Appendix A
Overview of Software

A.1 Introduction

Quite extensive software tools have become available over the past 20 years. A brief overview over some of the main tools which are oriented towards offshore/oil and gas applications are presented in this appendix. These tools have been categorised into the following:

- QRA software
- QRA software tools for scenario and probability analysis
- QRA software tools for consequence analysis
- Risk management software
- Qualitative risk assessment software
- Reporting and analysis of incidents and accidents

Brief summaries are presented as an overview, followed by brief sections presenting some of the main characteristics of these products. These summaries have been prepared by the software vendors. Only those products are detailed where a response was received from the vendors. The descriptions are structured as follows:

- Name and purpose of software
- Scope of software
- License conditions, pricing etc.

It should be stressed that there is a large amount of general software tools for CFD from many different suppliers. These have not been included in the presentations that follow throughout this appendix. Some of these may have quite valid applications during estimation of loads from fire or explosion, or for gas dispersion or oil slick movements. Because there are so many software tools available in this category, it becomes impossible to give an overview of all relevant tools. None of these are therefore included.

Software tools that are only directed at onshore usage are not included in the reviews, neither are tools for production/transport regularity analysis.

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Table A.1 Overview of software for quantitative risk analysis

Software	Purpose	Contact
ASAP®	3D geometrical description and analysis of a fixed set of event trees	Lilleaker Consulting, Oslo, Norway
COSAC®	Risk assessment tool for early project phases of a field development for concept evaluation and screening. The tool can also be used as an aid for HAZID of offshore platforms	Scandpower Risk Management, Kjeller, Norway
Safeti Offshore®	Comprehensive Offshore Quantitative Risk Assessment software	DNV Software, London, UK
PLATO®	3D geometrical platform model, analysing explicitly development and timing of escalating hazards, fire, explosion and structural collapse	Environmental Resources Management, London, UK
RiskSpectrum® PSA	Fault tree and event tree software	Scandpower AB, Stockholm, Sweden
RISK®	Comprehensive offshore quantitative risk assessment tool	ESR Technology, UK
SAFETI®	Comprehensive QRA tool for flammable, explosive and toxic impact	DNV Software, London, UK

All software tools that are mentioned in the following are commercially available from the vendor as listed (Table A.1).

A.2 Electronic Contacts

The following is a listing of electronic contacts to the software providers (Table A.2):

- ESR Technology, UK www.esrtechnology.com
- Lilleaker Consulting, Norway www.lilleaker.com
- ANSYS, US www.ansys.com
- DNV Software, London, UK www.dnv.com
- Safetec Nordic, Trondheim, Norway www.safetec.no
- EQECAT, USA www.eqecat.com
- Four Elements, London, UK www.erm.com
- Prediction Technologies Incw www.prediction–technology.com
- ABS Consulting, UK www.absconsulting.com
- BowTie Pro, UK www.bowtiepro.com
- Scandpower Risk Management, Kjeller, Norway www.scandpower.com
- Atkins, Bristol, UK www.atkinsglobal.com
- Gexcon, Bergen, Norway www.gexcon.com
- ComputIT, Trondheim, Norway www.computit.no
- SPT Group, Norway www.sptgroup.com
- Safer Systems, USA www.safersystem.com
- USFOS AS, Norway www.usfos.no
- Lihou Technical & Software Services, UK www.lihoutech.com
- Sunrise System Ltd, UK www.sunrise-sys.com
- Petrell AS, Norway www.petrell.no
- ACADS-BSG, Australia www.members.ozemail.com.au
- ReliaSoft, USA www.reliasoft.com
- Presight Solutions AS, Norway www.presight.com
- ExproSoft AS, Trondheim, Norway www.exprosoft.com

Table A.2 Overview of QRA software for scenario and probability risk analysis

Software	Purpose	Contact
BlowFAM®	Evaluation of blowout risk during specific well operations	Scandpower Risk Management, Kjeller, Norway
COAST®	Shipping traffic database, using GIS for user interface and graphical pres. of information on shipping routes and vessel characteristics	Safetec Nordic, Trondheim, Norway
COLLIDE®	Analysis of collision risk between vessels and platforms	Safetec Nordic, Trondheim, Norway
EGRESS®	Mustering and evacuation simulation for evacuation/rescue modelling	ESR Technology, UK
LEAK®	Calculation of the frequency of leaks at an installation	DNV Software, London, UK
R–DAT Plus®	Bayesian data analysis	Prediction Technologies, MD, USA
CARA–Fault Tree®	Fault tree analysis and construction	ExproSoft AS, Trondheim, Norway
US Offshore Energy Model™	A fully probabilistic risk model that quantifies prospective risk from hurricanes in the Gulf of Mexico	EQECAT, USA
BlockSim®	System analysis with RBDs or fault trees	ReliaSoft, USA
RENO®	Probabilistic event and risk analysis	ReliaSoft, USA
RiskSpectrum® HRA	Human reliability analysis tool to evaluate and quantify the probability of human errors	Scandpower AB, Stockholm, Sweden

A.3 Quantitative Risk Analysis Software

A.3.1 ASAP®

The following is a brief description of this software, the function, vendor, pricing and main features (Table A.3).

- Function 3D geometrical description and analysis of a fixed set of event trees
- Vendor Lillesoft a.s., Baerum, Norway
- Pricing License fee using ASAP® on the Lillesoft Terminal Server:
  NOK 190,000 (12 months)
  NOK 65,000 (3 months)
  NOK 30,000 (1 month)

ASAP® is a computer analysis package that calculates the risk related to HC leaks, fires and explosions on oil and gas installations. The first ASAP® version was released in 1988 and has been continuously developed since then (Table A.4).

Complex interactions in horizontal and vertical directions are taken care of by adjusting the models to three-dimensional geometry. Scenarios such as gas and

liquid jets followed by gas dispersion and fire development can be seen in 3D graphic, giving a good interpretation of the accident (Table A.5).

The calculation of gas dispersion, detection and ignition is transient such that the effect of safety barriers (detection, ignition control, shutdown and blowdown) forms part of the analysis. The latest feature of the program is that module ventilation and gas dispersion results from CFD codes (like e.g. FLACS®) can be imported into ASAP® to improve the accuracy of the risk calculations (Table A.6).

A.3.2 COSAC®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Risk assessment tool for early project phases of a field development for concept evaluation and screening

Table A.3 Overview of QRA software for consequence analysis

Software	Purpose	Contact
FIREX®	Empirical prediction of main fire characteristics and responses	Scandpower Risk Management, Kjeller, Norway
FLACS®	Explosion simulation	Gexcon, Bergen, Norway
KAMELEON FireEx–KFX®	Fire and gas dispersion simulation	ComputIT, Trondheim, Norway
OLGA®	Transient multiphase flow simulator for systems comprising flow lines, risers and process equipment.	SPT Group, Kjeller, Norway
PHAST®	Windows-based toolkit for determination of consequences of accidental releases of hazardous material	DNV Software, London, UK
SAFER TRACE™	Consequence Analysis for chemical facility	SAFER Systems, USA
USFOS/FAHTS	Structural fire and explosion analysis	USFOS AS, Norway
PIPENET™	Pressure loss and flowrate model for offloading, firewater and ventilation systems	Sunrise System Ltd, UK
VessFire	Heat transfer, depressurisation and stress modelling from fires	Petrell AS, Norway
HYENA	Fire sprinkler/hydrant analysis	ACADS-BSG, Australia
ANSYS Fluent	Physical modeling of flow, turbulence, heat transfer, and reactions for industrial applications	ANSYS, USA
ANSYS CFX	Fluid dynamics program to solve wide-ranging fluid flow problems	ANSYS, USA

Table A.4 Overview of software for qualitative risk analysis

Software	Purpose	Contact
HAZOP Manager	HAZOP Tool	Lihou Technical & Software Services, UK

Table A.5 Overview of software for accident/incident analysis

Software	Purpose	Contact
DNV BSCAT™	Modern risk-based safety management approaches to systematic root cause incident investigation	CGE Risk Management Solutions, The Netherlands

- Vendor Scandpower Risk Management, Kjeller, Norway
- Pricing Available on request.

COSAC® is a computerised tool for efficient risk assessment in the early project phases of a field development.

COSAC® analysis and results are tailor-made for concept evaluation and screening. Its aim is to increase the safety of new offshore developments by utilising 20 years of experience gained from risk analyses. Some of the main features of COSAC® include reducing uncertainty, improving the quality and efficiency of early phase safety evaluations. COSAC® provides a safety score for every risk factor associated with an offshore field development concept. A low score indicates safety concerns and/or lack of documentation of important safety issues. Therefore, a low safety score in COSAC® puts these issues in focus. In addition the user is provided with information on how to resolve the problems identified by COSAC®.

COSAC® has a unique explosion risk prediction model which calculates explosion loads for a variety of module configurations. The predictions are based on FLACS® simulations for comparable geometries.

A.3.3 Safeti Offshore®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Offshore risk analysis
- Vendor DNV Software, London, UK
- Pricing Available upon request

Safeti Offshore® is the successor to Neptune and OHRAT, and was released in 2012. Safeti Offshore® is a comprehensive software tool for designing, calculating

Table A.6 Overview of risk management software

Software	Purpose	Contact
ViewRisk	Risk summation and presentation tool, including outputs of risk contours, F–N data, risk transects and a listing of dominant events	Environmental Resources Management (ERM), London, UK
Synergi RBI®	Onshore and offshore risk based inspection tool	DNV Software, London, UK
BowTieXP®	Management of major risks to people, the environment, assets and reputation by means of A bowtie@ graphical interface diagram	CGE Risk Management Solutions, The Netherlands
THESIS	Management of major risks to people, the environment, assets and reputation by means of "bow-tie" graphical interface diagram	ABS Consulting, Warrington, UK
BowTie Pro™	Qualitative, semi-quantitative & illustrative risk analysis and risk management	BowTie Pro, Aberdeen, UK
Presight® Operations & Barrier Safety KPI Management	Reduce major accident risk with operations and context focused KPI management for barrier & process safety improvements and reduce down-time events. Convert complex multi-systems information into indicators, supporting risk awareness and safer operations decisions	Presight Solutions AS, Norway
Synergi Life	Complete business solution for risk and QHSE management, managing all non-conformances, incidents, risk, risk analyses, audits, assessments and improvement suggestions	DNV Software, London, UK
SafeGuard	Visualisation of status of major accident risk in a plant	Safetec Nordic, Trondheim, Norway

and providing full traceability of a quantitative risk assessment. The system architecture has been designed to provide a methodological approach to risk analyses using best practice techniques. Safeti Offshore® contains models for calculation of discharge, dispersion, pool formation and evaporation, flammable and toxic effects and impact. Also contained with Safeti Offshore® are models designed for the specific needs of offshore installations, such as inventory calculation from isolatable sections, safety systems for isolation and blowdown, fire and blast wall success and failure, event escalation, smoke generation, evacuation, endangerment of muster areas, collision with ships, in module dispersion, ignition and explosion and many more. Safeti Offshore® offers flexible modelling of hazards and risks through a wide range of analytic capabilities including consequence modelling, leak frequency calculations, sensitivity and what-if analysis. Safeti Offshore® operates under MS-Windows®.

A.3.4 PLATO®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function 3D geometrical platform model including representation of safety related engineering components and design features, analysing explicitly development and timing of escalating hazards, fire, explosion and structural collapse
- Vendor Environmental Resources Management (ERM), London, UK
- Pricing GBP 36,000 (leasing schemes also available)
  Optional annual maintenance: GBP 3,000 per year (telephone support and free minor software revisions).

PLATO® uses a 3D model of the platform in which all safety related engineering components and design features are explicitly represented. The development and timing of escalating hazards such as fire, explosion and structural collapse are simulated with automatic generation of scenarios where safety related components affect the outcome. Results can be processed not only for the overall level of societal and individual risk but also to determine the primary escalation mechanisms and key safety critical equipment. The primary benefits over event tree methods are modelling realism, auditability, explicit representation of geometry/time and ease of update for evaluation of design options or platform modifications.

A.3.5 RiskSpectrum® PSA

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Fault tree and event tree software
- Vendor Scandpower AB, Stockholm, Sweden
- Pricing On request.

RiskSpectrum® PSA offers Fault Tree and Event Tree modelling interface, analysis, reliability data management and quality assurance all in one application. The separate MCS and BDD Engine—RSAT—is used for the conversion of Fault Trees, Sequences and Consequences to MCS or BDD to enable quantification of e.g. CDF and LERF.

RiskSpectrum® PSA is the complete linked Fault Tree and Event Tree tool. Its basic blocks of functionality are:

- Fault Tree editor
- Event Tree editor
- Analysis Tool (MCS generator)

All data are stored in a relational database, which makes it easy to browse, find relations and update—data is never repeated but only stored in one place. RiskSpectrum® PSA has also a system for storing information about each records status—edit, review and approve status.

A.3.6 RISK®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Comprehensive offshore quantitative risk assessment tool
- Vendor ESR Technology, UK
- Pricing Not available.

RISK® is a linked spreadsheet QRA model developed on EXCEL®. It enables users to clearly identify the key stages of the risk assessment process and follow individual major hazard events from their initiation, through accident development, to the contribution they make to accident scenarios, TR Impairment, individual risk and PLL. Key features of RISK® are:

- Developed using industry standard spreadsheet software package (EXCEL®).
- Is user friendly and can be interrogated by engineers without the need for formal training.
- Is easy to tailor to meet specific project requirements.
- Is transparent and focuses on key scenarios at an appropriate level of detail.

A.3.7 SAFETI®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Comprehensive QRA software tool for flammable, explosive and toxic impact
- Vendor DNV Software, London, UK
- Pricing Available on request.

SAFETI® (Software for the Assessment of Flammable, Explosive and Toxic Impact) is the most comprehensive and widely used onshore QRA package available. It is a Windows® based system that provides a user friendly, industry standard method for quantifying major chemical risks. It enables analysis of the likelihood and severity of major hazards and makes use of the PHAST® models to predict the consequence of major releases. By combining these with their frequencies and taking account of population location and density, along with

ignition source location for flammable and explosive effects, a number of presentations of 'risk' are possible. These include risk contours, F/N curves, risk transects and risk ranking at specific points. Additionally, effect exceedance results including flammable radiation and explosion overpressure provide complete support for occupied building analysis. Safeti® performs 3D explosion calculations using the Multi-Energy and Baker Strehlow Tang explosion methodologies.

A.4 QRA Tools for Scenario and Probability Analysis

A.4.1 BlowFAM®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Evaluation of blowout risk during specific well operations through assessment of approximately 300 elements, which influence the probability of a blowout
- Vendor Scandpower Risk Management, Kjeller, Norway
- Pricing Available on request

BlowFAM® is a PC-tool for evaluation of blowout risk during specific well operations. BlowFAM® has been developed in close cooperation with drilling/well intervention professionals in the participating companies. In addition, drilling specialists from several contractor companies have contributed.

The BlowFAM® model has identified approximately 300 elements, that influence the probability of a blowout. Many of these are applicable for the whole well life while others are only relevant for a specific well phase, e.g. drilling of the well. These elements are rated in regard to their importance to the risk. Main risk contributors for a specific development can be identified and cost-efficient risk reducing measures may be implemented.

The BlowFAM® model is also a valuable tool for communicating risk elements to the drilling professionals involved in the well operations.

A.4.2 COAST®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Shipping traffic database holding details on regular shipping traffic on the Norwegian and UK Continental Shelves as well as other areas of the world. Includes graphical presentation of information on shipping routes and vessel characteristics using GIS

- Vendor Safetec Nordic, Norway
- Pricing Not available.

The Computer Assisted Shipping Traffic (COAST®) database was first developed by Safetec in 1996 under the funding of the HSE, UKOOA and DETR. Later it was increased to include the entire Norwegian continental shelf, under funding from the Norwegian Oil and Gas. Using COAST® you are able to identify all regular shipping traffic within a defined area both on the British and Norwegian continental shelves.

The COAST® database is based on a number of sources including Lloyd's Port Log Data, radar data from offshore and onshore radar stations, manual vessel traffic surveys, operator information etc. By combining these data, Safetec is able to identify both the location and width of shipping routes, the number of ships in each route, and the distribution of these ships within the route etc. The traffic patterns are displayed on electronic raster charts for easy identification.

The information from COAST® are used in several ways, including identification of the shipping traffic pattern in an area, calculation of the risk of collisions between ship and offshore installations, input to emergency preparedness analyses and assessment of threats to the marine environment.

COAST® was first released in 2002. Safetec recognised that the routing on the NCS will evolve and therefore continuous updates of the route database are undertaken. As changes to shipping routes are recognised (e.g. due to the installation of new offshore platforms) they are incorporated by Safetec and the new route database is issued. The most recent main update of COAST® was performed based on Lloyd's port log data, AIS data provided by Statoil Marine Sandsli and Ekofisk Radar (ConocoPhillips) and offshore vessel movements (supply, SBV and shuttle tanker routes) provided by the operators.

Recently, AIS data has become the most prominent data source to offer bespoke traffic survey services worldwide using the COAST® methodology.

A.4.3 COLLIDE®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Analysis of collision risk between vessels and platforms
- Vendor Safetec Nordic, Norway
- Pricing Not available.

The COLLIDE® software tool is mainly used for calculating collision frequencies and energies between approaching vessels and offshore installations, windfarms, etc. COLLIDE® is capable of modelling both passing and drifting vessels, as well as other drifting substances. The results of a COLLIDE® analysis is often used as input to risk analyses of offshore installations.

Field related traffic mainly consists of supply and standby vessels, in addition to shuttle tankers.

- Supply vessels—In recent years, supply vessels have been increasing in size and become more advanced, making them a threat to an offshore installation both during approach, and loading and unloading operations. The importance of having proper procedures and safety management systems in place to be able to cope with this threat has thus been strengthened.
- Shuttle tankers—Operating close to the installations when they are loading, and due to their size, even a low speed collision of a shuttle tanker can cause substantial material damage.

A.4.4 Egress®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Mustering and evacuation simulation for evacuation/rescue modelling
- Vendor ESR Technology, UK
- Pricing Not available.

The Egress® code allows the movement of large numbers of personnel, such as when mustering on an installation, to be simulated. The platform layout is modelled as a matrix of interconnecting cells. The code covers both the physical movement and behavioural decision-making of personnel. The output is graphical and the movement watched as a real-time graphical representation. It was developed as part of a joint industry project in the UK between ESR Technology, Shell, Texaco, Exxon, and the Health and Safety Executive.

The code has been used both offshore and onshore for the oil and gas and other industries to provide assessments of the movement of people during incidents.

A.4.5 LEAK®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Calculation of the frequency of leaks at an installation
- Vendor DNV Software, London, UK
- Pricing Available on request.

LEAK® is a software tool which calculates the frequency of leaks at an installation, typically an oil platform. Each installation is broken down into a number of areas which are themselves split into a number of segments each

containing a list of equipment groups. Each equipment group is built up of base elements such as valves, flanges, pipes, etc. LEAK® will calculate the leak frequency for the installation, area, segment or equipment group based on built-in historical leak frequency data. The total frequency for each user defined category is reported together with each contributor. The model used expresses the frequency of a leak being larger than a certain size as a continuous function of the equivalent hole size diameter. The historical data used in the calculations is read from a database, enabling the most up-to-date data to be included.

A.4.6 R–DAT Plus®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Bayesian data analysis
- Vendor Prediction Technologies, MD, USA
- Pricing Not available.

http://www.prediction-technologies.com/products/r-dat.brochure.pdf, R–DAT Plus® is a full-featured Bayesian data analysis package for risk and reliability analysts. It is designed for users who need to perform system specific analyses, but who also have a need to develop generic prior distributions based on industry data.

R–DAT Plus® provides the user with a powerful, yet simple and flexible environment for storing and organising many types of reliability data and related information. A hierarchical structure enables the user to develop functional or structural or any other type of breakdown, at any level of detail. The elements of this hierarchy act as folders containing the reliability data and the results of Bayesian analyses performed on the data sets.

With R–DAT Plus® the user may specify the prior distribution in many different ways depending on the type and level of information available. These include a wide variety of parametric distributions (e.g. lognormal, beta and loguniform) using any of a number of input options such as lower and upper bounds, mean and variance, or the distribution parameters. Furthermore, R–DAT Plus® enables the user to develop generic distributions based on industry data (counts of failures in other applications) as well as expert estimates. The resulting distributions will represent the plant-to-plant variability of failure rate of a given class of components or initiating events, and can be used in a plant-specific analysis in order to perform the Two-Stage Bayesian procedure.

A.4.7 CARA–Fault Tree®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Fault tree analysis and construction
- Vendor ExproSoft AS (www.exprosoft.com)
- Pricing The price for a single user license is NOK 30,000 (approximately USD 5000/EUR 4000).

CARA–FaultTree® is a tool for fault tree construction and analysis. A fault tree is a logical diagram that displays the interrelationships between a potential critical event (accident) in a system and the reasons for this event. By constructing a fault tree you analyse how a system can fail, and the analysis also gives you insight into how the components contributes to the system reliability. With its intuitive graphical user interface, the program lets you create fault trees quickly and efficiently. A total of six system performance measures and six measures of component importance are available, along with enhanced report utilities.

A.4.8 US Offshore Energy Model™

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function A fully probabilistic risk model that quantifies prospective risk from hurricanes in the Gulf of Mexico
- Vendor EQECAT, US
- Pricing Available on request.

US Offshore Energy Model™ is a fully probabilistic risk model that quantifies prospective risk from hurricanes in the Gulf of Mexico. The model is part of EQECAT's global multi-peril catastrophe modeling platform, RQE™ (Risk Quantification & Engineering). Since the initial release of the model in 2007, the model has been enhanced and updated to incorporate improvements to vulnerability functions, wave modelling, exposure definition, data processing functionality, and the application of complex insurance policy structures.

The model analyzes risk in the Bureau of Ocean Energy Management (BOEM) planning regions, as well as in US lease waters. Meanwhile, onshore oil and gas delivery points and processing facilities are modeled for wind and storm surge damage (and for effects on shut-in oil and gas production).

The model handles the risks derived from the following hazards:

- Wind: Gust and sustained wind speeds, as defined by the probabilistic event set.

- Waves: A separate wave module calculates wave heights from complex hazard elements, including key hurricane wind parameters, water depth, sea-floor slope, wind duration and ocean fetch.
- Landslides and sub-sea currents: These perils threaten sub-surface equipment and pipelines. Hazard is derived from hurricane and wave parameters, sea-floor slope and water depth. Regions of mudslide hazard to pipelines are defined.

A.4.9 BlockSim®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function System analysis with reliability block diagrams (RBDs) or Fault Trees
- Vendor ReliaSoft, US
- Pricing Single-Thread: €3.595,50
  Multi-Thread: €5.395,50

BlockSim® provides a comprehensive platform for system reliability, availability, maintainability and related analyses. The software offers a sophisticated graphical interface that allows you to model the simplest or most complex systems and processes using reliability block diagrams (RBDs) or fault tree analysis (FTA), or a combination of both approaches. BlockSim® supports an extensive array of RBD configurations and FTA gates and events, including advanced capabilities to model complex configurations, load sharing, standby redundancy, phases and duty cycles. Using exact computations and/or discrete event simulation, BlockSim® facilitates a wide variety of analyses for both repairable and non-repairable systems. This includes:

- System Reliability Analysis
- Identification of Critical Components
- Optimum Reliability Allocation
- System Maintainability Analysis
- System Availability Analysis
- Throughput Calculation

A.4.10 RENO®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Probabilistic Event and Risk Analysis
- Vendor ReliaSoft, US

- Pricing Single User License: €1.795,50

RENO® is a powerful and user-friendly platform for building and running complex analyses for any probabilistic or deterministic scenario using an intuitive flowchart modeling approach and simulation. Flowchart models can be created for complex reliability analyses, risk and safety analyses, decision making or maintenance planning. Users can also build models for other applications, such as optimizing your stock portfolio or testing your blackjack strategy.

RENO® can be used for a wide variety of applications including, but not limited to:

- Risk/Safety Analysis
- Complex Reliability Modeling
- Decision Making
- Maintenance Planning
- Optimization
- Operational Research
- Financial Analysis

A.4.11 RiskSpectrum® HRA

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Human Reliability Analysis (HRA) tool
- Vendor Scandpower AB, Stockholm, Sweden
- Pricing Available on request.

RiskSpectrum® HRA is a human reliability analysis tool to evaluate and quantify the probability of human errors.

RiskSpectrum® HRA helps the user standardize HRA analysis process: by going through necessary steps to generate human error probabilities for human failure events, and to document important assumptions, conditions, inputs and results in the HRA process at the same time. With the tool the user can consistently conduct HRA and produce results of high quality, good traceability and documentation.

RiskSpectrum® HRA can help the HRA analysis meet the requirements of the ASME PSA Standard and NRC HRA Good Practices. RiskSpectrum® HRA includes a number of commonly-used HRA methods, such as THERP, ASEP, HCR/ORE, SPAR-H and HEART, etc.

For each human failure event, multiple methods can be used in quantification. Different results from different methods could therefore be compared. Conservative screening value can be defined and assigned to the selected human failure events.

A.5 QRA Tools for Consequence Analysis

A.5.1 Firex®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Prediction of main fire characteristics and responses of fire scenarios based on empirical correlations
- Vendor Scandpower Risk Management, Kjeller, Norway
- Pricing Available on request.

The program system FIREX® is capable of predicting the main fire characteristics and responses of six fire scenarios:

- Pool fire in the open
- Pool fire in enclosure
- Fire on sea surface
- Jet fire
- Diffusive flare fire
- Fireball/BLEVE.

FIREX® is based on well known prediction methods, which have been compared and verified against experimental data. FIREX® predicts:

- Incident heat radiation onto targets not engulfed by the flames, as a function of the distance from the fire.
- Heat flux to targets engulfed by the flames as a function of time from the onset of the fire.
- Temperature response of steel structures as a function of time and degree and type of insulation.
- Smoke production and visibility in smoke as a function of time from the moment of ignition.
- Pool fire hazard ranges.
- Fireball hazard ranges.
- For pool fires in enclosures; ceiling temperature, development of hot gas.

A.5.2 FLACS®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function 3D CFD software tool for analysing gas and air flows in industrial environments as well as in the atmosphere. Major application areas include ventilation, dispersion and gas explosions and subsequent blast effects

- Vendor Gexcon, Bergen, Norway
- Pricing Prices start from €1707/month (Example: Domestic consulting license, FLACS-GasEx, 1 month lease)

The development of FLACS® has been carried out continuously since 1980 with the co-operation, support, direction and funding of ten international oil and gas companies as well as legislative bodies of three countries. Application specific validation, wide applicability and efficiency when using FLACS® has been given high priority in the development work.

FLACS® has been the leading tool for explosion consequence prediction on offshore and onshore petrochemical installations for more than a decade. Every year FLACS® is used in safety studies and risk assessments on more than one hundred offshore and onshore facilities worldwide. In addition, FLACS® is now approved for LNG Vapor Dispersion Modeling under U.S. Federal Regulations (49 CFR 193.2059).

The full FLACS-Standard version can handle explosion, dispersion, ventilation, mitigation and pool modelling. Separate modules/subset of FLACS-Standard include:

- FLACS-Dispersion
- FLACS-GasEX
- FLACS-Hydrogen
- FLACS-DustEx (former DESC)

Typical applications of FLACS® include:

- Quantitative risk assessments
- Accident/incident investigations
- Identify/evaluate worst-case
- Safety evaluation of modifications
- Explosion venting of coupled and non-standard vessels
- Room/module layout optimization
- Predicting the effect of mitigation
- Blast waves and control rooms
- Drag loads on piping
- Exhaust pipe explosions
- Toxic gas dispersion
- Heli-deck studies
- LNG dispersion studies
- Gas detector optimization
- Planning and QA of experiments
- Assist certification processes

A.5.3 KAMELEON FireEx–KFX®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function CFD-based tool for prediction of gas dispersion and fire characteristics and response in complex geometries, as well as fire mitigation and extinguishment analysis and design
- Vendor ComputIT, Trondheim, Norway
- Pricing Short and long term leasing contracts, licenses ranging from academic to commercial licenses.

Kameleon FireEx–KFX® is an advanced simulator dedicated to gas dispersion and fire simulation with the following main characteristics:

- Three-dimensional transient finite—volume CFD code.
- Includes CAD import capabilities (PDS, PDMS, IGES, Flacs macro, others).
- Interfaced with the finite—element structure response codes Fahts/Usfos for dynamic structural response analysis.
- Includes detailed Lagragian models for fire mitigation by water systems, for instance water mist systems, water curtains, deluge, sprinklers.
- Includes efficient and user—friendly pre- and post processor capabilities, including options for animation of simulation results and "moving cameras" through simulations.
- Originally developed by ComputIT/NTNU/SINTEF with the partners Statoil (N), Total (F), ENI-group (I), Hydro, ConocoPhillips (N,USA), Gaz de France (F), Ruhrgas (D) and Sandia National Laboratories (USA).
- Extensively validated against small and large scale experimental data.
- Used for a large number of industrial analyses world wide for more than 20 years.

Industrial analyses performed by KFX® can typically be:

- Simulation of all kind of fires; pool fires, jet fires, spray fires, flares, fire in enclosures, in complex geometries, in open space, in still air or in windy conditions. This includes detailed calculation of temperatures, radiation, smoke, visibility, concentrations of species, toxic gases, noise etc.
- Fire impact on structures and process equipment
- Optimization of passive fire protection
- Fire temperature, radiation and smoke impact on humans
- Evaluation of escape routes
- Simulation and evaluation of fire mitigation by water systems; sprinklers, deluge, mist, curtains
- Flare simulations; radiation, noise (not standard KFX® version), detailed tip simulations, ignition, startup
- Dispersion of gas
- Calculation of explosive cloud sizes

- Gas and fire detection systems
- Simulation and evaluation of LNG spills, including dispersion of LNG vapour and LNG fires
- Combustion in incinerators, furnaces, engines, burners and other combustion devices
- Reduction of emissions; CO, NO_x, others
- HVAC (ventilation simulations)
- Turbulent flow analysis with respect to safe helicopter operation
- Fluid flow and combustion in general
- 3D visualization, animations, contour plot in real CAD geometry.

A.5.4 OLGA®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Transient multiphase flow simulator covering both hydraulic and thermal phenomena. Simulation of wells, flow lines, risers and process equipment separately or as an integrated system. OLGA® is also used extensively for blowout simulation and relief well design. A separate OLGA® ABC (Advanced Blow-Out Control) tool is a stand-alone version specifically for this application area
- Vendor SPT Group, Kjeller, Norway
- Pricing Available as lease for a limited period or as a permanent licence.

OLGA® is a simulator for transient multi-phase flow phenomena. OLGA® can model general networks of wells, flowlines, risers as well as process equipment. OLGA® is also used extensively for blowout simulation and relief well design. A separate OLGA® ABC (Advanced Blow-Out Control) tool is a stand-alone version specifically for this application area.

OLGA® is accurate in predicting pressure gradients, liquid hold-up, flow regimes and flow rates. OLGA®'s ability to predict release behaviour from condensate pipeline (reflecting bottom topography), is of significant importance in risk analysis of offshore installations.

OLGA® is verified and validated against more than 10,000 experiments at the two and three-phase-flow test loop operated by SINTEF in Trondheim and IFE at Kjeller. Additionally OLGA® is verified by the largest database of multiphase wells and pipeline data in OLGA® Verification and Improvement Project (OVIP).

A.5.5 PHAST®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Windows-based toolkit for determination of consequences of accidental releases of hazardous material
- Vendor DNV Software, London, UK
- Pricing Available on request.

PHAST® (Process Hazard Analysis Software Tools) is a Windows-based toolkit, which determines the consequences of accidental releases of hazardous material. It examines the progress of a potential incident from initial release, through formation of a cloud, with or without a pool, to its dispersion. The program uses DNV's unique Unified Dispersion Model (UDM) to apply the appropriate entrainment and dispersion models as the conditions change and to integrate the relevant individual models such that the transition from one behaviour pattern to another is smooth, continuous and automatic. The discharge, pool formation and vapour and gas dispersion results are used to automatically calculate toxic dose, probit and lethality, flammable effects including pool fire, fireball, jet fire, flash fire and Multi Energy and Baker Strehlow Tang explosions. Access to specific calculations at any step is also possible for detailed analysis of individual phenomena. It is applicable to all stages of design and operation across a range of process and chemical industry sectors and may be used to identify situations which present potential hazards to life, property or the environment.

A.5.6 SAFER TRACE™

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Consequence Analysis for chemical facility
- Vendor SAFER Systems, USA
- Pricing Available on request.

TRACE™ is a consequence assessment solution that allows for rapid visualization of a potential failure involving airborne hazardous material. It allows engineers to study how incremental mitigation techniques may improve safety and help them focus on what must be put in place to mitigate the hazard. This, in turn, helps assess the value and need to conduct an intensive process hazard analysis.

TRACE™ incorporates an intelligent wizard feature that allows the user to easily and rapidly describe a scenario. Once processed, results can be viewed in tabular or graphical formats. Output information can be exported to other applications like word processors, spreadsheets and presentation managers.

TRACE™ can be used in a wide variety of applications, including:

- Accidental Release Modeling
- Hazards Identification
- Risk Management Planning
- Human Response Modeling
- Regulatory Modeling Requirements
- Evaluation of Mitigation Systems
- Population Exposure Assessment
- Worst-Case/Alternative Scenario Studies

A.5.7 USFOS®/FAHTS®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Structural fire and explosion analysis
- Vendor USFOS AS, Norway
- Pricing Available on request.

USFOS® is a computer program for collapse analyses and accidental load analyses of fixed offshore structures, intact or damaged. The program simulates the collapse process of space frame structures, from the initial yielding, through to the formation of a complete collapse mechanism and on to the final toppling of the structure.

The USFOS® program has been in commercial use since 1985 by oil companies and engineering consultants all over the world. The program has been extensively used in areas such as inspection planning, lifetime extension and integrity assessment of ageing structures, and in fire protection assessment for new designs. It is verified through participation in extensive benchmark activities both in Europe and USA, through comparison with experiments and through extensive scientific publication.

The particular characteristic features of USFOS® include:

- The program traces the entire collapse and post collapse behavior of the structure, including global unloading, member unloading and redistribution of forces.
- The program requires only one finite element per physical member of the structure.
- The program employs efficient solution algorithms (SPARSE technology), performing complete collapse analyses or time-domain dynamic analyses in short time.
- Robust incremental/iterative solution procedures are implemented, with automatic step scaling and verification of numerical solution accuracy.

- The program comes with an extremely powerful and versatile graphical post processor with full 3D graphics and image plots.

FAHTS® is a specialized tool for framed structures. The technology is based on non-linear finite element technique with a special handling of boundary conditions (such as insulation etc).

FAHTS® has an interface to Kameleon Fire Ex® (KFX), which ensures effecttive and accurate transfer of data to the structure. The software is used to prepare temperature data for structural response analysis with USFOS®.

FAHTS® can be used in the following applications:

- Evaluation of need for thermal insulation (passive fire protection of steel and aluminum structures
- Simulation of pipelines and pressurized vessels exposed to fire
- Optimization of Passive Fire Protection, PFP
- Estimation of structural integrity during fire (together with USFOS®)
- Evaluation of effect from deluge

A.5.8 PIPENET™

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Pressure loss and flowrate model for offloading, firewater and ventilation systems
- Vendor Sunrise System Ltd, Cambridge, UK
- Pricing Available on request.

PIPENET™ is extensively used in the field of flow analysis of pipe and duct networks in the steady state as well as dynamic state. The software can be used for hydrocarbon fluids, water, gases and steam. It is used around the globe in the oil and gas, power, petrochemical and shipbuilding industries.

The following three modules of PIPENET™ are used extensively:

- PIPENET™ Spray Sprinkler Module is exceptional for the design of fire protection systems especially in the oil and gas and process plant industries—deluge, ringmain, sprinkler or foam concentrate systems complying with the NFPA and other rules.
- PIPENET™ Transient Module is ideal for unsteady flow calculations for 'water hammer', 'steam hammer', control systems and hydraulic forces for pipe stress analysis and other safety related applications.
- PIPENET™ Standard Module is the tool for solving general flow problems with liquids, gases or steam—in pipe and duct networks—cooling water systems, steam distribution systems, HVAC systems.

Typical applications include:

- Design of fire protection systems for offshore platforms, FPSOs, onshore terminals, refineries, power stations and ships.
- Pipelines, loading/unloading systems, water injection systems, crude oil transfer lines, main steam lines in power stations, reheat lines, cooling water systems and fuel oil lines.
- Steam distribution systems, utility systems, ventilation systems and water distribution systems.

A.5.9 VessFire®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Heat transfer, depressurisation and stress modelling from fires
- Vendor Petrell AS, Norway
- Pricing Available on request.

VessFire® is a simulation program for time-dependent non-linear analysis of thermo-mechanical response during blow-down of process segments and process equipment exposed and unexposed to fire. VessFire® solves the problem of heat transfer, conduction, thermodynamics of object contents and stress using a coupled approach. VessFire® is based on a coupled solution of problems using a combined numerical and analytical approach to simulate:

- Heat transfer from the fire onto the vessel, flow line, heat exchanger and/or pipe work surface.
- Heat transfer through the fire protective coating, thermal insulation or protective shield.
- Heat conduction through the object shell.
- Heat transfer from the inner object surface to the object contents.
- Thermodynamics of the object contents.
- Variation of pressure in the object due to depressurization counter-acted by the increase of the pressure due to evaporation, boiling and expansion of object contents.
- Stress in the object shell.
- Temperature in the depressurization pipe work for material selection.
- Time to object failure.

A.5.10 HYENA®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Fire sprinkler/hydrant analysis
- Vendor ACADS-BSG
- Pricing Available on request.

HYENA® can be used to analyze automatic fire sprinkler systems with a simple end, side or center fed configuration or more complicated looped and gridded systems. It may also be used to analyze fire hydrant and hose reel installations or combined sprinkler, hydrant and/or hose reel systems or any other systems where the discharges can be represented by a k factor and minimum flow. With a given sized network the program performs a complete hydraulic analysis determining the water flow in, and pressure drop though, each pipe in the entered network taking account of all fittings entered by the user.

Main features of HYENA® include:

- The program is capable of analysing looped and gridded systems as well as the more conventional tree configurations.
- The program can be used to carry out a sprinkler system analysis in accordance with NFPA, NZ4541, AS2118 or SSPC52 (Singapore) or GB50084 (China) or to carry out an analysis of hydrant systems with or without hoses or hose reels
- The piping system can have up to 10 input points and these can be modelled as a fixed pressure, a town mains water supply or a pump.
- The program can work in a wide range of units including Metric and British or US and uses the Hazen-Williams formula for the hydraulic analysis.
- The program can also analyse mist systems in accordance with NFPA750 or A54587 using the Darcy Weisbach formula. This also allows the analysis of systems using fluids other than water.
- The program operates under WINDOWS® and all input data is via a series of screens with numerous features including drop down lists, selection lists, various sort options, etc; to facilitate easy data input.
- All nodes that are not nominated as discharges, or input points are automatically assigned as reference nodes to save input, the user only having to assign elevations.

A.5.11 ANSYS Fluent®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Physical modeling of flow, turbulence, heat transfer, and reactions for industrial applications

- Vendor ANSYS, USA
- Pricing Available on request.

ANSYS Fluent® software contains the broad physical modeling capabilities needed to model flow, turbulence, heat transfer, and reactions for industrial applications ranging from air flow over an aircraft wing to combustion in a furnace, from bubble columns to oil platforms, from blood flow to semiconductor manufacturing, and from clean room design to wastewater treatment plants.

User-defined functions allow the implementation of new user models and the extensive customization of existing ones. The interactive solver setup, solution and post-processing capabilities of ANSYS Fluent® make it easy to pause a calculation, examine results with integrated post-processing, change any setting, and then continue the calculation within a single application.

Case and data files can be read into ANSYS CFD-Post® for further analysis with advanced post-processing tools and side-by-side comparison of different cases.

A.5.12 ANSYS CFX®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Fluid dynamics program to solve wide-ranging fluid flow problems
- Vendor ANSYS, USA
- Pricing Available on request.

ANSYS CFX® software is a fluid dynamics program that has been applied to solve wide-ranging fluid flow problems for over 20 years. The highly parallelized solver is the foundation for an abundant choice of physical models to capture virtually any type of phenomena related to fluid flow. The solver and its many physical models are wrapped in a modern, intuitive, and flexible GUI and user environment, with extensive capabilities for customization and automation using session files, scripting and a powerful expression language.

Modeling Capabilities of ANSYS CFX® include the following:

- Laminar and turbulent
- Steady-state and transient
- Incompressible to fully compressible (subsonic, transonic, supersonic)
- Ideal and real gases
- Newtonian and non-Newtonian fluids
- Heat transfer
- Radiation
- Rotating and stationary

- Eulerian multiphase
- Free surfaces (VoF)
- Lagrangian particle tracking
- Chemical reactions and combustion
- Mesh motion and remeshing
- Immersed solids
- Fluid structure interaction

A.6 Qualitative Risk Assessment Software

A.6.1 HAZOP Manager®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function HAZOP Tool
- Vendor Lihou Technical & Software Services, UK
- Pricing Available on request.

HAZOP Manager® is a comprehensive Personal Computer program for the management of Hazard and Operability Studies (HAZOPs) and other similar safety-related reviews (e.g. PHA, HAZID, FEMA, SIL, etc.) It is extensively used to conduct more efficient and effective studies.

HAZOP Manager® incorporates features and facilities that:

- Serve as a framework within which preparation for the review can be structured.
- Ease the task of recording the meeting minutes, and help to maintain the team's focus of attention and interest.
- Give speedy access to material useful to the study team, such as previously identified problems, failure rate data and other such historical information.
- Allow professionally formatted reports to be produced with the minimum of effort.
- Permit additional management information to be extracted from the study records.
- Provide a comprehensive and easy to use system for effective action follow-up and close-out, without the significant administrative burden that this usually entails.

A.7 Reporting and Analysis of Incidents and Accidents

A.7.1 DNV BSCAT™

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Modern risk-based safety management approaches to systematic root cause incident investigation
- Vendor CGE Risk Management Solutions, The Netherlands
- Pricing Available on request.

The BSCAT™ method refers to a method that links modern risk-based safety management approaches to systematic root cause incident investigation. The "B" refers to barrier-based as each barrier identified in bowtie risk assessments is tested for why it failed.

SCAT (Systematic Cause Analysis Technique) is a well-established root cause analysis approach which incorporates the DNV loss causation model. The model is a sequence of dominos establishing the hierarchy of accident progression from the type of event, to the immediate cause back to fundamental root causes and system failures, and hence to necessary actions for improvement.

In short, BSCAT™ is the barrier based extension to DNV's SCAT method. The SCAT model was developed to help incident investigators apply the DNV loss causation model to actual events. This is done by means of the SCAT chart. The chart was created to build-out an event using standardized event descriptions that can fit the whole range of incidents and near misses. Due to using standardized categories, this assists investigators to assess events in a systematic manner and making these suitable for aggregation, leading to more insight into the weak areas of the safety management system and the underpinning risk assessment. The barrier-based accident investigation still applies the SCAT model but now it is applied to each barrier separately, not to the incident as a whole.

The BSCAT™ software allows investigators to reuse and link existing risk assessment information (bowties) and to do full integration of incident analysis and risk analysis. If applicable bowtie diagrams are available for use during the investigation, the analysis can bring events and barriers from the bowtie directly into the BSCAT™ analysis. This means that every incident investigation refers back to the risk assessment—a feature not present in other investigation methods.

By reusing the Bowtie risk analysis and/or describing the barriers in the incident analyses, more value is extracted from the incident analyses. Incidents highlight weaknesses in barriers and these in turn may indicate the risk assessment is too optimistic and that specified risk targets are not being met. This information is beyond that normally identified in incident investigations.

This entire process makes it possible to gauge barrier effectiveness and availability based on real operations and linked to ongoing incident analyses. This process is potentially the richest source of barrier performance information available to a facility.

In general, BSCAT™ is a well proven root cause analysis technique which uses standardized immediate and basic cause categories, and this allows incident analyses to aggregate for trends, leading to more insight into the weak areas of the facility safety management system. It has been updated to link it directly to facility risk assessments and thereby combines root cause analysis and risk assessment into a single tool.

A.8 Risk Management Software

A.8.1 ViewRisk®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Risk summation and presentation tool, including outputs of risk contours, F–N data, risk transects and a listing of dominant events
- Vendor Environmental Resources Management (ERM), London, UK
- Pricing License terms available from ERM on request.

ViewRisk® is a risk summation and presentation tool. A regulatory version is currently being developed for UK HSE. Outputs include risk contours, F–N data, risk transects and a listing of dominant events. The risk for each scenario is calculated, accounting for:

- wind direction, speed and stability
- the number of people affected in specified time periods
- whether populations are indoors/outdoors, fixed (e.g. within dwellings) or mobile (e.g. motorists)
- topographic effects (e.g. the presence of hills or cliffs)
- whether event locations are at a fixed point, multiple points or distributed along a line source (e.g. pipeline).

A.8.2 Synergi RBI®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Onshore and Offshore risk based inspection tool
- Vendor DNV Software, Høvik, Norway
- Pricing Available upon request.

Synergi RBI® are software tools that use DNV's Risk Based Inspection (RBI) techniques to help users optimise their inspection management programme. DNV's RBI technique, as described in DNV RP–G 101 "Recommended Practice for Risk-Based Inspection of Topsides Static Mechanical Equipment", is used to calculate the risk due to corrosion, erosion and cracking for pressure equipment in a marine environment. DNV's onshore RBI method fully comprises API 580 and 581 and goes further, providing complete support for a best practice approach to risk based inspection for onshore facilities.

Synergi RBI® is designed to help users sustain high productivity and reliability of their offshore platforms by minimising lost production and downtime through effective inspection and maintenance. It assists in the management of safety and equipment integrity to user specified levels.

It helps users to achieve these objectives systematically and efficiently. It allows you to quantify the risk for process and utility systems and equipment on topsides and FPSOs. Risk can be defined in terms of potential loss of life, cost, or both. A cost-effective inspection programme can then be devised based on the greatest risk reduction per cost of inspection.

A.8.3 BowTieXP®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Management of major risks to people, the environment, assets and reputation by means of 'bow-tie' graphical interface diagram
- Vendor CGE Risk Management Solutions, the Netherlands
- Pricing Available on request

The Bowtie method is a risk evaluation method that can be used to analyze and demonstrate causal relationships in high risk scenarios. The method takes its name from the shape of the diagram that you create, which looks like a men's Bowtie. A Bowtie diagram does two things. First of all, a Bowtie gives a visual summary of all plausible accident scenarios that could exist around a certain Hazard. Secondly, by identifying control measures, the Bowtie displays what a company does to control those scenarios.

However, this is just the beginning. Once the control measures are identified, the Bowtie method takes it one step further and identifies the ways in which control measures fail. These factors or conditions are called Escalation factors. There are possible control measures for Escalation factors as well, which is why there is also a special type of control called an Escalation factor control, which has an indirect but crucial effect on the main Hazard. By visualizing the interaction between Controls and their Escalation factors one can see how the overall system weakens when Controls have Escalation factors.

Besides the basic Bowtie diagram, management systems should also be considered and integrated with the Bowtie to give an overview of which activities keep a Control working and who is responsible for a Control. Integrating the management system in a Bowtie demonstrates how Hazards are managed by a company. The Bowtie can also be used effectively to assure that Hazards are managed to an acceptable level (ALARP).

By combining the strengths of several safety techniques and the contribution of human and organizational factors, Bowtie diagrams facilitate workforce understanding of Hazard management and their own role in it. It is a method that can be understood by all layers of the organization due to its highly visual and intuitive nature, while it also provides new insights to the HSE professional.

A.8.4 THESIS

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Management of major risks to people, the environment, assets and reputation by means of 'Bowtie' graphical interface diagram
- Vendor ABS Consulting, Warrington, UK
- Pricing GBP 500–2,000 per licence depending upon numbers of licences and software variants required

THESIS BowTie™ (THESIS) delivers simplified, integrated risk management for entire business portfolio. Enhanced visuals in THESIS make the elements in management process readily understandable at all levels across the organization.

Backed by ABS Consulting, THESIS helps clients analyze and manage the hazards and risks to which their business is exposed. Through a rich graphical interface, the software displays the relationship between hazards, controls, risk reduction measures and business activities. While communicating critical procedures and individual responsibilities to employees, the software demonstrates compliance clearly across all levels—senior management, regulators, principal investors and the public.

In response to corporate governance requirements across global corporations a fully web based version of THESIS has also been created to supplement the more traditional standalone version.

Areas where THESIS can be used:

- High level hazard identification (hazard register) and risk assessment
- Detailed HAZID—derivation of threats, consequences and controls
- GAP analysis
- Management of controls (safety critical elements and soft/non hardware types)
- Derivation of tasks and procedures
- Document management
- Shortfall and Remedial Action tracking

- Focusing on personnel critical tasks
- As a complement to the Safety Case, HSE Case or HSEIA
- Incident investigation
- Illustrates the status and management of risk within a business to senior management, the workforce and regulators
- Enterprise Risk Management
- As the Safety/Live Risk module

A.8.5 BowTie Pro™

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Qualitative, semi-quantitative and illustrative risk analysis and risk management
- Vendor BowTie Pro, Aberdeen, UK
- Pricing Available on request.

BowTie Pro™ is a tool to facilitate the creation of risk assessments utilizing the latest Microsoft.NET technology. The bowtie diagram is a powerful visual presentation of the risk assessment process that can be readily understood by the non-specialist.

BowTie Pro™ can have up to 6 diagrams open at once allowing the copy and paste between diagrams and tailor each diagram by reordering and changing the display properties. BowTie Pro™ also allows a great deal of detailed information to be recorded against the controls such as tasks, task assignment, documents, hyperlinks, verification method etc. There is also the facility to link the controls to incident investigation packages and record BRFs etc.

The analysis features of BowTie Pro™ include:

- Risk Profiling allows an interactive version of the hazard register to be analysed and modified on the screen.
- Risk Profiling Matrix allows the user to see how the risks have been assessed and how many times each item has been used.
- Critical Task Listings allows the visibility, filtering and use of tasks in an easy to use screen across a BowTie Pro™ file.
- The People Matrix displays responsibilities for items across a BowTie Pro™ file.
- Deficiency Analysis allows a range of functions to analyse any deficiencies identified when creating a diagram.
- The Layers of Protection allow a numerical analysis of each strand of a BowTie Pro™ diagram.
- The Quality Check module ensures that the data is relevant based on various criteria.

- The Document Matrix shows where a reference document is used within a BowTie Pro™ file.
- The Permitted Operations and Permitted boundary operations modules allow the creation of a matrix based on various criteria similar. This allows the creation of the Manual of Permitted Operation (MOPO).
- File Searching searches for all instances of a word within the current BowTie Pro™ file. These can easily be edited by double clicking on the item. There is also Report Searching where you search for the text within a report.

A.8.6 Presight® Operations and Barrier Safety KPI Management

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Reduce major accident risk with operations and context focused KPI management for barrier and process safety improvements and reduce down-time events. Convert complex multi-systems information into indicators, supporting risk awareness and safer operations decisions
- Vendor Presight Solutions AS, Norway (www.presight.com)
- Pricing Available on request.

Presight Solutions context-based barrier and technical safety KPI management software offers the enterprise the difference between a fit-for-purpose and a fit-for-use approach to barrier safety and prevention of major accidents happening. Presight removes the chance that critical process, technical, organization and human factor KPI's are 'aggregated away' from a major accident prevention perspective across the organization.

Keeping it simple for end-users improves risk awareness in operations. Recognizing users 'another management system' fatigue and their desire to just 'get on with the job' interests—Presight combines all safety and risk relevant MTO data from multiple sources such as maintenance, ERP, rotation and certificates, control systems, weather data and performance standards, to deliver useful operations and end-user focused indicators. Drill-down to underlying indicators, bowtie visualization or source system to identify the specific safety critical equipment, process, organization or human factor performance failures for follow up and action between off- and onshore units.

Early warning when status today and trend is not enough. The Energy Institute suggests that "*most well-run organizations can state how many accidents occurred over a certain period in the past, but the "real challenge" is to assess the likelihood of an incident happening tomorrow.*" Prevent the escalation of major accident risk scenarios through use of Presight advanced control and forecast indicators in decision making situations. Implement automatic barrier fail and early warnings notifications to responsible person or role, off- and onshore—through web, email or mobile devices—for corrective and preventive actions.

Track deviations and override decisions against individual indicators. Easily compare different indicators against period for performance analysis and experience transfer opportunities. Identify underlying causes and focus areas for operations safety performance improvement initiatives.

Enterprise strength KPI administration features. Presight off-the-shelf approach to development includes administration features to meet regional and global operations and regulatory standards. Presight is language and measure of unit independent, SharePoint ready, data integrity status, log of all changes, powerful search and multi-indicator edit and copy features for global and multi-asset operations.

A.8.7 Synergi Life®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Complete business solution for risk and QHSE management, managing all non-conformances, incidents, risk, risk analyses, audits, assessments and improvement suggestions
- Vendor DNV Software, London, UK
- Pricing Available on request.

The Synergi Life® software (previously named Synergi) is a complete business solution for risk and QHSE management, managing all non-conformances, incidents, risk, risk analyses, audits, assessments and improvement suggestions.

The Synergi Life® software covers every workflow process, such as reporting, processing, analysing, corrective actions, communication, experience transfer, trending and KPI monitoring.

Synergi Life® is a module based HSE and Risk Management solution developed with a full set of optional modules for the various business needs relevant to our clients. These modules can be used as stand-alone solutions, or in combination to fit the exact needs and focus of each individual client and user. It is the combinations of several modules that contribute to a total risk and QHSE Management solution. Modules in the Synergi Life software package include:

- Synergi Life® Incident Management software
- Synergi Life® Quality Management software
- Synergi Life® Audit Management software
- Synergi Life® Activity Management software
- Synergi Life® Risk Management software
- Synergi Life® Environmental Management software
- Synergi Life® Improvement Management software
- Synergi Life® Anonymous Incident Management software
- Synergi Life® Inspection and BBS Management software

- Synergi Life® Deviation Management software
- Synergi Life® Hospital Infection Management software
- Synergi Life® Adverse Drug Reaction Management software (ADR)

A.8.8 SafeGuard®

The following is a brief description of this software, the function, vendor, pricing and main features.

- Function Visualisation of status of major accident risk in a plant
- Vendor Safetec Nordic, Trondheim, Norway
- Pricing Available upon request.

SafeGuard® is an analysis tool and a visualisation tool for monitoring the status of major accident risk in a plant or on an offshore installation. The analysis is closely linked to risk analysis models and the risk picture at the installation and presents the status of all key factors influencing risk, from operations and technology at the "sharp end" to high-level organizational factors and even external influencing factors as required. The visualisation is intuitive and can be tailor-made for individual roles within the company and also for specific situations where information about risk is required. Operational management offshore can get information about e.g. activity level, status of technical systems, competence of available personnel etc before deciding on what actions to take. Similarly, high-level managers can see how their decisions can have an impact on e.g. operations and then on to major accident risk. The tool can also be used as a key element in monitoring the integrity of barriers in a plant, but combining this with other key information that is relevant for evaluating risk and making decisions.

Appendix B
Overview of Fatalities in Norwegian Sector

An overview of all fatalities in the Norwegian sector of North Sea and Norwegian Sea is presented. The focus is on a statistical overview, split in occupational and major accidents, diving accidents and helicopter accidents.

B.1 Introduction

B.1.1 Background

The research programme 'Safety Offshore' (SPS) established the first overview of all fatalities in the Norwegian offshore industry. But this effort stopped when the programme ended after a five year period from 1978 until 1983. The author was able to obtain a printout from the SPS project team, which was the starting point of work conducted in Safetec Nordic AS, partially funded by the Norwegian Research Council, until the author left the company. The records were given to the author from Safetec Nordic AS, and the work has been continued by the author since 1993, financed by Preventor AS. This work has been the source of overviews presented annually by PSA in the Risk Level project (PSA 2012).

The first well was spudded in the Norwegian sector in July 1966 using the Ocean Traveler mobile drilling unit. The first serious accident occurred on 6. November 1966, when the supply vessel Smith Lloyd 8 rammed into Ocean Traveler, puncturing 2 columns. Over 50 persons jumped overboard, whereas five persons remained onboard and managed to stabilize the installation before it capsized. All personnel in the sea were rescued by the supply vessel, and no fatalities occurred.

The first fatal accident occurred in 1967, this was a diving accident. The first accident on a mobile installation occurred in 1969, when the drilling manager was killed during testing of a manometer onboard Glomar Grand Isle. The first fatality on a production installation occurred in 1974, in a crane accident on Ekofisk B installation, when the crane fell overboard.

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B.1.2 Limitations

The fatalities included in the tables in this appendix are limited mainly to what falls under the petroleum law, with some additions. This implies that the following are included in the statistics:

- Fatalities on offshore production installations
- Fatalities on offshore mobile installations when operating at an offshore field
- Fatalities on attending vessels when operating within the safety zone of an offshore installation
- Fatalities on attending vessels when operating in association with offshore installations
- Fatalities on crane and pipe laying vessels when operating in association with offshore installations
- Helicopter fatalities during all phases of helicopter transportation to/from shore.

The implications of what is listed above are that the following are excluded in the statistics:

- Fatalities on production installations during construction inshore or yard
- Fatalities on production installations during inshore decommissioning activities

Table B.1 Fatalities on production installations, Norwegian sector, 1974–2012

Year	Fatalities in occupational accidents	Fatalities in major accidents	Year	Fatalities in occupational accidents	Fatalities in major accidents
1974	2		1994	1	
1975	2	3	1995	1	
1976	2		1996	0	
1977	2		1997	0	
1978	1	5	1998	0	
1979	0		1999	1	
1980	0	123	2000	1	
1981	0		2001	0	
1982	0		2002	1	
1983	0		2003	0	
1984	1		2004	0	
1985	1		2005	0	
1986	0		2006	0	
1987	0		2007	0	
1988	0		2008	0	
1989	1		2009	1	
1990	1		2010	0	
1991	3		2011	0	
1992	0		2012	0	
1993	2				

Table B.2 Fatalities on mobile installations, Norwegian sector, 1969–2012

Year	Fatalities in occupational accidents	Fatalities in major accidents	Year	Fatalities in occupational accidents	Fatalities in major accidents
1969	1		1991	0	
1970	1		1992	0	
1971	2		1993	2	
1972	0		1994	0	
1973	0		1995	0	
1974	1		1996	0	
1975	0		1997	0	
1976	0	6	1998	0	
1977	0		1999	0	
1978	0		2000	0	
1979	0		2001	0	
1980	0		2002	1	
1981	0		2003	0	
1982	1		2004	0	
1983	2		2005	0	
1984	0		2006	0	
1985	1	1	2007	0	
1986	0		2008	0	
1987	0		2009	0	
1988	0		2010	0	
1989	2		2011	0	
1990	1		2012	0	

- Fatalities on mobile installations during transit between offshore fields or to/from shore
- Fatalities on supply vessels when en route from shore to offshore installations
- Diving accidents during inshore training and testing

B.2 Production Installations

Table B.1 presents the overview of fatalities on production installations since the first fatality in 1974, until 31.12.2012. 1974 was the first year with manhours logged on production installations. The fatalities are split in occupational accidents and major accidents.

It should be noted that the three occupational fatalities in 1991 occurred when a helicopter was employed on Ekofisk to replace a flare tip. The rotor hit the structure causing a crash of the helicopter in the sea, and the three persons onboard perished. This accident is not associated with transport of personnel by helicopter, and does not belong in the section with helicopter fatalities during helicopter

Table B.3 Fatalities on attending vessels and pipe laying vessels, Norwegian sector, 1972–2012

Year	Occupational fatalities on attending vessels	Occupational fatalities on pipe laying vessels	Year	Occupational fatalities on attending vessels	Occupational fatalities on pipe laying vessels
1972	2		1993	0	
1973	1		1994	2	
1974	1		1995	1	
1975	1		1996	2	1
1976	0		1997	0	
1977	5		1998	0	
1978	2		1999	1	
1979	1		2000	1	
1980	0		2001	1	
1981	0	1	2002	0	
1982	0		2003	1	
1983	0		2004	0	
1984	0		2005	0	
1985	0		2006	0	
1986	0		2007	1	
1987	0		2008	0	
1988	0		2009	0	
1989	0		2010	0	
1990	0		2011	0	
1991	1		2012	0	
1992	0				

Table B.4 Fatalities during diving accidents, Norwegian sector, 1967–2012

Year	Fatalities in diving accidents	Year	Fatalities in diving accidents
1967	1	1978	0
1968	0	1979	0
1969	0	1980	0
1970	0	1981	0
1971	2	1982	0
1972	0	1983	5
1973	0	1984	0
1974	3	1985	0
1975	2	1986	0
1976	0	1987	1
1977	0		

Table B.5 Fatalities during helicopter transportation of personnel to/from shore, Norwegian sector, 1967–2012

Year	Fatalities in helicopter accidents	Year	Fatalities in helicopter accidents
1973	4	1993	0
1974	0	1994	0
1975	0	1995	0
1976	0	1996	0
1977	12	1997	12
1978	18	1998	0
1979	0	1999	0
1980	0	2000	0
1981	0	2001	0
1982	0	2002	0
1983	0	2003	0
1984	0	2004	0
1985	0	2005	0
1986	0	2006	0
1987	0	2007	0
1988	0	2008	0
1989	0	2009	0
1990	0	2010	0
1991	0	2011	0
1992	0	2012	0

transportation of personnel. It has therefore been included with the occupational accidents.

It should further be noted that the Alexander Kielland accident has been classified as production installation, although the Alexander Kielland installation was a mobile installation, a flotel, which was connected to a fixed installation.

There are two accidents after year 2000, on Gyda in 2002 (falling object) and Oseberg B (fall to lower level) in 2009.

B.3 Mobile Installations

Table B.2 presents the overview of fatalities on mobile installations since the first fatality in 1969, until 31.12.2012. The fatalities are split in occupational accidents and major accidents.

It should be noted that the six fatalities in a major accident in 1976 (grounding of Deep Sea Driller) occurred when the unit was towed to shore, just outside Fedje (north of Bergen). This accident should not be included if the criteria listed in Sect . B.1 are strictly adhered to, but this accident has for a long time been counted as an offshore accident.

There is only one accident after year 2000, on Byford Dolphin (falling object in the derrick) in 2002.

B.4 Vessels

Table B.3 presents the overview of fatalities on attending and pipe laying vessels since the first fatality in 1972, until 31.12.2012. The fatalities are split on attending vessels and pipe laying vessels separately. Attending vessels include supply vessels, standby vessels as well as anchor handling and tug vessels.

There were quite a number of fatal accidents on attending vessels in the period from 1994 until 2001. As a result of these eight fatalities, the authorities pushed the industry to focus on risk reduction, and it can be seen to have paid off, with no fatalities on attending vessels after 2001.

There are three accidents after year 2000, on Viking Queen in 2001 (hit by steel wire during anchor handling operations) and two on Saipem 7000 (falling object and fall overboard) in 2003 and 2007.

B.5 Shuttle Tankers

There has only been one fatal accident on shuttle tankers during the period from start of operations. The fatality occurred on the shuttle tanker Polytraveller on 1st August 1980, during off-loading on the Statfjord field. The mooring line failed, thus causing the loading hose to rupture and spill crude oil. The spill was ignited and the tanker captain who was positioned in the stern of the vessels was fatally injured by the fire.

No other fatalities have occurred during off-loading or during transit to onshore terminals and refineries.

B.6 Diving Accidents

Table B.4 presents the overview of diving fatalities in the Norwegian offshore operations since the first fatality in 1967, until 31.12.2012. No diving fatalities have occurred after 1987, but the volume of manned diving has been considerably reduced from the volume in the 1970s and 1980s. Use of Remote Operated Vehicle (ROV) has replaced the use of divers to a large extent.

It should be noted that fatalities during diving training inshore and similar activities have not been included. There are no diving accidents after 1987.

B.7 Helicopter Accidents

Table B.5 presents the overview of fatalities during helicopter transport of personnel between offshore installations and heliports onshore in the Norwegian

sector the first fatality in 1973, until 31.12.2012. No fatalities have occurred after 1997.

The fatal accident in 1997 occurred while the Norne FPSO was in the commissioning phase, prior to start-up of production operations. Personnel were being shuttled on a daily basis between shore and the FPSO on location, due to limited accommodation capacity onboard. Shuttling of personnel on such a scale was criticized after the accident, and has not been practiced since then. There has been a significant focus from the authorities to limit as far as possible the use of shuttling.

Reference

PSA (2012) Trends is risk levels, Main report 2011 (In Norwegian only), Petroleum Safety Authority; 24 April 2012

Appendix C
Network Resources

An overview of network resources that may be used for offshore risk assessment is presented, including data sources, investigation organisations and some recent investigation reports.

C.1 Data Sources

An overview of data sources is presented in Sect. 14.9. The following is an overview of the network accessible resources:

- All types of events
  - Oil and gas producers—http://www.ogp.org.uk/
  - RNNP—http://www.ptil.no/rnnp
  - Hazards Intelligence (HInt)—http://www.saunalahti.fi/ility/
- HC leaks
  - RNNP—http://www.ptil.no/rnnp
  - HCR database—https://www.hse.gov.uk/hcr3/
- Structural and marine accidents
  - WOAD—http://woad.dnv.com/
  - IMCA—http://www.imca-int.com/
- Reliability of safety systems etc
  - OREDA—http://www.oreda.com/
  - PDS Forum—http://www.sintef.no/PDS

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C.2 Investigation Bodies

The following is an overview of investigation boards and organisations for offshore and helicopter transportation accidents on a worldwide scale:

- Air Accidents Investigation Branch—www.aaib.gov.uk
- Transportation Safety Board (Canada)—www.tsb.gc.ca
- NTSB—National Transportation Safety Board (US)—www.ntsb.com
- US Chemical Safety Board (CSB)—www.csb.gov
- Bureau of Safety and Environmental Enforcement—www.bsee.gov
- PSA—Petroleum Safety Authority (Norway)—www.ptil.no
- Accident Investigation Board Norway (Statens havarikommisjon for transport)—www.aibn.no
- Health & Safety Laboratory—www.hsl.gov.uk
- National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA, Australia)—www.nopsema.gov.au
- Canada-Nova Scotia Offshore Petroleum Board (CNSOPB, Canada)—www.cnsopb.ns.ca
- Danish Maritime Authority, Division for Investigation of Marine Accidents (Denmark)—www.dma.dk

C.3 Investigation Reports

The following is an overview of some recent investigation reports for offshore and helicopter transportation accidents on a worldwide scale:

- Roncador P-36 accident (Petrobras), 2001—https://www.dpc.mar.mil.br/cipanave/rel_acidentes/P36/P36_ing.pdf
- Texas City fire and explosion accident (BP), 2005—www.bp.com/bakerpanelrerpot
- Usumacinta blowout (Pemex), 2007—http://www.pemex.com/files/content/usumacinta/informe_battelle.pdf
- Cougar helicopter crash (New Foundland), 2009—http://www.tsb.gc.ca/eng/rapports-reports/aviation/2009/a09a0016/a09a0016.pdf
- Helicopter ditching in North Sea (UK), 2009—http://www.aaib.gov.uk/cms_resources.cfm?file=/AAR%201-2011%20Eurocopter%20EC225%20LP%20Super%20Puma,%20G-REDU%2010-11.pdf
- Helicopter crash in North Sea (UK), 2009—http://www.aaib.gov.uk/cms_resources.cfm?file=/2-2011%20G-REDL.pdf

- Macondo burning blowout (BP), 2010—http://www.oilspillcommission.gov/chief-counsels-report, http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/gom_response/STAGING/local_assets/downloads_pdfs/Deepwater_Horizon_Accident_Investigation_Report.pdf, http://www.oilspillcommission.gov/final-report, http://ccrm.berkeley.edu/pdfs_papers/bea_pdfs/DHSG_ThirdProgressReportFinal.pdf, http://www.deepwater.com/_filelib/FileCabinet/pdfs/00_TRANSOCEAN_Vol_1.pdf, http://www.deepwater.com/_filelib/FileCabinet/pdfs/12_TRANSOCEAN_Vol_2.pdf
- Montara blowout (PTTEP, Australasia), 2009—https://www.dpc.mar.mil.br/cipanave/rel_acidentes/P36/P36_ing.pdf

Glossary

The following definitions are coordinated with NORSOK Z-013 (which reflects ISO terminology (ISO/IEC Guide 73:2002 and ISO31000:2009) where relevant, except that 'risk tolerance criteria' replaces 'risk acceptance criteria', in accordance with what is used internationally.

Accidental Event (AE)	Event or a chain of events that may cause loss of life or damage to health, assets or the environment.
Accidental Effect	The result of an accidental event, expressed as heat flux, impact force or energy, acceleration, etc. which is the basis for the safety evaluation.
Acute release	The abrupt or sudden release in the form of a discharge, emission or exposure, usually due to incidents or accidents.
Area exposed by the accidental event (AEAE)	Area(s) on the facility (or its surroundings) exposed by the accidental event.
Area risk	Risk personnel located in an area is exposed to during a defined period of time.
As Low as Reasonably Practicable (ALARP)	ALARP expresses that the risk shall be reduced to a level that is as low as reasonably practicable.
Average individual risk (AIR)	Risk an average individual is exposed to during a defined period of time.
Barrier element	Physical, technical or operational component in a barrier system.
Barrier function	Function planned to prevent, control, or mitigate undesired or accidental events.

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Barrier (or risk) influencing factor	Conditions that influence on the performance of barrier systems.
Barrier system	System designed and implemented to perform one or more barrier function.
BLEVE	Boiling Liquid Expanding Vapour Explosion, is defined as rupture of a hydrocarbon containing vessel due to being heated by fire loads.
Causal analysis	The process of determining potential combinations of circumstances leading to a top event.
Consequence	Outcome of and event.
Consequence evaluation	Assessment of physical effects due to accidents, such as fire and explosion loads.
Contingency planning	Planning provision of facilities, training and drilling for the handling of emergency conditions, including the actual institution of emergency actions.
Control (of hazards)	Limiting the extent and/or duration of a hazardous event to prevent escalation.
Cost/benefit evaluation	Quantitative assessment and comparison of costs and benefits. In the present context often related to safety measures or environmental protection measures where the benefits are reduced safety or environmental hazard.
Chronic release	The continuous or ongoing release in the form of a discharge, emission or exposure.
Defined situations of hazard and accident (DSHA)	Selection of hazardous and accidental events that will be used for the dimensioning of the emergency preparedness for the activity.
Design Accidental Event	Accidental events that serve as the basis for layout, dimensioning and use of installations and the activity at large, in order to meet the defined risk tolerance criteria.
Design Accidental Load	Chosen accidental load that is to be used as the basis for design.
Dimensioning Accidental Event (DAE)	Accidental events that serve as the basis for layout, dimensioning and use of installations and the activity at large.

Dimensioning accidental load (DAL)	Most severe accidental load that the function or system shall be able to withstand during a required period of time, in order to meet the defined risk tolerance criteria.
Emergency Preparedness	Technical, operational and organisational measures, including necessary equipment that are planned to be used under the management of the emergency organisation in case hazardous or accidental situations occur, in order to protect human and environmental resources and assets.
Emergency preparedness analysis (EPA)	Analysis which includes establishment of DSHA, including major DAEs, establishment of emergency response strategies and performance requirements for emergency preparedness and identification of emergency preparedness measure, including environmental emergency and response measures.
Emergency preparedness assessment	Overall process of performing a emergency preparedness assessment including: establishment of the context, performance of the EPA, identification and evaluation of measures and solutions and to recommend strategies and final performance requirements, and to assure that the communication and consultations and monitoring and review activities, performed prior to, during and after the analysis has been executed, are suitable and appropriate with respect to achieving the goals for the assessment.
Emergency preparedness organisation	Organisation which is planned, established and trained in order to handle occurrences of hazardous or accidental situations.
Emergency preparedness philosophy	Overall guidelines and principles for establishment of emergency response based on the operator vision, goals, values and principles.
Emergency response	Action taken by personnel, on or off the installation, to control or mitigate a hazardous event or initiate and execute abandonment.
Emergency response strategy	Specific description of emergency response actions for each DSHA.
Environment	Surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans and their interrelation.

Environmental impact	Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products or services.
Environmental resource	Includes a stock or a habitat, defined as:. Stock: A group of individuals of a stock present in a defined geographical area in a defined period of time. Alternatively: The sum of individuals within a species which are reproductively isolated within a defined geographical area. Habitat: A limited area where several species are present and interact. Example: a beach.
Environment Safety	Safety relating to protection of the environment from accidental spills which may cause damage.
Escalation	Escalation has occurred when the area exposed by the accidental event (AEAE) covers more than one fire area or more than one main area.
Escalation factor	Conditions that lead to increased risk due to loss of control, mitigation or recovery capabilities.
Escape	Actions by personnel on board surface installations (as well as those by divers) taken to avoid the area of accident origin and accident consequences to reach an area where they may remain in shelter.
Escape way	Routes of specially designated gangways from the platform, leading from hazardous areas to muster areas, lifeboat stations, or shelter area.
Escape route	Route from an intermittently manned or permanently manned area of a facility leading to safe area(s).
Establishment of emergency preparedness	Systematic process which involves selection and planning of suitable emergency preparedness measures on the basis of risk and emergency preparedness analysis.
Essential safety system	System which has a major role in the control and mitigation of accidents and in any subsequent EER activities.
Evacuation	Planned method of leaving the facility in an emergency.

Event tree analysis	Inductive analysis in order to determine alternative potential scenarios arising from a particular hazardous event. It may be used quantitatively to determine the probability or frequency of different consequences arising from the hazardous event.
Explosion load	Time dependent pressure or drag forces generated by violent combustion of a flammable atmosphere.
External escalation	When the area exposed by the accidental event (AEAE) covers more than one main area, external escalation has occurred.
Facility	Offshore or onshore petroleum installation, facility or plant for production of oil and gas.
Fault Tree Analysis	Deductive quantitative analysis technique in order to identify the causes of failures and accidents and quantify the probability of these.
Fire area	Area separated from other areas on the facility, either by physical barriers (fire/blast partition) or distance, which will prevent a dimensioning fire to escalate.
Functional requirements to safety and emergency preparedness	Verifiable requirements to the effectiveness of safety and emergency preparedness measures which shall ensure that safety objectives, risk tolerance criteria, authority minimum requirements, and established norms are satisfied during design and operation.
Group individual risk (GIR)	Average IR for a defined group.
Hazard	Potential source of harm.
Hazardous event	Incident which occurs when a hazard is realized.
Immediate vicinity of the scene of accident	Main area(s) where an accidental event (AE) has its origin.
Individual risk (IR)	Risk an individual is exposed to during a defined period of time.
Inherently safer design	In inherently safer design, the following concepts are used to reduce risk: • reduction, e.g. reducing the hazardous inventories or the frequency or duration of exposure; • substitution, e.g. substituting hazardous materials with less hazardous ones (but recognizing that there could be some trade-offs here between plant safety and the wider product and lifecycle issues);

	• attenuation, e.g. using the hazardous materials or processes in a way that limits their hazard potential, such as segregating the process plant into smaller sections using ESD valves, processing at lower temperature or pressure; • simplifications, e.g. making the plant and process simpler to design, build and operate, hence less prone to equipment, control and human failure.
Internal control	All administrative measures which are implemented to ensure that the work is in accordance with all requirements and specifications.
Internal escalation	When the area exposed by the accidental event (AEAE) covers more than one fire area within the same main area, internal escalation has occurred.
Main area	Defined part of the facility with a specific functionality and/or level of risk.
Main load bearing structures	Structure, which when it loses its main load carrying capacity, may result in a collapse or loss of either the main structure of the installation or the main support frames for the deck.
Main safety function	Most important safety functions that need to be intact in order to ensure the safety for personnel and/or to limit pollution.
Major accident	Acute occurrence of an event such as a major emission, fire, or explosion, which immediately or delayed, leads to serious consequences to human health and/or fatalities and/or environmental damage and/or larger economical losses.
Material Damage Safety	Safety of the installation, its structure, and equipment relating to accidental consequences in terms of production delay and reconstruction of equipment and structures.
Mitigation	Limitation of any negative consequence of a particular event.
MOB-boat	Man Over Board Boat.
Muster Station	A place where personnel may gather in a Safe Haven prior to evacuation or abandonment from emergency situations.

Muster area	Area on the platform where the personnel may be sheltered from accidental conditions until they embark into the lifeboats.
Normalisation	The normalisation phase starts when the development of a situation of hazard or accident has stopped.
Occupational Accidents	Accidents relating to hazards that are associated with the work places (falls, slips, crushing etc.), thus other hazards than hydrocarbon gas or oil under pressure. These accidents are normally related to a single individual.
Performance requirements for safety and emergency preparedness	Requirements to the performance of safety and emergency preparedness measures which ensure that safety objectives, RAC, authority minimum requirements and established norms are satisfied during design and operation.
Personnel Safety	Safety for all personnel involved in the operation of a field.
Probability	Extent to which an event is likely to occur.
Recovery time	Time from an accidental event causing environmental damage occurs until the biological features have recovered to a pre-spill state or to a new stable state taking into consideration natural ecological variations, and are providing ecosystem services comparable to the pre-spill services.
Reliability Analysis	Analysis of causes and conditions of failure, inspection, maintenance and repair, and the quantitative assessment of up-times and down-times.
Residual Accidental Event	Accidental event which the installation is not designed against, therefore it will be part of the risk level for the installation.
Residual risk	Risk remaining after risk treatment.
Risk	Combination of the probability of occurrence of harm and the severity of that harm.
Risk acceptance	Decision to accept a risk.
Risk analysis	Structured use of available information to identify hazards and to describe risk.

Risk assessment	Overall process of performing a risk assessment including: Establishment of the context, performance of the risk analysis, risk evaluation, and to assure that the communication and consultations, monitoring and review activities, performed prior to, during and after the analysis has been executed, are suitable and appropriate with respect to achieving the goals for the assessment.
Risk avoidance	Decision not to become involved in, or action to withdraw from, a risk situation.
Risk control	Actions implementing risk management decisions.
Risk evaluation	Judgement, on the basis of risk analysis and RAC, of whether a risk is tolerable or not.
Risk identification	Process to find, list and characterise elements of risk.
Risk management	Coordinated activities to direct and control an organisation with regard to risk.
Risk management system	Set of elements of an organisation's management system concerned with managing risk.
Risk perception	Way in which a stakeholder views a risk, based on a set of values or concerns.
Risk picture	Synthesis of the risk assessment, with the intention to provide useful and understandable information to relevant decision makers.
Risk reduction	Actions taken to lessen the probability, negative consequences, or both, associated with a risk.
Risk tolerance criteria (RAC)	Criteria that are used to express a risk level that is considered as the upper limit for the activity in question to be tolerable.
Risk transfer	Sharing with another party the burden of loss or benefit of gain, for a risk.
Risk treatment	Process of selection and implementation of measures to modify risk.
Rooms of significance to combating accidental events	CCR and other equivalent room(s) that are essential for safe shutdown, blowdown and emergency response.

Safe area(s)	Area(s) which, depending on each specific defined situation of hazard and accident (DSHA), are defined as safe until the personnel are evacuated or the situation is normalized.
Safety barrier	Physical or non-physical means planned to prevent, control, or mitigate undesired events or accidents.
Safety function	Measures which reduce the probability of a situation of hazard and accident occurring, or which limit the consequences of an accident.
Safety Goals	Concrete targets against which the operations of installations at the field are measured with respect to safety. These targets shall contribute to avoidance of accidents or resistance against accidental consequences.
Safety objective	Objective for the safety of personnel, environment and assets towards which the management of the activity will be aimed.
Serious Accidents	See major accidents.
Shelter Area	An area on the platform where the crew will remain safe for a specific period of time in an emergency situation.
Stakeholder	Any individual, group or organization that can affect, be affected by, or perceive itself to be affected by, a risk.
System	Common expression for installation(s), plant(s), system(s), activity/activities, operation(s) and/or phase(s) subjected to the risk and/or emergency preparedness assessment.
System basis	Inputs (regarding the system subjected to assessment) used as basis for the assessment.
System boundaries	System boundaries defines what shall and what shall not be subjected to the assessment.
Working Accidents	Accidents relating to other hazards than hydrocarbon gas or oil under pressure (falls, crushing etc.) normally related to a single individual.
Worst case consequence	The worst possible HSE consequences resulting from a hazardous event. For this to occur, all critical defences in place must have failed.

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