEL (Hawkins, 1987) and Reason's (1990) Accident Causation and generic error-modelling system (GEMS) frameworks, as well as Rasmussen's Taxonomy of Error (1987).		2	3	4					(aviation), (ATM)			x			• [GAIN AFSA, 2003]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
449.	INTENT	Tab	HRA	1991	Is aimed at enabling the incorporation of decision-based errors into PSA, i.e. errors involving mistaken intentions, which appears to include cognitive errors and rule violations, as well as EOCs. Four categories of error of intention are identified: action consequence; crew response set; attitudes leading to circumvention; and resource dependencies. A set of 20 errors of intention (and associated PSF (Performance Shaping Factor)) are derived, and quantified using seven experts. The methodological flow for INTENT involves six stages: Compiling errors of intention, quantifying errors of intention, determining human error probabilities (HEP) upper and lower bounds, determining PSF and associated weights, determining composite PSF, and determining site specific HEP's for intention.	Developed by Gertman et al.			3	4	5				nuclear			x			• [Kirwan, Part 1, 1998]
450.	Interdependence Analysis	Stat	SwD	1967	Aim is to examine the software to determine the interdependence among Computer Software Components (CSCs), modules, tables, variables, etc. Elements of software that directly or indirectly influence Safety Critical Computer Software Components (SCCSCs), e.g. shared memory blocks used by two or more SCCSCs, are also identified as SCCSCs, and as such should be analyzed for their undesired effects. The inputs and outputs of each SCCSC are inspected and traced to their origin and destination.	The term Interdependence analysis was coined by Beale et al, in 1967, and reappeared in the title of a monograph by Boyce et al., in 1974.				4					software		x				• [FAA00] • [Duncan & Dunn, 1999] • [Beale et al, 1967] • [Boyce et al, 1974]
451.	Interface Analysis	Step	HzI	1995 or older	The analysis is used to identify hazards due to interface incompatibilities. The methodology entails seeking those physical and functional incompatibilities between adjacent, interconnected, or interacting elements of a system, which, if allowed to persist under all conditions of operation, would generate risks.	Interface Analysis is applicable to all systems. All interfaces should be investigated; machine-software, environment- human, environment-machine, human-human, machine-machine, etc. See also Interface Testing. See also HSIA. See also LISA. See also SHEL.			3						electronics, avionics, space	x	x				• [FAA00] • [Leveson, 1995] • [Rakowsky] • [ΣΣ93, ΣΣ97]
452.	Interface Surveys	Gen	Dat	1977	Interface surveys are a group of information collection methods that can be used to gather information about specific physical aspects of the person-machine interface at which tasks are carried out. Examples of these techniques are Control/Display Analysis; Labelling Surveys; Coding Consistency Surveys; Operator modifications surveys; Sightline surveys; Environmental Surveys.			2							electronics, police, nuclear	x					• [Kirwan & Ainsworth, 1992]
453.	Interface Testing	Step	SwD	1992 or older	Interface testing is essentially focused testing. It needs reasonably precise knowledge of the interface specification. It has three aspects: 1) Usability testing (to discover problems that users have); 2) Correctness testing (to test whether the product does what it is supposed to do); 3) Portability testing (to make a program run across platforms).	Software design & development phase. See also HSIA. See also Software Testing. See also Interface Analysis.							7		software		x				• [EN 50128, 1996] • [Jones et al, 2001] • [Rakowsky] • [Rowe, 1999]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
454.	INTEROPS (INTEgrated Reactor OPerator System)	FTS	HFA, HRA, Task	1991	Cognitive performance simulation, which uses the SAINT simulation methodology. Has three independent models: a nuclear power plant model; a network model of operator tasks; and a knowledge base, the operator model being distributed between the latter two. The model is a single operator model. It diagnoses by observance of plant parameters, and subsequent hypothesis generation and testing of the hypothesis. The approach uses Markovian modelling to allow opportunistic monitoring of plant parameters. The model also simulates various errors and PSF (Performance Shaping Factor). Cognitive workload is also modelled, in terms of the contemporary information processing theory of concurrent task management. Also, INTEROPS can utilise a confusion matrix approach to make diagnostic choices.	The INTEROPS model allows the following to be simulated: forgetting, tunnel-vision; confirmation bias; and mistakes. See also SAINT.		2		4	5				nuclear			x			• [Kirwan, Part 1, 1998] • [Kirwan, 1995]
455.	Interview	Gen	Dat	1950 or older	Method of asking participants what they think about a topic in question, including follow-up questions for clarification. Interviews can be held in different ways: • Unstructured Interviews: Very open interviews. Usually an outline, used as a guide, with a limited set of broad questions. • Semi-Structured Interviews: A more structured set of open-ended questions is designed before the interview is conducted. Follow up questions are used for clarification. • Stratified Semistructured Interviews: Representative subgroups of an organisation are identified and randomly sampled individuals are interviewed for each subgroup. This aims to reduce the sampling error. • Structured Interviews: The interviewer has a standard set of questions that are asked of all candidates. Is more commonly used for systematic collection of information. • Exit Interview: Open-ended questions asked after a study or experiment. Purpose is to gather information about the perceived effectiveness of study. • Laddering is used to draw out the connections users make between different constructs of a task, their consequences, and the human values linked with those consequences. The researcher begins with a statement and then directs the expert through the task hierarchy. • Teachback is a process in which the subject matter expert (SME) describes a concept to the researcher. The researcher then explains the concept back to the SME until the SME is satisfied that the researcher has grasped the concept.	Interviews yield rich qualitative data and can be performed over the telephone or in person.	1	2	3	4	5	6	7	8	ATM, rail, road, manufacturing, healthcare, environment, social	x	x	x	x	x	• [FAA HFW] • [Hendrick, 1997] • [Kirwan & Ainsworth, 1992] • [Salvendy, 1997]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
456.	Invariant Assertions	Step	SwD	1967 or older	Aim is to detect whether a computer system has deviated from its intended function. An invariant assertion of an automaton A is defined as any property that is true in every single reachable state of A. Invariants are typically proved by induction on the number of steps in an execution leading to the state in question. While proving an inductive step, only critical actions are considered, which affect the state variables appearing in the invariant.	To be used on non-time critical safety related systems. Related to formal specification methods and fault containment techniques. See also Software Testing.							7		software		x				• [Bishop, 1990] • [Keidar & Khazan, 2000]
457.	IO (Investigation Organizer)	Min	Dat	2002	IO is a web-based information-sharing tool used to support mishap investigations in real-time as well as providing an analysis capability to optimise the investigation activities, report generation, and generic mishap investigation research. The tool functions as a document/data/image repository, a project database, and an “organisational memory” system. Investigation Organizer permits relationships between data to be explicitly identified and tracked using a cross-linkage mechanism, which enables rapid access to interrelated information. The tool supports multiple accident models to help give investigators multiple perspectives into an incident.	Uses Fault Trees. Developed at NASA Ames Research Center in 2002.								8	aviation, space	x			x		• [GAIN AFSA, 2003] • [IO example]
458.	IPME (Integrated Performance Modelling Environment)	FTS	HFA	1997 or older	IPME is a Unix-based integrated environment of simulation and modelling tools for answering questions about systems that rely on human performance to succeed. IPME provides: 1) A realistic representation of humans in complex environments; 2) Interoperability with other models and external simulations; 3) Enhanced usability through a user friendly graphical user interface. IPME provides i) a full-featured discrete event simulation environment built on the Micro Saint modelling software; ii) added functionality to enhance the modelling of the human component of the system; iii) a number of features that make it easier to integrate IPME models with other simulations on a real-time basis including TCP/IP sockets and, in the near future, tools for developing simulations that adhere to the Higher Level Architecture (HLA) simulation protocols that are becoming standard throughout the world.	Relation with Micro-SAINT. See also HPM.		2		4	5				navy, defence			x			• [IPME web] • [Dahn & Laughery, 1997] • [Winkler, 2003] • [FAA HFW] • [Alley, 2005]
459.	IPS (Interacting Particle System)	Math	Mod	2005	The aim of using this technique within safety analysis is to speed up Monte Carlo simulations that are used to determine the frequency of occurrence of rare events. The technique makes use of repeated sampling of ‘particles’ in Monte Carlo simulations. Particles that do not appear to reach a first area of interest are ‘killed’, after which the Monte Carlo simulation continues with the remaining particles until the next area of interest, and so on. The areas of interest ultimately zoom in to the rare event.	An example rare event evaluated using this technique is collision between two aircraft. Application of IPS to aviation has been developed as part of TOPAZ.				4					ATM				x		• [Cerou et al, 2002] • [Cerou et al, 2006] • [Blom & Krystul & Bakker, 2006] • [Blom & Krystul et al, 2007] • [Blom & Bakker & Krystul, 2007] • [Blom & Bakker & Krystul, 2009]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
460.	IRP (Integrated Risk Picture)	Int	OpR	2006	Intends to provide an integrated risk picture for the current and an adopted (2015) ATM concept using fault tree analysis [IRP, 2006]. Starting point is a fault tree for the current situation (see next column of this table). The predictive IRP for the adopted 2015 ATM concept uses a 4-stage approach: Stage 1: Identify the future ATM situation, i.e. identify the ATM changes that might be implemented in Europe the period up to 2020. Use HAZOPs and ongoing safety assessments for the different future ATM components to identify which aspects will positively influence safety, and which aspects will negatively influence safety (hazards). Stage 2: Make a functional model including the main actors, the information flow between them, and interdependencies, for the future situation, using SADT (Structured Analysis and Design Technique). Stage 3: Use this and the current risk fault tree to evaluate the future situation. Stage 4: Refine and quantify the future IRP by assessing correlated modification factors for the values in the IRP fault tree and the IRP influence model, thus modelling positive interactions, negative interactions, and migration of risk.	The current risk IRP [IRP, 2005] accumulates overall risk from five kinds of accident risk categories (CFIT, Taxiway collision, Mid-air collision, Runway collision, Wake turbulence). For each category there is a fault tree that represents the specific causal factors. And below each fault tree there is an influence model which is used to represent more diffuse factors such as quality of safety management, human performance, etc. Quantification is done by mixture of historical data and expert judgement. An adaptation of IRP for use in the SESAR (Single European Sky ATM research) programme is referred to as AIM (Accident Incident Model).		2	3	4	5			8	ATM	x		x			• [IRP, 2005] • [IRP, 2006]
461.	ISA (Intelligent Safety Assistant)	Dat	Dat	1987	ISA is intended to facilitate the interactive collection of data on accidents and near misses. It is a method of applying MORT methods for registration of incidents at work in order to ensure consistent data collection and the generation of diagnostic messages about critical or failing safety management factors underlying a single accident, near miss or Safety Management System (SMS) failure event.	ISA is claimed to contribute to consistency in reporting accidents and incidents, and to the development of causal hypotheses. Developed by Koorneef and Hale (Delft University of Technology, Netherlands).								8	healthcare, chemical, oil&gas, mining,aircraft, manufacturing	x		x	x	x	• [HEAT overview] • [Livingston, 2001] • [Korneef, 2000]
462.	ISAM (Integrated Safety Assessment Model)	Stat	OpR	2012	The objective of ISAM is to estimate the risk of the U.S. National Airspace System (NAS), in the baseline situation and specifically after introduction of NextGen Operational Improvements (OIs). The core of ISAM is a causal risk model consisting of 30 accident scenarios that are represented as Event Sequence Diagrams and associated Fault Trees. The model provides an estimate of the baseline risk of the U.S. NAS, using historic accident and incident information. This risk model is complemented with an ISAM predictive mode, i.e. an influence model and a graphical user interface (GUI) that can be used to solicit expert opinion to provide an estimate of the risk effects of NextGen changes to the NAS.	The structure of the model is based on the structure of two similar models developed in Europe, i.e. Eurocontrol's Integrated Risk Picture (IRP) and the Dutch Causal Model for Air Transport Safety (CATS), modified to appropriately represent accident and incident scenarios in the U.S. The ISAM model is currently still being developed.			3	4	5				(aviation), (ATM), (airport)	x		x		x	• [ISAM, 2011] • [Borener et al, 2012]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
463.	ISAM (IAEA Safety Assessment Methodology)	Int	OpR	2002	ISAM aims at evaluation of long-term safety of near surface nuclear waste disposal facilities. Steps are: Specification of the assessment context (incl. purpose, regulatory framework, timeframe, etc); Description of the waste disposal system (incl. near field, geosphere, biosphere); Development and justification of scenarios (using e.g. expert judgment, event trees, fault trees); Formulation and implementation of models (i.e. mathematical models and computer codes, incl. assumptions); and Analysis of results and building of confidence (development of results, quality assurance, sensitivity analysis, comparison of results to regulatory criteria).	Developed by coordinated research program of International Atomic Energy Agency (IAEA).	1	2	3	4	5				nuclear	x					• [Batandjieva & Torres-Vidal, 2002]
	Ishikawa diagram					See Cause and Effect Diagram															
464.	ISIM (Integrated Safety Investigation Methodology)	Int	OpR, Ret	1998	ISIM aims to provide a standardised and comprehensive methodology to support the investigation/analysis of multi-modal occurrences in the transportation sector. ISIM integrates the identification of safety deficiencies, with the analysis and validation of those deficiencies. The prime components of ISIM are: occurrence assessment; data collection; events and factors diagramming; use of the TSB's existing integrated investigation process to uncover the underlying factors (safety deficiencies); risk assessment; defence/barrier analysis; risk control options; and safety communications.	ISIM was developed by the Transportation Safety Board of Canada (TSB) in 1998. TSB plans to automate parts of the methodology and tie it more closely to their TSB's database systems. Uses other methods including 5M model, SHELL, FTA, MORT.								8	aviation, aircraft, (maritime), (rail), (oil&gas)	x	x	x	x		• [GAIN AFSA, 2003] • [Ayeko, 2002]
465.	ISRS (International Safety Rating System)	Tab	Org	1978	Safety culture audit tool that uses performance indicators, which are organised into groups. The scores on the sub-sets of safety performance areas are weighted and then translated into an overall index rating. ISRS consists of 15 key processes, embedded in a continual improvement loop. Each process contains subprocesses and questions. The questions are scored and commented, through interviews with process owners.	Qualitative. ISRS first edition was developed in 1978 by Frank Bird (DNV), following his research into the causation of 1.75 million accidents.								8	mining, manufacturing, nuclear, oil&gas, chemical, rail					x	• [ISRS brochure] • [Kennedy & Kirwan, 1998]
	JANUS					See HERA-JANUS															
	JAR-25					See EASA CS25.1309															
466.	Jelinski-Moranda model	Step	SwD	1972	This is a model that tends to estimate the number of remaining errors in a software product, which is considered a measure for the minimum time to correct these bugs.	Developed by Jelinski and Moranda of McDonnell Douglas Astronautics Company for use on Navy NTDS software and a number of modules of the Apollo program. Not considered very reliable, but can be used for general opinion and for comparison of software modules. See also Musa Models. See also Bug-counting model.							7		software		x				• [Bishop, 1990]
	JHA (Job Hazard Analysis)					See Job Safety Analysis. See also AET (Job Task Analysis)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
467.	JHEDI (Justification of Human Error Data Information)	Step	HRA, Task	1989	JHEDI is derived from the Human Reliability Management System (HRMS) and is a quick form of human reliability analysis that requires little training to apply. The tool consists of a scenario description, task analysis, human error identification, a quantification process, and performance shaping factors and assumptions. JHEDI is a moderate, flexible and auditable tool for use in human reliability analysis. Some expert knowledge of the system under scrutiny is required.	Developed by Kirwan et al. See also HRMS.								8	nuclear			x			• [HIFA Data] • [Kirwan, 1994] • [Kirwan, Part 1, 1998] • [PROMAI5, 2001]
	Job Process Chart					See OSD (Operational Sequence Diagram)															
468.	Job Safety Analysis	Step	Task	1960 about	This technique is used to assess the various ways a task may be performed so that the most efficient and appropriate way to do a task is selected. Each job is broken down into tasks, or steps, and hazards associated with each task or step are identified. Controls are then defined to decrease the risk associated with the particular hazards. Steps are: 1) Inventory occupations; 2. Inventory tasks within occupations; 3. Identify critical tasks; 4. Analyse critical tasks; 5. Write procedures and practices; 6. Put to work; 7. Update and maintain records.	Job Safety Analysis can be applied to evaluate any job, task, human function, or operation. A critical task is a task which has the potential to produce major loss to people, property, process and/or environment when not performed properly. Also referred to as Job Hazard Analysis (JHA) or Task Hazard Analysis.		2	3			6			oil&gas, chemical, manufacturing, healthcare			x	x		• [FAA00] • [ΣΣ93, ΣΣ97] • [FAA HFW] • [Gallant, 2001]
	Job Task Analysis					See AET. See also Job Safety Analysis.															
469.	Journaled Sessions	Tab	SwD	1993 or older	A journaled session is a way to evaluate the usability of software remotely. Users are provided with a disk or CD containing the prototype interface and are asked to perform a variety of tasks. The software itself captures information relative to the users' actions (keystrokes, mouseclicks). The software usually has dialog boxes that allow the user to input comments as well. Upon completion of the tasks the software is then returned for subsequent evaluation.	See also Self-Reporting Logs					5				software		x				• [Nielsen, 1993] • [FAA HFW]
470.	JSD (Jackson System Development)	Int	Des	1982	JSD is a system development method for developing information systems with a strong time dimension from requirements through code. JSD simulates events dynamically as they occur in the real world. Systems developed using JSD are always real-time systems. JSD is an object-based system of development, where the behaviour of objects is captured in an entity structure diagram. It consists of three main phases: the modelling phase; the network phase; and the implementation phase. JSD uses two types of diagrams to model a system, these are Entity Structure Diagrams and Network Diagrams. When used to describe the actions of a system or of an entity, JSD Diagrams can provide a modelling viewpoint that has elements of both functional and behavioural viewpoints. JSD diagrams provide an abstract form of sequencing description, for example much more abstract than pseudocode.	Developed by Michael A. Jackson and John Cameron. Considered for real-time systems where concurrency can be allowed and where great formality is not called for. Similarities with MASCOT. Tools available. Software requirements specification phase and design & development phase.		2							software		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
471.	KAOS (Knowledge Acquisition in autOmated Specification)	Stat	Des	1990	KAOS is a goal-oriented software requirements capturing approach which consists of a formal framework based on temporal logic and AI (artificial intelligence) refinement techniques where all terms such as goal and state are consistently and rigorously defined. The main emphasis of KAOS is on the formal proof that the requirements match the goals that were defined for the envisioned system. KAOS defines a goal taxonomy having 2 dimensions: Goal patterns (Achieve, Cease, Maintain, Avoid, Optimize.); Goal categories. Goal categories form a hierarchy. At the root of the hierarchy are system goals and private goals. System goals have the following sub-categories: Satisfaction goal, information goal, robustness goal, consistency goal, safety and privacy goal.	Designed by the University of Oregon and the University of Louvain (Belgium). Alternatively, KAOS stands for Keep All Objects Satisfied. See also i*. See also Goal Obstruction Analysis.		2				6			(manufacturing), (electronics), (healthcare)		x				• [Dardenne, 1993] • [KAOS Tutorial]
472.	KLM (Keystroke Level Model) or KLM-GOMS (Keystroke-Level Model GOMS)	Stat	Task	1983	KLM is an 11-step method that can be used to estimate the time it takes to complete simple data input tasks using a computer and mouse. It can be used to find more efficient or better ways to complete a task, by analyzing the steps required in the process and rearranging or eliminating unneeded steps. A calculation of the execution time for a task can be made by defining the operators that will be involved in a task, assigning time values to those operators, and summing up the times. Different systems can be compared based on this time difference. Uses: Obtain time predictions to compare systems of predict improvements. Input: Observable behaviour such as button pushes and mouse movements. Components: Six operators: K – keystroke or mouse movement; P – pointing to a target; D – moving the mouse to draw line segments; H – moving hands from mouse to keyboard; M – mental preparation; R – system response time	KLM is a simplified version of GOMS in that it focuses on very low level tasks. It is usually applied in situations that require minimal amounts of work and interaction with a computer interface or software design. See also CAT, CPM-GOMS, CTA, GOMS, GOMS, NGOMSL.		2					7		electronics, space			x			• [FAA HFW] • [Eberts, 1997] • [Hochstein, 2002] • [Card, 1983] • [John & Kieras, 1996]
473.	KTT (Kinetic Tree Theory)	Stat	Par	1969	Mathematical technique used to quantify top effect of fault trees, allowing for evaluation of instantaneous reliability or availability. Complete information is obtained from the existence probability, the failure rate, and the failure intensity of any failure (top, mode or primary) in a fault tree. When these three characteristics are determined, subsequent probabilistic information, both pointwise and cumulative, is obtained for all time for this failure. The application of the addition and multiplication laws of probability are used to evaluate the system unavailability from the minimal cut sets of the system.	Developed by W.E. Vesely (Idaho Nuclear Corporation) in 1969. Supported by computer program named KITT. Used for FTA.					5				nuclear, chemical, oil&gas	x					• [MUFTIS3.2-I, 1996] • [Vesely, 1970]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
474.	Laser Safety Analysis	Step	HzA	1960	This analysis enables the evaluation of the use of Lasers from a safety view. The purpose is to provide a means to assess the hazards of non-ionising radiation. As such, its intent is also to identify associated hazards and the types of controls available and required for laser hazards. Lasers are usually labeled with a safety class number, which identifies how dangerous the laser is, ranging from 'inherently safe' to 'can burn skin'.	Laser = Light Amplification by Stimulated Emission of Radiation. Theoretic foundations for the laser were established by Albert Einstein in 1917. The term LASER was coined by Gordon Gould in 1958. The first functional laser was constructed in 1960 by Theodore H. Maiman. Laser Safety Analysis is appropriate for any laser operation, i.e. construction, experimentation, and testing.			3			6			healthcare, defence	x					• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]
475.	Library of Trusted, Verified Modules and Components	Dat	Des		Well designed and structured PESs (Programmable Electronic Systems) are made up of a number of hardware and software components and modules which are clearly distinct and which interact with each other in clearly defined ways. Aim is to avoid the need for software modules and hardware component designs to be extensively revalidated or redesigned for each new application. Also to advantage designs which have not been formally or rigorously validated but for which considerable operational history is available.	Software design & development phase.								8	software, (rail)		x				• [EN 50128, 1996] • [Rakowsky]
	Likert Scale					See Rating Scales															
476.	Link Analysis (1)	Stat	Mod	1959	Is used to identify relationships between an individual and some part of the system. A link between two parts of the system will occur when a person shifts his focus of attention, or physically moves, between two parts of the system. A link between components represents a relationship between those components. The relationship may be shown by the thickness of the link.	Typical applications include equipment layout for offices and control rooms, and the layout of display and control systems.		2							nuclear, healthcare, ergonomics, defence, navy	x					• [Kirwan & Ainsworth, 1992] • [Kirwan, 1994] • [HEAT overview] • [Luczak, 1997] • [Wickens & Hollands, 1999] • [MIL-HDBK, 1999] • [Beevis, 1992]
477.	Link Analysis (2)	Math	Mod	1976	This is a collection of mathematical algorithms and visualisation techniques aimed at the identification and convenient visualisation of links between objects and their values in a network.	Developed in 1976 by Gabriel Pinski and Francis Narin. Tools available. Can be used in conjunction with Timeline Analysis to help determine travel times, etc. Also used by Google search engine for relevance rating, and by social media such as Facebook, Youtube.		2							management, social, police, electronics, finance, healthcare	x					• [PageRank web] • [Reena & jYoti Arora, 2015]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
478.	LISA (Low-level Interaction Safety Analysis)	Step	HzA	1999 or older	LISA was developed to study the way in which an operating system manages system resources, both in normal operation and in the presence of hardware failures. Instead of analysing the system functionality, LISA focuses on the interactions between the software and the hardware on which it runs. A set of physical resources and timing events is identified, and a set of projected failure modes of these resources is considered. The aim of the analysis is to use a combination of inductive and deductive steps to produce arguments of acceptability demonstrating either that no plausible cause can be found for a projected failure, or that its consequences would always lead to an acceptable system state. Step 1: Agree principles for acceptability; Step 2: Assemble source material; Step 3: Analyse timing events; Step 4: Analyse physical resources.	Developed by University of York. See also Interface testing. See also HSIA. See also Interface Analysis.				4	5				(avionics), defence	x	x				• [Pumfrey, 1999]
479.	Littlewood	Math	SwD	1957	Mathematical model that tends to provide the current failure rate of a program, and hence minimum time required to reach a certain reliability.	Not considered very reliable, but can be used for general opinion and for comparison of software modules.					5				(software)		x				• [Bishop, 1990]
480.	Littlewood-Verrall	Math	SwD	1957	A Bayesian approach to software reliability measurement. Software reliability is viewed as a measure of strength of belief that a program will operate successfully. The value of the hazard rate is modelled as a random variable. One of the parameters of the distribution of this random variable is assumed to vary with the number of failures experienced. The value of the parameters of each functional form that produce the best fit for that form are determined. Then the functional forms are compared (at the optimum values of the parameters) and the best fitting form is selected.	Not considered very reliable, but can be used for general opinion and for comparison of software modules.					5				(software)		x				• [Bishop, 1990] • [Narkhede, 2002]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
481.	Logic Diagram	Gen	Mod	300 or 1761	A Logic Diagram is intended to provide structure and detail as a primary hazard identification procedure. Its graphic structure is a means of capturing and correlating the hazard data produced by the other tools. Because of its graphic display, it can also be a hazard-briefing tool. There are three types of Logic Diagrams. (1) The Positive diagram is designed to highlight the factors that must be in place if risk is to be effectively controlled in the operation. It works from a safe outcome back to the factors that must be in place to produce it. (2) The Event diagram focuses on an individual operational event (often a failure or hazard identified using the "What If" tool) and examines the possible consequences of the event. It works from an event that may produce risk and shows what the loss outcomes of the event may be. (3) The Negative diagram selects a loss event and then analyzes the various hazards that could combine to produce that loss. It works from an actual or possible loss and identifies what factors could produce it.	Closely related techniques are FTA, ETA, RBD. Many other examples of Logic Diagrams have been described, such as Begriffsschrift, Binary decision diagrams, Concept maps, Implication diagrams, Kripke models, Venn diagrams, Euler diagrams, Existential graphs, Spider diagrams, Carroll diagrams, Karnaugh maps, Operation tables, Truth tables, Argument maps, Porphyrian trees, and Semantic tableaus. Some of these formalisms are quite old, e.g. Begriffsschrift dates from 1879. Venn diagrams date from 1880. Euler diagrams date from 1712. Porphyrian trees date from about the 3rd century AD. According to [MacQueen, 1967], the modern Logic Diagram dates from 1761.				4					all	x					• [FAA00] • [MacQueen, 1967]
	LOMS (Line Operations Monitoring System)					See Flight Data Monitoring Analysis and Visualisation															
482.	LOPA (Layer of Protection Analysis)	Tab	Mit	2001	A tabular representation of both the risk factors and the risk mitigating factors is used to determine a safety integrity level (SIL). LOPA starts by quantifying the consequences and likelihood of a hazardous event in the absence of any forms of protection or risk mitigation measures: the underlying process risk is defined. Potential risk reduction measures are then systematically analysed and their impact on the process risk is quantified to determine a mitigated risk. The mitigated risk is compared with risk targets, which then determines a risk reduction factor to be provided. The risk reduction factor translates directly into a SIL. A detailed LOPA procedure is required to define categories for hazardous event consequences, and guideline risk reduction factors for typical protection layers. Calibration of the LOPA procedure is needed to ensure that defined risk acceptability criteria are met.	Developed by the American Institute of Chemical Engineers Centre for Chemical Process Safety (CCPS) in response to the requirements of ISA S84.01 and was formally published in 2001 under the title 'Layer of Protection Analysis, Simplified Process Risk Assessment'. Reference [ACM, 2006] lists some advantages and disadvantages.					5	6			chemical, nuclear, oil&gas	x					• [Gulland, 2004] • [ACM, 2006] • [Summers, 2002]
483.	LOS (Level of Safety)	Math	Col	2000	Assessment of a Level of Safety for a dedicated block of airspace expressed as probability to encounter aircraft conflicts. LOS is a tool to quantify the potential hazards for persons or goods involved in aviation. Traffic behaviour, traffic level and infrastructure layout form individual scenarios for which a LOS figure can be computed. Intended to support procedure design and allow to increase the stakeholder's situational awareness to bottlenecks and to judge new concepts.	Current investigations focus on the TMA (Terminal Manoeuvring Area).				4	5				(ATM)	x		x			• [GfL web] • [GfL, 2001] • [TUD, 2005]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
484.	LOSA (Line Observation Safety Audit)	Dat, Step	HRA, Trai	1991	LOSA aims at identifying threats to aviation safety, minimize the risks such threats may generate and implement measures to manage human error in operational contexts. It aims to enable operators to assess their level of resilience to systemic threats, operational risks and front-line personnel errors, thus providing an approach to prioritize and implement actions to enhance safety. LOSA uses expert and trained observers to collect data about flight crew behaviour and situational factors on "normal" flights. The audits are conducted under strict no-jeopardy conditions; flight crews are not held accountable for their actions and errors that are observed. During flights that are being audited, observers record and code potential threats to safety; how the threats are addressed; the errors such threats generate; how flight crews manage these errors; and specific behaviours that have been known to be associated with accidents and incidents.	LOSA is closely linked with Crew Resource Management (CRM) training. Since CRM is essentially error management training for operational personnel, data from LOSA form the basis for contemporary CRM training refocus and/or design known as Threat and Error Management (TEM) training. The original version was aimed at cockpit operations; recent versions also cover maintenance and platform.							7	8	aviation			x	x	x	• [ICAO Doc 9803]
485.	LOTOS (Language for Temporal Ordering Specification)	Int	Des	1987	Formal Method. A means for describing and reasoning about the behaviour of systems of concurrent, communicating processes. Is based on CCS (Calculus of Communicating Systems) with additional features from related algebras CSP (Communicating Sequential Processes) and Circuit Analysis (CIRCAL). Describes the order in which events occur.	Software requirements specification phase and design & development phase.		2							software		x				• [EN 50128, 1996] • [Rakowsky]
	Low-Fidelity Prototyping					See Prototyping															
486.	LSCAT approach (Loughborough University Safety Climate Assessment Toolkit)	Tab	Org	1999	Aims to assess safety climate and to aid the promotion of a positive safety culture in the offshore environment. Four main dimensions are discussed with questionnaires: Organisational context, Social environment, Individual appreciation, and Work environment. Each dimension has several items. Another five dimensions are explored with interviews and focus groups: Co-operation, Competence and training, Management style, Managing change, and Shared values.	Developed in Loughborough University.								8	oil&gas					x	• [Mkrtchyan & Turcanu, 2012]
	MABA-MABA (Men are better at, Machines are better at)					See Fitts list															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
487.	MA-DRM (Multi-Agent Dynamic Risk Modelling)	Dyn, Int	Mod, OpR	2003	MA-DRM uses scenario-based Monte Carlo simulations and uncertainty evaluations to analyse the safety risk of future or current air traffic operations. It includes the development of a Multi-Agent stochastic dynamic risk model of the air traffic scenario, which defines the stochastic dynamics of agents (human operators and technical systems) in the air traffic scenario considered, as well as their dynamic interactions. Here, the dynamics and interactions include deterministic and stochastic relationships, as is appropriate for the human performance or system considered. The methodology incorporates a risk bias and uncertainty assessment, including sensitivity analysis, which gives insight into the extent to which the various agents contribute to both safety and safety risk.	MA-DRM was developed as part of the TOPAZ methodology, where typically, the stochastic dynamic model is formulated as an SDCPN (Stochastically and Dynamically Petri Net).	1	2	3	4	5	6		8	ATM	x	x	x	x	x	• [Blom & Stroeve & DeJong, 2006] • [Stroeve et al, 2011] • [Everdij et al, 2006] • [Stroeve et al, 2003] • [Stroeve et al, 2013]
488.	MAIM (Merseyside Accident Information Model)	Dat, Tab	Ret	1987	MAIM is a method of recording information on accidents, in order to trace an accident back to the first unforeseen event. It attempts to capture all relevant information in a structured form so that sets of similar accidents can be compared to reveal common causes. The concept is to identify the first unexpected event, perceived by the injured person, and to trace all subsequent events which lead to injury. Events are short sentences which can produce a brief report. MAIM records event verbs and objects in the environment. In addition, it records personal information and other components which may be relevant to the accidents. MAIM can be represented in a diagram.	Developed by Derek Manning, an occupational physician. Focused on studying injuries due to e.g. occupational or household events.								8	manufacturing, ergonomics	x		x	x		• [Kjellen, 2000] • [Liverpool, 2004] • [MAIM web] • [Davies & Shannon, 2011]
489.	MANAGER (MANagement Assessment Guidelines in the Evaluation of Risk)	Tab	Org	1990	Aims to assess the performance of the safety management system and provides recommendations for improvement. MANAGER is an auditing-based method, in which questionnaires are used to evaluate performance indicators associated with specific plant departments, such as operations and maintenance. Indices associated with the "quality" of these departments then are developed to provide a score relative to industry norms. The tool consists of approximately 114 questions, divided into 12 areas such as Written procedures, Safety policy, Formal safety studies, Organisational factors, etc.	MANAGER was the first technique to consider linking up ratings on its audit questions with PSA results.								8	chemical					x	• [Kennedy & Kirwan, 1998] • [Kirwan, 1994]
	Mapping Tool					See ZA or ZSA (Zonal (Safety) Analysis)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
490.	MAPPS (Maintenance Personnel Performance Simulations)	FTS	HFA, Task	1984	Computer-based, stochastic, task-oriented model of human performance. It is a tool for analysing maintenance activities in nuclear power plants, including the influence from environmental, motivational, task and organisational variables. Its function is to simulate a number of human 'components' to the system, e.g. the maintenance mechanic, the instrument and control technician together with any interactions (communications, instructions) between these people and the control-room operator.					4	5				(nuclear)			x	x	x	• [Kirwan, 1994] • [MIL-HDBK, 1999] • [THEMES, 2001]
491.	Markov Chains or Markov Modelling	Math	Mod	1906	Equal to SSG where the transitions to the next stage only depend on the present state. Only for this type of SSG, quantification is possible. Can be used to evaluate the reliability or safety or availability of a system.	Named after Russian mathematician A.A. Markov (1856-1922). Standard model for dependability evaluation of redundant hardware. Also used for decision making. Combines with FMEA, FTA, CCDM or CCA. Tools available.				4	5				manufacturing, chemical, finance, management, energy, environment, aircraft	x	x				• [Bishop, 1990] • [EN 50128, 1996] • [FT handbook, 2002] • [MUFTIS3.2-I, 1996] • [NASA-GB-1740.13-96] • [Rakowsky] • [Sparkman, 1992] • [Storey, 1996]
492.	Markov Latent Effects Tool	Math	Org	1999	The Markov Latent Effects Tool aims at the quantification of safety effects of organisational and operational factors that can be measured through "inspection" or surveillance. The tool uses a mathematical model for assessing the effects of organisational and operational factors on safety. For example, organisational system operation might depend on factors such as accident/incident statistics, maintenance personnel/operator competence and experience, scheduling pressures, and safety culture of the organisation. Because many of the potential metrics on such individual parameters could be difficult (and generally uncertain) to determine, the method includes guidance for this. Also, there may be ill-defined interrelations among the contributors, and this is also addressed through "dependence" metrics.	Markov Latent Effects Model is based on a concept wherein the causes for inadvertent operational actions are traced back through latent effects to the possible reasons undesirable events may have occurred. The Markov Latent Effects Model differs substantially from Markov processes, where events do not depend explicitly on past history, and Markov chains of arbitrary order, where dependence on past history is completely probabilistic.					5				aviation, aircraft				x	x	• [GAIN AFSA, 2003] • [Cooper, 2001] • [FAA HFW]
493.	MARS (Major Accident Reporting System)	Dat	Dat. Ret	1984	MARS was established to gather information regarding 'major accidents' and other events with 'unusual characteristics' in the nuclear processing domain.	Established by EU.								8	nuclear, oil&gas, chemical	x	x	x	x	x	• [Salmon et al., 2005]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
494.	MASA Propagation Model (Multi-Agent Situation Awareness Propagation Model)	Gen	Mod	2001 about	The Situation Awareness of an operator may be erroneous for several reasons, e.g., wrong perception of relevant information, wrong interpretation of perceived information, wrong prediction of a future state and propagation of error due to agent communication. A situation awareness error can evolve and expand as it is picked up by other humans or agents (‘Chinese whispering’). This error propagation between multiple agents can be modelled and analysed using e.g. stochastic hybrid models.	Chinese whispering is a game in which the first player whispers a phrase or sentence to the next player. Each player successively whispers what that player believes he or she heard to the next. The last player announces the statement to the entire group. Errors typically accumulate in the retellings, so the statement announced by the last player differs significantly, and often amusingly, from the one uttered by the first.				4					ATM			x	x		• [DiBenedetto et al, 2005] • [Stroeve & Blom & Park, 2003] • [Stroeve et al, 2012] • [Blom & Stroeve, 2004]
495.	MASCOT (Modular Approach to Software Construction, Operation and Test)	Stat	Des	1975	A method for software design aimed at real-time embedded systems from the Royal Signals and Research Establishment, UK. It is not a full method in the current sense of design methodology. It has a notation and a clear mapping between the design and physical components. MASCOT III copes better with large systems than did earlier versions, through better support for the use of sub-systems.	MASCOT originated within the UK defence industry in the 1970s. The MASCOT III standard was published in its final form in 1987. Considered for real-time systems where concurrency has to and can be used. Related to JSD. Tools available. Software requirements specification phase and design & development phase.		2				6			avionics, defence		x				• [Bishop, 1990] • [EN 50128, 1996] • [MASCOT handbook] • [Rakowsky]
496.	Materials Compatibility Analysis	Step	HzA	1988 or older	Materials Compatibility Analysis provides an assessment of materials utilised within a particular design. Any potential physical degradation that can occur due to material incompatibility is evaluated on potential contributory hazards or failures that can cause mishaps to occur. Material compatibility is critical to the safe operation of a system and personnel safety. The result of a material misapplication can be catastrophic.	Materials Compatibility Analysis is appropriate throughout most systems. Proper material compatibility analysis requires knowledge of the type, concentration and temperature of fluid(s) being handled and the valve body and seal material.			3		5				chemical, oil&gas, space, defence, nuclear, maritime	x					• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]
497.	MBSA (Model Based Safety Analysis)	Int	HzA	2005	MBSA is an approach in which the system and safety engineers share a common system model. The system design process captures, using a modelling language, the architecture and functional behaviour of the system under normal operating conditions (nominal model behaviour).The safety process augments the nominal model with failure mode models, failure condition formulae, and common cause events. The resulting model is called the Failure Propagation Model (FPM). The analyst applies a software application to perform an analysis of the system FPM and generate outputs such as failure sequences, minimal cutsets, or other results. These fault simulation scenario outputs are evaluated by safety engineers as part of the overall safety assessment process.	Developed as part of ARP4761A. The MBSA methodology may vary due to the type and capability of the system modelling languages, the extent to which nominal behaviour is captured, and the range of output results. These variants allow the methodology to be adapted to different scopes of analysis and varying complexity/ detail of the systems being modelled. Techniques that may be used are FTA, CCA, FMEA.			3	4	5	6			aircraft	x	x				• [Joshi et al, 2006]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
498.	MCA Analysis (Maximum Credible Accident Analysis) or WCA (Worst Case Analysis)	Step	OpR, Mit	1972 or older	This technique aims to determine the scenarios with the worst possible outcome but that are still credible, and to develop strategies to mitigate the consequences of these accidents. MCA analysis does not include quantification of the probability of occurrence of an accident. In practice, the selection of accident scenarios for MCA analysis is carried out on the basis of engineering judgement and past accident analysis.	Similar to Scenario Analysis, this technique is used to conduct a System Hazard Analysis.				4		6			oil&gas, nuclear, chemical, environment, (aircraft), (aviation)	x					• [FAA00] • [ΣΣ93, ΣΣ97] • [Oil India]
	MCDA (Multi-Criteria Decision Analysis)					See MCDM (Multiple Criteria Decision Making)															
499.	MCDET (Monte Carlo Dynamic Event Tree)	FTS	Mod	2006	MCDET couples DDET with discrete event Monte Carlo (MC) Simulation to investigate in a more efficient way (by acceleration of simulation) the whole tree of events. Discrete-valued variables are treated by DDET, whereas continuous-valued variables are handled by discrete event MC simulation. For each set of values provided by the discrete event MC simulation, MCDET generates a new DDET.	Developed by Gesellschaft für Anlagen- und Reaktorsicherheit (GRS).					5				nuclear	x					• [Kloos & Peschke, 2006] • [Hofer et al, 2001]
500.	MCDM (Multiple Criteria Decision Making) or MCDA (Multiple Criteria Decision Analysis)	Gen, Math	Dec	1960	MCDM is a sub-discipline of operations research that explicitly considers multiple criteria (e.g. cost, quality, safety, efficiency) in decision-making environments. It can be used to identify and model key factors to rank/evaluate scenarios about safety risk. Typically, there does not exist a unique optimal solution and it is necessary to use decision maker's preferences to differentiate between solutions. Normally one has to "tradeoff" certain criteria for others. A major distinction between MCDM problems is based on whether the solutions are explicitly or implicitly defined. In the latter case, the number of alternatives is usually very large or even infinite.	Many specific MCDM methods exist; see e.g. AHP. Different methods require different types of raw data and follow different optimization algorithms. Some techniques rank options, some identify a single optimal alternative, some provide an incomplete ranking, and others differentiate between acceptable and unacceptable alternatives. Numerous applications. See also Brown-Gibson model, SLIM.					5				road, finance, manufacturing, management, nuclear, environment, oil&gas, social	x	x	x	x	x	• [Linkov et al., 2004] • [Koksalan et al., 2011]
501.	MDTA (Misdiagnosis Tree Analysis)	Stat	OpR	2005	The MDTA process starts with a given scenario defined in terms of an initiating event. To identify diagnosis failures, a misdiagnosis tree is compiled with the procedural decision criteria as headers and the final diagnoses as end states. In connection with each decision criterion presented in the header, the analyst is guided to consider three types of contributors to diagnosis failures. • Plant dynamics: mismatch between the values of the plant parameters and the decision criteria of the diagnostic rule of the emergency operating procedure due to dynamic characteristics. • Operator error: errors during information gathering or rule interpretation. • Instrumentation failure: problems in the information system.	Developed at Korean Atomic Energy Research Institute.			3	4	5				nuclear	x		x			• [Kim et al, 2005] • [Reer, 2008]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
502.	Measurement of Complexity	Gen	SwD	1981 or older	Software's complexity is evaluated in order to determine if the level of complexity may contribute to areas of concern for workability, understandability, reliability and maintainability. Highly complex data and command structures are difficult, if not impossible, to test thoroughly and can lead to errors in logic either in the initial build or in subsequent updates. Complexity can be measured via McCabe's metrics, Halstead's metrics, or similar techniques. One can also examine critical areas of the detailed design and any preliminary code for areas of deep nesting, large numbers of parameters to be passed, intense and numerous communication paths, etc. Output products are complexity metrics, predicted error estimates, and areas of high complexity identified for further analysis or consideration for simplification.	Complex software may increase the likelihood of errors, is more likely to be unstable, or may suffer from unpredictable behaviour. Modularity is a useful technique to reduce complexity. See also Avoidance of Complexity.							7		software		x				• [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky]
503.	MEDA (Maintenance Error Decision Aid)	Int	HRA, Mit	1995	MEDA is a widely used attempt to systematise evaluation of events, problems and potential problems by using a repeatable, structured evaluation program. It is a structured investigation process used to determine the factors that contribute to errors committed by maintenance technicians and inspectors. MEDA is also used to help develop corrective actions to avoid or reduce the likelihood of similar errors. Most of these corrective actions will be directed towards the airline maintenance system, not the individual technical or inspector. The MEDA process involves five basic steps: Event, Decision, Investigation, Prevention Strategies, and Feedback.	MEDA was developed by Boeing as part of the Boeing Safety Management System (BSMS). Link to PEAT, REDA and CPIT. HFACS-ME is a Maintenance Extension of HFACS, similar to MEDA, applicable to navy maintenance events.								8	aircraft				x	x	• [Bongard, 2001] • [Escobar, 2001] • [HIFA Data] • [MEDA] • [FAA HFW] • [MEDA Users Guide]
504.	Memorizing Executed Cases	Step	Mit	1987	Aim is to force the software to fail-safe if it executes an unlicensed path. During licensing, a record is made of all relevant details of each program execution. During normal operation each program execution is compared with the set of licensed executions. If it differs a safety action is taken.	Little performance data available. Related to testing and fail-safe design. Software architecture phase. See also Fail Safety. See also Vital Coded Processor. Also referred to as Execution Flow Check. Related to Watchdog Timers.						6			software		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]
505.	MERMOS (Méthode d'Evaluation de la Réalisations des Missions Opérateur pour la Sureté)	Stat	HRA	1998	MERMOS is a HRA method based on the notion of Human Factor Missions, which refer to a set of macroactions the crew has to carry out in order to maintain or restore safety functions. Four major steps are involved in the MERMOS method. 1) Identify the safety functions that are affected, the possible functional responses, the associated operation objectives, and determine whether specific means are to be used. 2) Break down the safety requirement corresponding to the HF mission. 3) Bridge the gap between theoretical concepts and real data by creating as many failure scenarios as possible. 4) Ensure the consistency of the results and integrate them into PSA event trees.	Developed by Electricité de France, since early 1998. See also MONACOS.				4					nuclear			x			• [HRA Washington, 2001] • [Bieder et al., 1998] • [Jeffcott & Johnson, 2002] • [Straeter et al, 1999] • [THEMES, 2001] • [Wiegman et al, 2000]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
506.	MES (Multilinear Events Sequencing)	Int	OpR, Ret	1975	MES is an integrated system of concepts and procedures to investigate a wide range of occurrences, before or after they happen. It treats incidents as processes, and produces descriptions of the actions and interactions required to produce observed process outcomes. The descriptions are developed as matrix-based event flow charts showing the coupling among the interactions with links where sequential, if-then and necessary and sufficient logic requirements are satisfied. The investigations focus on behaviours of people and objects, demonstrating what they did to influence the course of events, and then defining candidate changes to reduce future risks.	The first version of MES was developed in 1975 by Starline Software. See also STEP.								8	police, aviation, chemical	x		x	x	x	• [GAIN AFSA, 2003] • [MES guide] • [Benner, 1975] • [MES tech] • [FAA HFW]
507.	MHD (Mechanical Handling Diagram)	Tab	HzA	1998 or older	Mechanical HAZOP.				3			6			nuclear	x					• [Kennedy & Kirwan, 1998]
	Micro-SAINT (Micro-Systems Analysis by Integrated Networks of Tasks)					See SAINT (Systems Analysis of Integrated Networks)															
508.	MIDAS (Man-Machine Integrated Design and Analysis System)	Int	HFA	1986	MIDAS is an integrated suite of software components to aid analysts in applying human factors principles and human performance models to the design of complex human systems; in particular, the conceptual phase of rotorcraft crewstation development and identification of crew training requirements. MIDAS focuses on visualisation, contains different models of workload and situation awareness within its structure and contains an augmented programming language called the Operator Procedure Language (OPL) incorporated into its programming code.	Developed by Jim Hartzell, Barry Smith and Kevin Corker in 1986, although the original software has been changed since. MIDAS v5 contains a visualization capability associated with the physical and cognitive operations in their respective contexts. Sometimes referred to as NASA MIDAS to distinguish it from its augmented version Air-MIDAS. See also Air-MIDAS.	1	2		4	5				(aircraft), nuclear, space, aviation, police, defence, navy			x	x		• [HAIL] • [GAIN ATM, 2003] • [Morrison, 2003] • [FAA HFW] • [Gore, 2010]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
509.	Mission Analysis	Int	OpR, Task	1971 or older	Is used to define what tasks the total system (hardware, software, and liveware) must perform. The mission or operational requirements are a composite of requirements starting at a general level and progressing to a specific level. Has two components: • Mission Profile. Provides a graphic, 2D representation of a mission segment. Represents the events or situations that maintainers or operators could confront in a new system. Mission profiles are mostly applicable in the conceptual phase. Mission profiles are highly effective for gross analysis. Relative complexity is simple. • Mission Scenario. Is a detailed narrative description of the sequence of actions and events associated with the execution of a particular mission. A description of each distinct event occurring during the mission. The events should be described from the human's perspective as s/he interacts with the system. The scenarios should describe operator actions and system capabilities needed to complete the mission. The detail of the narrative will depend on its purpose. It is useful to describe all essential system functions that would be overlooked, such as failure modes and emergency procedures.	Two methods, Mission Profile, and Mission Scenarios are especially useful for mission analysis. Alternative name for Mission Profile is Graphic Mission Profile. Alternative name for Mission Scenario is Narrative Mission Description. The information from the mission scenario can be used for Functional Flow Diagrams (FFD), Decision/Action Diagrams (DAD), and Action/ Information Requirements for the system.		2							defence, navy, space	x	x	x			• [HEAT overview] • [MIL-HDBK, 1999] • [FAA HFW] • [Beevis, 1992]
	Mission Profile					See Mission Analysis.															
	Mission Scenarios					See Mission Analysis.															
510.	MLD (Master Logic Diagram)	Stat	Mod	1983	Deductive approach similar to a high-level fault tree, but without the formal properties of the latter. MLD aim at identification of the initiating events that can lead to accidents or mission failure (what could go wrong). Four levels: first level is the top event, second level are formed by loss of functions leading to this top event, third level are the system failures leading to the loss of functions. Fourth level are the initiators.	See also MPLD.				4					chemical, space, nuclear	x		x			• [Mauri, 2000] • [Statematelatos]
511.	MMS (Maintenance Management System)	Dat	Dat	1985	MMS supports general maintenance logging, which contributes to daily system performance and incident reporting. The system tracks labor, materials, equipment and contract cost for activities performed by route and location. The system emphasizes economic use of personnel, equipment and materials. The basic building block upon which the MMS has been constructed is an individual activity. Maintenance activities have been subdivided to reflect the variety of duties, which are performed. The MMS allows for: Planning, Budgeting, Scheduling, Performing, Reporting, Analyzing maintenance activities.	Automatic reporting data.							7		road, environment	x					• [ATO SMS Manual v3.0] • [MMS, Chap 2] • [F&WS Handbooks, 2011]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
512.	MMSA (Man-Machine System Analysis)	Stat	HRA	1983	MMSA aims at identifying and reducing idle times for worker and/or machine, to minimize the overall operation cycle time. The MMSA steps are: 1) Definition: analysis of different types of human actions; 2) Screening: identify the different types of human interactions that are significant to the operation and safety of the plant; 3) Qualitative analysis: detailed description of the important human interactions and definition of the key influences; 4) Representation: modelling of human interactions in logic structures; 5) Impact integration: exploration of the impact of significant human actions; 6) Quantification: assignment of probabilities of interactions; 7) Documentation: making the analysis traceable, understandable and reproducible.	The MMSA steps can be arranged as a subset of the SHARP process, which is a qualitative screening method which is applied in HRA prior to full quantification; it filters out errors that are apparently incapable of affecting the system goal.		2	3		5				manufacturing, maritime, energy, nuclear	x		x			• [Straeter, 2001]
513.	Modelica	Gen	Mod	1997	Modelica is an object-oriented, declarative, multi-domain modelling language for modelling of systems containing mechanical, electrical, electronic, hydraulic, thermal, control, electric power or process-oriented subcomponents. Focus is on differential equations.	The Modelica language is developed by the non-profit Modelica Association, which also develops a Standard Library that contains over a thousand generic model components and functions in various domains.		2		4					manufacturing, energy	x					• https://www.modelica.org/
514.	Modelling	Gen	Mod		A model is anything used in any way to represent anything else. A few examples are Computer models, Mathematical models, Scientific models, Logical models. There are many forms of modelling techniques that are used in system engineering. Failures, events, flows, functions, energy forms, random variables, hardware configuration, accident sequences, operational tasks, all can be modelled.	Modelling is appropriate for any system or system safety analysis. See also Computer Modelling and simulation. See also Performance Modelling.				4					all	x	x	x	x	x	• [FAA00] • [ΣΣ93, ΣΣ97]
515.	MoFL (Modell der Fluglotsenleistungen (Model of air traffic controller performance))	Int	HRA	1997	MoFL is a model of the cognitive performance of experienced air traffic controllers in en-route control. The model focuses on information acquisition and representation of the traffic situation. MoFL's architecture comprises five modules: data selection, anticipation, conflict resolution, updates, and control derived from previous research. The implementation of the model MoFL is based on a production system in the programming language ACT-R (Adaptive Control of Thought - Rational).	See also ACT-R.				4					(ATM)			x			• [Leuchter et al, 1997] • [Leuchter, 2009] • [Niessen & Eyferth, 2001] • [Niessen & Leuchter & Eyferth,1998]
516.	MONACOS	Step ?	Ret	1999	MONACOS is a method of retrospective analysis of actual accidents and incidents. Based on MERMOS.					4					(nuclear)			x			• [HRA Washington, 2001] • [Le Bot & Ruiz, 2003]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
517.	Monte Carlo Simulation	FTS	Mod ?	1777	The objective of Monte Carlo simulation is to obtain a quantitative outcome from a given model by translating variation or uncertainties in model inputs to variation or uncertainties in model outputs. Each input parameter of the model is assumed to be described by a probability density function (pdf). In a MC simulation, all model input parameters are given values which are selected from their respective pdfs, and the model is simulated to obtain an output result. This procedure is repeated a large number of times. The outcome is a large number of separate and independent model output results. These results are assembled into a probability distribution or expected value for the output parameter of interest.	Reportedly, the method was first used by the Comte de Buffon, George Louis Leclerc, in 1777, to estimate the value for π. The name stems from WW II, and was coined by Stanislaw Ulam, who claimed to be stimulated by playing poker; the name refers to the Monte Carlo Casino in Monte Carlo, Monaco. This method is often used when the underlying model is complex, nonlinear, or involves more than just a couple of uncertain parameters.				4	5				ATM, aircraft, finance, road, environment, space, chemical, electronics, management, energy, leisure	x	x	x	x	x	• [EN 50128, 1996] • [MUFTIS3.2-I, 1996] • [Rakowsky] • [Sparkman, 1992] • [GAIN ATM, 2003] • [GAIN AFSA, 2003]
518.	MORS (Mandatory Occurrence Reporting Scheme)	Dat	Dat	1972	Primary purpose is to secure free and uninhibited reporting, and dissemination of the substance of the reports, where necessary, in the interest of flight safety. It covers operators, manufacturers, maintenance, repair and overhaul, air traffic control services, and aerodrome operators. Only certain kinds of incidents, namely, those that are "endangering" or "potentially endangering," are subject to mandatory reporting; others are not. Reporting of "day-to-day defects/incidents, etc" is discouraged. These are left to the CAA's Occurrence Reporting Scheme.	MORS was established by the United Kingdom Civil Aviation Authority (CAA) following a fatal accident in 1972.								8	aviation, ATM, airport, aircraft	x		x	x		• [GAIN ATM, 2003] • [CAP 382, 2011]
519.	MORT (Management Oversight and Risk Tree Analysis)	Stat	Ret	1972	MORT technique is used to systematically analyse an accident in order to examine and determine detailed information about the process and accident contributors. To manage risks in an organisation, using a systemic approach, in order to increase reliability, assess risks, control losses and allocate resources effectively. Is standard fault tree augmented by an analysis of managerial functions, human behaviour, and environmental factors. MORT is accomplished using the MORT diagrams, of which there are several levels available. The most comprehensive has about 10,000 blocks, a basic diagram has about 300 blocks. It is possible to tailor a MORT diagram by choosing various branches of the tree and using only those segments. The MORT is essentially a negative tree, so the process begins by placing an undesired loss event at the top of the diagram used. The user then systematically responds to the issues posed by the diagram. All aspects of the diagram are considered and the "less than adequate" blocks are highlighted for risk control action.	Originally developed in 1972 for US nuclear industry. This is an accident investigation technique that can be applied to analyse any accident. Useful in project planning, functional specification of a target (sub)system, accident/ incident analysis and safety programme evaluation. Since even the simplest MORT chart contains over 300 blocks, the full application of MORT is time-consuming and costly. Tools available. See also SMORT, Barrier Analysis, ETBA, HPIP, HSYS, ISA, STEP.								8	nuclear, (space)	x		x	x	x	• [Bishop, 1990] • [FAA00] • [Kirwan & Ainsworth, 1992] • [Kirwan, 1994] • [Leveson, 1995] • [ΣΣ93, ΣΣ97] • [FAA HFW]
520.	MPLD (Master Plan Logic Diagram)	Stat	Mod	1987	Outgrowth model of MLD (Master Logic Diagram), to represent all the physical interrelationships among various plant systems and subsystems in a simple logic diagram.					4					maritime, oil&gas	x					• [Mauri, 2000]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
521.	MRT (Multiple Resource Theory)	Stat	HFA, Mod	1984	The Multiple Resource Theory offers predictions of patterns of interference between competing tasks during periods of time-sharing. The theory has made the global assumption that interference is minimised when different resources are demanded. This assumption has been empirically validated in experiments. There are 4 dimensions to resources: (1) Stages – Perceptual/central processing vs. response selection/execution (2) Input modalities - Auditory vs. visual (3) Processing codes - Spatial vs. verbal (4) Responses - Vocal vs. manual	Proposed by C.D. Wickens in 1984, with a revision in 2002. Also referred to as an example of a (Human) Information Processing Model.				4					ATM, aviation, leisure, nuclear			x			• [Wickens, 2002] • [Wickens, 1992] • [Parasuraman & Rovira, 2005]
522.	MSC (Message Sequence Chart)	Stat	Des	1992	MSC is a graphical way of describing asynchronous communication between processes. A chart does not describe the total system behaviour, but is rather a single execution trace. For this reason an extension to MSCs, called High Level MSCs has also been proposed; HLMSCs allow for the combination of traces into a hierarchical model. MSCs have been used extensively in telecommunication systems design and in particular with the formal Specification and Description Language (SDL). They are used at various stages of system development including requirement and interface specification, simulation, validation, test case specification and documentation. HLMSCs have greatly increased the descriptive capabilities of MSCs as they allow for modular specifications.	MSC specifications have found their way into many software engineering methodologies and CASE tools, in particular in the area of telecommunications and concurrent real-time systems. MSC Specifications often represent early life-cycle requirements and high-level design specifications.		2							software		x				• [MSC]
523.	Multiple Greek Letters method	Step	Par	1983	Is used to quantify common cause effects. It involves the possible influences of one component on the other components of the same common cause group. Slight generalisation of Beta-factor method when the number of components involved is greater than two.	Developed by Fleming and Kalinowski. See also Beta-factor method.					5				nuclear	x					• [Charpentier, 2000] • [Mauri, 2000] • [MUFTIS3.2-I, 1996] • [Guey, 1984]
524.	Murphy Diagrams	Stat	HRA, Ret	1981	Method starts from a description of an accident (or significant error sequence) and then an attempt is made to identify all the individual sources of error which occurred, using a standard set of eight Murphy diagrams (fault-tree-like diagrams) to describe these errors. These Murphy diagrams define, at a general level, all the likely errors associated with decision processes. Retrospective.	Developed by R.W. Pew et al. Apparently not in current use or else used rarely. Name is based on the axiom of Murphy's law (dated around 1952), which states that 'if anything can go wrong, it will'.			3						energy, aviation, (rail)			x			• [Kirwan & Ainsworth, 1992] • [Kirwan, 1994] • [Kirwan, Part 1, 1998]
525.	Musa models	Math	SwD	1990 or older	This is a mathematical model that tends to estimate the number of remaining errors in a software product, as a measure for the minimum time to correct these bugs. Uses execution time instead of calendar time. Assumptions are that there are no failures at the beginning of testing, and the failure rate will decrease exponentially with the expected number of failures experienced.	Also known as "Execution Time Model". Developed by John D. Musa. Not considered very reliable, but can be used for general opinion and for comparison of software modules. Variant is Musa-Okumoto model, which is a logarithmic Poisson model. See also Bug-Counting Model. See also Jelinski-Moranda models.							7		software		x				• [Bishop, 1990] • [Davis, 2007] • [Krueger & Lai]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
526.	N out of M vote	Step	HwD	1981 ?	Aim of N out of M vote is to reduce the frequency and duration of system failure, to allow continued operation during test and repair. Voting is a fundamental operation when distributed systems involve replicated components (e.g. after Diverse Programming). Voting is defined as the number of redundant paths (N) required out of the total number of redundant paths (M) in order to carry out the (safety) function. For example, 2 out of 3 voting scheme means that if one of three components fails, the other two will keep the system operational. The hardware fault tolerance (HFT), which is defined as M-N, is a measure of redundancy.	Used for systems where any break in service has serious consequences. 'N out of M' is usually denoted by 'NooM', e.g. as in 1oo2 or 2oo3. A variant is Adaptive Voting, which aims to avoid that fault masking ability deteriorates as more copies fail (i.e. faulty modules outvote the good modules).						6			software		x				• [Bishop, 1990]
527.	NAIMS (National Airspace Information Monitoring System)	Dat	Dat	1985	NAIMS is a Federal Aviation Administration program to collect, maintain and analyse aviation statistical information based on reports of accidents and incidents in the US national airspace system. NAIMS produces a monthly report available to the public, supplies data to NASDAC, and responds to public inquiries for safety information. Reported incidents are: 1. near mid-air collisions (NMAC's); 2. operational errors (OE's); 3. operational deviations (OD's); 4. pilot deviations (PD's); 5. vehicle/ pedestrian deviations (VPD's); 6. surface incidents (SI's); 7. runway incursions (RI's); 8. flight assists (FA's). The NAIMS monthly report monitors trends in and apportionment of each of these indicators. For example, operational error rates (OE's per 100,000 operations) are shown for each ATC facility. The original forms are maintained for five years. A database containing an electronic copy of each form is maintained indefinitely.	NAIMS is currently known as ATQA (Air Traffic Quality Assurance).								8	aviation, ATM, airport	x		x	x		• [GAIN ATM, 2003] • [FAA HFW]
528.	Naked man / Naked person	Gen	Mit	1963 or older	This technique is to evaluate a system by looking at the bare system (controls) needed for operation without any external features added in order to determine the need/value of control to decrease risk.				3						space	x					• [FAA00] • [ΣΣ93, ΣΣ97]
529.	NARA (Nuclear Action Reliability Assessment)	Step	Par	2004	Enhanced and updated version of HEART specific to the nuclear industry.	Developed by Corporate Risk Associates (CRA) and commissioned by the Nuclear Industry Management Committee (IMC) and British Energy.					5				nuclear			x			• [Kirwan, 2004]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
530.	NARIM (National Airspace Resource Investment Model)	Int	Des, OpR, Dec	1998	NARIM aims at examining airspace concepts associated with future advances to the National Airspace System (NAS). It consists of three interrelated parts: 1) Operational modelling analyzes the movement of aircraft through the NAS to determine the impacts that new concepts, implemented through procedures and/or hardware, will have on the overall NAS performance. 2) Architectural/Technical modelling provides a means of assessing how procedural/ system changes affect the hardware/ software components of the NAS infrastructure (both FAA and users). 3) Investment analysis modelling provides a methodology to cost effectively trade between alternatives for a system, trade requirements within a system and across system and procedural investment alternatives, trade between services to be provided/included into the NAS, balance risk, and assess the investment decision as a of part of a total research portfolio.	NARIM is developed jointly by the FAA Investment Analysis and Operations Research Directorate and NASA Interagency Integrated Product Team (IPT) for Air Traffic Management (ATM).		2		4	5	6			aviation, airport, ATM	x	x	x	x	x	• [Dorado-Usero et al, 2004] • [Sherali et al, 2002] • [FAA HFW]
	Narrative Mission Description					See Mission Scenarios															
531.	NARSIM (NLR's Air Traffic Control Research Simulator)	RTS	Des	1994 from	NARSIM is an air traffic research simulator. Its aim is to evaluate new operational procedures, new controller assistance tools, and new human/machine interfaces. There are six AT consoles and up to 12 pseudo pilot positions, each of which can control up to 15 aircraft. The AT consoles and pseudo pilots are connected by a voice communication net. The computers driving each station are connected to the main NARSIM computer. The NARSIM software simulates most important aspects of a real air traffic control system, including realistic radar information. It has the capability to use actual recorded radar data, computer-generated data, pseudo pilot generated data, or combinations of the three.	NARSIM has been developed by National Aerospace Laboratory NLR and is integrated with NLR's Tower Research Simulator (TRS).		2				6	7	8	ATM, airport	x		x	x		• [GAIN ATM, 2003]
	NASA TLX (NASA Task Load Index)					See Rating Scales															
	NASDAC Database (National Aviation Safety Data Analysis Center Database)					Former name of ASIAS (Aviation Safety Information Analysis and Sharing)															
	Naturalistic Observation					See Field Study															
	NDE (Non-destructive Evaluation)					See NDI (Non-Destructive Inspection technique)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
532.	NDI (Non-Destructive Inspection)	Gen	HzI	1914 - 1918 war	Generic term rather than a specific technique. NDI can be defined as inspection using methods that in no way affect the subsequent use or serviceability of the material, structure or component being inspected. An NDI method explores a particular physical property of a material or component in an effort to detect changes in that property which may indicate the presence of some fault. Visual inspection is the most commonly used NDI technique.	NDI is commonly referred to as Non-destructive Testing (NDT) which is historically the original term used - NDI is the more commonly used term in the manufacturing environment where the testing of the suitability of materials to be used is often undertaken non-destructively. The "non-destructive" description was adopted to differentiate it from the various "destructive" mechanical tests already in use. The term Non-destructive Evaluation (NDE) is also used, most particularly in the sphere of R&D work in the laboratory. [NDT Test Methods] provides a list of NDT Test Methods.			3						manufacturing, electronics, healthcare, aircraft	x					• [Hollamby, 1997] • [Wassell, 1992] • [NDT Test Methods]
	NDT (Non-Destructive Testing)					See NDI (Non-Destructive Inspection technique)															
533.	Needs Assessment Decision Aid	Tab, Min	Dec	1987	The needs assessment decision aid tool is designed to help decide among three methods of gathering additional information about the user needs. The three options for collecting information are questionnaire, interview, and focus group. The tool includes a list of questions that when you answer them should assist you in selecting the preferred method of collecting the needs assessment data you desire.	Developed at Georgia Tech Research Institute.						6			social			x			• [FAA HFW] • [Patton, 1987] • [NADA]
	NE-HEART (Nuclear Electric Human Error Assessment and Reduction Technique)					See NARA (Nuclear Action Reliability Assessment).															
534.	Neural Networks	Math	Mod	1890	Neural networks are collections of mathematical models that emulate some of the observed properties of biological nervous systems and draw on the analogies of adaptive biological learning. The key element of the paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements that are analogous to neurones and are tied together with weighted connections that are analogous to synapses.	The concept of neural networks started in the late 1800s as an effort to describe how the human mind performed. It was inspired by the way the densely interconnected, parallel structure of the mammalian brain processes information. In [May, 1997], neural networks are used to model human operator performance in computer models of complex man-machine systems. Sometimes referred to as Artificial Neural Network (ANN).				4					road, chemical, environment, leisure, security, healthcare, social, finance, energy, management, electronics	x		x			• [May, 1997] • [FAA HFW]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
535.	NextGen Future Safety Assessment Game	Int	Dec	2011	This methodology aims at identifying possible NextGen futures and to perform an initial expert based ranking of risk and prioritization for further analysis. Its key method is serious gaming and infrastructure design, to model the total system and its dynamics.	NextGen is the name given to a new National Airspace System due for implementation across the United States in stages between 2012 and 2025. Serious gaming refers to simulations of real-world events or processes designed for the purpose of solving a problem.			3		5				(ATM)	x			x		• [Ancel et al, 2011]
536.	NFR (Non-Functional Requirements framework)	Stat	SwD	1992	NFR is a framework on Goal Modelling. The analysis begins with softgoals that represent NFR which stakeholders agree upon. These softgoals are then decomposed and refined to uncover a tree structure of goals and subgoals. Once uncovering tree structures, one tries to find interfering softgoals in different trees. These softgoal trees now form a softgoal graph structure. The final step in this analysis is to pick some particular leaf softgoals, so that all the root softgoals are satisfied.	Softgoals are goals that are hard to express, but tend to be global qualities of a software system. These could be usability, performance, security and flexibility in a given system. The NFR approach evolved into the Goal-oriented Requirement Language (GRL). GRL is part of the ITU-T URN standard draft which also incorporates Use Case Maps (UCM).						6			electronics		x				• [Mylopoulos et al, 1992] • [Chung & Nixon, 1995] • [Mylopoulos et al, 1999]
537.	NGOMSL (Natural GOMS Language)	Stat	Task	1988	NGOMSL builds on CMN-GOMS by providing a natural-language notion for representing GOMS models, as well as a procedure for constructing the models. Under NGOMSL, methods are represented in terms of an underlying cognitive theory known as Cognitive Complexity Theory (CCT), which addresses a criticism that GOMS does not have a strong basis in cognitive psychology. This cognitive theory allows NGOMSL to incorporate internal operators such as manipulating working memory information or setting up subgoals. Because of this, NGOMSL can also be used to estimate the time required to learn how to achieve tasks.	Natural GOMS Language technique was developed by David Kieras in 1988. See also CAT, CPM-GOMS, CTA, GOMS, KLM-GOMS.		2							electronics, nuclear, defence, manufacturing, ergonomics			x	x		• [Kieras, 1996] • [FAA HFW] • [John & Kieras, 1996] • [Morrison, 2003]
538.	NLA (Network Logic Analysis)	Math	Mod, HzI	1972 or older	Network Logic Analysis is a method to examine a system in terms of a Boolean mathematical representation in order to gain insight into a system that might not ordinarily be achieved. Steps are: Describe system operation as a network of logic elements, and develop Boolean expressions for proper system functions. Analyse the network and/or expressions to identify elements of system vulnerability to mishap.	The technique is appropriate to complex systems that can be represented in bi-model elemental form.		2							environment, defence, space	x	x				• [FAA00] • [ΣΣ93, ΣΣ97]
539.	NMAM (NIOSH Manual of Analytical Methods)	Gen	HzA	1973	NIOSH Manual of Analytical Methods is a collection of methods for sampling and analysis of contaminants in workplace air, and in the blood and urine of workers who are occupationally exposed. Results are aimed at determining whether action should be taken to reduce worker exposure.	Maintained by NIOSH (National Institute for Occupational Safety and Health), U.S.A. First edition was published 1973.			3						healthcare			x			• [NMAM Methods]
540.	NOMAC (Nuclear Organisation and Management Analysis Concept)	Int	Org	1994	NOMAC is an analysis framework that assesses the safety culture health of the organisation by looking for the presence or absence of indicators of safety performance.	Qualitative.			3				7	8	(nuclear)					x	• [Kennedy & Kirwan, 1998]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
541.	NOSS (Normal Operations Safety Survey)	Dat	Dat	2003	NOSS is a methodology for the collection of safety data during normal air traffic control (ATC) operations. By conducting a series of targeted observations of ATC operations over a specific period of time, and the subsequent analysis of the data thus obtained, the organisation is provided with an overview of the most pertinent threats, errors and undesired states that air traffic controllers must manage on a daily basis. One feature of NOSS is that it identifies threats, errors and undesired states that are specific to an organisation's particular operational context, as well as how those threats, errors and undesired states are managed by air traffic controllers during normal operations. The information thus obtained will enhance the organisation's ability to proactively make changes in its safety process without having to experience an incident or accident.	A normal ATC operation is defined as an operation during the course of which no accident, incident or event takes place of which the reporting and/or investigation are required under existing legislation or regulations. Training and check shifts are considered to be outside the scope of normal operations.								8	(ATM)			x	x		• [NOSS]
542.	NOTECHS (Non Technical Skills)	Tab	HRA	1998	Technique for assessing non-technical skills of crews. Focuses on the individual (pass or fail). The NOTECHS framework consists of four categories: Cooperation, Leadership and managerial skills, Situation awareness, Decision-making. Each category is subdivided into a number of elements. An individual is then assessed on each of the categories. The overall rating shows if the individual passes, or if further training is required.	Developed in Europe for JAA. JAA intends to use NOTECHS as evaluation tool in the same way as they evaluate technical skills. "Oxford NOTECHS" is an adapted version developed in 2003 by University of Oxford for application to personnel in operating theatres of hospitals.					5				aviation			x			• [Verheijen, 2002] • [Flin, 1998] • [Avermaete, 1998] • [JAR TEL, 2002] • [McCulloch et al, 2009] • [Mishra et al, 2009]
543.	NSCA (Nuclear Safety Culture Assessment)	Tab	Org	2009	Aim is safety culture assessment in nuclear power plants. The process is comprised of nine elements: Process inputs; Nuclear safety culture monitoring panel; Site leadership team; Communication; Regulatory oversight; Corrective actions; Other input sources; Site response; External input.									8	nuclear					x	• [Mkrtchyan & Turcanu, 2012]
544.	NSCCA (Nuclear Safety Cross- Check Analysis)	Step	SwD	1976	The NSCCA provides a technique that verifies and validates software designs associated with nuclear systems. The NSCCA is also a reliability hazard assessment method that is traceable to requirements-based testing.	At present applies to military nuclear weapon systems.			3				7		defence	x	x				• [FAA AC431] • [Rakowsky] • [ΣΣ93, ΣΣ97]
545.	NTSB Accident/Incident database (National Transportation Safety Board Accident/Incident database)	Dat	Dat	1967	The NTSB accident and incident database is the FAA official repository of aviation accident data and causal factors. In this database, personnel categorize events as accidents or incidents. Since its inception, the NTSB has investigated more than 132,000 aviation accidents and thousands of surface transportation accidents. Accident Reports provide details about the accident, analysis of the factual data, conclusions and the probable cause of the accident, and the related safety recommendations. Most reports focus on a single accident, though the NTSB also produces reports addressing issues common to a set of similar accidents.	Since 1967, the NTSB has investigated accidents in the aviation, highway, marine, pipeline, and railroad modes, as well as accidents related to the transportation of hazardous materials. Aviation accident reports from 1996 onwards are online at [NTSB Accidents]. FAA usage rules dictate using NTSB accident database as primary source for accidents, but to use FAA AIDS for incidents.			3					8	aviation, road, maritime, oil&gas, rail	x	x	x	x	x	• [NTSB Accidents] • [ATO SMS Manual v3.0] • [NTSB Home]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
546.	Nuclear Criticality Safety	Step	Mit	1983	Nuclear criticality safety is dedicated to the prevention of an inadvertent, self-sustaining nuclear chain reaction, and with mitigating the consequences of a nuclear criticality accident. A nuclear criticality accident occurs from operations that involve fissile material and results in a release of radiation. The probability of such accident is minimised by analyzing normal and abnormal fissile material operations and providing requirements on the processing of fissile materials.	All facilities that handle fissile material. See also Criticality Analysis or Criticality Matrix.						6			nuclear	x			x		• [ΣΣ93, ΣΣ97] • [O'Neal et al, 1984] • [Lipner & Ravets, 1979]
547.	Nuclear Explosives Process Hazard Analysis	Step	Mit	1997 or older	A nuclear explosive is an explosive device that derives its energy from nuclear reactions. Aim of Nuclear Explosives Process Hazard Analysis is to identify high consequence (nuclear) activities to reduce possibility of nuclear explosive accident.	Nuclear or similar high risk activities. See also Process Hazard Analysis.			3		5				(nuclear)	x			x		• [ΣΣ93, ΣΣ97]
548.	Nuclear Safety Analysis	Gen	HzA, OpR	1980 or older	The purpose is to establish requirements for contractors responsible for the design, construction, operation, decontamination, or decommissioning of nuclear facilities or equipment to develop safety analyses that establish and evaluate the adequacy of the safety bases of the facility/equipment. The DOE requires that the safety bases analysed include management, design, construction, operation, and engineering characteristics necessary to protect the public, workers, and the environment from the safety and health hazards posed by the nuclear facility or non-facility nuclear operations. The Nuclear Safety Analysis Report (NSAR) documents the results of the analysis.	All nuclear facilities and operations. DOE (Department of Energy) and NRC (Nuclear Regulatory Commission) have rigid requirements.						6			nuclear	x			x	x	• [FAA AC431] • [ΣΣ93, ΣΣ97]
	N-version Programming					See Diverse Programming															
549.	O&SHA (Operating and Support Hazard Analysis)	Int	HzA	1982 or older	The analysis is performed to identify and evaluate hazards/risks associated with the environment, personnel, procedures, and equipment involved throughout the operation of a system. This analysis identifies and evaluates: a) Activities which occur under hazardous conditions, their time periods, and the actions required to minimise risk during these activities/time periods; b) Changes needed in functional or design requirements for system hardware/software, facilities, tooling, or S&TE (Support and Test Equipment) to eliminate hazards or reduce associated risk; c) Requirements for safety devices and equipment, including personnel safety and life support and rescue equipment; d) Warnings, cautions, and special emergency procedures; e) Requirements for PHS&T (packaging, handling, storage and transportation) and the maintenance and disposal of hazardous materials; f) Requirements for safety training and personnel certification.	The analysis is appropriate for all operational and support efforts. Goes beyond a JSA. Alternative name is OHA (Operating Hazard Analysis).			3		5	6			aircraft	x	x	x	x		• [FAA AC431] • [FAA00] • [FAA tools] • [ΣΣ93, ΣΣ97]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
550.	OARU Model (Occupational Accident Research Unit Model)	Step	Mod	1980	Model for analysis of accidents. In this model a distinction is made between three phases in the accident process: two preinjury phases – the initial and concluding phase- followed by the injury phase, i.e. the pathogenic outcome of physical damage in a person. The initial phase starts when there are deviations from the planned or normal process. The concluding phase is characterised by loss of control and the ungoverned flow of energy. The injury phase starts when energies meet the human body and cause physical harm.	Developed by U. Kjellén.								8	healthcare, manufacturing			x			• [Kjellen, 2000] • [Engkvist, 1999]
551.	OATS (Operator Action Trees)	Stat	HRA	1982	Deals with operator errors during accident or abnormal conditions and is designed to provide error types and associated probabilities. The method employs a logic tree, the basic operator action tree, that identifies the possible postaccident operator failure modes. Three error types are identified: 1) failure to perceive that an event has occurred; 2) failure to diagnose the nature of event and to identify necessary remedies; 3) failure to implement those responses correctly and in timely manner. Next, these errors are quantified using time-reliability curves.				3	4	5				nuclear			x			• [Kirwan & Ainsworth, 1992] • [MUFTIS3.2-I, 1996] • [GAIN ATM, 2003] • [FAA HFW]
552.	OBJ	Int	Des	1976	OBJ (not an acronym) is an algebraic Specification Language to provide a precise system specification with user feed-back and system validation prior to implementation.	Introduced by Joseph Goguen in 1976. Powerful yet natural formal specification language for both large- and small-scale systems developments. Tools available. Software requirements specification phase and design & development phase.						6			software		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]
553.	ObjectGEODE	Int	Des	1999	ObjectGeode is a toolset dedicated to analysis, design, verification and validation through simulation, code generation and testing of real-time and distributed applications. It supports a coherent integration of complementary object-oriented and real-time approaches based on the UML, SDL and MSC standards languages. ObjectGeode provides graphical editors, a powerful simulator, a C code generator targeting popular real-time OS and network protocols, and a design-level debugger. Complete traceability is ensured from Requirement to code.	Developed by Verilog, which was bought by Telelogic in 1999, which was bought by IBM in 2007. It is reported that the ObjectGEODE tool is no longer commercialized or retained in another IBM product.							7		(avionics)		x				• [Telelogic Objectgeode] • [Garavel, 2013]
554.	Observational Techniques	Gen	Dat	1990	General class of techniques whose objective is to obtain data by directly observing the activity or behaviour under study. Examples of these techniques are direct visual observation, continuous direct observation, sampled direct observation, remote observation via closed-circuit television or video recording, participant observation, time-lapse photography.	Observational techniques are often employed when other, more obtrusive techniques such as questionnaires or interviews, are not appropriate.							7		space, healthcare, social, management, environment			x	x	x	• [Kirwan & Ainsworth, 1992] • [FAA HFW]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
555.	Ofan	Dyn	Mod	1995	Modelling framework describing human interaction with systems that have modes. Is based on the Statecharts and Operator Function Models (OFM). In Ofan, five concurrently active modules are used to describe the human-machine environment, namely the Environment, the Human Functions/Tasks, the Controls, the Machine, and the Displays. Applying the Ofan framework allows the identification of potential mismatches between what the user assumes the application will do and what the application actually does. The Ofan framework attempts to separate out the components of the whole environment.	Developed by Asaf Degani. Ofan is Hebrew for a set of perpetuating wheels, referring to an event in one wheel affecting the adjacent wheel and so on, in perpetuum.		2	3	4					electronics, road, healthcare, aviation, chemical	x		x			• [Andre & Degani, 1996] • [Degani, 1996] • [Degani & Kirlik, 1995] • [Smith et al, 1998]
556.	Off-Hour Surveillance Assessment Decision Aid	Step	HzA	2006 or older	The Off-Hour Surveillance Decision Aid is designed to assist in identifying risk and evaluating the effectiveness of air carrier activities conducted during off hours. Sufficient off-hour surveillance must occur to: a) Know what types and levels of activity are conducted during off-hours. b) Understand how the air carrier is managing and supervising off-hour activities, especially the interface with outsource maintenance and other contracted activities. c) Determine if the air carrier's processes and controls are sufficient to detect and correct any risks inherent with off-hour activities. d) Determine if the off-hour activities present a greater risk than activities done during normal FAA duty hours.	An example of off-hour air carrier activity in the air carrier flight/ground operations arena might be training that is conducted during off hours (midnight shift) or flight operations primarily conducted outside of normal FAA duty hours (e.g., overnight cargo operations).			3				7		aviation	x				x	• [FAA FSIMS, 2009] • [Notice 8300.123]
557.	OFM (Operator Function Model)	Stat	Task	1987	Describes task-analytic structure of operator behaviour in complex systems. The OFM is focused on the interaction between an operator and automation in a highly proceduralised environment, such as aviation. The OFM is a structured approach to specify the operator tasks and procedures in a task analysis framework made up of modes and transitions. Using graphical notation, OFM attempts to graph the high level goals into simpler behaviours to allow the supervision of the automation.	The power of OFM is based upon several important observations: the event-driven nature of automation, the proceduralised nature of high risk tasks, and the fact that many of the transitions and decisions made during system operation are discrete in nature. See also Ofan.		2							aviation, space			x			• [Botting & Johnson, 1998] • [Mitchell, 1987] • [Vakil, 2000] • [FAA HFW]
	OHA (Operating Hazard Analysis)					Alternative name for O&SHA (Operating and Support Hazard Analysis).															
	OHA (Operational Hazard Analysis)					See ED-78A (RTCA/EUROCAE ED-78A DO-264)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
558.	OHHA (Occupational Health Hazard Analysis)	Tab	HzA	1971	Is carried out to identify occupational health-related hazards and to recommend measures to be included in the system, such as provision of ventilation, barriers, protective clothing, etc., to reduce the associated risk to a tolerable level. Is carried out by means of audit and checklists.	Occupational health and safety is a cross-disciplinary area concerned with protecting the safety, health and welfare of people engaged in work or employment. The goal of the programs is to foster a safe work environment. OSHA (Occupational Safety and Health Administration) have been regulating occupational safety and health since 1971. See also Systematic Occupational Safety Analysis.			3			6			defence, mining	x		x	x		• [DS-00-56, 1999] • [ΣΣ93, ΣΣ97]
559.	OMAR (Operator Model Architecture)	FTS	HFA	1993	OMAR is a modelling and simulation tool that can generate high fidelity computer models of human behavior, as well as state-of-the-art intelligent agents for use in synthetic environments, distributed simulations, and information systems. OMAR aims at supporting the development of knowledge-based simulations of human performance, with a focus on the cognitive skills of the human operator. It models situated-cognition, where a human dynamically shifts between goals based upon events occurring in the environment.	Was developed for the US Air Force. OMAR has evolved into a distributed architecture version, D-OMAR, developed by BBN Technologies, which provides a suite of software tools from which to implement alternate architectures.		2		4					defence, ATM, aviation			x			• [Deutsch et al, 1993] • [FAA HFW] • [Pew, 2008] • [Leiden & Best, 2005] • [Morrison, 2003]
560.	OMOLA (Object Oriented Modelling Language)	Gen	Mod	1989	Object-oriented language tool for modelling of continuous time and discrete event dynamical systems.	Developed by A. Andersson (Lund Institute of Technology, Sweden). OmSim is an environment for modelling and simulation based on OMOLA.				4	5				energy	x					• [Andersson, 1993] • [OmolaWeb]
561.	OOD and Programming (Object-oriented Design and Programming)	Gen	Des	1966 or older	Uses "objects" – data structures consisting of data fields and methods together with their interactions – to design applications and computer programs. Programming techniques may include features such as data abstraction, encapsulation, modularity, polymorphism, and inheritance. Aim is to reduce the development and maintenance costs and enhance reliability, through the production of more maintainable and re-usable software.	Useful as one possible option for the design of safety-related systems. Also for construction of prototypes. Related to JSD and OBJ. Tools available. Software design & development phase. Also referred to as OOD/OOA, i.e. Object Oriented Design / Object Oriented Analysis.						6			software		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]
	Operations Analysis					See FPC (Flow Process Chart)															
562.	OPL (Operator Procedure Language)	Int	Mod, HFA	1986	Augmented programming language used in MIDAS. This computational human performance modelling tool possesses structures that represent human cognition and the agent's operational work environment and includes a comprehensive visualisation component to its output.			2							aviation			x			• [HAIL] • [Sherry et al, 2000] • [Sherry et al, 2001]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
563.	Opportunity Assessment	Int	Org, Dec	2000 or older	Opportunity Assessment aims at identifying opportunities to expand the capabilities of the organisation and/or to significantly reduce the operational cost of risk control procedures. It involves five key steps: 1) Operational areas that would benefit from expanded capabilities are identified and prioritized; areas where risk controls are consuming extensive resources or are constraining operation capabilities are listed and prioritized. 2) In areas where opportunities exist, analyze for risk barriers. 3) Attack the barriers by using the ORM (operational risk management) process: reassess the hazards, apply improved risk controls, improve implementation of existing controls. 4) When available risk management procedures don't appear to offer any breakthrough possibilities, seek out new ORM tools using benchmarking procedures or innovate new procedures. 5) Exploit any breakthroughs by pushing the operational limits or by cost saving until a new barrier is reached. The cycle then repeats and a process of continuous improvement begins.							6		8	manufacturing, management					x	• [FAA00]
564.	OPSNET (Operations Network)	Dat	Dat	1988	OPSNET is an official database of U.S. NAS (National Airspace System) air traffic operations and delay data. The data collected through OPSNET are used to analyze the performance of the FAA's ATC facilities traffic count and delay information, ATCT and Terminal Radar Approach Control operations, etc. OPSNET records the following information and data: Airport Operations; Tower Operations: TRACON Operations; Total Terminal Operations; Center Aircraft Handled; Facility Information; Delays.	OPSNET was created in 1988 and was regularly updated. The latest revision is from 2008, during which historical OPSNET operations data dating back to 1990 have been converted to be consistent with the revised air traffic count reporting standards. From October 22, 2007, all ATC facilities with the exception of flight service stations (FSS) are required to record OPSNET data and transmit data to the ATO System Operations, Quality Assurance (QA) office daily. The ATCSCC QA then processes the data and stores them into the OPSNET database.								8	(ATM)				x		• [ATO SMS Manual v3.0] • [FAA OPSNET] • [FAA OPSNET Manual] • [FAA Order JO 7210.55F]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
565.	OPT (Outsource Oversight Prioritization Tool)	Dat	Dat, Mit	2008 or older	The OPT is used for planning surveillance of air carrier maintenance providers. It allows for prioritization of air carrier maintenance providers to help determine specific data collection requirements. The OPT will assist the principal inspector (PI), other assigned inspectors, supervisors, and managers in identifying areas of concern or criticality, allowing them to target resources toward air carrier maintenance providers with the highest risk. The OPT is also used as part of the Enhanced Repair Station and Air Carrier Outsourcing Oversight System, along with the Repair Station Assessment Tool and the Repair Station Risk Management Process. The data resulting from the use of these tools resides in Safety Performance Analysis System (SPAS) and may provide valuable information to help an air carrier PI plan data collection activities for air carrier maintenance providers.	Only one OPT is required for each air carrier.			3			6			aviation	x			x	x	• [FAA FSIMS, 2009]
566.	Organisational learning	Gen	Dat, Mit, Org	1978	Organisational learning is the process of "detection and correction of errors." Organisations learn through individuals acting as agents for them: The individuals' learning activities, in turn, are facilitated or inhibited by an ecological system of factors that may be called an organisational learning system.	Term is introduced in the 1970s by Chris Argyris and Donald Schön. Four constructs are integrally linked to organisational learning: knowledge acquisition, information distribution, information interpretation, and organisational memory.								8	ATM, aviation, rail, nuclear, chemical, oil&gas, defence, healthcare, police					x	• Huge reference list on OL: [Polat, 1996]
567.	ORM (Operational Risk Management)	Int	Dec	1991 or older	ORM is a decision-making tool to systematically help identify operational risks and benefits and determine the best courses of action for any given situation. The ORM process comprises six steps. 1) Using a Task analysis as input, identify Hazards and their causes; 2) Assess the Risk; 3) Identify and analyze Risk Control Measures and prioritize those risk controls that will reduce the risk to an acceptable level; 4) Make Control Decisions; 5) Implement Risk Controls, by making the implementation directive clear, establishing accountability, and getting approval, commitment and support at the appropriate management level; 6) Supervise and Review, and establish a feedback system.	In contrast to an Operating and Support Hazard Analysis (O&SHA), which is performed during development, ORM is performed during operational use. The ORM concept grew out of ideas originally developed to improve safety in the development of new weapons, aircraft and space vehicles, and nuclear power. The US Army adopted Risk Management in 1991 to reduce training and combat losses. [FAA00] lists several techniques that can be used to support the process.							7		defence, navy, finance, food, security, nuclear, oil&gas, aviation, healthcare	x	x	x	x	x	• [AFP90-902, 2000] • [FAA00] • [ORM web]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
568.	ORR (Operational Readiness Review)	Step	Dec	1997 or older	An ORR is a structured method for determining that a project, process, facility or software application is ready to be operated or occupied (e.g. a new Air Traffic Control Centre; a new tower; a new display system, etc.). The ORR is used to provide a communication and quality check between Development, Production, and Executive Management as development is in the final stages and production implementation is in progress. This process should help management evaluate and make a decision to proceed to the next phase, or hold until risk and exposure can be reduced or eliminated. This review process can also be used to evaluate post operational readiness for continuing support and will also provide information to make necessary system/procedural modifications, and error and omissions corrections.	DOE (Department of Energy) requirement. Systematic approach to any complex facility. The details of the ORR will be dependent on the application.							7		nuclear, healthcare, chemical, oil&gas, space	x	x		x		• [DOE-3006, 2000] • [Dryden-ORR] • [ΣΣ93, ΣΣ97] • [Enterprise-ORR] • [NNSA-ORR]
	OSA (Operational Safety Assessment)					See ED-78A (RTCA/EUROCAE ED-78A DO-264)															
569.	OSD (Operational Sequence Diagram)	Stat	Task	1960	An operational sequence is any sequence of control movements and/or information collecting activities, which are executed in order to accomplish a task. Such sequences can be represented graphically in a variety of ways, known collectively as operational sequence diagrams. Examples are the Basic OSD, the Temporal OSD, the Partitioned OSD, the Spatial OSD, Job Process Charts.	Developed by F. Brooks for weapons industry. Operational Sequence Diagrams are extended (more detailed) forms of Flow Process Charts. Is useful for the analysis of highly complex systems requiring many time critical information-decision-action functions between several operators and equipment items. Sometimes referred to as SAT Diagram (Sequence and Timing Diagram) or Task Allocation Charts.		2		4					defence, navy, road, nuclear			x			• [HEAT overview] • [Kirwan & Ainsworth, 1992] • [MIL-HDBK, 1999] • [FAA HFW] • [Brooks, 1960] • [Beevis, 1992]
	OSED (Operational Service and Environment Definition)					See ED-78A (RTCA/EUROCAE ED-78A DO-264)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
570.	OSP (Oversee System Performance)	Int	OpR	2009	OSP is aimed at oversight of system performance and risk by balancing safety, business effectiveness, and stakeholder service objectives of the airworthiness organization. The functions defining the process are: (1) Collect data from various sources: process measures, non-process measures, risk measures; (2) Determine performance status and monitor risk: Data are gathered and are analyzed to determine if the process and non-process measures are within their thresholds; (3) In-depth analysis: If the measures are out of tolerance with the thresholds, then the data are further analyzed using different techniques in order to find trends, patterns, or causes, and then solutions; (4) Synthesis of solutions: Quantitative and qualitative solutions are integrated to enable the creation of the best solution given the consequences; (5) Management reviews and initiate corrective action: Reports are generated and shared with management. Corrective action solutions are prioritized and presented for review and consideration; (6) Report Results: The analysis results are finalized and posted to an organization dashboard for review. Data is archived and organized for the next analysis cycle.				3					8	(aircraft)	x					• [FAA ASKME]
571.	OSTI (Operant Supervisory Taxonomy Index)	Tab	Org	1986	Analysis framework that assesses the safety culture health of the organisation by looking for the presence or absence of indicators of safety performance. Uses a standardized taxonomy of behaviors as the basis for categorizing and describing behaviors exhibited by managers and supervisors.	Developed by Judith Komaki. Qualitative.								8	management, nuclear, police					x	• [Kennedy & Kirwan, 1998]
572.	OTA (Operator Task Analysis)	Step	Task	1987 or older	Operator Task Analysis is a method to evaluate a task performed by one or more personnel from a safety standpoint in order to identify undetected hazards, develop note / cautions / warnings for integration in order into procedures, and receive feedback from operating personnel. Also known as Procedure Analysis, which is a step-by-step analysis of specific procedures to identify hazards or risks associated with procedures.	Applicable to any process or system that has a logical start/stop point or intermediate segments, which lend themselves to analysis. This methodology is appropriate to any operation that has a human input. Other name for Procedure Analysis and often referred to as Task Analysis.			3						ATM, defence, navy, nuclear			x	x		• [FAA00] • [Leveson, 1995] • [ΣΣ93, ΣΣ97]
573.	OWAS Method (Ovako Working posture Analysis System Method)	Step	HFA, Task	1977	Movement and posture analysis. Aims to limit physiological costs and prevent disease. Goal: Work protection to prevent occupational diseases; Approach: Evaluation and combination of data matrices of postures and movements, analysis of frequencies, and derives necessities and measures for design; Describes**:** Working postures and movements; Frequency in a task structure; Assignment of tasks into the work segment; Necessity of design interventions; Distribution of movements over the body; Weights handled and forces exerted.	Developed in the Finnish steel industry (Ovako Oy) between 1974-78 and later enhanced by the Finnish Centre for Occupational Safety.					5	6			manufacturing, ergonomics, healthcare			x			• [FAA HFW] • [Luczak, 1997] • [Laurig & Rombach, 1989] • [Stoffert, 1985]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
574.	Pareto Chart	Tab	Dec	1906	The Pareto chart is a specialized version of a histogram that ranks the categories in the chart from most frequent to least frequent. A Pareto Chart is useful for non-numeric data, such as "cause", "type", or "classification". This tool helps to prioritize where action and process changes should be focused. If one is trying to take action based upon causes of accidents or events, it is generally most helpful to focus efforts on the most frequent causes. Going after an "easy" yet infrequent cause will probably not reap benefits.	Named after Vilfredo Federico Damaso Pareto (1848 – 1923), who developed this chart as part of an analysis of economics data. He determined that a large portion of the economy was controlled by a small portion of the people within the economy. The "Pareto Principle" (later generalised by Joseph M. Juran) states that 80% of the problems come from 20% of the causes.					5	6			finance, management, manufacturing, social	x			x		• [FAA HFW]
575.	PARI method (Precursor, Action, Result, and Interpretation Method)	Dat, Stat	Mit, Task , Trai	1995	In the PARI method, subject-matter experts are consulted to identify which issues to probe, and to aid in eliciting cognitive information from other subject-matter experts. For example, subject-matter experts may be asked to generate lists of potential equipment malfunctions and then engage in group discussions to reach agreement regarding a set of malfunction categories. Experts then design representative scenarios illustrating each category of malfunction. These scenarios are used to elicit information from a different set of subject-matter experts regarding how they would approach the situation presented in each scenario. Each expert is asked focused questions to identify actions or solution steps and the reasons (precursors) for those actions. The expert is then asked to interpret the system's response to his/her actions. The knowledge gathered in the interviews is represented using flow charts, annotated equipment schematics, and tree structures.	Cognitive Task Analysis technique developed at Brooks Air Force base. The PARI method is particularly useful in the development of training programs.			3	4		6			defence, healthcare			x			• [Hall et al, 1995] • [FAA HFW]
576.	Particular Risk Analysis	Step	HzA	1987	Common cause analysis related technique. Defined as those events or influences outside the system itself. For example, fire, leaking fluids, tire burst, High Intensity Radiated Fields (HIRF), exposure, lightning, uncontained failure of high energy rotating fields, etc. Each risk should be the subject of a specific study to examine and document the simultaneous or cascading effects, or influences, that may violate independence.	Is the second activity in a Common Cause Analysis; Zonal Analysis being the first and Common Mode Analysis being the third.			3						aircraft	x					• [Mauri, 2000] • [ARP 4761]
577.	Partitioning	Step	Des	1995 or older	Technique for providing isolation between functionally independent software components to contain and/or isolate faults and potentially reduce the effort of the software verification process. If protection by partitioning is provided, the software level for each partitioned component may be determined using the most severe failure condition category associated with that component.	See also Equivalence Partitioning and Input Partition Testing.						6			avionics, software		x				• [DO-178B, 1992] • [Skutt, 2001]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
578.	Parts Count method and Parts Stress method	Step	HwD	1981	Aims at approximating the reliability of a system. In the Parts Count method, the base failure rates of all components in the system are summed. The rates may be weighted by 'quality factors' of the components, if known. Then the mean time between failures (MTBF) equals 1 divided by this sum. In the Parts Stress method, there are additional weights for stress levels each component is subjected to.	It assumes that every subsystem failure can lead to total system failure. Used for electronic systems. Parts Count is used in early design phase; Parts Stress is used in detailed design.					5				electronics, defence, manufacturing, space, nuclear	x					• [FT handbook, 2002] • [MIL-217] • [MUFTIS3.2-I, 1996]
579.	PAS (Pseudo Aircraft Systems)	RTS	Trai	1990 or older	PAS is an air traffic control (ATC) simulator with a high-fidelity piloting system designed to simulate the flight dynamics of aircraft in controlled airspace. Realistic air traffic scenarios can be created for advanced automated ATC system testing and controller training. With PAS, researchers can examine air traffic flow in real time. PAS gives researchers the ability to provide air traffic control instructions to simulated aircraft, and receive verbal feedback from PAS operators ("pseudo-pilots") on a simulated radio network and visual feedback through a simulated radar display. PAS consists of three major software components: Simulation Manager, Pilot Manager, and one or more Pilot Stations. They combine to provide dynamic real-time simulations, robust piloting capabilities, and realistic aircraft modelling.	Supported by NASA Ames Research Center.							7		(ATM)			x	x		• [GAIN ATM, 2003] • [PAS web]
580.	PC (Paired Comparisons)	Step	Par	1927	Estimates human error probabilities by asking experts which pair of error descriptions is more probable. Result is ranked list of human errors and their probabilities. The relative likelihoods of human error are converted to absolute human error probabilities assuming logarithmic calibration equation and two empirically known error probabilities.	Developed by L.L. Thurstone in 1927. Does not restrict to human error only. Can be used together with APJ. Sometimes referred to as Pairwise comparison.					5				social, management, ATM, healthcare, nuclear	x		x			• [Humphreys, 1988] • [Kirwan, 1994] • [MUFTIS3.2-I, 1996] • [Hunns, 1982]
581.	PDARS (Performance data analysis and Reporting System)	Min	Dat	1998	Aim of PDARS is to provide Performance measurement metrics for the Federal Aviation Administration (FAA) at the national, as well as field level (individual en route and terminal facilities). PDARS collects and processes operational data (including aircraft tracks) and provides information to the users relevant to the air traffic system performance on a daily basis. 'TAP clients' are maintained at each facility site to continuously collect selective radar data, the data is processed and daily reports are generated, daily data is then sent to a central site for storage where the user can retrieve historical data, as well as conduct trend analysis.	See also GRADE, SIMMOD. Work on PDARS started in 1997. A first lab prototype, supporting off-line data processing, was demonstrated in 1998. The first live radar data tap was brought on line at the Southern California TRACON (SCT) in 1999.							7		ATM				x	x	• [SAP15] • [GAIN ATM, 2003] • [Braven & Schade, 2003] • [MtS, 2010] • [SoW, 2010] • [ATAC-PDARS]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
582.	PDP (Piecewise Deterministic Markov Process)	Math	Mod	1984	A PDP is a process on a hybrid state space, i.e. a combination of discrete and continuous. The continuous state process flows according to an ordinary differential equation. At certain moments in time it jumps to another value. The time of jump is determined either by a Poisson point process, or when the continuous state hits the boundary of an area.	Developed by Mark H.A. Davis in 1984. Through the existence of equivalence relations between PDP and DCPN (Dynamically Coloured Petri Nets), the development of a PDP for complex operations can be supported by Petri nets.				4					ATM, environment, finance, chemical	x	x	x	x	x	• [Davis, 1984] • [Everdij & Blom, 2003] • [Everdij & Blom, 2005]
583.	PEAT (Procedural Event Analysis Tool)	Step	Mit, Ret	1999	PEAT is a structured, cognitively based analytic tool designed to help airline safety officers investigate and analyse serious incidents involving flight-crew procedural deviations. The objective is to help airlines develop effective remedial measures to prevent the occurrence of future similar errors. The PEAT process relies on a non-punitive approach to identify key contributing factors to crew decisions. Using this process, the airline safety officer would be able to provide recommendations aimed at controlling the effect of contributing factors. PEAT includes database storage, analysis, and reporting capabilities.	Boeing made PEAT available to the airline industry in 1999. The PEAT program has benefited from lessons learned by its sister program, Maintenance Error Decision Aid (MEDA), which Boeing has provided to operators since 1995.								8	aviation			x	x	x	• [HIFA Data] • [GAIN AFSA, 2003] • [FAA HFW] • [GAIN example-PEAT]
584.	Performance Modelling	Gen	Mod	1961 or older	Aim is to ensure that the working capacity of the system is sufficient to meet the specified requirements. The requirements specification includes throughput and response requirements for specific functions, perhaps combined with constraints on the use of total system resources. The proposed system design is compared against the stated requirements by 1) defining a model of the system processes, and their interactions; 2) identifying the use of resources by each process; 3) Identifying the distribution of demands placed upon the system under average and worst-case conditions; 4) computing the mean and worst-case throughput and response times for the individual system functions.	Valuable provided modelling limitations are recognised. Tools available. See also Computer Modelling and simulation. See also Modelling.					5				electronics, environment, maritime	x	x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]
585.	Performance Requirements Analysis	Step	Val	1995 or older	In this analysis, performance requirements are interactively developed across all identified functions based on system life cycle factors. They are characterized in terms of the degree of certainty in their estimate, the degree of criticality to system success, and their relationship to other requirements. Each of the performance requirements is examined in turn to determine: 1) the success criteria to be obtained; 2) whether a measure against the success criteria can be obtained; 3) the potential accuracy of such measurements; 4) the project stages at which the measurements can be estimated; 5) the project stages at which measurements can be made. The practicability of each performance requirement is then analysed.	Performance Requirements refer to the extent to which a mission or function must be executed; generally measured in terms of quantity, quality, coverage, timeliness or readiness.	1								space, social	x	x				• [EN 50128, 1996] • [Rakowsky]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
586.	PERT (Program Evaluation Review technique)	Stat	Task	1957	PERT is a method to analyze the involved tasks in completing a given project, especially the time needed to complete each task, and to identify the minimum time needed to complete the total project. A PERT shows all the tasks, a network that logically connects the tasks, time estimates for each task and the time critical path.	Developed by US navy in 1950s. It is commonly used in conjunction with the critical path method (CPM).		2							navy, management, leisure	x	x	x	x	x	• Internet
587.	PET (Project Evaluation Tree)	Stat	OpR	1989	PET is a review and inspection tool that aims to provide an in-depth evaluation or analysis of a project or operation. The general approach is an analytical tree, which is used as a graphic checklist that helps to identify each procedure, individual/organisation, facility or piece of equipment to be analysed. PET is divided into three basic branches: Procedures, Personnel, Plant and hardware. It requires as input information regarding hardware, facilities, environment, policies and procedures, personnel, implementation plans, job descriptions, organisation charts, training records, interviews, drawings and specifications, test plans and records, etc.	PET is best suited for performing Operating Hazard Analysis or Accident Analysis. PET was developed as a less complex version of MORT.				4					(space), (defence)	x			x		• [FAA00] • [PET Purpose] • [Lewis & Haug, 2009]
588.	Petri Nets	Stat, Dyn	Mod	1962 from	A Petri Net is a bi-partite graph of Places and Transitions, connected by Arcs. A token inside a place denotes that the corresponding discrete state is the current one. Petri Nets can be used to model system components, or sub-systems at a wide range of abstraction levels; e.g. conceptual, top-down, detail design, or actual implementations of hardware, software or combinations. The best known Petri net is named Place/Transition net (P/T net). This basic Petri Net models discrete state space systems only, and no random inputs. Numerous extensions exist through which other states and stochastic inputs can be modelled. Some notable extensions are Time (transitions fire not immediately but after waiting some time; this time may be constant or stochastic), Colour (tokens have a colour or value, which may be constant or even changing through time), Different types of arcs, different types of transitions or places. The Petri Net formalism allows to specify in a compositional way an unambiguous mathematical model of a complex system. For different Petri Net extensions, one-to-one mappings with mathematical formalisms are known, by means of which the advantages of both Petri Nets and these mathematical formalisms can be combined.	Petri nets were first developed by C.A. Petri in 1962. P/T nets are a special case of SSG. Plenty of tools available, also free. A useful advantage of Petri nets is the compositional specification power. GSPN (Generalised Stochastic Petri Nets) have been used to model an ATC technical support system). SPN (Synchronised Petri Network) has been used for modelling Human Operator tasks. Petri net extensions that have been developed and used in safety assessments for complex air traffic operations are DCPN and SDCPN.				4	5				aviation, ATM, airport, defence, navy, space, rail, road, maritime, management, nuclear, chemical, oil&gas, manufacturing, healthcare, finance, electronics	x	x	x	x	x	• Huge amount of literature available, see for an overview e.g. [PetriNets World] • [Abed & Angue, 1994] • [Bishop, 1990] • [EN 50128, 1996] • [FAA AC431] • [FAA00] • [Kirwan & Ainsworth, 1992] • [MUFTIS3.2-I, 1996] • [ΣΣ93, ΣΣ97] • [FAA HFW]
589.	PFD (Process Flow Diagram)	Stat	Mod	1988 or older	A PFD displays the relationship between major equipment of a plant facility, such as process piping, control valves, recirculation systems. It does not show minor details such as piping details and designations.	Used in chemical and process engineering. See also FPC (Flow Process Chart), which is used for physical processes.		2							oil&gas, chemical, food	x					• [Luyben & Wenzel, 1988] • [Gow, 2003]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
590.	PHA (Preliminary Hazard Analysis)	Tab	HzA	1966	Identification of unwanted consequences for people as result of disfunctioning of system. Aim is to determine during system concept or early development the hazards that could be present in the operational system in order to establish courses of action. Sometimes it consists of PHI and HAZOP and/or FMEA. The PHA is an extension of a Preliminary Hazard List. As the design matures, the PHA evolves into a system of sub-system hazard analysis.	PHA was introduced in 1966 after the US Department of Defense requested safety studies to be performed at all stages of product development. PHA is considered for specification of systems which are not similar to those already in operation and from which much experience has been gained. Design and development phase. Use with FTA, FMEA, HAZOP. Initial effort in hazard analysis during system design phase. Emphasis on the hazard and its effects. Inductive and deductive.			3						aircraft, rail, ATM, defence, chemical, energy, environment	x	x				• [Bishop, 1990] • [FAA AC431] • [FAA00] • [FAA tools] • [Mauri, 2000] • [MUFTIS3.2-I, 1996] • [ΣΣ93, ΣΣ97] • [SRM Guidance, 2007] • [FT handbook, 2002]
591.	PHASER (Probabilistic Hybrid Analytical System Evaluation Routine)	Stat	HzA	1996	Software tool that solves the top event probability of a system fault tree. The basic concepts involve scale factors and confidence factors that are associated with the stochastic variability and subjective uncertainty (which are common adjuncts used in PSA), as well as safety risk extremes. Can be used for importance and sensitivity analysis, which help point out where any major sources of safety concern arise and where any major sources of uncertainty reside, respectively.	Implemented at Sandia National Labs, USA. The term hybrid in the name refers to events that are neither completely subjective nor completely stochastic. Uses fuzzy algebra. See also FTA.					5	6			(nuclear)	x					• [Cooper, 1996] • [ΣΣ93, ΣΣ97]
592.	PHEA (Predictive Human Error Analysis technique)	Tab	HRA, Task	1993	Simplified version of the earlier SHERPA. Comprises an error checklist. Focuses on particular task types depending on the industry concerned. Steps are: 1) Identify task steps where errors may result in accidents; 2) Specify the nature of the error; 3) Identify possible recovery; 4) Recommend preventative measures. Errors of several types are analysed: Planning Errors, Action Errors, Checking Errors, Retrieval Errors, Information Communication Errors, Selection Errors.	Equivalent to Human HAZOP.			3			6			oil&gas			x			• [Kirwan, Part 1, 1998]
593.	PHECA (Potential Human Error Causes Analysis)	Tab	HRA	1988	PHECA is s a computerised system based on the identification of error causes, which interact with performance shaping factors. It has a wider application than just error identification (e.g. potential error reduction strategies). Like HAZOP it uses guidewords to identify hazards.	Apparently not in current use or else used rarely.			3			6			no-domain-found			x			• [Kirwan, Part 1, 1998] • [PROMAI5, 2001]
594.	PHI (Preliminary Hazard Identification)	Gen	HzI	1991 or older	Reduced version of PHA, only containing a column with hazards. The results are recorded in the Preliminary Hazard List (PHL). Is sometimes considered a generic term rather than a specific technique.	Performed in the early stages of lifecycle.			3						(aircraft), (airport)	x					• [MUFTIS3.2-I, 1996] • [Storey, 1996]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
595.	PHL (Preliminary Hazard List)	Tab	HzI	1989 or older	Is an initial analysis effort within system safety. Lists of initial hazards or potential accidents are identified during concept development. The PHL may also identify hazards that require special safety design emphasis or hazardous areas where in-depth safety analyses are needed as well as the scope of those analyses. At a minimum, the PHL should identify: The Hazard; When identified (phase of system life cycle); How identified (analysis, malfunction, failure) and by whom; Severity and Probability of Occurrence; Probable/ actual cause(s); Proposed elimination/mitigation techniques; Status (Open-action pending /Closed-eliminated/Mitigated; Process of elimination/mitigation; Oversight/approval authority.	Usually the results are fed into a PHA.			3						(aircraft)	x	x				• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]
596.	PHRA (Probabilistic Human Reliability Analysis)	Int	HRA, Par	1990	Time-related method. A distinction is made between routine operation and operation after the event. Error probabilities are calculated for identified classes of routine operation with the help of simple evaluation instructions. Simulator experiments can be performed to evaluate the reliability of human actions after trouble has materialised. Various time-reliability curves for varying the complex trouble situations are determined from the experiments. Error probabilities are determined from the time-reliability curves.	Developed by EDF (Electricité de France). Update of HCR (Human Cognitive Reliability), in which advantages of HCR have been used and in which it was tried to eliminate the disadvantages.					5				nuclear			x			• [Straeter, 2000] • [Straeter, 2001]
597.	Plant walkdowns/ surveys	Step	HzI	1993 or older	Site-based systematic surveys, developed for rapid identification of hazards, effects and controls.	Alternative name: Site Visits			3			6			nuclear, oil&gas	x			x		• [Risktec]
598.	PMA (Phased Mission Analysis)	Math	Par?	1984	Mathematical technique used to quantify top effect of fault trees, accounting for different phases of a task, and allowing repairable components under certain conditions.						5				nuclear, space	x					• [MUFTIS3.2-I, 1996]
	PMTS (Predetermined Motion Time System)					See PTS (Predetermined Time Standards)															
	POMS (Profile of Mood States)					See Rating Scales															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
599.	PPAS (Professional Performance Analysis System)	Tab	HRA, Ret	1977	Main purpose is providing remedies to minimize pilot error and optimize pilot performance. The five interactive factors of the model include knowledge, skills, attitudes, systems environment, and obstacles. Four analysis steps: 1) Describe the process, function, task, error, or low performance, in order to see if the pilot was aware of risks, threats and consequences of their actions and if there was stimulus that degraded this awareness. 2) Assess the impact of the error on this particular accident or incident by determining whether removal would have prevented the accident. 3) Assess the visibility of the error to the crew members. 4) Analyze a detailed flow chart to see if the crew had adequate knowledge to cope with the errors and anomalies that occurred. Other questions are explored to determine deficiencies. Recommendations are given for each of the situations where a problem was perceived.	Four levels of learning are examined. These include unconsciously incompetent (crew is unaware that they don't know something), consciously incompetent (the crew is aware that they don't know something), consciously competent (the crew has knowledge and skill but must apply great effort to accomplish it), and unconsciously competent (the crew has over learned the knowledge or skill and can apply it without conscious thought).					5	6		8	aviation			x			• [Besco, 2005] • [Wiegman et al, 2000]
600.	PRA (Probabilistic Risk Assessment based on FTA/ETA)	Int	HzA	1965	Quantified probabilistic analysis of low probability, high severity events. Evaluates the risks involved in the operation of a safety critical system. The risk assessment forms the basis of design decisions. It uses techniques like FMEA, FTA, Event Tree Analysis (ETA), Event Sequence Diagrams (ESD), Master Logic Diagrams (MLD), Reliability Block Diagrams (RBD), etc. to quantify risk.	Initially nuclear power industry, now any system with catastrophic accident potential. Useful before major design decisions. Not reasonable for the minor system aspects. Tools available, e.g. WinNUPRA, see [GAIN AFSA, 2003]. Alternative names are Probabilistic Hazard Analysis, PSA (Probabilistic Safety Assessment), QSA (Quantitative Safety Assessment).			3	4	5				space, nuclear, oil&gas, defence, (aviation)	x					• [NASA PRA, 2011] • [Bishop, 1990] • [FAA00] • [Kirwan, 1994] • [MUFTIS3.2-I, 1996] • [ΣΣ93, ΣΣ97] • [Statematelatos] • [GAIN AFSA, 2003] • [Storey, 1996]
601.	PRASM (Predictive Risk Assessment and Safety Management)	Int	Mit	2000	Methodology for incorporating human and organisational factors in the risk evaluation and safety management in industrial systems. The methodology includes the cost-benefit analysis of the risk control measures and options to enable elaborating a rational risk control strategy for implementing more effective safety related undertakings in different time horizons.					4	5	6		8	no-domain-found			x		x	• [Kosmowski, 2000]
602.	PREDICT (PRocedure to Review and Evaluate Dependency In Complex Technologies)	Tab	HzA	1992	Is targeted at the relatively unpredictable or bizarre event sequences that characterise events, in that such events are incredible or not predictable until accidents give us 20:20 hindsight. The method utilises a group to identify errors, and is thus HAZOP-based, with keyword systems, followed by three categories of assumption-testing keywords. The technique essentially allows the analyst to test the assumptions underpinning the design and safety cases for plants. The method allows inserting a keyword randomly to enable the analyst to consider more 'lateral' possible causal connections.	PREDICT differs from HAZOP in that it directs the analysis both inside and outside the process and places greater emphasis on identifying ways in which latent failures may reveal themselves.			3	4		6			nuclear, (oil&gas)	x		x			• [Kirwan, Part 1, 1998]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
603.	PRIMA (Process RIsk Management Audit)	Stat	Org	1996	Safety management assessment linked to Quantitative Risk Assessment-type of approach. The PRIMA modelling approach provides insight into the management factors influencing the accident risk, but does not permit this insight to be translated into a detailed quantitative influence.	Also referred to as Sociotechnical Audit Method.								8	chemical, oil&gas, aviation			x		x	• [Kennedy & Kirwan, 1998] • [Nivolianitou & Papazoglou, 1998] • [Roelen et al, 2000]
604.	Prior Incident Analysis	Step	HzA	2008	This is based on the analysis of previous incidents, which then informs the hazard analysis, risk analysis and design processes about types of hazards, causal factors, frequencies and impacts. It is the feedback of the analysis of incident data from operations into the design and assessment process. Types of information available from prior incident analysis include: Types of historic failure (which can inform the hazid process); Rates of historic failure (which can inform the hazard analysis/likelihood judgement); Historical effects of failure types on safety of operations (which can inform the hazard analysis/severity judgement); Relatives rates and severities of incident causal factors (which can drive the decisions about what changes are necessary or desirable (see Safety Issues Register elsewhere in this database).	Link with other incident investigation methods like Accident Analysis, CIT, In-Depth Accident Investigation, Safety Issues Register. See also CBR (Case-Based Reasoning).			3					8	(environment), (food), (security)	x			x		• [Basnyat, 2006] • [Johnson, 2003]
605.	PRISM (Professional Rating of Implemented Safety Management)	Tab	Org	1993	Safety culture audit tool uses performance indicators that are organised into groups. The scores on the sub-sets of safety performance areas are weighted and then translated into an overall index rating.	Qualitative. By AEA Technology.								8	food					x	• [Kennedy & Kirwan, 1998]
606.	PRMA (Procedure Response Matrix Approach)	Tab	HzI	1994	Aim is to identify errors of commission (EOC), which are more closely linked to cognitive errors (global and local misdiagnoses), and slip-based EOCs during emergencies. PRMA to some extent represents a more sophisticated and detailed investigation than the FSMA, though one that is more resource-intensive. The approach has several major stages: develop a PRM for all initiating events that produce significantly different plant responses; for each PRM review the decision points in the procedural pathway; identify potential incorrect decisions resulting from misinterpretation or failure of the plant to provide the appropriate information, or due to a procedural omission (lapse).	Related to SHERPA and SCHEMA and TEACHER-SIERRA. The approach has strong affinities with FSMA, which has faults on one axis of its matrix and symptoms on the other one. The technique is useful for considering how system status indications and procedures will affect performance in abnormal or emergency events, such as a nuclear power plant emergency scenario requiring diagnosis and recovery actions using emergency procedures. As such, it can be used to evaluate alarm system design adequacy, for example.			3		5				(nuclear)	x		x			• [Kirwan, Part 1, 1998]
	Probabilistic cause-effect models					See BBN (Bayesian Belief Networks)															
	Probabilistic Hazard Analysis					See PRA (Probabilistic Risk Assessment based on FTA/ETA).															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
607.	Probabilistic testing	Step	SwD	1995 or older	Software Testing technique. Probabilistic considerations are based either on a probabilistic test or on operating experience. Usually the number of test cases or observed operating cases is very large. Usually, automatic aids are taken which concern the details of test data provision and test output supervision.	Software verification and testing phase and validation phase. See also Tests based on Random data. See also Software Testing.							7		software		x				• [EN 50128, 1996] • [Jones et al, 2001] • [Rakowsky]
	Procedure Analysis					See Operator Task Analysis															
	Process Charts					See FPC (Flow Process Chart).															
608.	Process Hazard Analysis	Gen	HzA	1989 or older	Is a means of identifying and analysing the significance of potential hazards associated with the processing or handling of certain highly hazardous chemicals. It is directed toward analyzing potential causes and consequences of fires, explosions, releases of toxic or flammable chemicals and major spills of hazardous chemicals, and it focuses on equipment, instrumentation, utilities, human actions, and external factors that might impact the process.	Requirement of 29 CFR (Code of Federal Regulations) 1910.119 for chemical process industry. A variety of techniques can be used to conduct a Process Hazard Analysis, including HAZOP, Checklist analysis, What-if Analysis, FMEA, LOPA. See also Nuclear Explosives Process Hazard Analysis.			3		5				chemical, oil&gas	x					• [FAA AC431] • [ΣΣ93, ΣΣ97]
609.	Process simulation	Gen	SwD	1975	Aim is to test the function of a software system, together with its interface to the outside world, without allowing it to modify the real world in any way. The simulation may be software only or a combination of software and hardware. This is essentially testing in a simulated operational situation. Provides a realistic operational profile, can be valuable for continuously operating systems (e.g. process control).	Hard to accumulate sufficient tests to get high degree of confidence in reliability. See also Computer Modelling and simulation.		2			5				chemical, manufacturing, nuclear, rail	x	x				• [EN 50128, 1996] • [Rakowsky]
610.	PROCRU (Procedure-oriented Crew Model)	FTS	HFA	1980	Early control-theoretic model that aims to investigate the crew workload impact of commercial aircraft operations in the approach-to-landing phase of a flight. It is a closed-loop system model incorporating submodels for the aircraft, the approach and landing aids provided by ATC, three crew members, and an air traffic controller. Outputs of PROCRU are vehicle trajectory, state estimation errors, and attention allocation of each crew member.			2			5				aviation, nuclear	x		x	x		• [Baron et al., 1980] • [Visser, 1987] • [CBSSE90, p30] • [MUFTIS3.2-I, 1996]
	Production Readiness Analysis					See AoA (Analysis of Alternatives)															
611.	Production System Hazard Analysis	Step	HzI	1985 or older	Production System Hazard Analysis is used to identify hazards that may be introduced during the production phase of system development which could impair safety and to identify their means of control. The interface between the product and the production process is examined.	The technique is appropriate during development and production of complex systems and complex subsystems.			3						(aircraft)	x					• [FAA00] • [ΣΣ93, ΣΣ97]
	Program Proving					See Formal Proof.															
	Pro-SWAT (Projective Subjective Workload Assessment Technique)					See SWAT (Subjective Workload Assessment Technique)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
612.	Protected airspace models	Math	Col	1996 or older	In attempting to estimate the number of conflicts, a volume of protected airspace is generally defined around each flying aircraft. Typically this volume has the shape of a right cylinder with radius r and height h. A conflict is then defined as the overlap of any two of these cylinders in airspace. The size of the volume defines the type of conflict, e.g. violation of ATC separation standards, near miss, actual collision.						5				(ATM)			x			• [MUFTIS1.2, 1996]
613.	Prototyping	Gen	Mod	1982 or older	Prototyping, or Prototype Development, provides a Modelling / Simulation analysis of the constructed early pre-production products, so that the developer may inspect and test an early version. Aim is to check the feasibility of implementing the system against the given constraints, and to communicate the interpretation of the system to the customer, in order to locate misunderstandings.	This technique is appropriate during the early phases of pre-production and test. Valuable if the system requirements are uncertain or the requirements need strict validation. Related to performance simulation. Tools available. Variations are High-fidelity Prototyping, Low-fidelity Prototyping, Rapid Prototyping, Video Prototyping, Wizard of OZ Technique, Scale Model, Storyboarding, Animation.							7		manufacturing, aircraft, electronics	x	x				• [Bishop, 1990] • [FAA00] • [ΣΣ93, ΣΣ97]
	PSA (Probabilistic Safety Assessment)					See PRA (Probabilistic Risk Assessment based on FTA/ETA)															
614.	PSSA (Preliminary System Safety Assessment) according to ARP 4761	Int	SwD, HwD, Mit	1994	The PSSA according to ARP 4761 establishes specific system and item safety requirements and provides preliminary indication that the anticipated system architecture can meet those safety requirements. The PSSA is updated throughout the system development process. A PSSA is used to ensure completeness of the failure conditions list from the FHA and complete the safety requirements. It is also used to demonstrate how the system will meet the qualitative and quantitative requirements for the various failure conditions identified.	This PSSA is a refinement and extension of JAR-25 steps (though JAR-25 does not use the term PSSA). It covers both hardware and software.				4	5	6			aircraft, avionics	x	x				• [ARP 4754] • [ARP 4761] • [Klompstra & Everdij, 1997] • [Lawrence, 1999]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
615.	PSSA (Preliminary System Safety Assessment) according to EATMP SAM	Int	OpR	2002	The PSSA according to EATMP SAM determines that the proposed system architecture is expected to achieve the safety objectives. PSSA examines the proposed system architecture and determines how faults of system elements and/or external events could cause or contribute to the hazards and their effects identified in the FHA. Next, it supports the selection and validation of mitigation means that can be devised to eliminate, reduce or control the hazards and their end effects. System Safety Requirements are derived from Safety Objectives; they specify the potential means identified to prevent or to reduce hazards and their end effects to an acceptable level in combination with specific possible constraints or measures. Five substeps are identified: 1) PSSA initiation; 2) PSSA planning; 3) Safety requirements specification; 4a) PSSA validation; 4b) PSSA verification; 4c) PSSA assurance process; 5) PSSA completion. Most of these steps consist of subtasks.	This PSSA is a refinement and extension of JAR-25 steps and of the PSSA according to ARP 4761, but its scope is extended to Air Navigation Systems, covering AIS (Aeronautical Information Services), SAR (Search and Rescue) and ATM (Air Traffic Management).	1			4	5	6			ATM	x	x	x	x		• [EHQ-SAM, 2002] • [Review of SAM techniques, 2004]
616.	PTHA (Probabilistic Tsunami Hazard Assessment)	Step	HzA	2014	PTHA is a tsunami hazard assessment approach based on the Monte Carlo approach to probabilistic seismic hazard assessment (PSHA) and adapted to tsunami. The aim of a PTHA is to calculate the probability of exceeding a set of tsunami heights at the coast or near shore. The PTHA can be performed using an empirical and numerical method, and applies statistical analysis of historical tsunami data. The result is a tsunami hazard curve that determines a tsunami return period for a target coastal area or a target nuclear power plant site.	Approach should be followed by a tsunami fragility assessment that evaluates a failure probability of safety-related equipment and structures caused by the force and inundation height of a tsunami wave, and by a system analysis that calculates the risk caused by a tsunami using event trees and fault trees.					5				nuclear, environment	x					• [Gibbons et al, 2020] • [Horspool et al, 2014]
617.	PTS (Predetermined Time Standards)	Gen	HFA, Par	1948	PTSs are internationally recognised time standards used for work measurement. They are employed to estimate performance times for tasks that can be decomposed into smaller units for which execution times can be determined or estimated. The time necessary to accomplish these fundamental motions should be constants.	Also referred to as Predetermined Motion Time System (PMTS). Several PTS exist, including MTM, MOST, MODAPTS, GSD, SeqEasy, TMU, MTS.					5				navy, manufacturing, healthcare			x			• [MIL-HDBK, 1999]
618.	PUEA (Predictive Use Error Analysis)	Tab	HRA, Task	2007	Proactive analytical method for use error analysis. Is a further development of the methods Action Error Analysis (AEA), Systematic Human Error Reduction and Prediction Approach (SHERPA) and Predictive Human Error Analysis (PHEA). PUEA employs a process for breaking down the user's tasks into steps and then identifying and investigating potential errors of use for each step. Makes use of two question levels: one applied to tasks/functions, and the second to operations. It builds on human cognition theory. The results of the analysis are presented in matrixes showing which tasks have the most serious consequences, which error types gives rise to the highest risk, in which tasks there are errors difficult to detect, etc.	Aims at analysis of medical equipment designs. See also AEA, SHERPA, PHEA.			3		5				healthcare, road, leisure	x		x			• [Bligard & Osvalder, 2014] • [Sekar Fadlilah et al, 2019] • [Lundgren et al, 2011] • [Bligard & Osvalder, 2007]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
619.	PUMA (Performance and Usability Modelling in ATM)	Int	Task	1995 about	PUMA is a toolset designed to enable the prediction and description of controller workload for ATC scenarios. It is capable of assessing the effect on controller workload of various computer assistance tools. PUMA uses observational task analysis to try to capture all the relevant information about cognitive activities in a task, usually based on video analysis of someone (i.e. an ATCO) performing the task. Each task or activity is then classified by a PUMA analyst and its impact on workload calculated as a function of its usage of cognitive resources, and as a function of other activities' (competing) resource requirements. Some tasks or activities will conflict more with each other as they are demanding the same cognitive resources, as defined in a 'conflict matrix' within PUMA. Central to the PUMA methodology is a workload prediction algorithm, which calculates how different task types will impact on workload alone, and together. This algorithm is based on the Wickens (1992) multiple resource theory. The output is a prediction of MWL (Mental Workload) as it changes throughout the overall task.	The PUMA Toolset was developed for NATS by Roke Manor Research Limited. PUMA has been applied to a number of future operational concepts, providing useful information in terms of their likely workload impacts, and potential improvements in the designs of future tools for the ATCO. The motivation for using PUMA stems from the fact that real time simulation is resource intensive, requiring a lot of manpower to plan, prepare for, conduct, analyse and report each trial. It is therefore useful to apply the PUMA 'coarse filter' to new operational concepts before expensive real time simulation. This allows the more promising and the less promising options to be identified, before proceeding with the better options, to full simulation.		2			5				ATM			x			• [Kirwan et al, 1997] • [GAIN ATM, 2003] • [FAA HFW]
620.	Pure Hazard Brainstorming	Tab	HzI	1996	Hazard identification through "pure" brainstorming with experts, generally along scenarios. Allows identification of many hazards that are unimaginable for some other approaches. Rule 1: no analysis during the session and no solving of hazards; Rule 2: criticism is forbidden; Rule 3: use a small group; Rule 4: brainstormers should not be involved in the operation's development; need to play devil's advocates; current expertise is better than past experience; Rule 5: moderator should watch the basic rules; should make the brainstorm as productive as possible; needs to steer the hazard identification subtly; write short notes on flip-over or via beamer; Rule 6: short sessions and many coffee breaks and...bottles of wine for the most creative hazard; the last hazard; and inspiration, if necessary...	Also referred to as Scenario-based Hazard brainstorming or TOPAZ-based hazard brainstorming.			3						ATM	x	x	x	x	x	• [DeJong, 2004] • [DeJong et al, 2007] • [DeJong et al, 2007a]
	Q Sort					See Card Sorting															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
621.	Q850 (CAN/CSA-Q850 Risk Management Guideline for Decision-Makers)	Int	OpR, Dec	1997	Q850 is a guidance for risk management steps, intended to assist decision- makers in managing risk issues, including injury or damage to health, property, the environment, or something else of value. The process consists of six steps which are typically followed in several iterations: 1) Initiation – define the problem and scope and assemble the risk management team; 2) Preliminary analysis – identify hazards, start risk information library; 3) Risk estimation – estimate frequency and consequences of risk scenarios; 4) Risk evaluation – Estimate and integrate benefits and costs and assess stakeholder acceptance of risk; 5) Risk control – identify feasible risk control options and evaluate them; 6) Action/monitoring – develop implementation plan, evaluate effectiveness of risk management decision process, establish monitoring process. Complementary to all steps is Risk communication.	Q850 has been approved as a National Standard of Canada by the Standards Council of Canada. The guidelines do not provide specific technical tools for risk analysis, evaluation, and control	1	2	3	4	5	6	7	8	maritime, environment, chemical	x	x	x	x	x	• [CSA Q850.97, 2002]
622.	QCT (Quantified Causal Tree)	Math	Par?	1996 or older	Bayesian method to determine probability of top event from the probabilities of the basic events of a causal tree.						5				(aviation)	x					• [Loeve & Moek & Arsenis, 1996]
623.	QFGR (Quantifying Fire Growth Rates)	Math	Par	2014	Method for determining a distribution of fire growth rates for different buildings. It is based on fire growth rates for first objects ignited, and fire statistics regarding what kind of first objects are ignited. The method also provides a way to quantify the severity of the chosen fire growth rate, e.g. the 95th percentile fire growth rate.						5				police	x					• [Nilsson etal., 2014]
624.	QRAS (Quantitative Risk Assessment System)	Step	HzA	1998	QRAS is a PC-based software tool for conducting a Probabilistic Risk Assessment (PRA) on a system. The tool helps in modelling deviations from the system's nominal functions, the timing and likelihood of such deviations, potential consequences, and scenarios leading from initial deviations to such consequences.	Tools available, e.g. WinNUPRA, see [GAIN AFSA, 2003]. Developed by University of Maryland and by NASA for space missions.				4	5				space, healthcare	x					• [GAIN ATM, 2003] • [GAIN AFSA, 2003]
	QSA (Quantitative Safety Assessment)					See PRA (Probabilistic Risk Assessment based on FTA/ETA)															
625.	Quality Assurance	Gen	Val	2500 BC	Quality Assurance (QA) refers to a program for the systematic monitoring and evaluation of the various aspects of a project, service, or facility to ensure that standards of quality are being met. Two key principles characterise QA: "fit for purpose" (the product should be suitable for the intended purpose) and "right first time" (mistakes should be eliminated). Aim is to ensure that pre-determined quality control activities are carried out throughout development.	Tools available. Very old approach; it may even be dated back to the time of construction of the Egypt Pyramids (2500 BC)								8	healthcare, social, chemical, food, environment	x	x			x	• [Bishop, 1990]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
626.	Questionnaires	Gen, Tab	Dat	1975 or older	Questionnaires are sets of predetermined questions arranged on a form and typically answered in a fixed sequence. Is the basic tool for obtaining subjective data (provided the questions are unbiased). Questionnaires provide a structured means of collecting information from system users. They usually consist of specific questions about the performance of the system and human interface.	Of all the subjective methods, the questionnaire is the most frequently used and is invaluable in the expedient collection of human error data								8	all	x	x	x	x	x	• [Kirwan & Ainsworth, 1992] • [FAA HFW] • [MIL-HDBK, 1999]
	QUORUM Perilog					See Data Mining															
627.	Radiological Hazard Safety Analysis	Step	HzA	1997 or older	Structured approach to characterisation and categorisation of radiological hazards.	Broadly applicable to all facilities engaged in managing radioactive materials.			3						nuclear	x					• [ΣΣ93, ΣΣ97]
628.	RADS (Radar Analysis Debriefing System)	RTS	Trai	2003	RADS is a PC-based, real-time, tool for playback of radar and voice in a highly intuitive, three-dimensional format. It can be used for analysis of incidents and/or training and is adaptable to any Air Traffic Control environment.	Developed by NAV Canada. RADS is based on Flightscape's Recovery, Analysis and Presentation System (RAPS).								8	ATM	x		x	x		• [GAIN ATM, 2003]
629.	RAIT (Railway Accident Investigation Tool)	Step	Ret	1993	Tool developed to investigate accidents by identifying contributions to and aggregate Railway Problem Factors, i.e. representative of significant organisational and managerial root causes of railway infrastructure accidents. RAIT starts with the accident outcome and then traces back to the active and latent failures that originated higher up within the organisation.	Developed for use at British rail by James Reason and others. Also used as basis for training courses. MAIT (Marine Accident Investigation Tool) is a derived version for Marine safety.								8	rail	x	x	x	x	x	• [PROMAI5, 2001] • [RAIT slides] • [Reason et al, 1994]
630.	RAM (Resilience Analysis Matrix)	Stat	Ret	2013	Aims to analyse resilience characteristics with a focus on functions and on paths/instantiations. RAM matrix has rows and columns labelled by functions. Element (k,m) contains the input from function m to function k (k not equal to m) and (k,k) contains the output of function k. Rows and columns are ordered such that rows for functions are placed below all functions that they receive inputs from. If there are feedback loops, these are visible above the diagonal; otherwise the area above the diagonal is empty. Next, lines are drawn through all functions that are involved in an instantiation (set of couplings among functions for specified time intervals) of the function network. Visual inspection enables analysing upstream and downstream interactions, and differences and similarities between instantiations.	Can be used with SADT/IDEF0 or with FRAM. RAM can be used for retrospective (reconstructing the actual instantiations of an event) as well as prospective (possible instantiations in future behaviour of the system) analysis.				4					aviation, defence				x		• [Lundberg & Woltjer, 2013]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
631.	RAMS Plus (Reorganized ATC (Air Traffic Control) Mathematical Simulator)	FTS	Des	1995	RAMS Plus is a PC-based simulation tool that allows the users to create a model of an air traffic control system, ATC procedures, 4D performance of over 300 aircraft, 4D conflict detection and rule -based conflict resolution, and controller actions based on the current demand. It includes controller workload assignment based on dynamic system conditions, TMA (terminal manoeuvring area) runway sequencing and holding stack operations, airspace routing, free flight and Reduced Vertical Separation Minima zones, stochastic traffic generation, and graphical animation. The tool produces a detailed list of events created in text form for analysis.	The original RAMS is a fast-time simulation tool developed by the Eurocontrol Experimental Center (EEC) at Bretigny (France) and CACI Inc. in 1993. RAMS official release 2.0 was carried out in November 1995. RAMS Plus is developed, supported, and distributed exclusively by ISA Software.							7		ATM	x		x	x		• [GAIN ATM, 2003] • [FAA HFW]
	RAP (Risk Analysis Process)					See RAT (Risk Analysis Tool)															
	Rapid Prototyping					See Prototyping															
	RAPS and Insight (Recovery, Analysis, & Presentation System & Insight)					See Flight Data Monitoring Analysis and Visualisation															
632.	RAREAD (Risk Assessment for Reciprocating Engine Airworthiness Directives)	Step	HwD	2000	Method dedicated to risk assessment of reciprocating engines. Steps are: a) Determine consequences of engine service problem (hazardous, major, minor). b) Identification of suspect population (i.e. all engines on which the service problem might occur). c) Event rate (i.e. number of service problem events per operating hour; may be time-dependent). d) Exposure to failure condition, i.e. number of engines in suspect population, times number of hours per engine per year, times specified time period. e) Expected number of events (i.e. c times d). This number can then be compared to historical data or safety objectives for the respective criticality level (hazardous, major, minor) to determine the appropriate form of FAA action, if any.	A reciprocating engine, also known as a piston engine, is a heat engine that uses one or more reciprocating pistons (i.e. pistons moving up-and-down, or back-and-forth) to convert pressure into a rotating motion.		2			5	6			(aircraft)	x					• [SADAD Manual]
633.	RAS (Requirements Allocation Sheets)	Stat	Des	1969 or older	Requirements allocation sheets are used to translate functions into performance and design requirements. The functional analysis (usually a Function Flow Diagram) is used as a basis for the data entered on the sheets. RAS are normally prepared for each function block. In some cases, closely related functions may be analysed using the same RAS. Design requirements are identified in terms of the purpose of the function, parameters of the design, design constraints, and requirements for reliability, human performance, accuracy, safety, operability, maintainability. Thus the RAS bridges the systems engineering activities of function analysis and synthesis. The format of a RAS is not fixed. Each RAS documents the performance requirements and the design requirements for a specific system function.	The RAS is most useful during concept development and design definition. It must be preceded by a functional analysis and some system design synthesis. It provides the basis of detailed task analyses, performance prediction, and interface and workspace design. It is less useful during the latter stages of design and development.				4		6			defence, space	x		x			• [HEAT overview] • [Beevis, 1992]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
634.	RASRAM (Reduced Aircraft Separation Risk Assessment Model)	Int	Col	1997	RASRAM is used for quantitative assessment of the increase in risk of aircraft operations due to reduced separation requirements, and/or reduced risk due to new surveillance or navigational technology. It is a PC-based tool that is based on a large database of aircraft data, incorporating aircraft and air traffic controller data. The overall organisation of RASRAM is a fault-tree analysis of the major failure modes in specific operational scenarios. The approach includes time-budget analyses of dynamic interactions among multiple participants in a scenario, each with defined roles, responsibilities, information sources, and performance functions. Examples are response times for pilots and air traffic controllers. The methodology works directly with the functional form of probability distributions, rather than relying on Monte Carlo simulation techniques. The probability of a Near Mid-Air Collision (NMAC) is computed, and from this, the probability of a collision, using a factor of collisions/NMAC. Probability distributions of lateral miss distance and simultaneous runway occupancy are also computed.	RASRAM was developed by Rannoch Corporation.			3	4	5				(ATM)	x			x		• [GAIN ATM, 2003] • [Sheperd, 1997]
635.	RAT (Risk Analysis Tool)	Tab	Ret	2009	The RAT aims to analyse a reported incident event in order to understand the factors involved, to place the event in context with other events, to identify risk elements, and to prioritise actions designed to reduce the effect of those risk elements. The RAT uses a marksheet system in which a user can gives scores to determine the severity of the occurrence and the probability that a similar occurrence will recur in the future. There are separate marksheets for encounters between multiple aircraft, between two aircraft under tower control, between an aircraft and a vehicle on the ground, and for a situation where one aircraft is making a level bust or an airspace infringement, and for a situation with an ATM technical problem.	Developed by Eurocontrol. The FAA has adopted the tool under the name RAP (Risk Analysis Process), and uses it to assess the risk of Risk Analysis Events (RAEs), which are given events in which two airborne aircraft came closer than 66% of the radar separation minimum.					5				ATM	x	x	x	x		• [RAT Guidance, 2009] • [ATO SMS Manual v3.0] • [GAO, 2011] • [Licu et al, 2011]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
636.	Rating Scales	Tab?	Mod ?	1930 from	A Rating Scale is a set of categories designed to elicit information about a quantitative or a qualitative attribute. Generally, it couples a qualitative description of a criterion to a numerical measure. Various specific Rating Scales can be identified [FAA HFW], e.g. • Bedford Workload Scale (Workload) • Behaviorally Based Performance Rating Scale • China Lake Situational Awareness Rating Scale • Cooper Harper Rating Scale (Workload) • Dynamic Workload Scale (Workload) • Hart & Bortolussi Rating Scale (Workload) • Hart & Hauser Rating Scale (Workload) • Haworth-Newman Avionics Display Readability Scale (Investigation of displays) • Likert Scale (Agreement) • NASA TLX (NASA Task Load Index) • POMS (Profile of Mood States) • SA/BARS (Situation Awareness Behavioural Rating Scales) • SARS (Situation Awareness Rating Scales) • Semantic Differential Scales (Perception, Attitude/Agreement) • SUS (System Usability Scale) (User satisfaction with software) • Thurstone Scale (Attitude/Agreement)	The Dynamic Workload Scale is used in aircraft certification, e.g. by Airbus. See also SART. See also SWAT.				5				healthcare, avionics, social, software, aircraft			x			• [FAA HFW]
637.	RBD (Reliability Block Diagrams)	Stat	Mod	1972	Technique related to FTA where one is looking for a success path instead of failure path. Aim is to model, in a diagrammatical form, the set of events that must take place and conditions which must be fulfilled for a successful operation of a system or task. An RBD is drawn as a series of blocks connected in parallel or series configuration. Each block represents a component of the system with a failure rate. If a path may be found through the network from beginning to end, the system still works. An RBD may be converted to a success tree by replacing series paths with AND gates and parallel paths with OR gates. A success tree may then be converted to a fault tree by applying de Morgan's theorem.	Alternative name: SDM (Success Diagram Method). Useful for the analysis of systems with relatively straightforward logic, but inferior to fault tree analysis for more complex systems. In some references referred to as Dependence Diagrams (DD). RBD is also sometimes referred to as equivalent to a Fault Tree without repeated events. Tools available, but tools for FTA may also be useful.				4				aircraft, energy, oil&gas, food	x					• [Bishop, 1990] • [EN 50128, 1996] • [FT handbook, 2002] • [MUFTIS3.2-I, 1996] • [Sparkman, 1992]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
638.	RBRT (Risk Based Resource Targeting)	Step	Dec	2007	RBRT is a structured process designed to support aircraft certification oversight in determining risk, assigning resources based on that risk, and providing options to mitigate risk through targeted application of resources. A technical specialist answers RBRT questions about the applicant's organization and their experience with similar products or modifications. Next, RBRT assigns weights to the indicator questions associated with probability of noncompliance. These weights are combined with a severity rating based on the criticality of the product or modification to arrive at a composite risk value (CRV) for the project. RBRT's assessment tool also provides a 'group risk score' (low, medium, or high) for each technical discipline (electrical, mechanical, propulsion, etc).	In an audit report at http://www.oig.dot.gov/library-item/5591 it is argued that RBRT needs to be improved (e.g. it is stated to underestimate risk and be subjective).					5	6			aircraft	x	x				• [Notice IR N 8110.100] • [DoT AV-2011-136, 2011] • [Order IR 8110.102] • [FAA RBRT slides]
639.	RCA (Root Cause Analysis)	Step	Org, Ret	1955	This method identifies causal factors to accident or near-miss incidents. The technique goes beyond the direct causes to identify fundamental reasons for the fault or failure; it asks why things happen, instead of treating the symptoms. It is a systematic process of gathering and ordering all relevant data about counter-quality within an organisation; then identifying the internal causes that have generated or allowed the problem; then analysing for decision-makers the comparative benefits and cost-effectiveness of all available prevention options. To accomplish this, the analysis methodology provides visibility of all causes, an understanding of the nature of the causal systems they form, a way to measure and compare the causal systems, an understanding of the principles that govern those causal systems, and a visibility of all internal opportunities for the organisation to control the systems.	The root cause is underlying contributing causes for observed deficiencies that should be documented in the findings of an investigation. Several training courses, tools and supporting packages are (commercially) available.								8	healthcare, nuclear, chemical,oil&gas, aviation, ATM, rail	x		x	x	x	• [FAA00] • Several Internet sources • [ΣΣ93, ΣΣ97] • [Browne et al, 2008]
640.	RCFF (Regulatory-based Causal Factor Framework)	Tab	HzA	2009	The RCFF is a system safety process for analyzing hazards and associated causal factors due to introducing new technology into NAS (U.S. National Airspace System). It provides a qualitative means of identifying and assessing hazards controlled by existing regulations. The process starts at Part level of the current regulatory framework. Parts are associated with functions, which are intended to provide a contextual backdrop for the regulations. The functions are then associated with hazards. Finally, causal factors and their linkages associated with the hazards are identified using a text mining tool. The linkages are envisioned as the illustration of the influence or of the conditional dependency between two nodes constituting a network structure.	Has been applied to the introduction of unmanned aerial systems into manned airspace.			3	4	5				aviation, aircraft	x			x		• [FAA UAS SMS] • [FAA UAS SMS slides] • [FAA RCFF results] • [FAA RCFF approach] • [Oztekin 2009]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
641.	RCM (Reliability Centered Maintenance)	Step	HwD, Des	1978	RCM is the concept of developing a maintenance scheme based on the reliability of the various components of the system or product in question. Aims to anticipate the times when the system is down for maintenance, and to schedule other activities or processes accordingly. Seven steps: 1) Selection of equipment for RCM analysis; 2) Define the boundaries and function of the systems that contain the selected equipment; 3) Define the failure modes of the system; 4) Identify the root causes of the failure modes; 5) Assess the effects of failure; 6) Select a maintenance tactic for each failure mode; 7) Implement and then regularly review the maintenance tactic that is selected.	Approach varies between industries, but usually relies on FMECA. RCM is defined in the standard SAE JA1011, Evaluation Criteria for Reliability-Centered Maintenance (RCM) Processes. See also FMECA.		2	3		5	6			aircraft, defence, nuclear, leisure, navy, maritime, chemical, oil&gas, manufacturing, healthcare, food, rail	x		x			• [Cotaina et al, 2000] • [Moubray, 2000] • [NASA-RCM] • [Relex-RCM] • [Nowlan & Heap, 1978] • [Rausand & Vatn, 1998] • [Cotaina et al., 2000]
642.	RCS (Risk Classification Schemes)	Tab	Dec	1977 or older	These are matrices that relate the severity of risk or hazard to its maximum tolerated probability.	These exist for different domains and different types of systems, see the references for a collection. In many industries used to define a Safety Integrity Level. See also Safety Targets Setting.	1								ATM, management, healthcare, finance, food	x					• [Storey, 1996]
	Real-Time Simulation					See Computer modelling and simulation															
643.	Real-time Yourdon	Int	Des	1985	Complete software development method consisting of specification and design techniques oriented towards the development of real-time systems. The development scheme underlying the technique assumes a three phase evolution of a system being developed: 1) building an 'essential model' that describes the behaviour required by the system; 2) building an implementation model which describes the structures and mechanisms that, when implemented, embody the required behaviour; 3) actually building the system in hardware and software.	Worth considering for real-time systems without a level of criticality that demands more formal approaches. Related to SADT. Tools available. Software requirements specification phase and design & development phase.						6			software		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]
644.	REASON Root Cause Analysis	Stat	Ret	2002	REASON aims at determining root causes of events retrospectively, by constructing a logic tree model of the causal process. Next, for each root cause, it determines the significance that it played in producing a problem, and applies a cost-benefit analysis to determine how effective it will be to act upon the root cause.	REASON is supported by software that provides graphics.								8	healthcare, (aviation)	x		x	x		• [GAIN AFSA, 2003] • [FAA HFW]
	Reason's model					See Swiss Cheese Model.															
645.	Recovery blocks or Recovery Block Programming	Step	Des	1975 ?	Aim is to increase the likelihood of the program performing its intended function. A number of routines are written (in isolation) using different approaches. In addition, an Acceptance Test is provided and the first routine to satisfy the acceptance test is selected.	Effective in situations without strict temporal constraints. Software architecture phase. Can be regarded as an alternative execution of Diverse Programming, where each version is followed by an acceptance test.						6			software		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky] • [Sparkman, 1992] • [SSCS]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
646.	RECUPERARE	Step	Ret	2000	Model based on systematic analysis of events including Human Reliability in Nuclear Plants. Model puts emphasis on the recovery process during events and uses a classification for the default-recovery links and delays for detection diagnosis and actions. The method aims at the following objectives: 1) Identify the main mechanisms and parameters which characterise events occurring in the French PWSs (power series solution) during one year; 2) Provide a way of classifying deficiencies and associated recoveries; 3) Provide a way of classifying events according to previous parameters; 4) Record these data in a base to make trend analyses.	Developed by IRSN (Institute for Radiological Protection and Nuclear safety) for operating experience feedback analysis. For the time being, IRSN emphasises the difficulty in connecting performance indicators to safety. Has also been adapted for healthcare domain, in a version called RECUPERARE-Health.			3		5		7		nuclear, healthcare			x			• [Matahri, 2002] • [Matahri, 2003] • [Straeter, 2001]
647.	REDA (Ramp Error Decision Aid)	Int	Ret	1999 ?	The REDA process focuses on a cognitive approach to understand how and why the event occurred, not who was responsible. REDA contains many analysis elements that enable the user to conduct an in-depth investigation, summarise findings and integrate them across various events. The REDA data organisation enables operators to track their progress in addressing the issues revealed by the analyses. REDA is made up of two components: the interview process and contributing factors analysis. It consists of a sequence of steps that identify key contributing factors to ramp crew errors and the development of effective recommendations aimed at the elimination of similar errors in the future.	Developed by Boeing. REDA is based on MEDA. REDA is designed to investigate incidents that occurred during the receiving, unloading, loading, servicing, maintaining, and dispatching of commercial aircraft at an airport.								8	airport				x	x	• [GAIN AFSA, 2003] • [Reda example] • [Balk & Bossenbroek, 2010] • [REDA User Guide]
648.	Redundancy for Fault Detection	Gen	Des	1980 ?	By employing redundancy, checks may be made for differences between units to determine sub-system failures.	Useful in safety computer applications.						6			software	x					• [Bishop, 1990]
649.	Refined Reich collision risk model	Math	Col	1993	Refinement of Reich collision risk model (CRM) to evaluate risk of collision between aircraft. Replaces the two restrictive Reich assumptions by one less restrictive one.						5				(ATM)				x		• [Bakker & Blom, 1993] • [Mizumachi & Ohmura, 1977] • [MUFTIS3.2-II, 1996]
650.	REHMS-D (Reliable Human Machine System Developer)	Int	Des, Mit	1995	REHMS-D uses a six-stage system engineering process, a cognitive model of the human, and operational sequence diagrams (OSD) to assist the designer in developing human-machine interfaces subject to top-level reliability or yield requirements. Through its system engineering process, REHMS-D guides the designer through the understanding of customer requirements, the definition of the system, the allocation of human functions, the basic design of human functions, the assignment of job aids, and the design of tests to verify that the human functions meet the allocated reliability requirements. REHMS-D can be used for both the synthesis of new systems and the analysis of existing systems.	REHMS-D is called a major advance in system and reliability engineering that has broad application to systems and processes. It can be used to synthesise or analyse radar and sonar systems, control rooms and control systems, communications systems, geographic information systems, manufacturing processes, maintenance processes, biomedical systems, transportation systems, and other systems and processes that involve human-computer interfaces.		2				6			(defence), (manufacturing)	x					• [MIL-HDBK, 1999] • [FAA HFW] • [LaSala, 2003] • [Alley, 2005]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
651.	Reich Collision Risk Model	Math	Col	1964	This model estimates the probability of a mid-air collision between two en route level flying aircraft. The main objective is the determination of sufficiently safe lateral separation between adjacent parallel routes or vertical separation between adjacent flight levels. Important assumptions are that there are no collision avoidance manoeuvers, there is independence of position and velocity, and deviations from track in the lateral and vertical dimensions are independent of time. The model is primarily applicable to procedurally controlled oceanic traffic.	Developed by UK Royal Aircraft Establishment.					5				ATM				x		• [Reich, 1964] • [ICAO-CIR319, 2009] • [Bakker & Blom, 1993] • [Brooker, 2002] • [MUFTIS3.2-II, 1996] • [ICAO Doc 9574] • [Endoh, 1982]
652.	Relative Ranking	Step	HwD, Mit	1971	Rank hazardous attributes (risk) of process. Hazards can be ranked based on e.g. frequency of occurrence or on severity of consequences, etc. The ranking may lead to prioritisation of mitigating measures.	Versions of this method were developed by Fine and by Kinney & Wiruth (Naval weapons center, California). Applicable to any system wherein a ranking approach exists or can be constructed. See also PC (Paired Comparisons). See also Rapid Risk Ranking.					5				navy, ergonomics, management, healthcare, energy	x					• [ΣΣ93, ΣΣ97] • [Kinney & Wiruth, 1976]
	Relevance Diagram					Equal to Influence Diagram															
	Relevance Tree					See How-How Diagram															
	Relex Human Factors Risk Analysis					See HF PFMEA															
653.	Reliability Growth Models	Math	SwD	1972	Aim is to predict the current software failure rate and hence the operational reliability. After a software component has been modified or developed, it enters a testing phase for a specified time. Failures will occur during this period, and software reliability can be calculated from various measures such as number of failures and execution time to failure. Software reliability is then plotted over time to determine any trends. The software is modified to correct the failures and is tested again until the desired reliability objective is achieved.	Some problems have been reported during application. Tools available. See Musa model for an example.					5				software		x				• [Bishop, 1990] • [Sparkman, 1992]
654.	Remedy-oriented Analysis and Evaluation Procedure	Int	Ret	1994	A remedy-oriented system for systematically analysing and evaluating human-related incidents occurring in nuclear power plants. This method aims particularly at identifying causal factors and at deriving proposals for specific hierarchical countermeasures. Incorporates techniques such as: (a) a modified fault tree method for searching the underlying causal factors, (b) compilation of related events into sequential charts, (c) a technique for devising proposed hierarchical redundant countermeasures, and (d) implementation procedures set out in a practical manual form for easy familiarisation and application. Stages are: 1) Correct understanding of events; 2) Circumstantial analysis; 3) Causal analysis; 4) Proposal of countermeasures	Developed by Takano et al, Central Research Institute of Electric Power Industry, Japan.				4		6		8	nuclear			x			• [Takano et al, 1994] • [Ziedelis & Noel, 2011]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
655.	REPA (Risk and Emergency Preparedness Analysis)	Int	OpR	1993	Aim is to get a total overview of the risks involved for concept selection and to check compliance with acceptance criteria. REPA consists of two parts: risk analysis, and emergency-preparedness analysis. The risk analysis involves four activities: 1) System description; 2) Identification of hazards and listing of initial events; 3) Accident modelling, consequence evaluation and assessment of probabilities; 4) Evaluation of risk and comparison with risk-acceptance criteria. The emergency-preparedness analysis identifies dimensioning accidental events, i.e. major accidents which generate the most severe accidental loads that the safety barriers must be able to withstand.			2	3	4	5				oil&gas	x			x		• [Kjellen, 2000]
656.	Requirements Criticality Analysis	Step	Mit	1996 or older	The requirements of the software/ hardware system are analysed and those are identified that could present catastrophic or critical hazards. Identified potential hazards are then addressed by adding or changing the system requirements and reflowing them to hardware, software and operations as appropriate. Safety critical requirements are placed into a tracking system to ensure traceability of software requirements throughout the software development cycle from the highest level specification all the way to the code and test documentation.				3						software, (avionics), (nuclear), (space)		x				• [FAA00] • [NASA-GB-1740.13-96]
657.	Re-try Fault Recovery	Gen	Mit	1990 or older	Aim is to attempt functional recovery from a detected fault condition by re-try mechanisms, i.e. re-executing the same code or by re-booting. There are three general categories of methods used to recover to a previous state: (1) checkpointing, (2) audit trails, and (3) recovery cache.	Should be used with care and always with full consideration of the effect on time-critical events, and the effect of lost data during re-boot. Combine with software time-out checks or watchdog timers. Software architecture phase.						6			software		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky] • [Sparkman, 1992]
658.	Return to Manual Operation	Gen	Des	1990 or older	Aim is to provide the operator or supervisor the information and the means to perform the function of the failed automatic control system.	Useful provided it is used with care.						6			electronics	x					• [Bishop, 1990]
659.	RFA (Repetitive Failure Analysis)	Step	HzA	1991 or older	Aim is to model recurring events that prevent a technical system from performing its function. It provides a systematic approach to address, evaluate and correct repetitive failures, such as Repeated failure of a piece of equipment; Repeated failure of items belonging to a system or subsystem; Failures of the same/similar parts in various different equipment or systems.	Applicable in maintenance, e.g. in an RCM process.				4		6			nuclear, manufacturing, oil&gas	x					• [ΣΣ93, ΣΣ97]
660.	RHA (Requirements Hazard Analysis)	Step	Mit	1995 or older	The purpose of RHA is to perform and document the safety design requirements/design criteria for a technical system or facility undergoing development or modification, and to develop safety requirements from regulations, standards, laws, etc. that are generic and not related to a specific identified hazard.	RHA is typically executed after concept exploration and as input to preliminary design. According to [Ericson, 2005] this is an alternative name for SRCA.			3						(aircraft), (navy)	x	x				• [FAA00] • [AF SSH, 2000] • [Ericson, 2005]
	RIA (Risk Influence Analysis)					See RIF diagram (Risk Influencing Factor Diagram)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
661.	RIF diagram (Risk Influencing Factor Diagram) or RIA (Risk Influence Analysis)	Stat	Mod	1998	RIFs are classified according to Operational RIFs, Organisational RIFs and Regulatory related RIFs. The Operational RIFs are divided into technical, human and external factors. The RIFs are next arranged in an (Accident) Frequency Influence Diagram and an (Accident) Consequence Influence Diagram. All RIFs are characterized by their status (present state) and their effect (influence) on other RIFs. Arrows indicate the influence between one RIF and another, usually at the next upward level.	Alternative to fault trees and event trees. A RIF is a set of relatively stable conditions influencing the risk. It is not an event, and it is not a state that fluctuates over time. RIFs are thus conditions that may be influenced or improved by specific actions. Also referred to as Influence Diagrams.					5				aviation, rail, oil&gas	x		x			• [Vinnem, 2000] • [Hokstad et al, 1999] • [Albrechtsen & Hokstad, 2003]
662.	Risk Decomposition	Math	Mod	1996	The aim of this technique is to mathematically decompose the frequency of occurrence of a rare event into a product of frequencies and conditional frequencies of less rare events. This is to be done in such a way that the decomposition is mathematically sound, and the evaluation of the factors in the product is less demanding than the evaluation of the rare event itself.	An example rare event evaluated using this technique is the collision between two aircraft. The factors in the product are to be evaluated using other methods such as Monte Carlo simulation of a stochastic dynamic risk model. Developed as part of TOPAZ.				4					ATM				x		• [Blom & Bakker et al, 2003] • [MUFTIS3.2-II, 1996]
663.	Risk Graph Method	Stat	HzA	1994	Risk Graphs are used to determine safety integrity levels (SIL) using process risk factors or parameters for hazardous events. Usually, four parameters are employed: consequence (C), frequency and exposure time (F), probability of avoiding the hazardous event (P), and probability of the unwanted occurrence (W). The four factors are evaluated from the point of view of a theoretical person being in the incident impact zone. The likelihood and consequence are determined by considering the independent protection layers during the assessment. Once these factors are determined, the risk graph is utilized to determine a SIL that will reduce the risk to a tolerable level.	Developed by IEC 61508. Reference [ACM, 2006] lists some advantages and disadvantages. A Safety Integrity Level (SIL) is a numerical target for the probability of failure of a Safety Instrumented Function (SIF), which is a set of actions to protect against a single specific hazard. Risk Graphs are mainly popular in Europe; In the US, Layers of Protection Analysis (LOPA) is a more popular alternative to determine SILs.					5				electronics, chemical, nuclear	x					• [Gulland, 2004] • [IEC 61508, 1998] • [ACM, 2006] • [Summers, 1998] • [Risk Graph Example]
664.	Risk-Based Decision Analysis	Gen	Dec	1983 or older	Risk-Based Decision Analysis aims at quantifying, and taking into account, the actual costs, benefits and risks associated with the decision-making process, regarding alternative policies. The assessed probability of policy failure, e.g. resulting from stochastic simulation of environmental systems under study, forms useful information in this decision-making.	Risk-Based Decision Analysis is commonly regarded as a generic term; many different techniques can be used in the analysis. It is of particular use in cases where information relative to a specific state of an activity may be insufficient and/or inadequate.				4	5	6			environment, management, food, nuclear, finance	x					• [Mylopoulos & Mylopoulos, 1999] • [Faber & Stewart, 2003] • [Evans et al, 1993] • [ARES-RBDA] • [FAA00] • [ΣΣ93, ΣΣ97]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
665.	RITA (Replay Interface of TCAS (Traffic Collision Avoidance System) Alerts)	RTS	Trai	1995	RITA 2 is an experience feedback tool for the training of air traffic controllers and to reinforce the training of flight crews. It shows on the same screen what both pilots and controllers could see and a transcript of what was said. Although individual use is possible, RITA is best used by instructors in briefing sessions with small groups of pilots and controllers. Its display is divided into three main parts: 1) a visual display simulating the radar display provided by radar recordings, 2) a visual display of the pilot's view on either an Instantaneous Vertical Speed Indicator (IVSI) or an Electronic Flight Instrument System (EFIS), with the associated aural alarms, 3) display of the transcript of voice communication between controller(s) and pilots.	RITA was initially developed by Centre d'Etudes de la Navigation Aérienne (CENA) in 1995 for the ACAS (Aircraft Collision Avoidance System) training of French controllers. RITA 2 is a new PC-based European version whose main objectives are to include TCAS II Version 7 events and to implement modern radar and TCAS displays. A library of TCAS alert events are being assembled, selected based on their relevance to training needs.								8	aviation, ATM			x			• [GAIN ATM, 2003]
666.	RMA (Rate Monotonic Analysis)	Int	SwD	1973	It ensures that time critical activities will be properly verified. RMA is a collection of quantitative methods and algorithms that allows engineers to specify, understand, analyse, and predict the timing behaviour of real-time software systems, thus improving their dependability and evolvability. RMA can be used by real-time system designers, testers, maintainers, and troubleshooters, as it provides 1) mechanisms for predicting real-time performance; 2) structuring guidelines to help ensure performance predictability; 3) insight for uncovering subtle performance problems in real-time systems. This body of theory and methods is also referred to as generalised rate monotonic scheduling (GRMS).	Is a useful analysis technique for software. Also referred to as Rate Monotonic Scheduling.					5				software, (avionics), (space)		x				• [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky] • [Sha & Klein, 1991]
	ROBDD (Reduced Ordered Binary Decision Diagram)					See BDD (Binary Decision Diagram).															
667.	RRR (Rapid Risk Ranking)	Step	Par	2004	Rapid qualitative judgements of the expected frequency and consequences of the identified hazards, enables trivial hazards to be screened out, such that the subsequent quantitative work focuses on the significant hazards only.	Developed by European integrated Hydrogen Project (EIHP). See also Relative Ranking.					5				oil&gas	x					• [EQE Web]
668.	RSM (Requirements State Machines)	Stat	Mod	1991	An RSM is a model or depiction of a system or subsystem, showing states and the transitions between states. Its goal is to identify and describe all possible states and their transitions.	Developed by Jaffe & Leveson and others. Is a special form of Finite State Machine (FSM).		2							software	x	x				• [Jaffe & Leveson etal, 1991] • [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
669.	RSSB approach (Rail Safety and Standards Board approach)	Tab	Org	2008	Aims to assess safety culture of a railway-related organisation. Uses a questionnaire that covers: 1. Effective and appropriate safety management systems (barriers and influences, training, communications), 2. Demonstrable management commitment to safety (organizational commitment, management commitment, supervisor's role), 3. Participation involvement and workforce attitude to safety (personal role, work mate's influence, risk taking behaviours, employee participation), 4. Organizational learning and continuous improvement. Using a five point Likert-type scale, the percentage of the answers, the mean values and standard deviations are calculated for each safety culture factor.	Has been used by Birse Rail, GB Rail freight, Scotrail, Southern Railways.								8	rail					x	• [Mkrtchyan & Turcanu, 2012]
670.	RTSRA (Real-Time Safety Risk Assessment)	Math	OpR	2014	Human-centered method that gives a real-time safety assessment for managers of construction sites, by using locations of workers and supervisors (obtained by GPS-tracked telephone) and their neighbourhood to static and dynamic hazardous equipment such as heavy machinery. A hidden Markov model (HMM) is used to find the most likely probability distribution of each monitored worker's states, followed by obtaining the real-time safety risk for each worker.				3		5				manufacturing			x			• [Hanchen et al, 2014]
671.	Rule violation techniques	Gen	Des	1995 or older	These are techniques that try to avoid violations of rules, e.g. by designing the system such that the violation is prohibited, or such that an alert follows after the violation.	See also TOPPE.						6			oil&gas, nuclear, mining		x	x			• [HSEC, 2002]
	SA/BAR (Situational Awareness Behaviorally Anchored Rating Scale)					See Rating Scales															
672.	SAC (Safety Assessment Curve)	Step	HzA	2013	SAC is a graphical approach for safety assessment in petrochemical industry. The curve visualises the effect of temperature, pressure, heat of reaction, inventory, flammability, explosiveness, toxicity and reactivity, and shows the correlation between the parameters assessed on the score of 100. Technique aims to find the safer route among several numbers of alternatives for chemical synthesis or process retrofitting, and to highlight the potential source of hazards in the process.						5				oil&gas				x		• [Ahmad, Hashim & Hassim, 2013]
673.	SACRI (Situation Awareness Control Room Inventory)	Tab	HFA	1995	Adaptation of SAGAT to evaluate nuclear power plant operator's situational awareness and uses the freeze technique to administer control room based situational awareness queries.	SACRI was developed as the result of a study investigating the use of SAGAT in process control rooms. The freeze technique involves the freezing of the exercise at random times, during which the subjects respond to questions.					5				nuclear			x			• [Hogg et al, 1995] • [Collier et al, 1995]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
674.	SADA (Safety Architectural Design Analysis)	Step	SwD	1996 or older	Analysis performed on the high-level design to verify the correct incorporation of safety requirements and to analyse the Safety-Critical Computer Software Components (SCCSCs). It uses input from the Architectural Design, the results of the Software Safety Requirements Analysis (SSRA), and the system hazard analyses. The SADA examines these inputs to: a) Identify as SCCSCs those software components that implement the software safety requirements identified by the SSRA. Those software components that are found to affect the output of SCCSCs shall also be identified as SCCSCs; b) Ensure the correctness and completeness of the architectural design as related to the software safety requirements and safety-related design recommendations; c) Provide safety-related recommendations for the detailed design; d) Ensure test coverage of the software safety requirements and provide recommendations for test procedures. The output of the SADA is used as input to follow-on software safety analyses.	In [FAA00] referred to as ADA (Architectural Design Analysis).							7		(software), (space)		x				• [FAA00] • [NASA-STD-8719] • [Rakowsky]
675.	SADT (Structured Analysis and Design Technique)	Stat	Dec, Task	1973	SADT aim is to model and identify, in a diagrammatical form using information flows, the decision making processes and the management tasks associated with a complex system. A SADT model is an organised sequence of diagrams, each with supporting text. SADT also defines the personnel roles in a software project. Main boxes contain the name of the process/action. On the left hand side of a box, incoming arrows model inputs of the action. On the upper part, incoming arrows model data necessary for the action. On the bottom, incoming arrows model the means used for the action. On the right hand side, outgoing arrows model the outputs of the action.	Developed by Douglas T. Ross and SofTech, Inc. between 1969-1973. Good analysis tool for existing systems, and can also be used in the design specification of systems. Software requirements specification phase and design & development phase. SADT also defines the personnel roles in a software project. The military equivalent to SADT is IDEF0.		2							finance, maritime, ATM	x	x				• [Bishop, 1990] • [EN 50128, 1996] • [HEAT overview] • [Rakowsky] • [Beevis, 1992]
	SAFE (Software Analysis for Flight Exceedance)					See Flight Data Monitoring Analysis and Visualisation															
676.	Safe Subset (Safe Language Subsets or Safe Subsets of Programming Languages)	Gen	Des	1990 or older	With the Safe Subset approach, the definition of a programming language is restricted to a subset, by excluding programming constructs that are either error-prone or difficult to analyse, for example, using static analysis methods. Aim is to reduce the probability of introducing programming faults and increase the probability of detecting any remaining faults.	Software design & development phase. Tools available. See also Design and Coding Standards.						6			software, (space)		x				• [Bishop, 1990] • [EN 50128, 1996] • [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
677.	SAFER (Safety Assessment For Explosives Risk)	Math	OpR	2000	SAFER was developed to provide a more comprehensive assessment of the overall risk of explosives operations. It calculates risk in terms of the statistical expectation for loss of life from an explosives event. Three components are multiplied to estimate annual maximum probability of fatality, P(f), and the expected fatalities, E(f): (1) the probability of an explosives event, P(e), (2) the probability of a fatality given an event, P(f/e), and (3) the average exposure of an individual, E(p). SAFER calculates risk using the following basic equations: $P(f) = P(e) \times P(f/e) \times E(p)$ to determine individual risk; $E(f) = \Sigma(P(e) \times P(f/e) \times E(p))$ to determine group risk. Risk exceeding individual and group risk limits constitutes a violation of the risk acceptance criteria.	Developed for DDESB (Department of Defense Explosives Safety Board), and for Defence application only. See also Explosives Safety Analysis. See also Process Hazard Analysis.					5				defence	x					• [DDESB, 2000]
678.	Safety Bag	Step	Mit	1969 ?	Aim is to protect against residual specification and implementation faults in software that adversely affect safety. In this technique, an external monitor, called a safety bag, is implemented on an independent computer using a different specification. The primary function of the safety bag is to ensure that the main system performs safe - but not necessarily correct - operations. The safety bag continually monitors the main system to prevent it from entering an unsafe state. If a hazardous state does occur, the system is brought back to a safe state by either the safety bag or the main system.	May be considered for fail-systems, provided there is adequate confidence in the dependability of the safety bag itself. Tools are not applicable. Software architecture phase. The Safety Bag is a form of Fault Detection and Diagnosis (FDD).			3			6			space, electronics	x	x				• [Bishop, 1990] • [EN 50128, 1996] • [Sparkman, 1992]
679.	Safety Monitoring	Step	HzI	1992 or older	Safety monitoring is a means of protecting against specific failure conditions by directly monitoring a function for failures that would contribute to the failure condition. Monitoring functions may be implemented in hardware, software, or a combination of hardware and software. Through the use of monitoring technique, the software level of the monitored function may be reduced to the level associated with the loss of its related system function.								7		aircraft, software, healthcare	x	x				• [DO-178B, 1992]
680.	Safety Review or Safety Audit	Gen	HzI, Val, Ret		A Safety Review assesses a system, identifies facility conditions, or evaluates operator procedures for hazards in design, the operations, or the associated maintenance.	Periodic inspections of a system, operation, procedure, or process are a valuable way to determine their safety integrity. A Safety Review might be conducted after a significant or catastrophic event has occurred.							7		road, rail, manufacturing, healthcare, nuclear, chemical, aviation, aircraft, software				x		• [FAA00] • [Storey, 1996] • [ΣΣ93, ΣΣ97]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
681.	Safety Scanning	Tab	Org, Dec	2010	Safety Scanning aims at scanning a given operational change on all aspects important for safety. These aspects are referred to as "Safety Fundamentals", and they are divided into Safety Regulatory aspects, Safety Management aspects, Operational Safety aspects, and Safety Architecture aspects. Application of the method results in addressing key issues that need to be part of a consistent safety argument, which should provide the basis for regulatory acceptance of an operational change.	Developed for Eurocontrol SRC (Safety Regulatory Commission) by University of Kassel, National Aerospace Laboratory NLR and Helios Ltd. Was built on 'Safety Screening Techniques', but with more focus on Regulatory Safety issues. The method is supported by the Safety Scanning Tool (SST) which is an electronic wizard implemented in MS Excel that asks up to 5 questions per Safety Fundamental. The method can be used in all lifecycle stages of a proposed change, but is most effective during earlier stages.	1	2						8	aviation, ATM, airport	x	x	x	x	x	• [SCAN TF, 2010] • [SCAN TF, 2010a] • [SCAN TF, 2010b]
682.	Safety Screening Techniques	Step	OpR	2006	Collection of four methods of screening Air Traffic Management (ATM) system changes, built upon the rationale of the "Safety Fundamentals", in order to make a preliminary assessment of their safety implications, and also to enable systematic consideration of safety issues within ATM strategy development. The objectives of the methods are: • To anticipate safety issues at an early stage in ATM concept development, including both positive and negative effects on safety. • To prioritise ATM changes for more detailed safety assessment studies. • To enable systematic consideration of safety issues within ATM strategy development.	The four methods have been proposed by four groups of experts, from Eurocontrol, NLR (National Aerospace Laboratory), DNV (Det Norske Veritas), TÜV (Technischer Überwachungs-verein). Successor tool is named SST (Safety Scanning Tool), see at Safety Scanning.		2			5				(ATM)	x		x	x		• [Straeter, 2006]
683.	Safety targets setting	Gen	Dec	2001 or older	Setting requirements for the level of safety that is tolerated.	See also Risk Classification Schemes.	1								ATM, nuclear, road, rail, oil&gas, chemical, aviation, aircraft, food	x		x			• [SPF-safety01]
684.	SAFMAC (SAFety validation framework for MAjor Changes)	Int	Val	2006	Framework for the development of a validated operational concept for a major change in air transport operations in which multiple stakeholders play an important role. Consists of two complementary components. The first is a framework of four synchronised processes: 1) Joint goal setting by all stakeholders involved; 2) Development of operational concept; 3) Allocation of tasks and information flows to individual stakeholders; 4) Validation. The second SAFMAC component is a list of 32 safety validation quality indicators to characterise which aspects should be addressed by a safety validation for a major change in air transport operations.	Developed by NLR, together with Dutch regulatory and Oversight authorities, the Dutch ANSP, and Eurocontrol. See also Safety Scanning.	1	2	3	4	5	6	7	8	aviation, ATM					x	• [Everdij et al, 2006b] • [Everdij & Blom, 2007] • [Everdij et al, 2009]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
685.	SAFSIM (Simulations for Safety Insights)	RTS	HRA	2002	SAFSIM is a process and a toolbox of measures. The process involves either the measurement of the safety of air traffic controller performance when faced with specific safety-related events (e.g. hazards) in a real-time human-in-the-loop simulation, or else general safety monitoring using less intrusive procedures to see if any safety-relevant information arises during a real time simulation.	Launched by EEC (Eurocontrol Experimental Centre) in 2002.			3		5				ATM			x	x		• [SAFSIM guidance] • [Scaife, 2000] • [Gordon, 2004] • [Shorrock et al, 2005] • [Gizdavu02] • [SAP15]
686.	SAGAT (Situation Awareness Global Assessment Technique)	Tab	HFA	1988	SAGAT is a specialised questionnaire for querying subjects about their knowledge of the environment. This knowledge can be at several levels of cognition, from the most basic of facts to complicated predictions of future states. It is administered within the context of high fidelity and medium fidelity part-task simulations, and requires freezing the simulation at random times.	Developed by Mica Endsley. SAGAT is a method that provides an objective measure of situation awareness (SA) during a simulated operation. It is not intended for use during an actual operation.							7		defence, aviation, healthcare, ATM			x		x	• [Endsley, 1997] • [HIFA Data] • [MIL-HDBK, 1999] • [FAA HFW] • [GAIN ATM, 2003] • [Alley, 2005]
687.	SAI DCT (Safety Attribute Inspection Data Collection Tool)	Dat	Dat	1999 or older	This tool is used to collect data about regulatory compliance in order to assess the adequacy of the design of the processes associated with each system element for an air carrier. The tool is organized in accordance with six safety attributes, i.e. qualities of a system, (e.g., authority, responsibility, procedures, controls, process measurements, and interfaces) that should be present in well-designed air carrier systems and processes.	Inspectors use the Safety Attribute Inspection questions to collect data for design assessment. Air carrier applicants use SAI DCTs during initial certification to document the results of their self audit.		2					7		aviation				x	x	• [FAA FSIMS, 2009] • [SAI-AQP, 2008] • [GAO, 1999]
688.	SAINT (Systems Analysis of Integrated Network of Tasks)	FTS	Task	1974	SAINT is a general purpose network modelling and simulation technique that can be used in the design and development of complex human-machine systems. Using a Monte Carlo approach, SAINT provides the conceptual framework and the means for modelling systems whose processes can be described by discrete and continuous functions/tasks, and interactions between them. It provides a mechanism for combining human performance models and dynamic system behaviours in a single modelling structure.	Micro-SAINT (1985) is a commercial version of SAINT. It is easier to use than SAINT but has fewer features. It is a discrete-event task network modelling tool that can be used to analyse and improve any system that can be described by a flow diagram. It can be used to answer questions about the costs of alternative training, about how crew workload levels or reaction times affect system performance, and about the allocation of functions between people and machines.		2							avionics, navy, defence, ATM, aviation, nuclear	x		x			• [CBSSE90, p40] • [HEAT overview] • [Kirwan, 1994] • [Kirwan, Part 1, 1998] • [THEMES, 2001] • [GAIN ATM, 2003] • [Pritsker et al., 1974] • [Beevis, 1992] • [Morrison, 2003]
689.	SALIANT (Situational Awareness Linked Indicators Adapted to Novel Tasks)	Tab	HFA	1993	SALIANT involves the use of a theoretically based list of behaviours to assess team behavior. It is an inferential technique that requires experts to rate situation awareness (SA) based upon implicit evidence from observable correlates. SALIANT comprises 5 phases: Phase 1: Delineation of behaviours theoretically linked to team SA. Phase 2: Development of scenario events to provide opportunities to demonstrate team SA behaviours. Phase 3: Identification of specific, observable responses. Phase 4: Development of script. Phase 5: Development of structured observation form.	Developed by the US Naval Air Warfare Centre.				4	5				navy			x			• [Muniz et al, 1998] • [Smith et al, 2007] • [FAA HFW] • [Muniz et al., 1993]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
	SAM (Safety Assessment Methodology)					See EATMP SAM															
690.	SAME (Safety Assessment Made Easier)	Int	OpR	2008	SAME describes the broad framework on to which the EATMP SAM-defined processes, and the associated safety, human-factors and system-engineering methods, tools and techniques, are mapped in order to explain their purpose and interrelationships. Where EATMP SAM focuses on the negative contribution to risk, SAME additionally considers the positive contribution of the concept under investigation to aviation safety. It does this by proposing a 'broader approach to safety assessment', consisting of complementary success and failure approaches: The success approach seeks to show that an ATM system will be acceptably safe in the absence of failure; The failure approach seeks to show that an ATM system will still be acceptably safe, taking into account the possibility of (infrequent) failure. In SAME, the safety assessment is driven by a safety argument structured according to system assurance objectives and activities.	SAME was developed by EUROCONTROL. See also EATMP SAM, and SESAR SRM.	1	2	3	4	5	6	7		ATM	x	x	x	x		• [SAME PT1, 2008] • [Fowler et al., 2009]
691.	SAMPLE (Situation Awareness Model for Pilot-in-the-Loop Evaluation)	FTS	HFA	1996	SAMPLE models the situation awareness and actions of operators (individuals or crews) of complex human-machine systems. Recent variants have been applied to the study of the effects of individual differences and environmental stressors on cognitive performance. SAMPLE assumes that the actions of an operator are guided by highly structured standard procedures and driven by detected events and assessed situations. Some variants assume a multitasking environment. In all cases, the operator (or crew) is concerned primarily with performing situation assessment, continuous control and communication, and discrete procedure execution.	Developed by G.L. Zacharias and K.A. Harper, Charles River Analytics. It has been applied to e.g. combat aviation, commercial aviation and air traffic control, battlefield command and control, and Military Operations on Urban Terrain (MOUT).				4	5				aviation, ATM, defence, nuclear, police			x			• [GAIN ATM, 2003] • [FAA HFW] • [Parasuraman & Rovira, 2005] • [Zacharias et al, 1995] • [Morrison, 2003]
692.	SAR (Safety Action Record)	Tab	Val	2000 or older	A SAR is a unique record used to document a hazard in a hazard tracking system. Each SAR includes: A description of the hazard, status; An updated narrative history, including origin and context of hazard identification; A current risk assessment; Justification for the risk severity and probability to include existing controls, and requirements for the SRVT (Safety Requirements Verification Table); A mitigation and verification plan; Potential effects if the hazard is realized. Each SAR must be classified according to status (Proposed, Open, Monitor, Recommend closure, Closed). All program SARs are reviewed with (1) Proposed status, (2) Open status, and (3) current high risk. This review is to occur at least biannually per program. The key is the maintenance and accessibility of a SAR.	See also HTRR and SRMTS.						6	7		(aircraft), (ATM)	x	x				• [SAP15] • [FAA00] section 2.2.3 • [SRM Guidance, 2007]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
693.	SARA (Small Airplane Risk Assessment)	Math	HwD	2000	In this method, one first determines the Safety Effect (i.e. the potential outcome of the known failure condition, being catastrophic, hazardous, major or minor effect) and the Safety Risk Factor (i.e. Safety Effect (a) x Operational Use (b) x Percentage used by population (c) + Number of Occurrences (d) + Events versus Population (e) + Time between Events (f) + Aircraft Type (g)). Each of (a) though (g) is translated to a number between -3 and +4. The higher the Safety Effect and the higher the Safety Risk Factor, the more negative the airworthiness effect. The results are plotted on an Initial Risk Assessment Evaluation Chart (Safety effect on y-axis, Safety Risk Factor on x-axis). From the chart, the most likely responsive action is determined, ranging from providing service information (lower left corner), to emergency action (upper right corner).	SARA is also referred to as "14 CFR Part 23 (AD) Risk Assessment" or "Risk Assessment for Airworthiness Concerns on Small Airplane Directorate Products". The term 'Small Airplane' refers to airplanes in a range from manned balloons, gliders, and turbine engine airplanes to commuter category airplanes.					5	6			(aircraft)	x					• [SADAD Manual] • [FAA AC 23-11B]
694.	SARD (Strategic Assessment of ATM Research and Development results)	Step	Val	2008	SARD defines a process and a set of 'transition criteria' for the analysis of ATM R&D (air traffic management research and development) results per operational concept from a strategic view point. The process assesses the maturity of operational concepts, in terms of the phases of the Concept Lifecycle Model of E-OCVM, and provides recommendations for next steps.	The SARD process has been successfully applied and further improved through application to two ATM operational concepts. In principle it can be used for any ATM improvement under development. See also E-OCVM.						6			(ATM)	x	x	x	x	x	• [CAATS II D13, 2009]
695.	SART (Situation Awareness Rating Technique)	Tab?	Mod ?	1989	SART is a multi-dimensional rating scale for operators to report their perceived situational awareness. It examines the key areas of SA: understanding, supply and demand. These areas are further broken down into the 14 dimensions ([Uhlarik & Comerford, 2002] mentions 10 dimensions). From the ratings given on each of the dimensions situational awareness is calculated by using the equation SA =U-(D-S) where U is summed understanding, D is summed demand and S is summed supply.	Developed by R.M. Taylor in 1989. SART is simple, quick and easy to apply. It has been applied to several complex domains, including air traffic control. 3D-SART is a narrowed-down version of SART, applicable to aircrew, and covering only 3 dimensions: (a) Demands on Attentional Resources - a combination of Instability of Situation, Complexity of Situation, and Variability of Situation; (b) Supply of Attentional Resources - a combination of Arousal of Situation, Concentration of Attention, Division of Attention, and Spare Mental Capacity; and (c) Understanding of Situation - a combination of Information Quantity, Information Quality, and Familiarity. See also Rating Scales.					5				ATM, defence, aviation	x	x	x	x	x	• [MIL-HDBK, 1999] • [Uhlarik & Comerford, 2002] • [FAA HFW] • [Taylor, 1990] • [GAIN ATM, 2003]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
696.	SAS (Safety Assessment Screening)	Tab	Val	2010 or older	SAS is a form that is used to document the FAA ARP (Airport operations) Safety Assessment process. It is used to document the appropriate level of assessment, the steps of safety risk management and the final signatures and approvals, hence it documents the evidence to support whether a proposed action is acceptable from a safety risk perspective. There are three versions of the SAS: one each for Projects, Modification of standards, and Advisory circular standards.	[Order 5200.11] provides a SAS form.							7		(airport)	x				x	• [ARP SMSs, 2011] • [Order 5200.11] • [ARP SMS Guide, 2011]
697.	SA-SWORD (Situational Awareness Subjective Workload Dominance)	Tab	Task	1989	SA-SWORD is a Situation Awareness adaptation of SWORD, which measures workload of different tasks as a series of relative subjective judgments compared to each other. SWORD has three steps: 1. Collect subjective between-tasks comparative ratings using a structured evaluation form after the subject has finished all the tasks; 2. Construct a judgment matrix based on the subjective ratings; 3. Calculate the relative ratings for each task.	See also Paired Comparisons.					5				aviation			x			• [Vidulich et al, 1991] • [Snow & French, 2002]
	SAT Diagram (Sequence and Timing Diagram)					See OSD (Operational Sequence Diagram)															
698.	SATORI (Systematic Air Traffic Operations Research Initiative)	Dat	Dat, Trai	1993	Incident reporting system. Goal is to gain a better understanding of the interaction between the various elements of displayed information, verbal interactions, and the control actions taken by air traffic control specialists. SATORI enables its users to re-create segments of operational traffic in a format similar to what was displayed to the ATCS, for example, showing relative location and separation, speeds, and headings of aircraft. SATORI can display data blocks, beacon targets, and conflict alerts. Video and audio are synchronized, and the air traffic situation can be displayed in four dimensions.	Developed by FAA Civil Aerospace Medical Institute (CAMI). Is used, for example, to review training management issues, investigate accidents and operational errors, develop facility specific specialty training programs, and present facility-wide briefings on operational incidents.								8	ATM	x		x			• [Pounds, 2003] • [FAA HFW]
699.	SAVANT (Situation Awareness Verification and Analysis Tool)	Tab	HFA	2000	SAVANT is a combination of SAGAT and SPAM, implemented in software. The SAVANT measure is an attempt to retain and combine the advantages of both techniques. The specific advantages to be retained from SAGAT are: (1) queries are anchored in the airspace (i.e. the location of aircraft on the sector map); (2) the controller enters responses directly into the system. From SPAM the specific advantages to be retained are: (1) no interruption of the simulation, (2) no extensive use of memory, (3) queries of relational information instead of verbatim information.	SAVANT was developed by the FAA Technical Center in New Jersey, USA. It is applied during a simulated operation.							7		ATM			x			• [FAA HFW] • [Willems & Heiney, 2002]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
700.	SCA (Sneak Circuit Analysis)	Stat	HzI	1967	SCA aims to identify sneak (or hidden) paths in electronic circuits and electro-mechanical systems that may cause unwanted action or inhibit desired functions. It is based on identification of designed-in inadvertent modes of operation rather than on failed equipment or software. Sneak conditions are classified into: 1. Sneak paths - unintended electrical paths within a circuit and its external interfaces. 2. Sneak timing–unexpected interruption or enabling of a signal due to switch circuit timing problems. 3. Sneak indications–undesired activation or deactivation of an indicator. 4. Sneak labels–incorrect or ambiguous labelling of a switch.	This technique is applicable to control and energy-delivery circuits of all kinds, whether electronic/ electrical, pneumatic, or hydraulic. Tools available. Originally developed by Boeing for NASA Apollo Program to look at unintended connections in wiring systems. [Hahn et al., 1991] present an adaptation that considers errors of commission in HRA. Highly resource-intensive.		2	3	4					space, defence, navy, aircraft, nuclear	x	x	x			• [Boeing, 1970] • [Bishop, 1990] • [EN 50128, 1996] • [FAA AC431] • [FAA00] • [Kirwan, 1995] • [Kirwan, Part 1, 1998] • [Rakowsky] • [ΣΣ93, ΣΣ97] • [Sparkman, 1992] • [Ericson, 2005] • [Hahn et al., 1991] • [Miller, 1989]
701.	SCART (Safety Culture Assessment Review Team)	Tab	Org	2008	Aim is safety culture assessment by means of questions in five groups: 1. Safety value, 2. Safety leadership. 3. Safety accountability. 4. Integration of safety into activities. 5. Safety learning.									8	nuclear					x	• [Mkrtchyan & Turcanu, 2012]
702.	SCDM (Safety Case Development Manual)	Int	OpR	2003 and 2006	The Safety Case Development Manual gives an overview of a methodology being proposed for the construction and development of Safety Cases. The manual includes the concept of a Safety Case as presenting the entirety of argument and evidence needed to satisfy oneself and the regulator with respect to safety. It does not provide guidance on the generation or documentation of the evidence itself.	Developed by Eurocontrol. Version 2.2 (dated 2006) is a complete rewrite of Version 1.3 which was published in 2003, taking into consideration user needs and recent experience with Safety Case developments.	1							8	ATM					x	• [SCDM, 2006]
703.	Scenario Analysis	Step	OpR	1979 or older	Scenario Analysis identifies and corrects hazardous situations by postulating accident scenarios where credible and physically logical. Scenario analysis relies on the asking "what if" at key phases of flight and listing the appropriate responses. Steps are: 1) Hypothesize the scenario; 2) Identify the associated hazards; 3) Estimate the credible worst case harm that can occur; 4) Estimate the likelihood of the hypothesized scenario occurring at the level of harm (severity).	Scenarios provide a conduit for brainstorming or to test a theory in where actual implementation could have catastrophic results. Where system features are novel, subsequently, no historical data is available for guidance or comparison, a Scenario Analysis may provide insight.			3		5				finance, defence, aviation, healthcare	x			x		• [FAA00] • [ΣΣ93, ΣΣ97]
704.	Scenario Process Tool	Step	HzI	2000 or older	The Scenario Process tool aims at identifying unusual hazards by visualizing them. The flow of events established in an analysis of the operation considered is used as a guide. The user of the tool next attempts to visualize the flow of events in an operation by constructing a "mental movie". The flow of events can also be visualised twice. The first time, the user sees the events as they are intended to flow. The next time, the user injects "Murphy" at every possible turn. As hazards are visualized, they are recorded for further action.	Also referred to as 'the mental movie tool'. The tool is especially useful in connecting individual hazards into situations that might actually occur. Similar to What-If Analysis.			3						defence	x	x	x	x		• [FAA00]
	Scenario-based hazard brainstorming					See Pure Hazard Brainstorming															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
705.	SCHAZOP (Safety Culture Hazard and Operability)	Tab	Org, HzA	1996	HAZOP adapted for safety management assessment. By application of 'safety management' guidewords to a representation of the system, it identifies: Areas where the safety management process is vulnerable to failures; the potential consequences of the safety management failure; the potential failure mechanisms associated with the safety management failure; the factors which influence the likelihood of the safety management failures manifesting themselves; error recovery and reduction measures.				3			6			no-domain-found					x	• [Kennedy & Kirwan, 1998]
706.	SCHEMA (System for Critical Human Error Management and Assessment OR Systematic Critical Human Error Management Approach)	Int	HRA, Task	1992	Integrated framework of techniques for human factors assessment. The method has been implemented as a computer program called Theta (Top-down Human Error and Task Analysis). Includes techniques like HTA, SLIM. It has a flow chart format following the SHERPA method.	Originated from SHERPA.					5				chemical			x			• [Kirwan, Part 1, 1998] • [MUFTIS3.2-I, 1996]
707.	SCM (Software configuration management)	Gen	Des	1950 s	Requires the recording of the production of every version of every significant deliverable and of every relationship between different versions of the different deliverables. The resulting records allow the developer to determine the effect on other deliverables of a change to one deliverable.	Technique used throughout development. In short it is "To look after what you've got sofar". Evolved from its hardware version CM; see also CM.						6			software		x				• [EN 50128, 1996] • [Jones et al, 2001] • [Rakowsky] • [SCM biblio]
708.	SCMM (Safety Culture Maturity Model)	Tab	Org	1999	Aims to assess safety culture maturity and to identify actions required to improve safety culture. Consists of five maturity levels: Emerging level, Managing level, Involving level, Cooperating level, Continually improving level. Each level consists of ten safety culture components such as visible management commitment, safety communication, and productivity versus safety. A card sorting technique is used to provide an indication of an organization's level of maturity.	Developed by Keil Centre. Based on capability maturity model concept, see CMMI.								8	aviation, road, rail, oil&gas, manufacturing, food, electronics, healthcare					x	• [Mkrtchyan & Turcanu, 2012]
709.	SCOP approach (Safety Culture Oversight Process)	Tab	Org	2010	Aims to improve nuclear safety and emergency preparedness. The following functional areas are reviewed: Management, organization and administration; Training and qualification; Operation and maintenance; Technical support; Operational experience feedback; Radiation protection; Emergency planning and preparedness.									8	nuclear					x	• [Mkrtchyan & Turcanu, 2012]
710.	SDA (Software Deviation Analysis)	Stat	SwD	1996	SDA is a Safeware hazard analysis technique that converts formal software requirements into a diagram that encodes causal information between system variables. This diagram is used to evaluate deviations in the software inputs, and to develop constraints on the execution states of the software that are sufficient to lead to output deviations.				3						road, avionics		x				• [Reese & Leveson, 1997]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
711.	SDA (Sequence Dependency Analysis)	Stat	Task	1999 or older	SDA follows from TLA and notes the dependency between different task elements. It can also estimate the qualitative uncertainty in time estimates for each sub-task, and the timing data source used. SDA is useful in identifying tasks whose reliability is critical, and therefore tasks that require a high quality of human factors design. SDA can therefore lead to error reduction recommendations (often via the TTA and Ergonomics Review) that will have a general effect on human reliability across a scenario or several scenarios. SDA also helps to identify the longest time likely for the task sequence, and where it may perhaps be best to gain more accurate time estimates to ensure the TLA is accurate.			2	3			6			nuclear			x			• [Kirwan & Kennedy & Hamblen]
712.	SDAT (Sector Design Analysis Tool)	FTS	HzI, HRA	1990	SDAT supports nearly all airspace and traffic data sources used within the FAA and overlays the traffic data on the airspace environment. The user is able to select from menus the portions of the data to display and how the data are displayed. SDAT permits the user to postulate changes in the airspace and/or traffic data to compare the analysis results to those with the original. SDAT analysis tools include measures of traffic loadings within control sectors or within a given radius of a specified fix. SDAT also performs a calculation of the expected number of ATC aircraft separations per hour in each airspace sector. This allows the user to see in advance how a proposed change could impact controller task load, particularly separation assurance task load, and possibly prevent errors resulting from excessive demands on the controllers' attention.	SDAT concept start was in 1985; it came in full operation in 1990. Developed by Washington Consulting Group.					5				ATM			x	x		• [GAIN ATM, 2003] • [FAA HFW]
713.	SDCPN (Stochastically and Dynamically Coloured Petri Nets)	Dyn	Mod	2006	SDCPN is an extension of DCPN (Dynamically Coloured Petri Nets), in the sense of allowing token colours that stochastically evolve, while the powerful mathematical properties of DCPN are retained.	SDCPN are mathematically equivalent to HSMP (Hybrid State Markov Processes). DCPN and SDCPN are the main modelling formats used for MA-DRM. See also MA-DRM, see also TOPAZ, see also DCPN.				4	5				ATM	x	x	x	x	x	• [Everdij & Blom, 2006] • [Everdij et al, 2006] • [Everdij & Blom, 2008] • [Everdij & Blom, 2010] • [Everdij & Blom, 2010a] • [Everdij, 2010]
714.	SDFG (Synchronous Data Flow Graphs)	Stat	Mod	1988 or older	An SDFG is a graph with 'actors' as vertices and 'channels' as edges. Actors represent basic parts of an application which need to be executed. Channels represent data dependencies between actors. Streaming applications essentially continue their execution indefinitely. Therefore, one of the key properties of an SDFG which models such an application is liveness, i.e., whether all actors can run infinitely often.	SDFG is a data flow model of computation that is traditionally used in the domain of Digital Signal Processing platforms. Possible approach for the implementation of concurrent real-time control systems. Tools available. Relation with Petri Nets.		2							software		x				• [Bishop, 1990] • [Ghamarian, 2008] • [Pullaguntla, 2008]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
715.	SDHA (Scenario-Driven Hazard Analysis)	Step	OpR	2005	The SDHA is used to understand the dynamics of an accident. The first step involves the generation of possible scenarios. This includes scenario description, initial contributors, subsequent contributors, life-cycle phase, possible effect, system state and exposure, recommendations, precautions and controls. Next, hazards are classified and communicated. Hazard "counts" are obtained, which lead to implicit proportions or percentages of the hazard system and subsystem sources as derived from the scenarios.	Developed by Raheja and Allocco (2005), building on an approach by Hammer (1972).				4					(aviation)				x		• [Oztekin, 2007] • [Luxhoj, 2009]
716.	SDL (Specification and Description Language)	Int	Des	1976	Aims to be a standard language for the specification and design of telecommunication switching systems. SDL is an object-oriented, formal language defined by The International Telecommunications Union–Telecommunications Standardisation Sector (ITU–T) as recommendation Z.100. The language is intended for the specification of complex, event-driven, real-time, and interactive applications involving many concurrent activities that communicate using discrete signals.	Based on Extended FSM, similar to SOM. Tools available. Software requirements specification phase and design & development phase.		2							electronics	x	x				• [Bishop, 1990] • [EN 50128, 1996]
	SDM (Success Diagram Method)					See RBD (Reliability Block Diagrams)															
717.	SDRS (Service Difficulty Reporting System)	Dat	Dat	1966	SDRS is an FAA database containing records of mechanical malfunctions, defects, and failures on civil aviation aircraft. The aviation community submits these reports to the FAA whenever a system, components, or part of an aircraft powerplant, propeller, or appliance fails to function in a normal or usual manner. SDRD data assists the FAA in achieving prompt and appropriate correction of conditions adversely affecting continued airworthiness of aeronautical products. FAA managers and inspectors also use SDRS data to measure the effectiveness of the self-evaluation techniques being employed by certain segments of the civil aviation industry.	The reports submitted are known by a variety of names: Service Difficulty Reports (SDR), Malfunction and Defect reports (M or D) and Mechanical Reliability Reports (MRR).								8	aircraft	x					• [GAIN Info Collection Programs]
718.	SEAMAID (Simulation-based Evaluation and Analysis support system for MAn-machine Interface Design)	RTS	Task	1996	SEAMAID is a simulation-based evaluation and analysis support system for human-machine interface design in the domain of nuclear power plants. It simulates the interaction between an operator and human machine interfaces (HMI), and aims to support improving workload and human error. The operator simulator copes with a single abnormal event, according to the operation manuals.	Has functionality similar to CAMEO-TAT.				4	5				nuclear			x			• [Fumizawa, 2000] • [Kirwan, Part 1, 1998] • [Nakagawa]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
719.	Secondary Task Monitoring	Step	Task	1986 or older	Secondary task monitoring is a method of measuring mental workload in which the operator is required to perform two tasks concurrently—the primary task of interest and another (related or unrelated) task. The operator's performance on the secondary task is used to estimate primary task workload. The method of secondary task monitoring is an important tool to help the human error practitioner assess mental workload so that especially stressful tasks can be identified and redesigned or re-allocated.	See also MRT (Multiple Resource Theory).							7		(aviation)			x			• [FAA HFW] • [MIL-HDBK, 1999]
720.	SEEA (Software Error Effects Analysis)	Tab	SwD	1973	SEEA aims to identify critical software modules, and to detect software errors and their consequences.	Qualitative Design tool. Similar to SFMEA (Software FMEA). Software architecture phase.			3						software		x				• [Fragola&Spahn, 1973] • [EN 50128, 1996] • [Lutz & Woodhouse, 1996] • [Rakowsky]
721.	Seismic Analysis	Step	Mit	1927	Seismic Analysis is a structural analysis technique that involves the calculation of the response of a building (or nonbuilding) structure to earthquakes. Aim is to ensure that structures and equipment resist failure in seismic events.	Physical structures and equipment.						6			manufacturing	x					• [ΣΣ93, ΣΣ97]
722.	Self testing and Capability testing	Step	SwD	1978 or older	Software Testing technique. Aim is to verify on-line that the system maintains its capability to act in the correct and specified manner.	Essential on a normally dormant primary safety system. See also Software Testing.						6			software	x	x				• [Bishop, 1990]
723.	Self-Reporting Logs	Gen, Dat	Dat, Task	1998 or older	Self-reporting logs are paper-and-pencil journals in which users are requested to log their actions and observations while interacting with a product.	Alternative name: Diary Method. See also Journaled Sessions.		2							healthcare	x	x	x			• [FAA HFW]
724.	SEM (Safety Element Method)	Tab	Org	1997	SEM is an assessment and development tool for improvement of the safety, health and environment (SHE) management, tailored for application in the Norwegian mining industry. The method identifies the current SHE performance and the desired future of the organisation. The tool also gives aid to find improvement measures. SEM emphasises consensus decisions through internal group discussions. The method is designed as a matrix, where the columns represent five phases of development. The rows define the safety elements considered. The content is divided in six main elements that ought to be considered by the organisation; Goals/ambitions, Management, Feedback systems/learning, Safety culture, Documentation and Result Indicators.	Method is tailored for application in the Norwegian mining industry. Development of the tool has been carried out through a structured group problem solving process. The participants were resource persons representing different parties in the industry.					5	6			mining				x	x	• [Kjellen, 2000] • [Alteren & Hovden, 1997]
	Semantic Differential Scales					See Rating Scales															
725.	Semi-Markov Chains	Math	Mod	1969	Markov chains that also allow non-exponential transitions.	Tools available (e.g. ASSIST: Abstract Semi-Markov Specification Interface to the SURE Tool).				4	5				environment, aviation, energy	x	x				• [Butler & Johnson, 1995] • [MUFTIS3.2-I, 1996] • [NASA-Assist, 2001]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
726.	Sensitivity Analysis	Gen, Math	Val		Sensitivity Analysis is a term representing a variety of techniques that study how the variation (uncertainty) in the output of a mathematical model can be apportioned, qualitatively or quantitatively, to different sources of variation in the input of the model. The analysis systematical changes values for parameters in a model to determine the effects of such changes.	Many techniques exist to determine the sensitivity of the output with respect to variation in the input, such as linearisation, sampling, variance based methods, Monte Carlo methods. See also What-If Analysis. See also B&UA (Bias and Uncertainty Assessment). See also Uncertainty Analysis.					5				all	x	x	x			• [Saltelli et al, 2008] • [Morgan & Henrion, 1990]
727.	Sentinel	Min	Dat	2005	Sentinel monitors airline safety data, enabling users to pinpoint potential areas of concern. Incident reports are filed in a data repository for trending and analysis. Sentinel analyses this accumulated information and helps detect patterns and trends which are significant or may become significant. The results can be transmitted in real time to safety specialists within an organisation and can be shared with other Sentinel users around the world. Aim is to support adopting preventative strategies and target resources.	Developed by Mercator (the IT division of Emirates Airline) by updating WinBASIS and BASIS. It is in use at over 100 airlines and aviation companies.							7	8	aviation	x	x	x	x	x	• www.mercator.com
728.	sequenceMiner	Min	Dat	2006	Approach to model the behaviour of discrete sensors in an aircraft during flights in order to discover atypical behavior of possible operational significance, e.g. anomalies in discrete flight data. The sequenceMiner analyzes large repositories of discrete sequences and identifies operationally significant events. The focus is on the primary sensors that record pilot actions. Each flight is analyzed as a sequence of events, taking into account both the frequency of occurrence of switches and the order in which switches change values. It clusters flight data sequences using the normalized longest common subsequence (nLCS) as the similarity measure and using algorithms based on a Bayesian model of a sequence clustering that detect anomalies inside sequences. In addition, it provides explanations as to why these particular sequences are anomalous. The sequenceMiner algorithm operates by first finding groups of similar flight sequences, and then finding those sequences that are least similar to any of the groups. It uses the normalized longest common subsequence as the similarity measure, and ideas from bioinformatics such as Multiple Sequence Alignment to determine the degree to which a given sequence is anomalous.	sequenceMiner was developed with funding from the NASA Aviation Safety Program. The approach is stated to be general and not restricted to a domain, hence can be applied in other fields where anomaly detection and event mining would be useful.							7	8	aviation	x	x	x			• [Budalakoti et al, 2006]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
729.	SESAR SRM (Single European Sky Air traffic management Research Safety Reference Material)	Int	OpR	2013	This is a framework with guidance material, which supports the development of safety cases for gate-to-gate air navigation services. Aim is to establish safety arguments addressing the system engineering lifecycle up to and including the pre-industrialisation phase of an operational improvement (OI). In each lifecycle stage the aim is to build a 'success case' that shows that any pre-existing hazards are acceptable with the introduction of the new OI, as well as a 'failure case' that shows that any new hazards introduced by the OI are acceptable. Safety performance requirements are developed to be fed back to the further development of the OI, as input to the next lifecycle stage.	Developed by Eurocontrol with partners, and is being regularly updated. Is used in the SESAR (Single European Sky ATM Research) programme for safety analysis and assurance that the SESAR-developed operational improvements are acceptably safe. It is built on EATMP SAM, SAME, and AIM, with references to many other methods in its Guidance Material.	1	2	3	4	5	6			ATM	x	x	x	x		• [Fowler et al, 2011]
730.	SEU (Subjective Expected Utility)	Math	Dec	1954	SEU aims to transform concepts like safety, quality of life, and aesthetic value into a form that can be used for cost/benefit analyses. The theory of SEU combines two subjective concepts: first, a personal utility function, and second a personal probability distribution (based on Bayesian probability theory). The likelihood of an event (which is subject to human influence) occurring (the expectancy variable) is seen as the subjective probability that the outcome will occur if a behavior is undertaken. The value variable (the subjectively determined utility of the goal) is multiplied by the expectancy. The product is the subjective expected utility.	Promoted by L.J. Savage in 1954					5				finance, social		x				• [Savage, 1954] • [FAA HFW]
731.	Severity Distribution Analysis	Step	Par, OpR	1982	Is used in estimations of the probability of severe accidents at a workplace and in comparing different workplaces with respect to the expected severity of the accidents. It is based on the accidents for a specified period of time and follows a step-wise procedure: 1) Arrange the accidents by consequence in an ascending order; 2) Divide the highest registered consequence value into intervals such that each interval has approximately the same size on a logarithmic scale; 3) Tally the number of accidents in each interval and the cumulative number; 4) Calculate the cumulative percentage of accidents for each interval and use a log-normal paper to plot the results.	See also Comparison Risk Analysis.								8	finance, road, manufacturing, healthcare	x			x		• [Kjellen, 2000]
732.	SFG (Signal Flow Graph)	Stat	Mod	1966	Identifies the important variables and how they relate within a given technical system. The graph consists of nodes and directed branches; the nodes are the variables of a set of linear algebraic relations. The analysis is conducted by selecting a system output variable and then identifying all the variables that could influence this. The network presents the system variables as nodes connected by flows.	Also known as Mason graph. Related to State Transition Diagrams. An SFG can only represent multiplications and additions. Multiplications are represented by the weights of the branches; additions are represented by multiple branches going into one node.		2							electronics			x			• [Kirwan & Ainsworth, 1992] • [HEAT overview] • [FAA HFW]
	SFMEA (Systems Failure Mode and Effect Analysis)					See FMEA (Failure Mode and Effect Analysis)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
733.	SFMEA or SWFMEA (Software Failure Modes and Effects Analysis)	Tab	SwD	1979	This technique identifies software related design deficiencies through analysis of process flow-charting. It also identifies areas for verification/ validation and test evaluation. It can be used to analyse control, sequencing, timing monitoring, and the ability to take a system from an unsafe to a safe condition. This should include identifying effects of hardware failures and human error on software operation. It uses inductive reasoning to determine the effect on the system of a component (includes software instructions) failing in a particular failure mode. SFMEA was based on FMEA and has a similar structure.	Software is embedded into vital and critical systems of current as well as future aircraft, facilities, and equipment. SFMEA can be used for any software process; however, application to software controlled hardware systems is the predominate application. Unlike Hardware FMEA, which analyzes both severity and likelihood of the failure, an SFMEA usually analyzes only the severity of the failure mode.			3						avionics, space	x	x				• [FAA00] • [Lutz & Woodhouse, 1996] • [ΣΣ93, ΣΣ97] • [Pentti & Atte, 2002] • [Ippolito & Wallace, 1995] • [Reifer, 1979]
734.	SFTA (Software Fault Tree Analysis)	Stat	SwD	1983	This technique is employed to identify the root cause(s) of a “top” undesired event. To assure adequate protection of safety critical functions by inhibits interlocks, and/or hardware. Based on Fault Tree Analysis. If a branch of a hardware FTA refers to system software, the SFTA is applied to that portion of software controlling that branch of the hardware FTA.	Any software process at any level of development or change can be analysed deductively. However, the predominate application is software controlled hardware systems. See also FTA.				4	5				avionics, space	x	x				• [FAA00] • [Leveson, 1995] • [NASA-GB-1740.13-96] • [ΣΣ93, ΣΣ97]
735.	SHA (System Hazard Analysis)	Step	HzA	1993 or older	System Hazard Analysis purpose is to concentrate and assimilate the results of the Sub-System Hazard Analysis (SSHA) into a single analysis to ensure the hazards of their controls or monitors are evaluated to a system level and handled as intended. SHA build on preliminary hazard analysis (PHA) as a foundation. SHA considers the system as a whole and identifies how system operation, interfaces and interactions between subsystems, interface and interactions between the system and operators, and component failures and normal (correct) behaviour could contribute to system hazards. The SHA refines the high-level design constraints generated during PHA. Conformance of the system design to the design constraints is also validated. Through SHA, safety design constraints are traced to individual components based on the functional decomposition and allocation.	Any closed loop hazard identification and tracking system for an entire program, or group of subsystems can be analysed. Identifies system design features and interface considerations between system elements that create hazards. Inductive.			3	4					aviation, defence, healthcare food chemical	x					• [FAA00] • [FAA tools] • [SEC-SHA] • [ΣΣ93, ΣΣ97]
736.	SHARD (Software Hazard Analysis and Resolution in Design)	Tab	SwD	1994	Adaptation of HAZOP to the high-level design of computer-based systems. Provides a structured approach to the identification of potentially hazardous behaviour in software systems. SHARD uses a set of guidewords to prompt the consideration of possible failure modes. Based on software failure classification research, five guidewords are used in the SHARD method - omission, commission, early, late and value failure. These guidewords are applied systematically to functions and/or flows in a software design. Use of SHARD facilitates the systematic identification of software contributions to system level hazards and the definition of associated software safety requirements.	Developed by DCSC (Dependable Computing Systems Centre). Early version was referred to as CHAZOP (Computer HAZOP)			3			6			defence		x				• [McDermid, 2001] • [McDermid & Pumfrey] • [Mauri, 2000]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
737.	SHARP (Systematic Human Action Reliability Procedure)	Int	HRA	1984	Helps practitioners picking up the right Human Reliability Analysis method to use for a specific action / situation. It employs a 4-phase procedure: 1) Identification of potential human errors (using detailed description of operator tasks and errors, and techniques like FMEA); 2) Selecting significant errors (e.g. based on likelihood and whether it leads directly to undesirable event); 3) Detailed analysis of significant errors (likelihood analysis); 4) Integration into a system model (studying the dependence between human errors and system errors and the dependence of human errors on other errors). SHARP suggests a number of techniques to be used.	Developed by Hannaman & Spurgin (Electric Power Research Institute).			3	4	5				nuclear			x			• [MUFTIS3.2-I, 1996] • [Wright et al, 1994]
738.	SHCM (Software Hazard Criticality Matrix)	Tab	SwD	1993 or older	The Software Hazard Criticality Matrix (SHCM) assists the software safety engineering team and the subsystem and system designers in allocating the software safety requirements between software modules and resources, and across temporal boundaries (or into separate architectures). Software hazards are allocated to cells in a matrix with vertically the various control categories (i.e. the level at which the software controls the critical hardware systems or components), and horizontally the effects of the hazard (catastrophic, critical, marginal, negligible). The software control measure of the SHCM also assists in the prioritization of software design and programming tasks.	Available in military standard MIL-STD-882C.						6			(defence)		x				• [FAA00]
739.	SHEL or SHELL model	Stat	Mod	1972	In the SHELL model, S=Software (procedures, symbology, etc.); H=Hardware (machine); E=Environment (operational and ambient); L=Liveware (human element). The model has the form of a plus-sign (+), consisting of 5 blocks, each with one letter of SHELL in it, with one of the 'L'-s in the middle. A connection between blocks indicates an interconnection between the two elements. The match or mismatch of the blocks (interconnection) is just as important as the characteristics described by the blocks themselves.	Developed by Prof Dr. E. Edwards of Birmingham University in 1972. Modified in about 1975 by Cpt Frank Hawkins of KLM, who added the second L. The m-SHELL model of Kawano includes the element management. SCHELL, where C stands for Cultural, also includes management. See also 5M Model.		2							aviation, aircraft, healthcare, ergonomics, nuclear, maritime, rail, manufacturing, road, management	x	x	x			• [Edwards, 1972] • [Edwards, 1988] • [FAA00] • [Hawkins, 1993] • [ICAO Doc 9806] • [Itoh et al, 2004] • [Kawano, 2002] • [Keightley, 2004] • [Perry & Perezgonzalez, 2010] • [Silva & Trabasso, 2013]
740.	SHERPA (Systematic Human Error Reduction and Prediction Approach)	Stat	HRA, Task	1986	Focuses on particular task types depending on the industry concerned. Root of TRACEr, HERA I, HERA II. The description of activities developed using HTA is taken task-by-task and scrutinised to determine what can go wrong. Each task is classified into one of 5 basic types (i.e. checking, selection, action, information communication and information retrieval) and a taxonomy of error types is applied. The immediate consequences for system performance are recorded. For each error type, an assessment of likelihood and criticality is made. Finally, potential recovery tasks and remedial strategies are identified.	Developed by D.E. Embrey. Related to SCHEMA and PHEA. Equivalent to FMEA used in reliability Technology. Also does it work like a human HAZOP. Originally developed for nuclear domain, but now also applied in other domains.			3		5	6			nuclear, aviation, healthcare, electronics			x			• [Kirwan, 1994] • [Kirwan, Part 1, 1998] • [FAA HFW]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
741.	Shock method	Step	Par	1981	Is used to quantify common cause failures. Components are taken as failing two by two, three by three, etc. A probability value is assigned to each of these events; different methods are proposed to distribute the failure rates according to the number of components involved.	Developed by Apostolakis & Kaplan. A 'shock' is an event that occurs at a random point in time and acts on all components of the system simultaneously. In a 'lethal shock', all components are failing; in a 'non-lethal shock' each component fails with a different probability.					5				nuclear	x					• [MUFTIS3.2-I, 1996] • [Matthews, 1991] • [NUREG/CR-4780] • [Apostolakis & Kaplan, 1981]
742.	SIMMOD (Airport and Airspace Simulation Model)	FTS	OpR	1980 from	SIMMOD is an aviation simulation platform used for conducting fast-time simulations of airport and airspace operations. The impacts are measured in terms of capacity and aircraft delay-related metrics caused by a variety of inputs, including traffic demand and fleet mix, route structures (both in the airspace and on the airport surface), runway use configurations, separation rules and control procedures, aircraft performance characteristics, airspace sectorization, interactions among multiple airports, and weather conditions.	Developed by ATAC. Several enhancements have been developed: SIMMOD PRO! allows incorporating rules-based dynamic decision making. NASMOD is for analyzing military aviation operational alternatives. JSIMMOD allows for more flexibility and larger models. Visual SIMMOD enhances modelling features and ease of use.				4					ATM, airport, aviation				x	x	• [SAP15] • [SIMMOD Manual] • [SIMMOD Review, 1996]
	Simulators/mock-ups					See Computer Modelling and Simulation. See Prototype Development or Prototyping or Animation.															
	SIRA (Safety Issue Risk Assessment)					See ARMS															
	Site Visits					See Plant walkdowns/ surveys															
	Situation Awareness Error Evolution					See MASA Propagation Model															
743.	SLIM (Success Likelihood Index Method)	Step	HRA, Par	1981	Estimates human error probabilities. Two modules: MAUD (Multi-Attribute Utility Decomposition, used to analyse a set of tasks for which human error probabilities are required) and SARAH (Systematic Approach to the Reliability Assessment of Humans, used to transform success likelihoods into human error probabilities (HEP)).	Developed by D.E. Embrey et al, Brookhaven National Laboratory, Department of Nuclear Energy. Similar to APJ. Can be reserved for difficult HEP assessments that HEART and THERP are not designed for.					5				nuclear, chemical, manufacturing, security			x			• [Humphreys, 1988] • [Kirwan & Kennedy & Hamblen] • [Kirwan, 1994] • [MUFTIS3.2-I, 1996] • [GAIN ATM, 2003]
744.	SLM (Step Ladder Model)	Stat	HFA	1976	SLM is an information-processing model that assumes an expected sequence of mental operations in the course of decision making. The 8 steps are 'Activation', Observe, Identify, Interpret and Evaluate, Define Task, Formulate Procedure, and Execute. Errors can occur when operators avoid intermediate steps to decrease mental demand. Three types of decisions are conceptualised (skill, rule, knowledge-based model): "Skill-based" decisions proceed directly from detection to the execution with few intermediate mental steps. "Rule-based" decisions require a mental representation of the system state (e.g. the air traffic situation), and the selection of an appropriate procedure based on that recognition. "Knowledge-based" decisions proceed through causal reasoning.	Developed by Rasmussen. Considers cognitive elements not only behavioural patterns.		2	3	4					security, (nuclear), (aviation)			x			• [FAA HFW] • [Rasmussen, 1986] • [Weitzman, 2000] • [GAIN ATM, 2003] • [Carayon & Kraemer, 2002]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
745.	SMHA (State Machine Hazard Analysis)	Stat	HzI, Mod	1987	Used to identify software-related hazards. A state machine is a model of the states of a system and the transitions between them. Software and other component behaviour is modelled at a high level of abstraction, and faults and failures are modelled at the interfaces between software and hardware.	Often used in computer science. For complex systems, there is a large number of states involved. Related to Petri nets. Procedure can be performed early in the system and software development process.			3	4					avionics		x				• [Leveson, 1995] • [Houmb, 2002]
746.	SMORT (Safety Management Organisation Review Technique)	Tab	Org, Ret	1987	SMORT is a simplified modification of MORT. This technique is structured by means of analysis levels with associated checklists, while MORT is based on a comprehensive tree structure. The SMORT analysis includes data collection based on the checklists and their associated questions, in addition to evaluation of results. The information can be collected from interviews, studies of documents and investigations. It can be used to perform detailed investigation of accidents and near misses. It also serves as a method for safety audits and planning of safety measures.	Developed by U. Kjellén et al. (Norway).								8	no-domain-found					x	• [Kjellen, 2000] • [NEMBS, 2002]
747.	SOAM (Systematic Occurrence Analysis Methodology)	Step	Org, Ret	2005	Aim is to broaden the focus of an investigation from human involvement issues, also known as "active failures of operational personnel" under Reason's original model, to include analysis of the latent conditions deeper within the organisation that set the context for the event. The SOAM process follows six steps: 1) Review gathered data; 2) Identify barriers; 3) Identify human involvement; 4) Identify contextual conditions; 5) Identify organisational factors; 6) Prepare SOAM chart.	Reason's original Swiss Cheese model has been adapted in accordance with a "just culture" philosophy. 'Unsafe acts' are referred to as Human Involvement; 'Psychological precursors of unsafe acts' as Contextual conditions; 'Fallible decisions' as Organisational and system factors. Data gathering is according to the SHEL model.							7		ATM	x		x	x	x	• [Licu, 2007] • [Eurocontrol, 2005] • [Arnold, 2009]
748.	SOAR (State, Operator, and result)	Int	HFA	1983	Soar uses a set of principles and constraints to construct models of knowledge-based behaviour, including interaction with external systems and environments.	Developed by J. Laird and A. Newell, CMU (Carnegie Mellon University).				4					healthcare, social, defence			x			• [Morrison, 2003]
	Sociotechnical Audit Method					See PRIMA (Process RIsk Management Audit)															
749.	SOCRATES (Socio-Organisational Contribution to Risk Assessment and the Technical Evaluation of Systems)	Int	Org	1998	Analysis of organisational factors. Is intended to aid conceptualising the role that organisational factors play in shaping plant performance and how they influence risk.	Developed by Idaho National Engineering and Environmental Laboratory (INEEL). According to [Oien et al, 2010], US NRC terminated the project and no final report exists.			3		5				(nuclear)	x				x	• [HRA Washington, 2001] • [NEA, 1999] • [Oien et al, 2010]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
750.	SOFIA (Sequentially Outlining and Follow-up Integrated Analysis)	Stat	HzA	2001	SOFIA is an analytical and graphical method supporting the process of ATM safety occurrence investigation to distinguish between the causes of an occurrence. It is for use during factual information gathering; event reconstruction; event analysis and issuing recommendations. It refers to the three layers in the Swiss Cheese model: unsafe acts, local workplace factors and organisational factors. The method uses event/ condition building blocks to describe the causal chain leading to an occurrence. Building blocks are associated with a unique actor at a particular moment in time. Actor(s) can be any representative player in the occurrence, including persons but also technical systems or any attribute that is important and is dynamic in the course of particular occurrence like separation.	Developed in EUROCONTROL in collaboration with the Bulgarian Air Traffic Services Authority. Link with TOKAI and HERA.								8	ATM	x		x	x		• [Blajev, 2003]
751.	Software Testing	Gen	SwD	1976 or older	Software Testing provides an objective, independent view of the software to allow the business to appreciate and understand the risks at implementation of the software. Test techniques include, but are not limited to, the process of executing a program or application with the intent of finding software bugs. Several methods of testing exist, e.g.: • Assertions and plausibility checks. • Avalanche/Stress Testing. • Back-to-back Testing. • Boundary value analysis. • Equivalence Partitioning and Input Partition Testing. • Probabilistic testing. Self testing and Capability testing. • Tests based on Random Data. • Tests based on Realistic data. • Tests based on Software structure. • Tests based on the Specification.	See also • Code Analysis • Code Coverage • Code Inspection Checklists • Code Logic Analysis. • Complexity Models • Control Flow Checks • Interface Testing. • Test Adequacy Measures.							7		software		x				• [Bishop, 1990] • [EN 50128, 1996] • [ISO/IEC 15443, 2002] • [Jones et al, 2001] • [Rakowsky]
752.	Software Time-out Checks	Gen	Des	1980 or older	Aim is to provide time limits for software running non-deterministic tasks.	Useful to provide determinism on non-deterministic task in safety computer systems. Related to error-recovery and time-out checks.						6			software		x				• [Bishop, 1990]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
753.	SOL (Sicherheit durch Organisationales Lernen, Safety through Operational Learning)	Stat	Ret	1997	SOL aims at facilitating organisational learning from events by supporting the process of analysing events, ensuring its standardised conduct and mobilising expert knowledge and creativity in the analysis. The SOL method covers the identification of human factors as well as technical, organisational and management factors. Phases are: 1) Collect the event objective data, without questioning its significance. 2) Organise the data into elements of the event as individual actions performed by the personnel, organisational unit or systems. 3) Classify the actions chronologically and represent in an actor-action-time illustration. The method uses a predetermined set of direct causes and contributing factors, and proposes questions to be addressed to help identify the contributing causes.	Developed by Bernhard Wilpert, Berlin University of Technology in collaboration with the TÜV. Originally developed for the nuclear industry, but a version for chemical industry was developed as well. SOL has been adopted by the Swiss and German nuclear industries as standard procedure for their in-depth event analyses.								8	nuclear, chemical, police			x		x	• [Ziedelis & Noel, 2011] • [Izso et al, 2019]
754.	SOM (SDL-Oriented Method or Structured Object Model)	Int	Des	1979	SOM is a development language and methodology covering the development of systems consisting of software and hardware from requirements to implementation, with special emphasis on real-time systems.	SOM was initially spelled Structure-Oriented Method, but this was later adjusted to SDL-Oriented Method, to emphasize its suitability for SDL (Specification and Description Language).Based on Extended Finite State Machines, related to SBC, CCS, SDL, SADT. Tools available.		2				6			electronics, management	x	x				• [Bishop, 1990] • [Kraemer, 2008]
755.	SORA (Specific Operations Risk Assessment)	Step	OpR	2019	The SORA is a methodology for the classification of the risk posed by a drone flight mission lying into the specific category of operations. It is based on the evaluation of ground risk and air risk. The ground risk is related to the risk of a person, property or critical infrastructure being struck by an unmanned aircraft (UA) and therefore considers the operating environment with respect to the population density, the type of operation (in or beyond Visual Line of Sight) and the UA size. The determination of the air risk considers the probability of encountering manned aircraft in the airspace, which is chiefly derived from the density and composition of manned air traffic in the airspace. After obtaining the Ground Risk Class and Air Risk Class respective values, the combination of both leads to the final rating of the mission, the so-called SAIL (Specific Assurance and Integrity Level), with a high value representing a high potential risk. Mitigations, which can be either additional equipment or changes to the operation including subscription to a U-space service, can be used to reduce the ground and air risks and thereby the SAIL.	The SORA concept was developed by Working Group 6 (WG6) of the Joint Authorities for the Rulemaking of Unmanned Systems (JARUS). It has been endorsed by the European Aviation Safety Agency (EASA) as an Acceptable Means of Compliance (AMC) to fulfil the requirements of the EU Regulations (Basic Regulation, Implementing Act, Delegated Act and Annexes).			3		5	6			aviation	x			x		• [SORA, 2019]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
756.	SoTeRiA (Socio-Technical Risk Analysis)	Int	OpR	2007	SoTeRiA is a probabilistic risk assessment framework aiming to evaluate the effects of organizational factors on accidents and incidents. Fault tree and Event Sequence Diagram are used to determine the probability of an undesired event and subsequently the risk. Risk values are then fed into System Dynamics (SD) that updates the value/status of risk influencing factors at various levels and calculates the corresponding probabilities. These probabilities are fed into a Bayesian Belief Network to calculate leaf node probabilities of the Fault tree.	Developed by Zahra Mohaghegh from the Center for Risk and Reliability at the University of Maryland. SoTeRiA is at an academic level, though it has been applied to a test case (addressing airline maintenance system risk) in order to demonstrate its feasibility and added value.				4	5				(aviation), (nuclear)					x	• [Mohaghegh, 2010] • [Mohaghegh & Mosley, 2009]
757.	SPAM (Situation-Present Assessment method)	Tab	HFA	1998	SPAM is a method of measuring situation awareness (SA) by verbally asking questions. In contrast to SAGAT, the SPAM method uses response latency as the primary dependent variable and does not require a memory component. It acknowledges that SA may sometimes involve simply knowing where in the environment to find some information, rather than remembering what that information is exactly.						5				ATM, navy			x			• [HIFA Data] • [Durso, 1995] • [FAA HFW]
758.	SPAR-H (Standardised Plant Analysis Risk-Human Reliability Analysis)	Tab	HRA	1999	Quick HRA technique that uses a worksheet to diagnose HRA issues such as available time, stress, complexity, experience, procedures, ergonomics, fitness for duty, etc. Significant revision of ASP (Accident Sequence Precursor). Supports ASP analysis of operating events at Nuclear Power Plants. Incorporates the advantages of other human reliability assessment methods (e.g. IPE, HPED, INTENT).	Qualitative and quantitative. In 1994, in support of the Accident Sequence Precursor Program (ASP), the NRC, with the Idaho National Laboratory (INL), developed the ASP Standardized Plant Analysis Risk Model (ASP/SPAR) HRA method, which was used in the development of nuclear power plant models. Based on experience gained in field testing, this method was updated in 1999 and renamed SPAR-H. In an earlier paper, [HRA Washington, 2001], the method was referred to as SPAR-HRA (Simplified Plant Analysis Risk Human Reliability Analysis).					5				nuclear			x			• [HRA Washington, 2001] • [Gertman et al, 2005]
	SPAR-HRA (Simplified Plant Analysis Risk Human Reliability Analysis).					See SPAR-H (Standardised Plant Analysis Risk-Human Reliability Analysis)															
759.	SPC (Statistical Process Control)	Step	HzA, Mit	1920 s	Aim is to improve product quality by reducing process variation. Four general steps: 1) Describe the distribution of a process; 2) Estimate the limits within which the process operates under 'normal' conditions; 3) Determine if the process is 'stable', sample the output of the process and compare to the limits. Decide: a) 'process appears to be OK; leave it alone, or b) 'there is reason to believe something has changed' and look for the source of that change; 4) Continuous process improvement.	Pioneered by Walter A. Shewhart at Bell Laboratories in the early 1920s. Any process where sufficient data can be obtained. Many training courses available.						6			manufacturing	x	x				• [Leavengood, 1998] • [ΣΣ93, ΣΣ97]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
760.	SPEAR (System for Predictive Error Analysis and Reduction)	Tab	HRA, Task	1993	SPEAR uses an error taxonomy consisting of action, checking, retrieval, transmission, selection and planning errors and operates on a HTA of the task under analysis. The analyst considers a series of performance-shaping factors for each bottom level task step and determines whether or not any credible errors could occur. For each credible error, a description of it, its consequences and any error reduction measures are provided.	Taxonomic approach to Human Error Identification (HEI) similar to SHERPA. SPEAR was developed by the Centre for Chemical Process Safety (CCPS) for use in the American processing industry's HRA programme.					5				chemical			x			• [Baber et al, 2005] • [Stanton et al, 2005]
761.	Specification Analysis	Gen	SwD	1990 or older	Specification Analysis evaluates the completeness, correctness, consistency and testability of software requirements. Well-defined requirements are strong standards by which to evaluate a software component. Specification analysis evaluates requirements individually and as an integrated set.								7		software, (avionics), (space)		x				• [NASA-GB-1740.13-96]
762.	SpecTRM (Specification Tools and Requirements Methodology)	Int	Des	2002	SpecTRM helps system and software engineers develop specifications for large, complex safety-critical systems. It enables engineers to find errors early in development so that they can be fixed with the lowest cost and impact on the system design. It also traces both the requirements and design rationale (including safety constraints) throughout the system design and documentation, allowing engineers to build required system properties into the design from the beginning. SpecTRM provides support for manual inspection, formal analysis, simulation, and testing, while facilitating communication and the coordinated design of components and interfaces.	Developed by Nancy Leveson. Is based on the principle that critical properties must be designed into a system from the start. As a result, it integrates safety analysis, functional decomposition and allocation, and human factors from the beginning of the system development process.		2	3			6			(aircraft), (ATM), (aviation), (avionics), (space)		x				• [Leveson, 2002] • [SafeWare web] • [Leveson et al, 1998]
763.	SPFA (Single-Point Failure Analysis)	Step	HzA	1980	This technique is to identify those failures that would produce a catastrophic event in items of injury or monetary loss if they were to occur by themselves. The SPFA is performed by examining the system, element by element, and identifying those discrete elements or interfaces whose malfunction or failure, taken individually, would induce system failure. Next, the local and system effects of these failure modes are determined.	This approach is applicable to hardware systems, software systems, and formalised human operator systems. It is sometimes referred to as another standard name for FMEA.			3						nuclear, space	x	x	x			• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]
	Spotfire					See FDM Analysis and Visualisation Tools															
764.	SRCA (Safety Requirements Criteria Analysis)	Step	Val	1993	The objective of the SRCA is to ensure that the intent of the system safety requirements (SSRs) in the system is met and that the SSRs eliminate, mitigate, and/or control the identified causal factors. The SRCA also provides the means for the safety engineer to trace each SSR from the system level specification, to the design specifications, to individual test procedures and test results' analysis. The safety engineer should also identify all safety-critical SSRs to distinguish them from safety-significant SSRs. The SRCA is a "living" document that the analyst constantly updates throughout the system development.	Safety-critical SSRs are those that directly influence a safety-critical function, while safety-significant SSRs are those that indirectly influence safety-critical functions.							7		navy, (aircraft)	x	x				• [FAA00] • [Software SSH, 1999] • [Ericson, 2005] • [MIL-STD 882C]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
765.	SRG CAP 760 (Safety Regulation Group CAA Publication 760)	Int	OpR	2006	CAP 760 provides guidance on the conduct of hazard identification, risk assessment and the production of safety cases for aerodrome operators and air traffic service providers. The risk assessment and mitigation guidance addresses seven process steps: 1) System description; 2) Hazard and consequence identification; 3) Estimation of the severity of the consequences of the hazard occurring; 4) Estimation/assessment of the likelihood of the hazard consequences occurring; 5) Evaluation of the risk; 6) Risk mitigation and safety requirements; 7) Claims, arguments and evidence that the safety requirements have been met and documenting this in a safety case. There are feedback loops from steps 5, 6 and 7 back to earlier steps, based on acceptability of risks analysed.	Developed by UK CAA's Safety Regulation Group (SRG). The method refers to other techniques to support some of the steps, e.g. FMECA, HAZOP, ETA.		2	3	4	5	6	7		(ATM), (airport)	x		x	x		• [CAP 760, 2006]
766.	SRHA (Software Requirements Hazard Analysis)	Tab	SwD	1994	In an SRHA, software requirements are divided into sets, each of which addresses a particular quality (e.g. accuracy, capacity, functionality, reliability, robustness, safety, security) of the software. SRHA examines each quality, and each requirement within the quality, against a set of guide phrases to assess the likely impact on hazards. Output of SRHA is a list of software hazards, a criticality level for each hazard that can be affected by the software, acriticality level for each software requirement, an analysis of the impact on hazards of the software when it operates correctly or incorrectly with respect to meeting each requirement.				3		5				software, (space), (defence)		x				• [Lawrence, 1995]
767.	SRK (Skill, Rule and Knowledge-based behaviour model)	Stat	HRA	1981	Psychologically-based model, assuming three levels: 1) Skill-based level: A query of an agent is accepted and by searching the knowledge-base, proper immediate action is selected. 2) Rule-based level: A query of an agent is accepted and a case data base is consulted to determine the action. 3) Knowledge-based level: A query is accepted and the agent uses its knowledge base to interact with the other agent and identify the actual needs. After this problem identification level, the proper action is determined by consulting other agents.	Developed by Jens Rasmussen of Risø laboratories. Rarely used as model on its own. Also referred to as Human Error Model.		2							chemical, aviation, nuclear			x			• [Reason, 1990] • [Cacciabue, 1998] • [SAP15] • [Kirwan, Part 1, 1998] • [SRK]
	SRM (Safety Reference Material)					See SAME (Safety Assessment Made Easier)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
768.	SRMTS (Safety Risk Management Tracking System)	Dat	Dat, Val	2009	The SRMTS is a web-based tool used to identify, analyze, track and monitor safety risks and changes to the National Aerospace System (NAS), providing the air traffic organization key insight into potential high risks and hazards. SRMTS allows users to: Improve tracking of SRM efforts, hazards and the predicted residual risk; Provide a centralized document repository for SRM documentation; Automate hazard analyses; Improve efficiency of the application of SRM; Improve reporting capabilities and trends analysis.	In 2009, FAA selected STATURE software (developed by Dyadem, Toronto) to support its SRMTS. See also HTRR.							7	8	ATM, airport	x	x	x	x	x	• [Falteisek - ATO SRM] • [Dyadem for SRMTS, 2009] • [ATO SMS Manual v3.0]
769.	SRS-HRA (Savannah River Site Human Reliability Analysis)	Tab	HRA	1994	Data-based approach based on data collected from four existing SRS databases (based on incidents, logs, etc.): fuel processing; fuel fabrication; waste management; and reactors. The approach is contextual and taxonomy-based. Uses a checklist and is relatively easy to use.	Related to JHEDI. The name comes from the Savannah River Site, which is a nuclear reservation in South Carolina, USA, established in 1950 to produce special radioactive isotopes for national security purposes.			3		5				nuclear			x			• [Kirwan, Part 1, 1998]
770.	SRVT (Safety Requirements Verification Table)	Tab	Val	2002 or older	The SRVT is intended to provide a continuing list and status of requirements and objectives that result from a safety risk management process, and is used to accomplish a Validation and Verification process for the safety requirements. It contains the following information: 1) List of requirements and objectives identified in any safety assessment for a given program; 2) Source of the requirement (i.e. OSA, PHA, CSA, etc.); 3) Validation and verification information; 4) Level of risk controlled by the requirement.	'Objectives' are controls that do not meet the criteria for a requirement, design constraints, and statements of work. An SRVT format is provided at [SRVT Format]						6	7		aircraft	x	x				• [SSM program AMS SRM, 2003] • [SRVT Format] • [SRM Guidance, 2007]
771.	SSA (System Safety Assessment) according to ARP 4761	Int	Val	1994	The SSA according to ARP 4761 collects, analyses, and documents verification that the system, as implemented, meets the system safety requirements established by the FHA and the PSSA. It is a systematic, comprehensive evaluation of the implemented system functions to show that relevant safety requirements are met.	This SSA is a refinement and extension of JAR-25 steps (though JAR-25 does not use the term SSA). It covers both hardware and software.							7		aircraft, avionics	x	x				• [ARP 4754] • [ARP 4761] • [Klompstra & Everdij, 1997] • [Lawrence, 1999]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
772.	SSA (System Safety Assessment) according to EATMP SAM	Int	Val	2004	The SSA according to EATMP SAM collects arguments, evidence and assurance to ensure that each system element as implemented meets its safety requirements and that the system as implemented meets its safety objectives throughout its lifetime. It demonstrates that all risks have been eliminated or minimised as far as reasonably practicable in order to be acceptable, and subsequently monitors the safety performance of the system in service. The safety objectives are compared with the current performances to confirm that they continue to be achieved by the system. Five substeps are identified: 1) SSA initiation; 2) SSA planning; 3a) Safety evidences collection during implementation and integration (including training); 3b) Safety evidences collection during transfer to operations; 3c) Safety evidences collection during operations and maintenance; 3d) Safety evidences collection during system changes (people, procedures, equipment), 3e) Safety evidences collection during decommissioning; 4a) SSA validation; 4b) SSA verification; 4c) SSA assurance process; 5) SSA completion. Most of these steps consist of subtasks.	This SSA is a refinement and extension of JAR-25 steps and the SSA according to ARP 4761, but its scope is extended to Air Navigation Systems, covering AIS (Aeronautical Information Services), SAR (Search and Rescue) and ATM (Air Traffic Management).	1						7		ATM	x	x	x	x		• [EHQ-SAM, 2002] • [Review of SAM techniques, 2004]
773.	SSCA (Software Sneak Circuit Analysis)	Stat	SwD	1975	SSCA is designed to discover software code logic that could cause undesired program outputs, incorrect program operation, or incorrect sequencing/timing. When software controls a safety critical function, an SSCA can help detect sneak paths that would result in a mishap. A software sneak path is a latent path or condition in software code that inhibits a desired condition or initiates an unintended or unwanted action.	SSCA is an extension of the hardware Sneak Circuit Analysis technique, except that the system and data consists of software code instead of electrical circuits. See also SNEAK.			3						software		x				• [FAA00] • [ΣΣ93, ΣΣ97] • [Ericson, 2005]
774.	SSG (State Space Graphs (or Discrete State Space Graphs))	Stat	Mod	1991 or older	Models all discrete states of a system and associates to each discrete state a level of severity of consequences on the service delivered. Petri Nets may be used during the modelling.			2		4					management, leisure	x	x				• [MUFTIS3.2-I, 1996]
775.	SSHA (Subsystem Hazard Analysis)	Step	HzI	1972 or older	The SSHA is performed to identify and document hazards associated with the design of subsystems including component failure modes, critical human error inputs, and hazards resulting from functional relationships between components and assemblies within the subsystems as well as their external interfaces. It includes software whose performance, degradation, functional failure or inadvertent functioning could result in a hazard. It also includes a determination of the modes of failure including reasonable human errors, single point failures and the effects on safety when failures occur within subsystem components and assemblies.	This protocol is appropriate to subsystems only.			3						defence, aircraft	x	x				• [FAA AC431] • [FAA00] • [FAA tools] • [ΣΣ93, ΣΣ97]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
776.	SSI (Sustainable Safety Indicator)	Step	Ret	2000	Aims to measure accident density of a road by dividing the road into 25-meter sections, and scoring each section regarding 20 characteristics. The total score per section provides the SSI score per section, which can be averaged for the whole road. Compensation for traffic density remains to be done.	Was used to measure accident density of road in two towns in the Netherlands. Example characteristics are inclusion of bus-stops, maximum speed, parking zones, bicycle tracks.					5				road	x					• [Wijlhuizen & Schermers, 2014]
777.	SSRFA (Software Safety Requirements Flowdown Analysis)	Tab	SwD	1996 or older	Safety requirements are flowed down into the system design specifications. Tools and methods for requirements flowdown analyses include checklists and cross references. A checklist of required hazard controls and their corresponding safety requirements should be created and maintained.							6	7		software, (avionics), (space)		x				• [NASA-GB-1740.13-96]
778.	STAHR (Socio-Technical Assessment of Human Reliability)	Stat	HRA, Par	1985	Determines human reliability by the combined influences of factors, which influences are in turn affected by other lower level influences. The effect of each identified influence is evaluated quantitatively, with the resulting values used to calculate human error probability estimates.	Supporting tool commercially available. Developed in the field of decision analysis. Former name is Influence Diagram Approach (IDA, 1980). Is not considered very accurate.				4	5				nuclear, oil&gas			x			• [Humphreys, 1988] • [Kirwan & Ainsworth, 1992] • [Kirwan, 1994] • [MUFTIS3.2-I, 1996]
779.	STAMP (Systems-Theoretic Accident Model and Processes)	Gen	OpR	2002	STAMP is a set of principles that are used as baseline for several safety risk analysis methods. These principles are: -) Systems are viewed as interrelated components that are kept in a state of dynamic equilibrium by feedback loops of information and control. -) Each level of control over safety is affected by (1) component failures, (2) dysfunctional interactions among components, or (3) unhandled environmental disturbances at a lower level. -) There are four types of hazardous control actions that need to be eliminated or controlled to prevent accidents: a) A control action required for safety is not provided or is not followed; b) An unsafe control action is provided that leads to a hazard; c) A potentially safe control action is provided too late, too early, or out of sequence; d) A safe control action is stopped too soon or applied too long. -) Accidents are more than a chain of events, they involve complex dynamic processes. Accidents should be treated as a control problem, not as a failure problem, and they can be prevented by enforcing constraints on component behaviour and interactions.	STAMP was developed by Nancy Leveson and first presented at MIT Internal Symposium in May 2002. Two approaches that are both based on STAMP principles are CAST (for analysis of accidents) and STPA (for hazard analysis).		2						8	space, oil&gas, rail, healthcare, nuclear, chemical, manufacturing, defence, aviation, ATM	x	x	x	x	x	• [Leveson2004] • [Leveson2006] • [Leveson, 2011]
780.	STAR (Safety Target Achievement Roadmap)	Stat	HzA?	2007	STAR is a version of an IRP that is aimed to predict how risks will be affected as Operational Improvements (ATM Changes) are implemented and traffic grows, and to help optimize the implementation strategy from the safety point of view.	STAR interpolates between an Integrated Risk Picture (IRP) for 2005 and an IRP for 2020.					5				ATM	x		x			• [Perrin, 2007]
	Starlight					See FDM Analysis and Visualisation Tools															
	State Transition Diagrams					See Finite State Machines															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
781.	STEADES (Safety Trend Evaluation, Analysis & Data Exchange System)	Min	Dat	2001	STEADES is a database containing de-identified incident reports with over 350,000 records. It provides a forum for the analysis, trending, and general inquiry of the leading indicators of industry safety in order to develop a comprehensive list of prevention strategies. It can be used for global safety trending, customised analysis projects, ad-hoc mini-analysis requests. Results can be provided to members: -) Daily, through the safety data management & analysis (SDMA) website and ad-hoc mini-analysis requests; -) Monthly: with the STEADES safety bulletin, providing a regular pulse of accident information by email; -) Quarterly: with the STEADES safety trend analysis report, highlighting the latest safety features found in the incident data; -) Yearly: with the IATA safety report, featuring in-depth synopsis of the previous years accidents, including analysis of contributing factors.	STEADES was an initiative of the IATA Safety Committee. The data is gathered from airlines.								8	aviation, ATM, airport	x		x	x		• [STEADES]
782.	STEP or STEPP (Sequentially-Timed Events Plot or Sequential Timed Event Plotting Procedure)	Stat	OpR, Ret	1987	This method is used to define systems; analyse system operations to discover, assess, and find problems; find and assess options to eliminate or control problems; monitor future performance; and investigate accidents. It is an events-analysis-based approach in which events are plotted sequentially (and in parallel, if appropriate) to show the cascading effect as each event impacts on others. It is built on the management system embodied in the Management Oversight and Risk Tree (MORT) and system safety technology.	Developed by Hendrick and Benner in 1987. In accident investigation, a sequential time of events may give critical insight into documenting and determining causes of an accident. STEP is a refinement of Multilinear Event Sequencing (MES). It is used for complex events with many actors, and when the time sequence is important.						6		8	aviation, (nuclear), (chemical), (mining)	x			x	x	• [FAA00] • [ΣΣ93, ΣΣ97] • [Wilson & Stanton, 2004] • [Henrick & Brenner, 1987]
783.	Stochastic Differential Equations on Hybrid State Space	Math	Mod	1990	These are differential equations on hybrid state space with stochastic elements. The stochastic elements may model noise variations in processes, or the occurrence of random events. The advantage of using this esoteric modelling formalism is the availability of powerful stochastic analysis tools.	Relation with some Petri nets also established. These Petri nets can be used to make a compositional specification of the operation considered which fit the esoteric but powerful stochastic differential equation models.				4					ATM	x	x	x	x	x	• [Blom, 1990] • [Blom, 2003] • [Krystul & Blom, 2004] • [Krystul & Blom, 2005] • [Everdij & Blom, 2004a] • [Krystul et al, 2012] • [Krystul et al, 2007]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
784.	STPA (Systems Theoretic Process Analysis)	Tab	Mit	2008	STPA is a qualitative hazard analysis technique that assumes that accidents occur not simply because of component failures, but because constraints on component behavior are inadequately enforced. It is used to identify instances of inadequate control that could lead to the presence of hazards, to identify safety-related constraints necessary to ensure acceptable risk, and to gain insight into about how those constraints may be violated. This information can be used to control, eliminate, and mitigate hazards in the system design and operation. STPA can be applied to existing designs, or in a proactive way to help guide the design and system development.	STPA is based on STAMP and was developed by Nancy Leveson and co-authors.			3	4		6			avionics, ATM, aviation, oil&gas, defence, space, rail, food	x	x	x	x	x	• [Leveson, 2011] • [Thomas & Leveson, 2011]
785.	STRES Battery (Standardized Tests for Research with Environmental Stressors)	Tab	HFA	1989	The STRES Battery is a computer-supported test battery for the examination of mental performance. It is comprised of seven tests: Reaction Time, Mathematical Processing, Memory Search, Spatial Processing, Unstable Tracking, Grammatical Reasoning, and Dual Task (unstable tracking with concurrent memory search). To evaluate stressors the performance of participants is compared under controlled conditions to determine the effects of stressors such as sleep deprivation, fatigue, monotony and boredom, illnesses' toxic fumes, hypoxia, temperature extremes, and alcohol and other drugs.	Recommended by the committee for psychological issues in AGARD (Advisory Group for Aerospace Research and Development). Most of the tasks are based on the CTS (Criterion Task Set) battery.					5				healthcare, ergonomics, space			x			• [FAA HFW] • [DLR AGARD web] • [AGARD, 1989]
786.	Stress Reduction	Gen	Des		Aim is to ensure that under all normal operational circumstances both hardware components and software activity are operated well below their maximum stress levels.							6			no-domain-found	x	x				• [Bishop, 1990]
	Stress Testing					See Avalanche/Stress Testing															
787.	Strongly Typed Programming Languages	Gen	Des	1974	The term strong typing is used to describe those situations where programming languages specify one or more restrictions on how operations involving values having different data types can be intermixed. Strong typing implies that the programming language places severe restrictions on the intermixing that is permitted to occur, preventing the compiling or running of source code which uses data in what is considered to be an invalid way. Aim is to reduce the probability of faults by using a language that permits a high level of checking by the compiler.	Tools available. Software design & development phase.						6			software		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
788.	Structural Safety Analysis	Math	HzA	1979 or older	Is used to validate mechanical structures. Inadequate structural assessment results in increased risk due to the potential for latent design problems causing structural failures, i.e., contributory hazards. Structural design is examined via mathematical analysis to satisfy two conditions: 1) Equilibrium of forces, and 2) Compatibility of displacements. The structure considered as a whole must be in equilibrium under the action of the applied loads and reactions; and, for any loading, the displacements of all the members of the structure due to their respective stress-strain relationships must be consistent with respect to each other.	The approach is appropriate to structural design; i.e., airframes, buildings.			3			6			aircraft, nuclear	x					• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]
789.	Structure Based Testing or White-Box Testing	Step	SwD	1995 or older	Software Testing technique. Based on an analysis of the program, a set of input data is chosen such that a large fraction of selected program elements are exercised. The program elements exercised can vary depending upon level of rigour required.	See also Software Testing.							7		software		x				• [EN 50128, 1996] • [Rakowsky]
790.	Structure Diagrams	Stat	Des	1995 or older	Notation which complements Data Flow Diagrams. They describe the programming system and a hierarchy of parts and display this graphically, as a tree, with the following symbols: 1) rectangle annotated with the name of the unit; 2) an arrow connecting these rectangles; 3) A circled arrow, annotated with the name of data passed to and from elements in the structure chart. Structure Diagrams document how elements of a data flow diagram can be implemented as a hierarchy of program units.	See also UML.		2							software		x				• [EN 50128, 1996] • [Rakowsky]
791.	Structured Programming	Gen	Des	1967	Aim is to design and implement the program in a way that makes the analysis of the program practical. This analysis should be capable of discovering all significant program behaviour. The program should contain the minimum of structural complexity. Complicated branching should be avoided. Loop constraints and branching should be simply related to input parameters. The program should be divided into appropriately small modules, and the interaction of these modules should be explicit.	Tools available. Software design & development phase.						6			software		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]
792.	Structuring the System according to Criticality	Gen	Des	1989	Aim is to reduce the complexity of safety critical software.	Info from HAZOP, FTA, FMEA can be used.						6			no-domain-found		x				• [Bishop, 1990]
	Success Case					See SAME (Safety Assessment Made Easier)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
793.	SUMI (Software Usability Measurement Inventory)	Tab	SwD	1993	This generic usability tool comprises a validated 50-item paper-based questionnaire in which respondents score each item on a three-point scale (i.e., agree, undecided, disagree). SUMI measures software quality from the end user's point of view. The questionnaire is designed to measure scales of: 1) Affect - the respondent's emotional feelings towards the software (e.g., warm, happy). 2) Efficiency - the sense of the degree to which the software enables the task to be completed in a timely, effective and economical fashion. 3) Learnability - the feeling that it is relatively straightforward to become familiar with the software. 4) Helpfulness - the perception that the software communicates in a helpful way to assist in the resolution of difficulties. 5) Control - the feeling that the software responds to user inputs in a consistent way and that its workings can easily be internalized.	SUMI was developed by the Human Factors Research Group (HFRG), University College, Cork.					5				management, software		x				• [Kirakowski, 1996] • [SUMI background] • [FAA HFW] • [Van Veenendaal, 1998]
	Surveys					See Interface Surveys. See Plant walkdowns/surveys															
	SUS (System Usability Scale)					See Rating Scales															
794.	SUSI (Safety Analysis of User System Interaction)	Stat	HzI	1993	HAZOP has been modified to handle Human-computer interaction. The approach adopted in the SUSI methodology is a natural extension of standard hazard analysis procedures. The principal development has been in the creation of an appropriate representation of user system interaction. A major advantage of this process is that the dataflow representation gives an overview of the complete system. The representation of the system as processes and data/control flows is understood by individuals with no software design training, such as operators and users. The review process can lead to detailed insights into potential flaws in the procedures and processes. Designers with different viewpoints are able to use a common representation and believe that it increases their understanding of the total system.			2	3			6			oil&gas, road, healthcare, maritime	x		x	x		• [Chudleigh & Clare, 1994] • [Falla, 1997] • [Stobart & Clare, 1994]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
795.	SWAT (Subjective Workload Assessment Technique)	Tab	HFA	1981	SWAT is a technique to assess the workload placed on operators of complex human-machine systems. It is designed to be easy to use, low cost, non-intrusive, and sensitive to workload variations. SWAT is composed of subjective operator ratings for three orthogonal dimensions of workload: time load, mental effort load, and psychological stress load. For time load, the question is about how much spare time the operator has. For mental effort load, the question is how much mental effort or concentration is required. For psychological stress load, the question is about confusion, risk, frustration, and anxiety. Each dimension is represented on a three-point scale with verbal descriptors for each point. Individual assessments are scaled and conjoint analysis is carried out on the results to convert them to a single metric of workload. There are 27 possible combinations; the user can decide how to rank order these values.	SWAT is reported to have two main problems: it is not very sensitive for low mental workloads and it requires a time-consuming card sorting pretask procedure. SWAT can also be applied to predict operator workload prior to a system being built; in such applications it is referred to as Pro-SWAT (Projective SWAT). See also Card Sorting. See also Rating Scales (particularly NASA TLX).							7		ATM, healthcare, defence, nuclear			x			• [GAIN ATM, 2003] • [HEAT overview] • [FAA HFW] • [Reid et al., 1989] • [Luximon & Goonetilleke, 2001] • [Beevis, 1992]
796.	SWHA (Software Hazard Analysis)	Tab	HzA	1984 or older	The purpose of this technique is to identify, evaluate, and eliminate or mitigate software hazards by means of a structured analytical approach that is integrated into the software development process. The SWHA identifies hazardous conditions incident to safety critical operator information and command and control functions identified by the PHA, SHA, SSHA and other efforts. It is performed on safety critical software-controlled functions to identify software errors/paths that could cause unwanted hazardous conditions. The SWHA can be divided into two stages, preliminary and follow-on.	This practice is universally appropriate to software systems.			3		5	6			healthcare, manufacturing, electronics		x				• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
797.	SWIFT (Structured What-IF Technique)	Tab	HzI	1992	SWIFT is a systematic team-oriented technique for hazard identification in chemical process plants. It addresses systems and procedures at a high level. SWIFT considers deviations from normal operations identified by brainstorming, with questions beginning “What if…?” or “How could…?”. The brainstorming is supported by checklists to help avoid overlooking hazards. SWIFT relies on expert input from the team to identify and evaluate hazards. There is no single standard approach to SWIFT; it can be modified to suit each individual application. An example protocol is: 1. Identify design boundaries. 2. Define the design intent and normal operating conditions. 3. Choose a question category. 4. Identify a deviation from design intent by applying a system of guidewords/ questions. 5. Identify possible causes for, and consequences of, the deviation. A deviation can be considered "meaningful" if it has a credible cause and can result in harmful consequences. 6. For a meaningful deviation, identify safeguards and decide what action, if any, is necessary. 7. Record the discussion and action. Steps 4 to 7 are repeated until all the guidewords/questions have been exhausted and the team is satisfied that all meaningful deviations have been considered. The team then goes back to Step 3 and repeats the process for the next question category. When all question categories have been exhausted, the team then goes back to Step 1 and repeats the process for the next phase/case.	SWIFT may be used simply to identify hazards for subsequent quantitative evaluation, or alternatively to provide a qualitative evaluation of the hazards and to recommend further safeguards where appropriate. As its name suggests SWIFT will generate answers more quickly than HAZOP but is less thorough in looking at the detail. Developed by DNV.			3			6			chemical, healthcare	x			x		• [DNV-HSE, 2001]
798.	Swiss Cheese Model	Stat, Gen	Mod, Mit	1990	James Reason’s Swiss Cheese model presents human error as a consequence rather than a cause, and should be the starting point for further investigation rather than the end of the search for incident or accident causes. Reason’s key points can be best described as follows: 1) Hazards, errors and other threats to aircraft operations happen all the time, but accidents do not—because most safety threats are caught and corrected by a variety of defenses.2) The aviation environment has multiple or redundant layers of protection—designed to prevent; mistakes or system failures from cascading into accidents; 3) Each layer of protection has flaws. As flaws develop in a layer, the risk for an accident begins to increase; 4) Accidents occur only when sufficient layers of protection are penetrated.	James Reason’s model of accident causation is intended as an approach toward understanding incidents and accidents and their underlying or contributing factors. Its value, therefore, lies primarily in the orientation or attitude towards investigations it has inspired. The model is usually depicted as a series of slices of cheese with holes. Arrows going through a hole in one slice may be stopped by the next slice having no hole at that point.			3	4		6		8	nuclear, aviation, ATM, healthcare, police, chemical, oil&gas			x		x	• [GAIN AFSA, 2003] • [Reason, 1990] • [Swiss Cheese]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
799.	SYBORG (System for the Behaviour of the Operating Group)	RTS	HFA	1996	A cognitive simulation approach which is the first to try to deal with emotional aspects of performance. It aims to predict what emotions personnel will experience when dealing with difficult nuclear power plant events, and aims to determine how these emotions will affect attention, thought, action, and utterances. The emotions considered include fear, anxiety, tension, surprise, etc.	There is ongoing work to determine how emotions interact with each other and with error forms. SYBORG is stated to be "the first approach that, in the future, may be able to identify idiosyncratic errors, or errors caused by extreme stress in a situation."		2	3						(nuclear)			x			• [Kirwan, Part 1, 1998] • [Lenne et al, 2004]
800.	Symbolic Execution	Step	Val	1976	Aim is to show the agreement between the source code and the specification. The program is executed substituting the left hand side by the right hand side in all assignments. Conditional branches and loops are translated into Boolean expressions. The final result is a symbolic expression for each program variable. This can be checked against the expected expression.	Useful for safety critical software providing the number of paths is small and there is good tool support. Tools available. See also Validation and Verification.							7		software		x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]
	Systematic Inspection					See Formal Inspections. And see Inspections and walkthroughs. And see Safety Review or Safety Audit.															
	Systematic Observation					See Field Study															
	Systematic Occupational Safety Analysis					See Occupational Health Hazard Analysis.															
801.	T/LA (Time/ Loss Analysis for Emergency Response Evaluation)	Step	HzA	1980 or older	This technique is a system safety analysis-based process aimed to semi-quantitatively analyse, measure and evaluate planned or actual loss outcomes resulting from the action of equipment, procedures and personnel during emergencies or accidents. T/LA provides graphic time/loss curves showing expected versus actual loss growth during emergencies or mishaps. These curves are used to describe the change in the outcome produced by intervention actions at successive states of the emergency response. The T/LA approach defines organised data needed to assess the objectives, progress, and outcome of an emergency response; to identify response problems; to find and assess options to eliminate or reduce response problems and risks; to monitor future performance; and to investigate accidents.	Although it is a system level analysis, due to lack of design definition and maturity, T/LA is not usually initiated until after the SSHA has begun and uses the SSHA data before it is integrated into the SHA.								8	(aviation)	x		x	x		• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]
802.	Table-top analysis	Gen	Dat, Task	1974	A group of experts who have an understanding of a specific aspect of a system, meet together as a discussion group to define or assess particular aspects of a task. The discussions must be directed around some basic framework.	See also Brainstorm. Several variations exist for specific applications, such as TableTop Needs Analysis (TTNA), Table-Top Job Analysis (TTJA).		2	3						aviation	x		x			• [Kirwan & Ainsworth, 1992] • [FAA HFW] • [Naikar, 2006]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
803.	TAFEI (Task Analysis For Error Identification)	Stat	HRA, Task	1991	Task analysis method based on State Space Diagrams, describing user interactions with equipment in terms of transition (input-output) boxes (non-Markovian: qualitative in nature). For a particular task the network of transition boxes is developed, and then examined to determine what illegal transitions could take place, such as skipping over task elements, sequence errors, etc., though in theory EOCs (errors of commission) could be developed from such networks.	Developed by C. Baber and N. Stanton. Related to State Space Diagrams.		2	3						ergonomics, energy	x		x			• [Kirwan, Part 1, 1998] • [Baber & Stanton, 2002]
804.	TALENT (Task Analysis-Linked EvaluatioN Technique)	Int	Task	1988	An assessment framework which also contains a strong task analysis bias, utilising Task Analysis or Sequential Task Analysis, Timeline Analysis, and Link Analysis for each task sequence. Then, tasks are identified for inclusion in the fault and event trees, through a collaborative effort between the behavioural scientists and the safety assessors. PSF (Performance Shaping Factor) are then identified for each task, and then the tasks are quantified using either THERP or SLIM.	TALENT was applied for an evaluation of the US Peach bottom nuclear power plant. It has not been used substantially recently.			3	4	5				nuclear			x			• [Kirwan, Part 1, 1998]
805.	Talk-Through Task Analysis	Step	Task	1986	Similar to Walk-Through, but is undertaken more remotely from the normal task location, so that the tasks are verbalised rather than demonstrated.			2	3						social			x	x		• [Kirwan & Ainsworth, 1992]
806.	TapRooT	Int	Ret	1990	The TapRooT is a suite of tools for accident/incident investigation. It systematically leads an investigator through the techniques/steps used to perform an in-depth accident investigation or incident analysis. TapRooT focuses on uncovering the root causes of accident/incident and helps in proactively improving performance.	Developed at System Improvements Inc.								8	manufacturing, oil&gas, aviation, chemical, healthcare, electronics	x		x	x		• [FAA HFW] • [GAIN ATM, 2003] • [GAIN AFSA, 2003] • [Hutchins, 1995]
807.	TARAM (Transport Airplane Risk Assessment Methodology)	Math	OpR	2011	TARAM aims to give guidance on how to calculate specific levels of risk associated with identifiable design flaws in transport airplanes. The method uses a worksheet in which the user is to fill out estimates of particular parameters. Next, the worksheet computes (through simple mathematical formulas) the following five values: 1) Total uncorrected fleet risk, i.e. number of weighted events statistically expected in the remaining life of the affected fleet if no corrective action is taken. 2). Uncorrected individual risk, i.e. highest probability per flight hour that an exposed individual will be fatally injured. 3). 90-day fleet risk, i.e. total risk within the affected fleet over the next 90 days if no corrective action is taken. 4). Control program fleet risk, i.e. risk within the affected fleet during the period when corrective action is being accomplished. 5). Control program individual risk, i.e. highest probability per flight hour that an exposed individual will be fatally injured. The results are next compared with guidance values as input to decision making.	TARAM aims to support an existing Monitor Safety/Analyze Data (MSAD) regulation, which requires a shift to a mathematical treatment of risk, in furtherance of an effort to implement a safety management system (SMS)-based approach to the aircraft certification process.				4	5	6			aircraft	x	x				• [TARAM Handbook, 2010]
	Task Allocation Charts					See OSD (Operational Sequence Diagram)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
	Task Analysis					See AET, CAMEO/TAT, Critical Path Method, Critical Task Analysis, CTA, Decision Tables, FPC, GDTA, HECA, HTA, OSD, Operator Task Analysis, PERT, TAFEI, TALENT, Talk-Through Task Analysis, Team CTA, TTA, TTM, Walk-Through Task Analysis															
808.	Task Decomposition	Gen	Task	1953	Task decomposition is a structured way of expanding the information from a task description into a series of more detailed statements about particular issues which are of interest to the analyst.			2							aviation, ATM, defence, navy, space, nuclear, chemical, oil&gas, manufacturing, healthcare, management			x			• [Kirwan & Ainsworth, 1992] • [FAA HFW]
809.	Task Description Analysis	Int	Task	1986 or older	Method supported by several different methods designed to record and analyse how the human is involved in a system. It is a systematic process in which tasks are described in terms of the perceptual, cognitive, and manual behaviour required of an operator, maintainer or support person.			2							(defence)			x			• [MIL-HDBK, 1999]
810.	TCI model (Task-Capability-Interface model)	Gen	Mod	2000	In this model task difficulty arises out of the interface between the demands of the driving task and the capability of the driver. Task demands depend on factors such as road context, vehicle, speed, and other road users. Capability depends on driver experience and training, hampered by fatigue, drugs, stress, distraction and effort. The combination of task demand and capability leads to either control over the vehicle, or loss of control, which may be compensated for by e.g. decrease of speed.			2							road				x		• [Fuller, 2000] • [Fuller & Bonney, 2004]
811.	TDA (Task Demand Assessment)	Step	Mit	2010	Aims to assess task difficulty and to propose better and efficient work practices. It assesses construction activities, based on characteristics of the activity and independent of the workers' capabilities, and analyzes how changes in operation parameters can affect potential of accidents.						5	6			manufacturing			x			• [Mitropoulos & Namboodiri, 2011]
	Teachback					See Interview															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
812.	TEACHER/ SIERRA (Technique for Evaluating and Assessing the Contribution of Human Error to Risk [which uses the] Systems Induced Error Approach)	Int	HRA, Task	1993	Alternative HRA framework more aimed at lower consequence accidents than PSA traditionally aims at. It has a number of components. The first is SIERRA. This states that humans have basic error tendencies that are influenced by PIFs (Performance Influencing Factors). TEACHER focuses on defining a task inventory, then determining the prioritisation of critical tasks according to their risk potential, leading to a rating on a risk exposure index for each task. Following the screening analysis a HTA and PHEA analysis are carried out, following which, those errors with significant consequence potential are analysed with respect to a set of PIF audit questions, to develop remedies for the error. Each PIF audit question allows the analyst to rate the task according to, e.g., the extent to which procedures are defined and developed by using task analysis, on a seven-point semantic differential, anchored at each end-point. Risk reduction is then determined by the analyst.	Developed by D. Embrey.		2	3		5	6			(chemical)			x			• [Kirwan, Part 1, 1998]
813.	Team CTA (Team Cognitive Task Analysis)	Step	Task	1982	Team CTA considers the team as an intelligent entity that can be studied to aid team task design, team composition, team training. The model emphasizes the importance of communication, and shared situational awareness and focuses on “action teams”. It can be used to diagnose and offer suggestions for treatment of existing problems in teamwork as well as to help design training materials for new team members by outlining the knowledge and skills required for team membership.	Was developed on the notion that current methods of task analysis fail to capture team characteristics such as interdependence and co-operation. Applying a method of analysis designed for individuals to teams is not sufficient for true understanding of how a team works.		2						8	nuclear, navy			x		x	• [Klein, 2000] • [Klinger, 2003] • [Salmon et al, 2004] • [FAA HFW]
814.	Telelogic Tau	Int	Des	2001 or older	Telelogic Tau provides specialised tool sets for every phase of a project: 1) Telelogic Tau UML Suite for requirement capture and analysis; 2) Telelogic Tau SDL Suite for design and implementation, and 3) Telelogic Tau TTCN Suite for comprehensive testing. In addition, a) SCADE Suite (sold to Esterel) facilitates the capture of unambiguous software specifications. It allows detecting corner bugs in the early stages of the development and reduces the coding and testing efforts. b) Telelogic Tau Logiscope Detects Coding Errors in C, C++, Ada and Java, Identifies and Locates Error-Prone Modules and Provides Code Coverage Analysis.	Software tools that cover all phases of the development process: analysis, design, implementation and testing.			3			6			software		x				• [Telelogic Tau]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
815.	Temporal Logic	Math	Mod	1957	Direct expression of safety and operational requirements and formal demonstration that these properties are preserved in the subsequent development steps. Formal Method. It extends First Order Logic (which contains no concept of time) by adding model operators. These operators can be used to qualify assertions about the system. Temporal formulas are interpreted on sequences of states (behaviours). Quantified time intervals and constraints are not handled explicitly in temporal logic. Absolute timing has to be handled by creating additional time states as part of the state definition.	Useful as descriptive and demonstrative technique for small systems or small parts of large systems. Computer based tools are necessary for large systems. Related methods are Petri nets, finite state machines. Software requirements specification phase and design & development phase.		2					7		social, electronics	x	x				• [Bishop, 1990] • [EN 50128, 1996] • [Rakowsky]
816.	TESEO (Tecnica Empirica Stima Errori Operatori (Empirical technique to estimate operator errors))	Step	Par	1980	Assesses probability of operator failure. Used more as a tool of comparison between different designs of the man-machine system than for obtaining absolute probabilities. Human Error Probability (HEP) is the product of five values: (1) complexity of action, requiring close attention or not. (2) time available to carry out the activity. (3) experience and training of the operator. (4) operators emotional state, according to the gravity of the situation. (5) man-machine and environment interface.	Developed in 1980 by G.C. Bello and C. Colombari (ENI Research Centre). Applicable to assessing operator failure in control rooms. Not considered very accurate.					5				chemical, (nuclear), aviation, maritime			x			• [Humphreys, 1988] • [Bello & Colombari, 1980] • [Mariani, 2012] • [MUFTIS3.2-I, 1996] • [GAIN ATM, 2003]
817.	Test Adequacy Measures	Step	Val	1972 or older	Aim is to determine the level of testing applied using quantifiable measures.	See also Software Testing. See also Code Coverage.							7		software		x				• [Bishop, 1990]
818.	Test Coverage	Gen	SwD	1992 or older	For small pieces of code it is sometimes possible to achieve 100% test coverage. However due to the enormous number of permutations of states in a computer program execution, it is often not possible to achieve 100% test coverage, given the time it would take to exercise all possible states. Several techniques exist to reach optimum test coverage. There is a body of theory that attempts to calculate the probability that a system with a certain failure probability will pass a given number of tests. Monte Carlo simulation may also be useful. Test coverage should at least consider safety critical Must-Work-Functions and software safety requirements.	Some analysis is advisable to assess the optimum test coverage as part of the test planning process. See also Code Coverage.					5				software, (avionics), (space)		x				• [DO-178B, 1992] • [FAA00] • [Shahid et al., 2011] • [Shahid & Ibrahim, 2011]
819.	Test Results Analysis	Step	Val	2000 or older	Test Results Analysis aims to verify that all safety requirements have been satisfied. The analysis also aims to verify that all identified hazards have been eliminated or controlled to an acceptable level of risk. The results of the test safety analysis are provided to the ongoing system safety analysis activity. All test discrepancies of safety critical software should be evaluated and corrected in an appropriate manner.								7		aircraft		x				• [FAA00]
820.	Tests based on Random Data	Gen	SwD	1984 or older	Software Testing technique. Aim is to cover test cases not covered by systematic methods. To minimise the effort of test data generation.	Useful if there is some automated means of detecting anomalous or incorrect behaviour. See also Software Testing.							7		environment		x				• [Bishop, 1990]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
821.	Tests based on Realistic data	Gen	SwD	1976 or older	Software Testing technique. Aim is to detect faults likely to occur under realistic operating conditions.	Not particularly effective or appropriate at the early stages of software development. Useful for system testing and acceptance testing. See also Software Testing.							7		aviation, space, manufacturing		x				• [Bishop, 1990]
822.	Tests based on Software structure	Gen	SwD	1976 or older	Software Testing technique. Aim is to apply tests that exercise certain subsets of the program structure.	Essential part of an overall test strategy for critical systems. Tools available. See also Software Testing.							7		software		x				• [Bishop, 1990]
823.	Tests based on the Specification	Gen	SwD	1985 or older	Software Testing technique. Aim is to check whether there are any faults in the program that cause deviations from the specified behaviour of the software.	Essential part of an overall test strategy. See also Software Testing.							7		electronics, finance		x				• [Bishop, 1990]
824.	THA (Threat Hazard Analysis)	Step	HzA	1997 or older	A THA lays out all possible threat environments that a weapon could possibly be exposed to during its lifecycle and is the baseline for establishing the parameters for the safety and environmental test program. These tests and analyses are performed to verify the ruggedness and soundness of the design to withstand or protect the weapon against these environments.	Weapons systems. Mandatory requirement of MIL STD 2105B.			3		5				defence	x					• [ΣΣ93, ΣΣ97] • [AQ, 2003]
825.	THEA (Technique for Human Error Analysis)	Stat	HRA	1997	THEA is a technique designed for use by interactive system designers and engineers to help anticipate interaction failures. These may become problematic once designs become operational. The technique employs a cognitive error analysis based on an underlying model of human information processing. It is a highly structured approach, intended for use early in the development lifecycle as design concepts and requirements concerned with safety and usability – as well as functionality – are emerging. THEA employs a systematic method of asking questions and exploring interactive system designs based on how a device functions in a scenario. Steps are: 1. Detailed System Description; 2. Usage Scenarios; 3. Structure the scenarios (e.g. HTA); 4. Error Identification Error Consequence; 5. Underlying model of "human error"; 6. Suggestions for new requirements & Implications for design.	THEA aims to inform human-computer interface design at an early stage of development.		2	3	4	5	6			aviation, ATM			x			• [Fields, 1997] • [Pocock, 2001]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
826.	THERP (Technique for Human Error Rate Prediction)	Tab, Stat	HRA	1981	Aim is to predict human error probabilities and evaluate degradation of a man-machine system likely to be caused by human error, equipment functioning, operational procedures and practices, etc. Steps are: 1. Define the system failures of interest. 2. List and analyse the related human operations, and identify human errors that can occur, as well as relevant human error recovery modes. This stage of the process necessitates a comprehensive task and human error analysis. The tasks and associated outcomes are input to an HRAET (human reliability analysis event tree) in order to provide a graphical representation of a task's procedure. 3. Estimate the relevant human error probabilities (HEPs) for each sub-task, and enter these into the tree. 4. Estimate the effects of human error on the system failure events. 5. Recommend changes to the system and recalculate the system failure probabilities.	Developed by Swain & Guttman, Sandia Laboratories for the US Nuclear Regulatory Commission. Longest surviving HRA (Human Reliability Analysis) technique. Developed in 1960-1970; released in 1981. This technique is the standard method for the quantifying of human error in industry.					5				nuclear, defence, oil&gas, manufacturing, space			x			• [FAA00] • [Humphreys, 1988] • [Kirwan, 1994] • [Kirwan, Part 1, 1998] • [MUFTIS3.2-I, 1996] • [ΣΣ93, ΣΣ97] • [FAA HFW] • [Swain & Guttman, 1983] • [GAIN ATM, 2003]
827.	Think-Aloud Protocol or Verbal Protocol	Dat	Task	1912	Think aloud protocol, or Verbal protocol, is a technique applied in user testing where users are asked to vocalise their thoughts, feelings and opinions whilst interacting with a site as they perform a task. While the focus in user testing is primarily on how effectively a user performs the required tasks (and not on how users believe they are performing), verbalisations are useful in understanding situation awareness, mistakes that are made, getting ideas for what the causes might be and how the interface could be improved to avoid those problems.	Method known already in the 1910s, but the theoretical framework for think-aloud protocol experiments is provided mainly by the work of Ericsson and Simon (1984, 1993). Two variations are Co-discovery, in which two participants jointly attempt to perform tasks together while being observed in a realistic work environment, and Cooperative Evaluation.		2							social, healthcare, food, nuclear, chemical			x	x		• [FAA HFW] • [Nielsen, 1997] • [Thinkaloud] • [Bernardini, 1999] • [Kirwan & Ainsworth, 1992] • More refs: see [Refs Think Aloud Protocol]
	Threshold Analysis					See Trend Analysis															
	Thurstone Scale					See Rating Scales															
828.	Timeline Analysis	Stat	Task	1959	Analytical technique for the derivation of human performance requirements which attends to both the functional and temporal loading for any given combination of tasks. Timeline Analysis examines the precise sequence of events in a scenario. Visualises events in time and geographically.	Timeline Analysis has been used for years by the defence and intelligence communities, primarily for predicting foreign government actions and responses to world events. Tools available. See also HTLA and VTLA.		2		4	5				police, electronics, nuclear, oil&gas, navy, defence			x	x		• [FAS_TAS] • [HEAT overview] • [Kirwan & Ainsworth, 1992] • [Kirwan, 1994] • [MIL-HDBK, 1999] • [Mucks & Lesse, 2001] • [FAA HFW] • [Luczak, 1997] • [Wickens & Hollands, 1999] • [Parks, 1989]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
829.	Timing, Throughput and Sizing Analysis	Step	SwD	1996 or older	This technique aims to evaluate software requirements for safety critical functions that relate to execution time and memory allocation, focusing on program constraints. The adequacy and feasibility of safety critical timing and sizing requirements are evaluated, and it is evaluated whether adequate resources have been allocated in each case, under worst case scenarios. Quantifying timing/sizing resource requirements can be very difficult; estimates can be based on the actual parameters of similar existing systems.	Typical constraint requirements are maximum execution time and maximum memory usage. Or input/output channels can be overloaded by many error messages, preventing safety critical features from operating.							7		software, (avionics), (space)		x				• [NASA-GB-1740.13-96]
830.	TKS (Task-Knowledge Structures)	Stat	Task	1989	There are two different parts of a TKS, a goal structure and a taxonomic structure. The goal structure represents the sequencing of task activities, and the taxonomic structure models extensive knowledge about objects, their relationships and their behaviors. There is an explicit assumption that knowledge modeled within a TKS is not of equal status, some is more important to successful task performance than others. The status of individual knowledge components must be modeled in order that systematic assumptions about usability can be made.	TKS was developed as a theoretical approach to analyzing and modelling tasks with the purpose of design generation.		2		4					ATM, healthcare			x	x		• [Johnson & Johnson, 1991] • [FAA HFW]
	TLX (Task Load Index)					See NASA TLX (NASA Task Load Index). See Rating Scales															
831.	TOKAI (Tool Kit for Occurrence Reporting and Analysis)	Min	Dat	2000	TOKAI is a database management system containing imbedded tools that permit: 1) Air traffic management staff to report occurrences, 2) local investigators to investigate, analyse and assess occurrences, to develop safety recommendations, 3) safety departments to investigate, exchange data and develop statistics on groups of occurrences, 4) regulators to develop remedial policies. TOKAI's occurrence notification form is the ATS Occurrence Reporting Form developed by Eurocontrol. The data gathered is based on Eurocontrol ATM occurrence data taxonomy called HEIDI.	TOKAI was designed to support the Eurocontrol member states in implementing a reporting system compliant with Eurocontrol Safety Regulatory Requirements (ESARR 2). It assures that reports submitted by the various providers are of uniform quality and format to allow aggregated data to remain meaningful.								8	(ATM)	x		x	x		• [GAIN ATM, 2003] • [TOKAI web]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
832.	TOPAZ (Traffic Organisation and Perturbation AnalyZer)	Int	OpR	1993 from	TOPAZ is a methodology aiming to systematically support all stages of the safety risk assessment of a novel operation in air traffic management, including the provision of effective safety feedback to operational concept design experts. The methodology integrates several individual safety techniques, such as Pure Hazard Brainstorming, TOPAZ hazard database, Hazard crystallization into safety relevant scenarios, Agent Based Modelling and Simulation (ABMS), formal modelling using the powerful Petri net formalism SDCPN, model Verification & Validation, Rare event Monte Carlo simulation, Bias and Uncertainty Assessment, and Risk mitigation brainstorming with operational experts. A complementary step is to use monitoring data to verify the assumptions adopted. The quantitative safety methods combined form the MA-DRM safety method in this list. Because Rare event MC simulation forms a key element within MA-DRM, for the particular application a choice can be made from various separately listed mathematical techniques such as: HSMP, Stochastic Differential Equations on Hybrid State Space, Generalised Reich Collision Risk Model, Risk decomposition and Interacting Particle System.	The TOPAZ methodology and several of its integrated safety assessment techniques have been developed by National Aerospace Laboratory NLR from 1993 onwards. Most individual safety techniques are separately described in this list. Supporting TOPAZ toolsets have been developed for many different conflict scenarios and operations. Applications include collision risk assessment between aircraft on parallel en route lanes, between aircraft in terminal manoeuvring area, between taxiing and landing aircraft at an airport, and between aircraft flying under airborne self-separation.	1	2	3	4	5	6		8	ATM	x	x	x	x	x	• [Blom et al, 1998, 2001] • [Blom & Stroeve & DeJong, 2006] • [MUFTIS3.2-II, 1996] • [GAIN ATM, 2003] • [FAA HFW] • [TOPAZ Applications]
833.	TOPAZ hazard database	Dat	HzI	1999	Database of hazards gathered using dedicated TOPAZ-based hazard brainstorms for various ATM operations.	Technique used for TOPAZ-based hazard brainstorms is Pure hazard brainstorming, or Scenario-based hazard brainstorm.			3						ATM	x	x	x	x	x	• [TOPAZ hazard database]
	TOPAZ-based hazard brainstorming					See Pure Hazard Brainstorming															
834.	TOPPE (Team Operations Performance and Procedure Evaluation)	Step	HRA	1991	A procedure validation and team performance evaluation technique. It uses judges to evaluate team performance when carrying out emergency procedures. It is therefore not designed as a Human Error Identification tool. However, it can identify procedural errors (omissions, wrong procedural transitions etc.), and team leadership or co-ordination problems. As such, an approach could be developed to determine credible procedural and co-ordination errors of these types, based on observation of emergency exercises which all nuclear power plant utilities are required to carry out.				3				7		(nuclear)				x		• [Kirwan, 1995] • [Kirwan, Part 1, 1998]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
835.	TOR (Technique Of Operations Review)	Tab	HzA, Ret	1973	The focus of TOR analysis is on system failures, seeking to identify management failures rather than 'blaming' employees involved. TOR analysis is presented in a work sheet format. It is a group technique requiring participants to progress through the work sheet answering yes or no to a series of questions. A condition of TOR analysis is that the group reaches a consensus on the answers to the questions. There are four basic steps in the TOR analysis process: 1) Establish the facts. 2) Trace the root causes. 3) Eliminate insignificant causes. 4) Identify realistic actions.	TOR analysis was initially developed by Weaver (1973) as a training tool to assist with the prevention of incidents. It has subsequently found application as an investigatory technique for the identification of root causes associated with incidents and accidents.						6			finance, management, healthcare			x	x	x	• [FAA HFW]
836.	TRACEr (Technique for the Retrospective Analysis of Cognitive Errors in Air Traffic Management)	Step	HRA, Ret	1999	Aim is to predict human errors that can occur in ATM systems, and to derive error reduction measures for ATM. The design process is aided by predicting what errors could occur, thus helping to focus design effort. It is designed to be used by ATM system designers and other operational personnel. The tool helps to identify and classify the 'mental' aspects of the error, the recovery opportunities, and the general context of the error, including those factors that aggravated the situation, or made the situation more prone to error.	Human factors in ATM; Reduced scope version of TRACEr is named TRACEr lite (2001). A version applicable to railways is named TRACEr-Rail; a version for Australian scope is TRACEr-RAV. HERA is TRACEr for European use.			3			6		8	ATM, rail			x			• [HIFA Data] • [Shorrock, 2001] • [Shorrock & Kirwan, 1998] • [Shorrock & Kirwan, 1999] • [Shorrock & Kirwan, 2002] • [TRACEr lite_xls] • [Scaife, 2001] • [GAIN ATM, 2003]
	Training Systems Requiremenets Analysis					See Front-End Analysis															
837.	TRAM (Tool for Rapid Analysis of Monte Carlo simulations)	FTS	Dec	2010	TRAM is a tool that aims to automatically rank individual design variables and combinations of variables according to how useful they are in differentiating Monte Carlo simulation runs that meet certain requirements from those that do not. To produce these rankings, the separability of 'good' data points from 'bad' data points is used to find regions in the input and output parameter spaces that highlight the differences between the successful and failed simulation runs in a given Monte Carlo set.	See also Monte Carlo simulation.					5				space	x					• [Restrepo & McCall, 2013]
838.	Translator Proven in Use	Gen	Des	1996 or older	A translator is used whose correct performance has been demonstrated in many projects already. Translators without operating experience or with any serious known errors are prohibited. If the translator has shown small deficiencies the related language constructs are noted down and carefully avoided during a safety related project.	Software design & development phase.						6			rail		x				• [EN 50128, 1996] • [Rakowsky]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
839.	Trend Analysis	Gen	Mod		This method can assist in identifying trends, outliers, and signal changes in performance. The method is widely used particularly for analysis of events, human performance, equipment failure/ reliability/ maintainability, process systems performance, etc. The method is used to first characterise data, trend it over time to establish a baseline, and then by expert judgement or statistical inference establish thresholds or control points that when exceeded indicate a significant change in the performance of what is being monitored.	Can be used for safety, maintenance, and manufacturing production applications.							7		aviation, nuclear, social, healthcare, environment, finance, manufacturing	x		x			• [GAIN AFSA, 2003]
840.	TRIPAC (Third party Risk analysis Package for aircraft ACcidents around airports)	Math	OpR	1992 and 1999	Typical third party risk assessment method. It consists of three submodels: an accident probability model, an accident location probability model and an accident consequence model. The results of these submodels are combined to calculate individual risk levels (local probability of death), which are usually presented as risk contours on a topographical map, and societal risk (probability of death of a group of N or more people).	Developed by National Aerospace Laboratory NLR. The method is applied in many airports risk studies. With the experience gained over the years in application of the method, and due to the availability of improved historical data, the risk models were updated in 1999, consisting of adaption of model parameters and conceptual changes of the external risk models.				4	5				airport				x		• [Pikaar, 2000] • [OPAL, 2003]
841.	TRIPOD	Int	Mit, Ret	1994	Tripod is an incident investigation and analysis method that identifies latent failures in the organisation of safety critical operations and comes up with recommendations for improvement. It aims to identify and correct the latent failures that are behind operational disturbances, like production incidents, environmental incidents, IT incidents, financial incidents, by focusing on the organisation rather than the individual.	Two tools developed by the Royal Dutch/Shell Group to measure safety and investigate accidents based on the Tripod theory are Tripod-BETA and Tripod-DELTA. Tripod-BETA is a methodology for conducting an accident analysis in parallel with (as opposed to at the end of) the investigation; highlighting avenues of investigation leading to latent failures and assigning general failure type categories to latent failures. Tripod-DELTA is a methodology for identifying weaknesses in the Safety Management System; providing a pro-active tool for planning Safety management actions; getting workforce involvement in the identification of weaknesses and planning of corrective actions; and development of root cause thinking to promote a learning organisation.			3			6	7	8	oil&gas, aviation, rail				x	x	• [Aberdeen, 2003] • [Groeneweg] • [Kennedy & Kirwan, 1998] • [PROMAI5, 2001] • [Tripod Beta] • [Tripod Solutions]
	TRM (Team Resource Management)					See CRM (Crew Resource Management)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
842.	TSA (Test Safety Analysis)	Step	HzA	1979 or older	Test Safety Analysis is used to ensure a safe environment during the conduct of systems and prototype testing. It also provides safety lessons to be incorporated into the design, as applicable. Each test is evaluated to identify hazardous materials or operations. Each proposed test needs to be analyzed by safety personnel to identify hazards inherent in the test and to ensure that hazard control measures are incorporated into test procedures. It is during the process of test safety analysis that safety personnel have an opportunity to identify other data that may be useful to safety and can be produced by the test with little or no additional cost or schedule impact.	A lessons learned approach of any new systems 'or potentially hazardous subsystems' is provided. This approach is especially applicable to the development of new systems, and particularly in the engineering/ development phase.						6			(space), (rail), (software)	x					• [FAA AC431] • [FAA00] • [ΣΣ93, ΣΣ97]
843.	TTA (Tabular Task Analysis)	Tab	Task	1989 or older	Aim is to specify the context in which important task steps take place and to identify aspects that may be improved. The TTA usually follows on from a Hierarchical Task Analysis (HTA) and is columnar in format. It takes each particular task-step or operation and considers specific aspects, such as Who is doing the operation, What displays are being used.	Is useful for dynamic situations which involve a considerable amount of decision-making.		2							ATM, nuclear			x			• [Kirwan, 1994] • [Vinnem, 2000]
	TTM (Truth Table Method)					See Decision Tables															
844.	UML (Unified Modelling Language)	Int	Des	1997	UML is the industry-standard language for specifying, visualising, constructing, and documenting the artefacts of software systems. It simplifies the complex process of software design, making a "blueprint" for construction.			2							software		x				• [UML]
845.	Uncertainty Analysis	Gen	Val		Uncertainty Analysis addresses, quantitatively and qualitatively, those factors that cause the results of an assessment to be uncertain. Uncertainty generally has two types of impact on the assessed risk level: Bias and Variation. Important components of uncertainty analysis include qualitative analysis that identifies the uncertainties, quantitative analysis of the effects of the uncertainties on the decision process, and communication of the uncertainty. The analysis of the uncertainty depends on the problem. Differences result from differences in spatial and temporal scale, available data and information, models and objectives.	Uncertainty analysis covers a wide range of techniques, from simple descriptive procedures to quantitative estimation of uncertainty, to more formal decision-based procedures. The analysis may be qualitative or quantitative, depending on the level of resolution required and the amount of information available. The assessment of uncertainty is also tied to the view of uncertainty from the scientist and risk manager. Sometimes known as Error Propagation. See also Bias and Uncertainty Assessment. See also Sensitivity Analysis.					5				all	x	x	x	x		• [FAA00] • [ΣΣ93, ΣΣ97] • [Smith, 2002] • [Morgan & Henrion, 1990]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
846.	Unused Code Analysis	Gen	SwD	1996 or older	A common coding error is to generate code that is logically excluded from execution; i.e., preconditions for the execution of this code will never be satisfied. There is no specific technique for identifying unused code; however, unused code is often identified during the course of performing other types of code analysis. It can be found during unit testing with COTS coverage analyser tools.	Unused code is undesirable for three reasons; a) it is potentially symptomatic of a major error in implementing the software design; b) it introduces unnecessary complexity and occupies memory or mass storage which is often a limited resource; and c) the unused code might contain routines which would be hazardous if they were inadvertently executed (e.g., by a hardware failure or by a Single Event Upset). See also Code Coverage.			3						software, (avionics), (space)		x				• [FAA00] • [NASA-GB-1740.13-96] • [Rakowsky]
	Usability Heuristic Evaluation					See Heuristic Evaluation															
847.	User Analysis	Gen	Dat, Task		Aims to describe the user population in order to identify user specific factors impacting the task(s). Components to be considered include: Usage Objectives, User Roles, User Characteristics, Usage Environment, User Interface Guidelines.	Some user factors to consider include knowledge, skills, limitations, experience, age, height, size, weight, strength, maturity, and many other considerations.		2							electronics, healthcare			x			• [FAA HFW] • [Do & Gatica, 2010]
848.	V&V (Verification and Validation)	Gen	Val	1982 or older	Verification: to build the product right (which refers to product specifications); Validation: to build the right product (which refers to user's needs).	Essential for safety-related systems. Tools available. Several frameworks for validation and/or verification exist, e.g. E-OCVM or SAFMAC, but numerous safety methods in this database are applicable to V&V activities.							7	8	all	x	x				• [Bishop, 1990]
849.	VDM (Vienna Development Method)	Math	Des	1972	Systematic specification and implementation of sequential programs. Formal Method. Mathematically based specification technique and a technique for refining implementations in a way that allows proof of their correctness with respect to the specification. The specification language is model-based in that the system state is modelled in terms of set-theoretic structures, on which defined invariants (predicates) and operations on that state are modelled by specifying their pre-and post conditions in terms of the system state. Operations can be proved to preserve the system invariants.	The origins of VDM specification language lie in the IBM Laboratory in Vienna where the first version of the language was called the Vienna Definition Language (VDL). Recommended especially for the specification of sequential programs. Established technique, training courses available. Closely related to Z. Tools available. Software requirements specification phase and design & development phase.		2				6			electronics, finance, avionics		x				• [Bishop, 1990] • [EN 50128, 1996]
850.	VEMER (Veiligheid, Efficiency en Milieu Effect Rapportage, i.e. Safety Efficiency and Environment (SEE) Framework)	Int	OpR	2004	VEMER is a frame of reference for the definition of the quality of LVNL's Air Traffic Management (ATM) Service Provision. The Safety Assessment takes place within the broader context of a trade-off between safety, efficiency and environment. The framework uses two iterative Mechanisms: I. Formulation of SEE targets, Generation of scenarios, Definition of question, scope & level of detail, and Selection of SEE Model. II. SEE evaluation for the generated scenarios using the selected SEE Model, using the ATM system description or a concept of operation as input.	LVNL is the main air navigation service provider in the Netherlands.	1	2	3	4	5	6	7	8	ATM	x	x	x	x	x	• [VEM, 2004] • [LVNL Safety Criteria] • [Bos et al., 2007]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
	Verbal Protocol					See Think-Aloud Protocol															
	Video Prototyping					See Prototyping															
851.	Vital Coded Processor	Step	Mit	1989	Aim is to be fail-safe against computer processing faults in the software development environment and the computer hardware. In this technique, three types of errors – operation, operator and operand errors – can be detected by redundant code with static signatures.	Overcomes most of the insecurities associated with microprocessor-based technology. Useful on relatively simple applications that have a safe state. See also Fail Safety. See also Memorizing Executed Cases.						6			rail	x	x				• [Bishop, 1990]
852.	VTLA (Vertical Timeline Analysis)	Tab	Task, HFA	1987 or older	Investigates workload and crew co-ordination, focuses on crew activities and personnel. A series of columns are used: task; sub-task (action) description; time the sub-task begins; time the sub-task ends; and a column each for the operators involved in the whole task/scenario, indicating in each row which operators are involved in the sub-task. If an operator moves from their usual location this is noted under the column for that operator at the time it happens. The VTLA helps to identify where team co-ordination will be particularly required, and also where workload may be unevenly spread, and where human resources may be insufficient. The VTLA can also discriminate between actions and monitoring, and can show potential actions given other plant failures or system recoveries. Lastly, key system/transient events can be indicated on the x-axis.	See also HTLA. See also Timeline Analysis. VTLA focuses on crew activities and personnel whereas HTLA focuses on task sequencing and overall timing.		2		4	5				(nuclear), (oil&gas)			x	x		• [Kirwan & Kennedy & Hamblen] • [Kirwan, 1994] • [Task Time]
853.	WAAS (World Aircraft Accident Summary)	Dat	Dat	1990	Provides brief details of all known major operational accidents involving air carriers operating jet and turboprop aircraft and helicopters and the larger piston-engined types worldwide.	WAAS was produced on behalf of the British Civil Aviation Authority, by Airclaims Limited. A subset, containing data and descriptive information about all known fatal airline accidents with passenger fatalities for the last ten years, was purchased by FAA.								8	aviation, aircraft	x			x		• [WAAS Database] • [ER Library - Aviation Safety]
854.	Walk-Through Task Analysis	Step	Task	1986	This technique is a systematic analysis that can be used to determine and correct root causes of unplanned occurrences related to maintenance.	This technique is applicable to maintenance. See also Inspections and Walkthroughs.			3				7		(energy), (nuclear)			x	x		• [FAA00] • [EN 50128, 1996] • [Kirwan & Ainsworth, 1992] • [Kirwan, 1994] • [ΣΣ93, ΣΣ97]
	Walkthroughs					See Inspections and Walkthroughs															
855.	Watchdog timers	Gen	Des	1977 or older	Watchdog timers are hardware devices with the capability to reset (reboot) the system should the watchdog not be periodically reset by software. The computer has to “say hello” from time to time to the watchdog hardware to let it know that it is still alive. If it fails to do that then it will get a hardware reset. Aim is to provide a non-software related reliable hardware checking method of the software operation.	Useful on all safety critical and real-time control systems. Related to software time-out checks. Sometimes referred to as Computer Operating Properly timer.						6			electronics, space	x	x				• [Bishop, 1990] • Internet

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
856.	WBA (Why-Because Analysis)	Stat	HzA, Ret	1998	Why-Because Analysis (WBA) is a rigorous technique for causally analysing the behaviour of complex technical and socio-technical systems. WBA is based on a rigorous notion of causal factor. Whether one event or state is a necessary causal factor in the occurrence of another is determined by applying the Counterfactual Test. During analysis, a Why-Because Graph (WB-Graph or WBG) is built showing the (necessary) causal connections between all events and states of the behaviour being analysed. The completed WBG is the main output of WBA. It is a directed acyclic graph where the nodes of the graph are factors. Directed edges denote cause-effect relations between the factors.	WBA primary application is in the analysis of accidents, mainly to transportation systems (air, rail and sea). It is also used in the Ontological Analysis method for safety requirements analysis during system development.				4					aviation, rail, maritime, electronics	x	x				• [WBA Homepage] • [Ladkin & Loer, 1998]
	WCA (Worst Case Analysis)					See MCA (Maximum Credible Accident Analysis) / WCA (Worst Case Analysis)															
857.	What-If Analysis	Step	HzI	1992 or older	What-If Analysis methodology identifies hazards, hazardous situations, or specific accident events that could produce an undesirable consequence. The procedure is: 1. Define the activity or system of interest. 2. Define the problems of interest for the analysis. 3. Subdivide the activity or system for analysis. 4. Generate what-if questions for each element of the activity or system. 5. Use a team of subject matter experts to respond to each of the what-if questions, and develop recommendations for improvements wherever the risk of potential problems seems uncomfortable or unnecessary. 6. Further subdivide the elements of the activity or system (if necessary or otherwise useful); generally, the goal is to minimize the level of resolution necessary for a risk assessment. 7. Evaluate recommendations from the analysis and implement those that will bring more benefits than they will cost in the life cycle of the activity or system.	An example of a What-If analysis is Scenario Process Tool. Another variation of What-if analysis is Sensitivity Analysis. See also Check List Analysis.			3			6			chemical, finance, maritime, oil&gas, nuclear, aviation, airport, management, healthcare	x		x	x		• [FAA00] • [ΣΣ93, ΣΣ97] • [FAA HFW]
858.	Why-Why Diagram	Stat	HzA	1994 or older	A Why-Why Diagram is a Tree Diagram where each child statement is determined simply by asking 'why' the parent occurs. Four steps: 1) State the problem / situation on the left side of paper; 2) Create a decision tree of causes to the right side of the problem, by asking a) a succession of Why's (why is this happening; why is it a problem); b) a succession of why's for each of the possible causes; 3) Continue the process until each strand is teased out as far as possible; 4) Analyse the Why-Why diagram to identify main issues and to restate the problem in terms of its root cause.	Similar in use to a Cause and Effect Diagram, and techniques may be borrowed from Cause And Effect Diagram usage. See also How-How diagram.				4					healthcare	x					• [Kjellen, 2000] • [IE, Why-Why] • [Switalski, 2003]
	WinBASIS					See BASIS (British Airways Safety Information System)															

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
859.	WinCrew	FTS	HFA	1996	WinCrew is used for constructing system performance models for existing or conceptual systems when a central issue is whether the humans and machines will be able to handle the workload. It also can be used to predict operator workload for a crew given a design concept. Additionally, WinCrew can simulate how humans dynamically alter their behavior under high workload conditions, including the dropping of tasks based on task priority, task time, and accuracy degradation.	Adapted for Windows personal computer from SAINT and Micro-SAINT. Builds on MRT (Multiple Resources Theory).				4					navy			x			• [Mitchell, 2000] • [FAA HFW] • [Lewis, 1996] • [Alley, 2005]
860.	Wind/ Tornado Analysis	Gen	HzA	1888	Analysis of hazards resulting from all types of winds. This may include probabilistic wind field models, stochastic models of tornado occurrence, distributions of tornado parameters from analysis of storms, etc.	All structures and buildings. A first set of rules for tornado forecasting was established in 1888 by John. P. Finley (US Army). Multiple different variations and techniques have been developed. Wind/Tornado intensity is measured using e.g. Beaufort scale or Fujito scale or enhancements thereof.			3		5				environment, manufacturing, nuclear	x					• [ΣΣ93, ΣΣ97] • [Hossain et al, 1999]
	Wizard of OZ Technique					See Prototyping															
861.	Workload Analysis	Gen	Task	1986 or older	Provides an appraisal of the extent of operator or crew task loading, based on the sequential accumulation of task times. Method permits an evaluation of the capability of the operator or crew to perform all assigned tasks in the time allotted by mission constraints. As capability is confirmed, hardware design requirements can be more precisely designated. If limitations are exposed, alternate function allocations and operator or crew task assignments are considered and implemented.	See also CWA (Cognitive Workload Analysis).		2				6			defence, electronics	x		x			• [MIL-HDBK, 1999]
862.	WPAM (Work Process Analysis Model)	Int	Org, Task	1994	Safety management assessment linked to PSA-type of approach. The first part (WPAM-I) is qualitative; basically a task analysis is performed on the work process to which the tasks involved, actions and the defences in the task, and their failure modes are investigated. Next, the organisational factors matrix is defined for each key work process. The organisational factors influencing each task in the given work process are then ranked according to their importance. WPAM-II is next used to modify minimal cut set frequencies to include organisational dependencies among the PSA parameters, i.e. candidate parameter group. The next step in the WPAM-II is quantification. SLIM is used to find new frequencies for each minimal cut set.	WPAM may double-count the dependence of the organisational factors, if the HEPs used have already taken into the account the underlying factors, which may at times be implicitly modelled.		2	3	4	5				nuclear				x	x	• [Kennedy & Kirwan, 1998]

Id	Method name	For-mat	Pur-pose	Year	Aim/Description	Remarks	Safety assessment stage								Domains	Application					References
							1	2	3	4	5	6	7	8		Hw	Sw	Hu	Pr	Or	
863.	WSA (Work Safety Analysis)	Tab	Task, HzA	1981	Systematic investigation of working methods, machines and working environments in order to find out direct accident potentials. Similar to HAZOP, but the search process is applied to work steps.	Related to Barrier Analysis, but looks more in detail at each step of the task to see what hazards could occur, and to provide a rough quantitative calculation of their relative risks, and hence what barriers are needed. In some references referred to as equal to Job Safety Analysis.			3		5	6			manufacturing, ergonomics	x		x			• [Kirwan & Ainsworth, 1992] • [Leveson, 1995]
864.	Z or Z notation (Zermelo notation)	Int	Des	1977	Specification language notation for sequential systems and a design technique that allows the developer to proceed from a Z specification to executable algorithms in a way that allows proof of their correctness with respect to the specification.	Formal Method. Named after Zermelo-Fraenkel set theory. Powerful specification notation for large systems. Commercial training available. Related to VDM. Tools available. Software requirements specification phase and design & development phase.						6			rail		x				• [Bishop, 1990] • [Cichocki & Gorski, 1999] • [EN 50128, 1996]
865.	ZA or ZSA (Zonal (Safety) Analysis)	Step	HzA	1987	Used to identify sources of common cause failures and effects of components on their neighbours. Zonal Analysis is an analysis of the physical disposition of the system and its components in its installed or operating domain. It should be used to determine: a) The consequences of effects of interactions with adjacent systems in the same domain. b) The safety of the installation and its compliance with relevant standards and guidelines. c) Areas where maintenance errors affecting the installation may cause or contribute to a hazard. d) The identification of sources of common cause failure; e.g. environmental factors. e) Transportation and storage effects.	In [FAA00] ZSA is named Mapping Tool. See also Beta-factor method, CCA (Common Cause Analysis), Multiple Greek Letters method, Particular Risk Analysis, Shock method.			3						aircraft	x					• [ARP 4761] • [DS-00-56, 1999] • [Mauri, 2000] • [FAA00] • [MUFTIS3.2-I, 1996]
866.	ZHA (Zurich Hazard Analysis)	Step	HzA	1981	Aims to identify and manage various types of hazards from a risk perspective. Steps are: 1) Define the scope; 2) Choose the team and team leader; 3) Identify hazards, define and assess hazard scenarios; 4) Build the risk profile, set the risk tolerance boundary and plot the risks; 5) Develop risk improvement actions; 6) Implement the risk improvements; 7) Review the analysis. Step 3 uses team brainstorms following a defined route (pathway) through the scope of the analysis, encouraged by a set of thought-provoking words (tickler list). In step 4, the risk profile is a matrix divided into four severity categories and six probability levels; the risk tolerance boundary is a line drawn across the risk profile.	Developed by Zurich Insurance Company, Switzerland.	1	2	3	4	5	6	7		manufacturing, electronics, chemical, food, finance	x			x		• [ZIC, 1998]

Part 2: Statistics

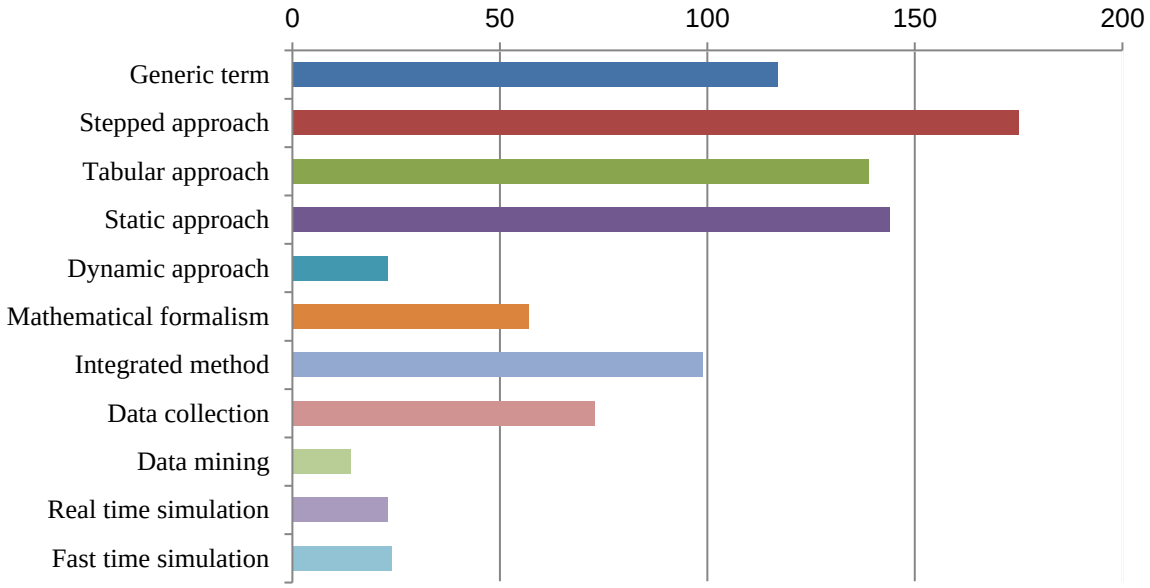
This Part provides statistics on the following details for each of the 866 methods as collected in Part 1:

- **A. Format,** specifies the general format of the method, e.g. whether it is a stepped approach, or a mathematical model, or a combination of various techniques, etc.
- **B. Purpose,** specifies the primary purpose of the method, e.g. whether it is for data gathering, for hardware dependability analysis, for human reliability analysis, etc.
- **C. Year**, i.e. year of development of the method. If uncertain, then words like 'about' or 'or older' are added.
- **D. Safety assessment stage**, which lists the stages of a generic safety assessment process, proposed in [SAP 15], during which the method can be of use. These stages are: **1**) Scope the assessment; **2**) Learning the nominal operation; **3**) Identify hazards; **4**) Combine hazards into risk framework; **5**) Evaluate risk; **6**) Identify potential mitigating measure to reduce risk; **7**) Safety monitoring and verification; **8**) Learning from safety feedback.
- **E. Domains**, i.e. the domains of application the method has been used in, such as nuclear, chemical, ATM (air traffic management), rail, healthcare.
- **F. Application**, i.e. is the method applicable to hardware, software, human, procedures, or to organisation.

A. Statistics on classes defined for Format column:

The Safety Methods Database provides information on the format of each method, defined by the classes in the table below. The last column and the graph provide statistics on the number of methods collected for each class.

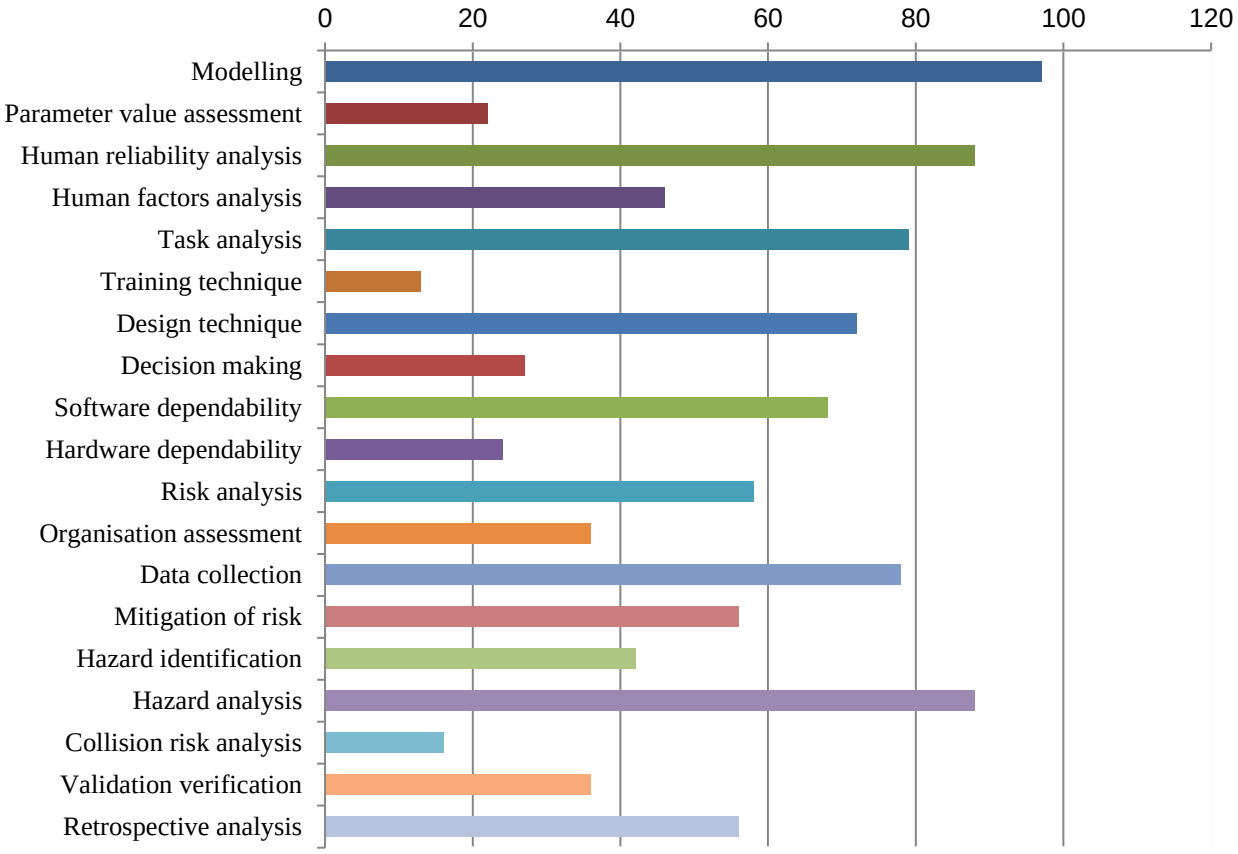
Classes in Format column		**Nr of methods**
Gen	Generic term or principle or theory, rather than a specific technique	117
Step	Stepped approach or technique or specific way of working	175
Tab	Static approach with tabular, checklist or questionnaire support	139
Stat	Static model or approach with graphical support (e.g. flow charts, trees, graphs)	144
Dyn	Dynamic model with graphical support, often with mathematical base	23
Math	Mathematical formalism or expression, with no or limited graphical support	57
Int	Framework or Integrated method of more than one technique	99
Dat	Database or data collection tool	73
Min	Data analysis tool or data mining tool	14
RTS	Real-time simulation	23
FTS	Fast-time simulation	24



B. Statistics for classes defined for Purpose column:

The Safety Methods Database provides information on the purpose of each method, defined by the classes in the table below. The last column and the graph provide statistics on the number of methods collected for each class. In some cases one method may have multiple purposes, which is why the total may add up to be larger than the number of methods collected.

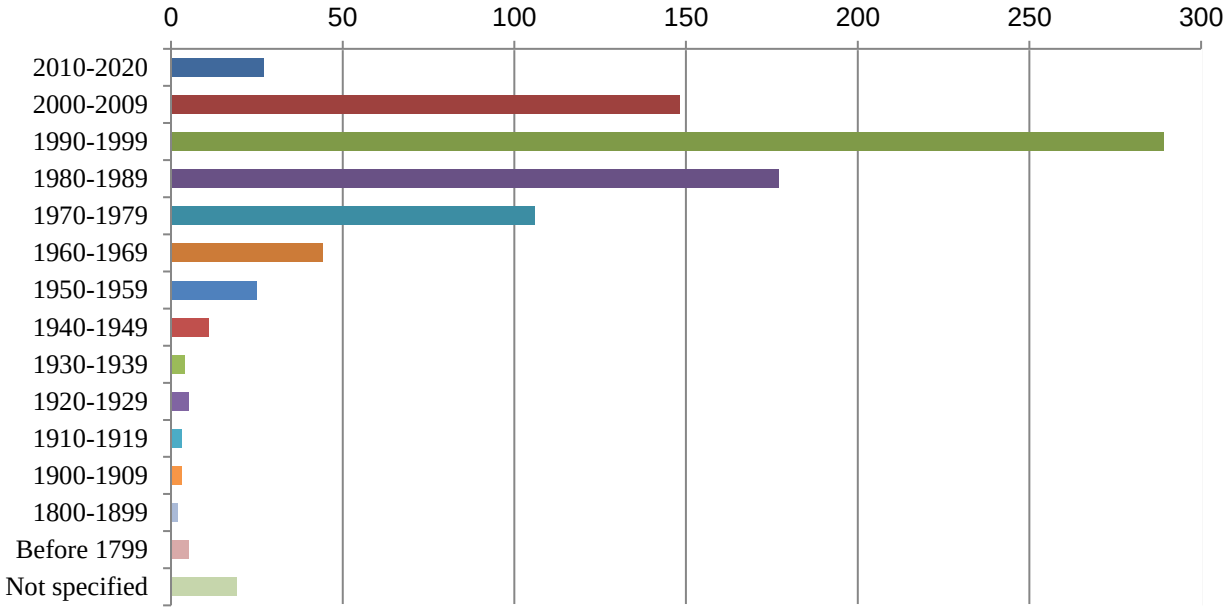
Classes in Purpose column		**Nr of methods**
Mod	Developing a model (e.g. as input to or as part of analysis)	97
Par	Parameter value assessment (e.g. human error probabilities, failure frequencies)	22
HRA	Human Reliability Analysis or Human Error analysis method	88
HFA	Human Factors Analysis (beyond reliability; e.g. behaviour, situation awareness)	46
Task	Human Task analysis	79
Trai	Training technique or method to analyse training	13
Des	Design technique (about making/ensuring a safe design, rather than about analyzing whether the design is safe)	72
Dec	Decision-making	27
SwD	Software dependability analysis or Software testing technique	68
HwD	Hardware dependability analysis (reliability, maintainability, availability, etc)	24
OpR	Risk analysis of an operation or of a safety-critical scenario	58
Org	Organisation, Safety management, or Safety culture assessment	36
Dat	Data collection and information sharing	78
Mit	Mitigation of risk	56
HzI	Identification of hazards /safety concerns /causes /issues	42
HzA	Identification and analysis of frequency and/or severity of hazards / safety concerns / causes / issues	88
Col	Collision risk analysis or Conflict risk analysis, typically between aircraft	16
Val	Validation, Verification, Bias and uncertainty analysis, Documentation/Tracking, and Oversight/Monitoring	36
Ret	Retrospective accident or event analysis	56



C. Statistics for classes defined for Year:

The Safety Methods Database also indicates the method's year of development. For 17 of the 866 methods collected, this information was not available. For some other methods, only an estimated year could be identified, and for others only a 'latest' year is available, i.e. the method existed in that year, but it is possible that it was developed earlier than that. Statistics on the number of methods developed in each period of time are provided in the table and the figure below. The oldest methods are Quality Assurance (2500 BC), Error Detection and Correction (150 AD), Logic Diagrams (300 AD for 'Porphyrian trees'; the modern Logic Diagram Dates from 1761), Data Mining (1750), Monte Carlo simulation (1777), Wind/Tornado Analysis (1888), Neural networks (1890), Factor analysis (1900), Markov chains (1906) and Pareto charts (1906).

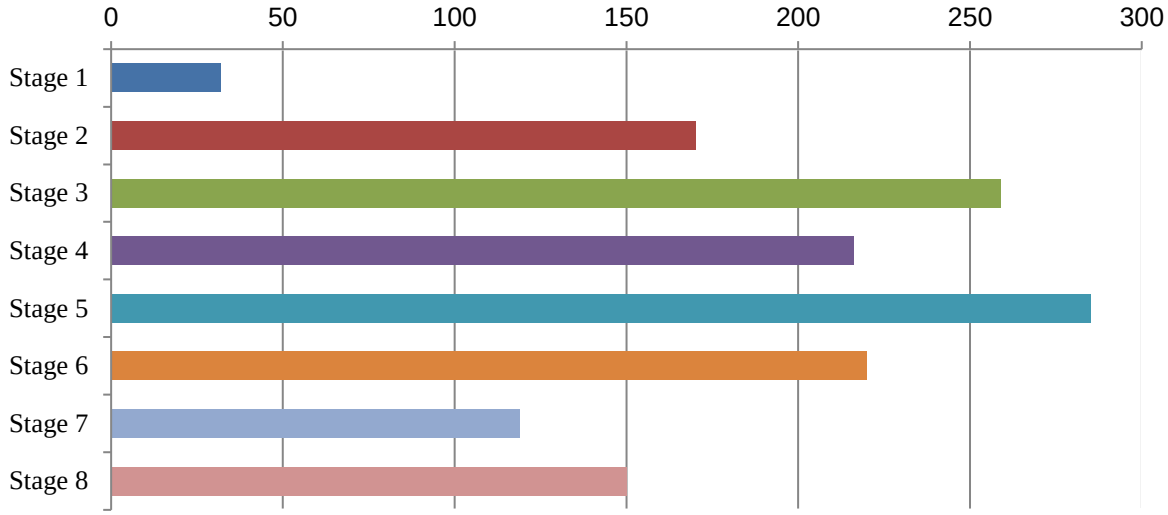
Years	Number	Percentage
2010-2020	27	3 %
2000-2009	148	17 %
1990-1999	289	33 %
1980-1989	177	20 %
1970-1979	106	12 %
1960-1969	44	5 %
1950-1959	25	3 %
1940-1949	11	1 %
1930-1939	4	0 %
1920-1929	5	1 %
1910-1919	3	0 %
1900-1909	3	0 %
1800-1899	2	0 %
Before 1799	5	1 %
Not specified	17	2 %
Total	**866**	**100 %**



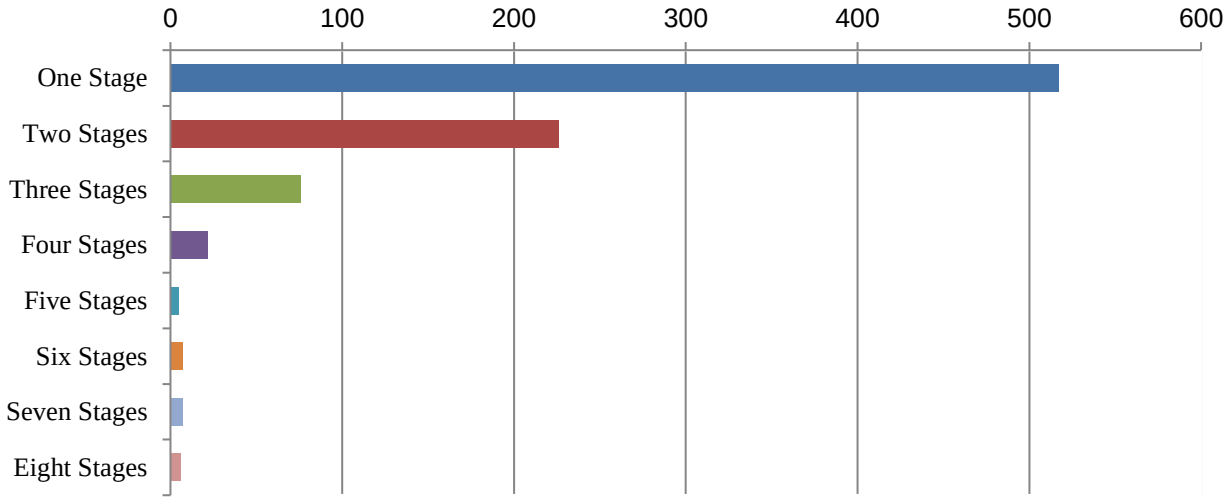
D. Statistics on coverage of eight stages of generic safety assessment process

The Safety Methods Database also indicates in which stages of the generic safety assessment process the method can be of use; these stages are explained in [SAP 15]. A summary distribution of methods among the eight stages is given below.

Stages of generic safety assessment process	Number	Percentage
Stage 1 (Scope the assessment)	32	4 %
Stage 2 (Learning the nominal operation)	170	20 %
Stage 3 (Identify hazards)	259	30 %
Stage 4 (Combine hazards into risk framework)	216	25 %
Stage 5 (Evaluate risk)	285	33 %
Stage 6 (Identify potential mitigating measures to reduce risk	220	25 %
Stage 7 (Safety monitoring and verification)	119	14 %
Stage 8 (Learning from safety feedback)	150	17 %



The following chart shows how many methods address multiple stages.



The following table shows how many methods address which combinations of stages.

# stages	Stages of Generic Safety Assessment process								Number of methods in this class	
	1	2	3	4	5	6	7	8		
8	x	x	x	x	x	x	x	x	6	**6**
7	x	x	x	x	x	x	x		5	**7**
	x	x	x	x	x	x		x	2	
6	x	x	x	x	x	x			2	**7**
		x	x	x	x	x	x		5	
5	x	x	x	x	x				1	**5**
		x	x	x	x	x			2	
	x		x	x	x	x			1	
		x	x	x	x			x	1	
4	x	x	x	x					1	**22**
	x	x		x	x				1	
	x			x	x	x			1	
		x	x	x	x				3	
		x	x		x	x			6	
		x		x	x	x			1	
		x				x	x	x	1	
			x	x	x	x			3	
			x	x		x		x	2	
			x		x		x	x	1	
			x			x	x	x	1	
				x	x	x		x	1	
3	x	x						x	3	**76**
	x		x	x					1	
		x	x	x					4	
		x	x		x				4	
		x	x			x			5	
		x		x	x				5	
		x			x	x			3	
			x	x	x				18	
			x	x		x			6	
			x		x	x			13	
			x		x		x		1	
			x		x			x	1	
			x			x		x	3	
			x				x	x	3	
				x		x		x	2	
				x	x	x			3	
					x	x		x	1	

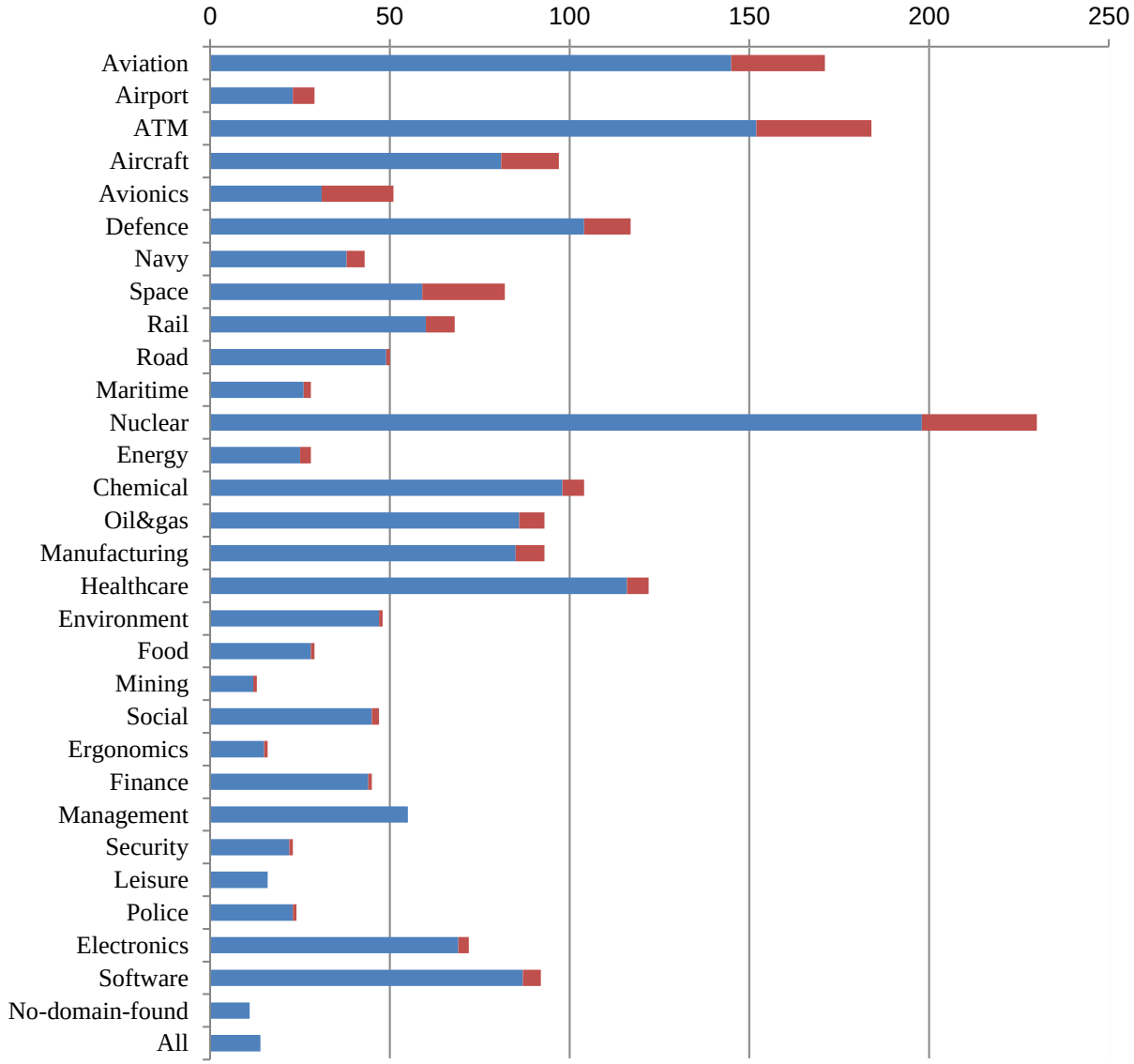
# stages	Stages of Generic Safety Assessment process								Number of methods in this class	
	1	2	3	4	5	6	7	8		
2	x	x							1	**226**
	x						x		2	
	x							x	1	
		x	x						8	
		x		x					8	
		x			x				10	
		x				x			12	
		x					x		5	
		x						x	3	
			x	x					10	
			x		x				32	
			x			x			29	
			x				x		7	
			x					x	9	
				x	x				44	
				x		x			4	
				x				x	1	
					x	x			15	
					x			x	1	
						x	x		5	
						x		x	6	
							x	x	13	
1	x								4	**517**
		x							62	
			x						63	
				x					72	
					x				92	
						x			74	
							x		64	
								x	86	
tot	**32**	**170**	**259**	**216**	**285**	**220**	**119**	**150**	**866**	**866**

E. Statistics for classes defined for Domain column:

The Safety Methods Database covers many domains of application, such as aviation, nuclear industry, chemical industry, manufacturing industry, etc. For each method the Database indicates the domains of application to date. Note that for some methods we found proof or a strong indication that method has in fact been applied in this domain; statistics on this are provided in column 'Applied' below. For some methods we found indication that the method is (apparently) intended for application in this domain, but found no strong indication (yet) that the method has in fact been applied; statistics on this are provided in column '(Applicable)' below. For some methods, no applications were found (yet), not even in an example illustration, so that the domain is currently unclear. Finally, there are a few approaches that are very generic and that have been used in virtually all domains.

Classes in Domain column		**Applied**	**(Applicable)**	**Total**
Aviation	Operation of individual aircraft or aircraft fleets, including pilot and crew factors and airline operations	145	26	171
Airport	Airport operations and airport design	23	6	29
ATM	Air traffic management and air traffic control	152	32	184
Aircraft	Aircraft technical systems and airworthiness issues. Also including rotorcraft such as helicopters.	81	16	97
Avionics	Electronic systems used on aircraft, satellites, and spacecraft, including communication, navigation, cockpit display.	31	20	51
Defence	Military, on land or in the air, including military aviation, weapon systems and nuclear weapon systems. Excluding military at sea.	104	13	117
Navy	Navy, military at sea, including sub-marines	38	5	43
Space	Space safety, including spacecraft, satellites, space missions. Excluding aircraft, excluding avionics.	59	23	82
Rail	Rail transport and operation of trains, including railway design. Excluding manufacturing of trains.	60	8	68
Road	Road transport and operation of cars, including road design, tunnels. Excluding manufacturing of cars.	49	1	50
Maritime	Marine, maritime or inland water transport, e.g. ships, vessels, ferry's, and coast guard search and rescue. Excluding navy, sea pollution, oil spills.	26	2	28
Nuclear	Nuclear power industry. Excluding nuclear weapon systems.	198	32	210
Energy	Energy or electricity-generating plants, solar energy, windturbines, thermal power plants. Excluding nuclear power.	25	3	28
Chemical	Chemical industry and processes, including production of medicine, biochemical industry. Excluding oil&gas, petrochemical, food and beverages.	98	6	104
Oil&gas	Oil and/or gas industry, including offshore oil&gas industry, petrochemical industry	86	7	93
Manufacturing	Manufacturing plants, including automotive or automobile manufacturing, construction of buildings, ship building, and process industry (i.e. processing of bulk resources into other products). Excluding food, chemical or petrochemical industry.	85	8	93
Healthcare	Health care, hospitals, nursing, medical operations, biomedical issues. Excluding production of medicine and other chemicals, and excluding ergonomics.	116	6	122
Environment	Environment safety, e.g. air pollution, sea pollution, fuel and oil spills, wastewater treatment plants, fish and wildlife reserves, biology, earthquakes, water management	47	1	48
Food	Food and beverages, including public water supply systems, agriculture	28	1	29
Mining	Mining industry	12	1	13
Social	Psychology, psychometrics, behavioural sciences, social sciences, education, safety culture studies.	45	2	47
Ergonomics	Ergonomics, i.e. workplace equipment design, intending to reduce operator fatigue and discomfort. Also including household safety	15	2	17
Finance	Finance, banking, insurance, economics	44	1	45
Management	Management and organisation, including project management, information management, product management, marketing,	55	0	55

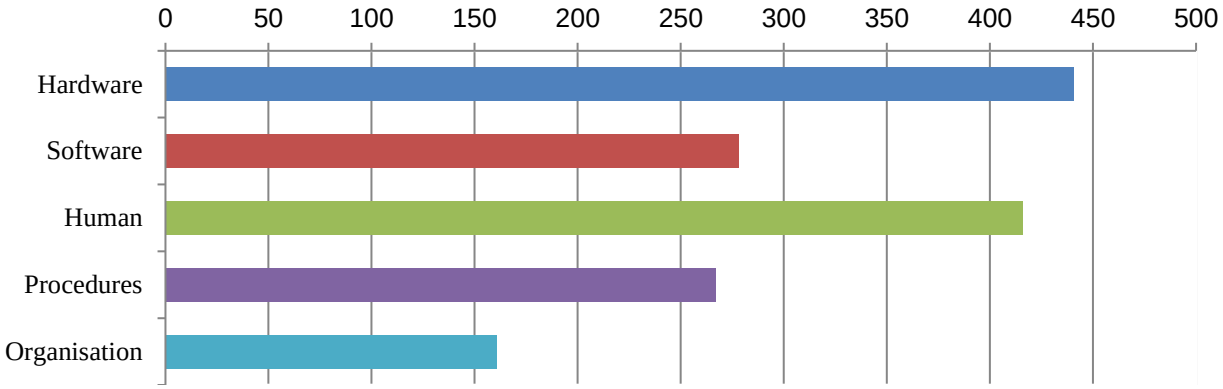
	operations research, logistics.			
Security	Security, i.e. dealing with protection from harm due to intentional criMinal acts such as assault, burglary or vandalism. Excluding police and fire fighting	22	1	23
Leisure	Leisure and amusement industry, amusement parks, games, video games, media (e.g. tv advertisements), leisure-related search and rescue	16	0	16
Police	Police and Fire fighting, including forensics and law.	23	1	24
Electronics	Electronics, electronic equipment, telecommunications, digital forensics	69	3	72
Software	Method has been applied to software design or analysis, but the industry sector in which the software is actually used is unclear or unspecified.	87	5	92
No-domain-found	No applications were found (yet) for this method, not even in an example illustration, so that the domain is currently unclear.	11	0	11
All	There are a few approaches that are very generic and that have been used in virtually all domains.	14	0	14



F. Statistics on coverage of concept aspects (columns ‘Hw’, ‘Sw’, ‘Hu’, ‘Pr’, ‘Or’)

Finally, another detail provided for each method listed in the Safety Methods Database is whether it is aimed at assessing Hardware aspects, Software aspects, Human aspects, Procedures, or Organisation. Some Statistics on these results are given below.

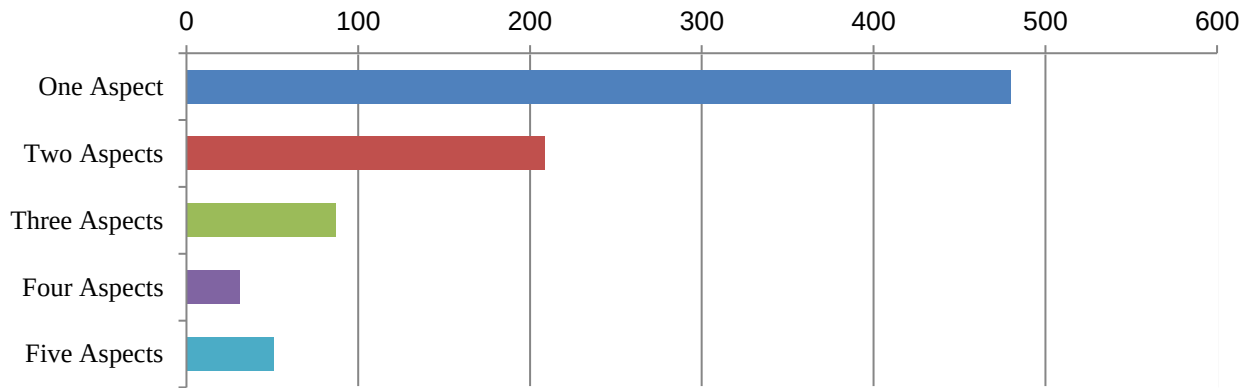
Concept aspects	Number	Percentage
Hardware	441	51 %
Software	278	32 %
Human	416	48 %
Procedures	267	31 %
Organisation	161	19 %



Note that one method may cover several of these concept aspects, so some methods are counted more than once. The following table shows how many methods cover which of these aspects.

	Hardware	Software	Human	Procedures	Organisation	Number of methods in this class	
5 aspects	x	x	x	x	x	52	52
4 aspects	x	x	x	x		14	33
	x	x	x		x	0	
	x	x		x	x	0	
	x		x	x	x	19	
		x	x	x	x	0	
3 aspects	x	x	x			11	89
	x	x		x		2	
	x	x			x	1	
	x		x	x		49	
	x		x		x	3	
	x			x	x	8	
		x	x	x		0	
		x	x		x	0	
		x		x	x	0	
			x	x	x	15	
2 aspects	x	x				70	212
	x		x			40	
	x			x		36	
	x				x	8	
		x	x			2	
		x		x		0	
		x			x	3	
			x	x		33	
			x		x	10	
				x	x	10	
1 aspect	x					128	480
		x				123	
			x			168	
				x		29	
					x	32	
	441	**278**	**416**	**267**	**161**	**866**	**866**

One may see that there are a lot of methods (i.e. 480 methods, or 55%) that cover one concept aspect only.



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