Helikoptersikkerhetsstudie 3

Helicopter Safety Study 3

Vedlegg /Appendices

SINTEF RAPPORT

SINTEF Teknologi og samfunn
Sikkerhet

Postadresse: 7465 Trondheim
Besøksadresse: S P Andersens veg 5
7031 Trondheim
Telefon: 73 59 03 00
Telefaks: 73 59 28 96

Foretaksregisteret: NO 948 007 029 MVA

TITTEL

Helikoptersikkerhetsstudie 3 (HSS-3)
Helicopter Safety Study 3 (HSS-3)

VEDLEGGSRAPPORT

FORFATTER(E)

Ivonne A. Herrera, Solfrid Håbrekke, Tony Kråkenes, Per R. Hokstad

OPPDRAGSGIVER(E)

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SAMMENDRAG

Hovedmålsettingen med Helikoptersikkerhetsstudie 3 (HSS-3) er å bidra til økt sikkerhet ved personelltransport med helikopter til, fra og mellom faste og flyttbare olje- og gassinnretninger på den norske kontinentalsokkelen. Prosjektet er en oppfølger av de to foregående helikopterstudiene *Helicopter Safety Study* (HSS-1) og *Helicopter Safety Study 2* (HSS-2). Disse foreligger på engelsk. HSS-3 er rapportert på norsk, med engelsk sammendrag. Hovedrapporten beskriver en metodikk for kvantifisering av risikoen, utviklingstrekk for periodene 1999–2009 og 2010–2019, samt statistiske/historiske data og estimater for risikonivå. Dessuten gis det en beskrivelse av hvordan et utvalg av passasjerer opplever risikoen ved å bli transportert i helikopter, og det gis forslag til hvordan sikkerheten kan følges opp ved hjelp av reaktive og proaktive indikatorer. Til slutt gis det anbefalinger i form av en rekke forslag til tiltak for hvordan sikkerheten kan forbedres eller i det minste opprettholdes. Vedleggsrapporten inneholder underlagsmaterialet for studien.

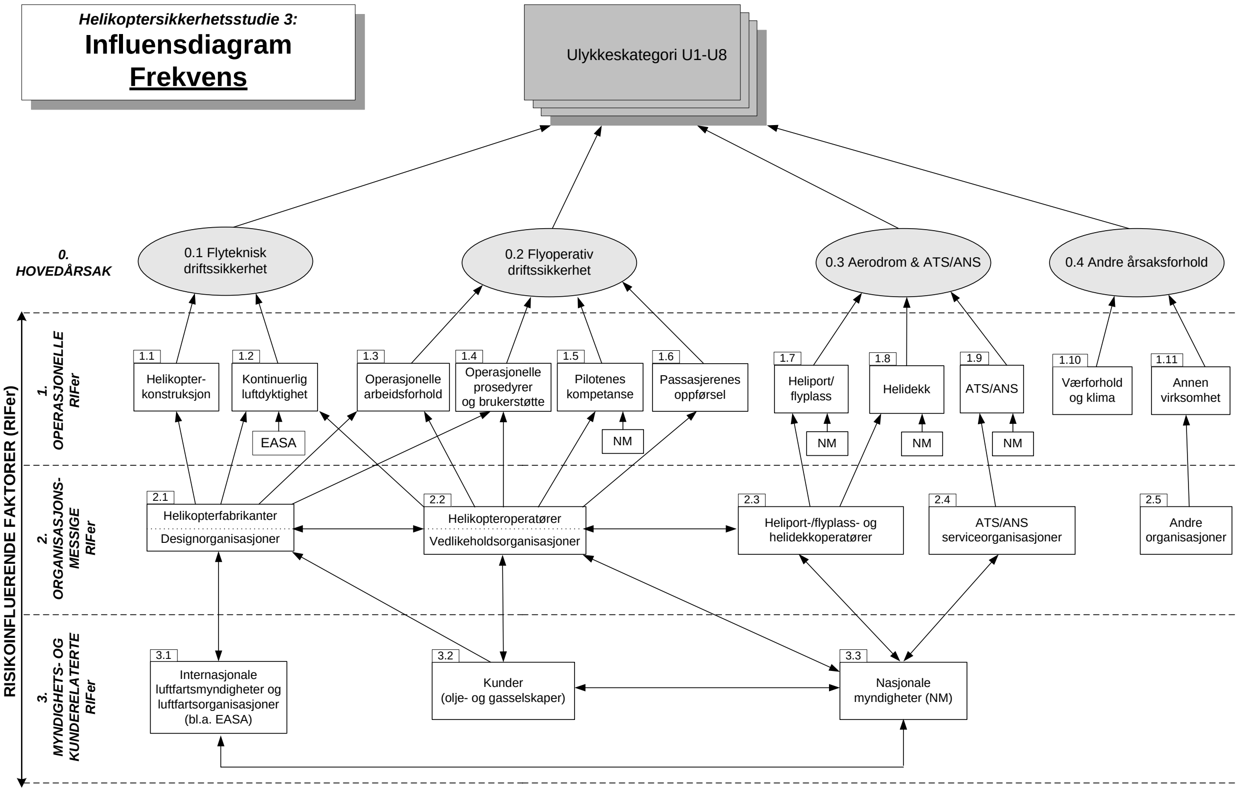
The overall objective of the Helicopter Safety Study 3 (HSS-3) is to contribute to improved safety in helicopter transport of personnel to, and from, fixed and floating oil- and gas installations on the Norwegian Continental Shelf (NCS). The study is a follow-up of the previous studies Helicopter Safety Study (HSS-1) and Helicopter Safety Study 2 (HSS-2). The present (HSS-3) report is in Norwegian language with an English executive summary.

STIKKORD	NORSK	STIKKORD
GRUPPE 1	Sikkerhet	Safety
GRUPPE 2	Helikopter	Helicopter
EGENVALGTE	Helikoptersikkerhet	Helicopter safety
	Flysikkerhet	Flight safety
	Risikonivå	Risk level
	Resiliens	Resilience

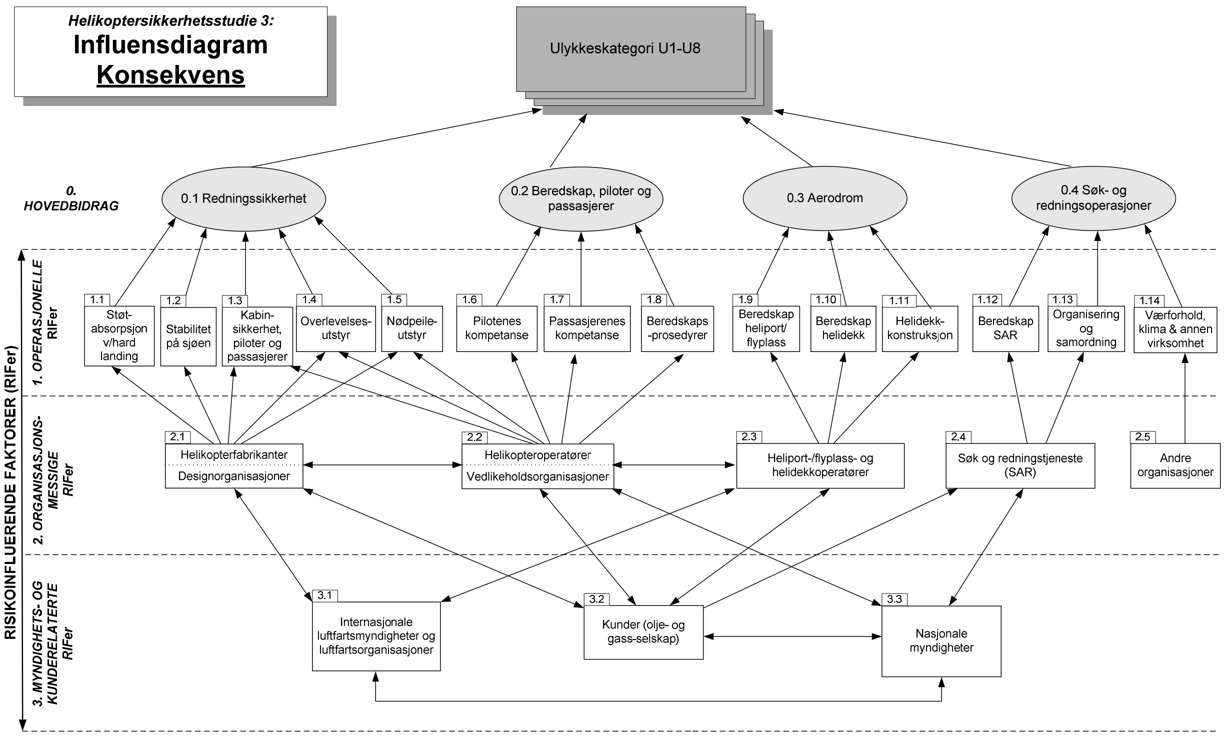
INNHOLDSFORTEGNELSE

1 INFLUENSDIAGRAM

Under vises norske versjoner av influensdiagram for hhv. frekvens og konsekvens. Se beskrivelse av RIFer i kapittel 2.

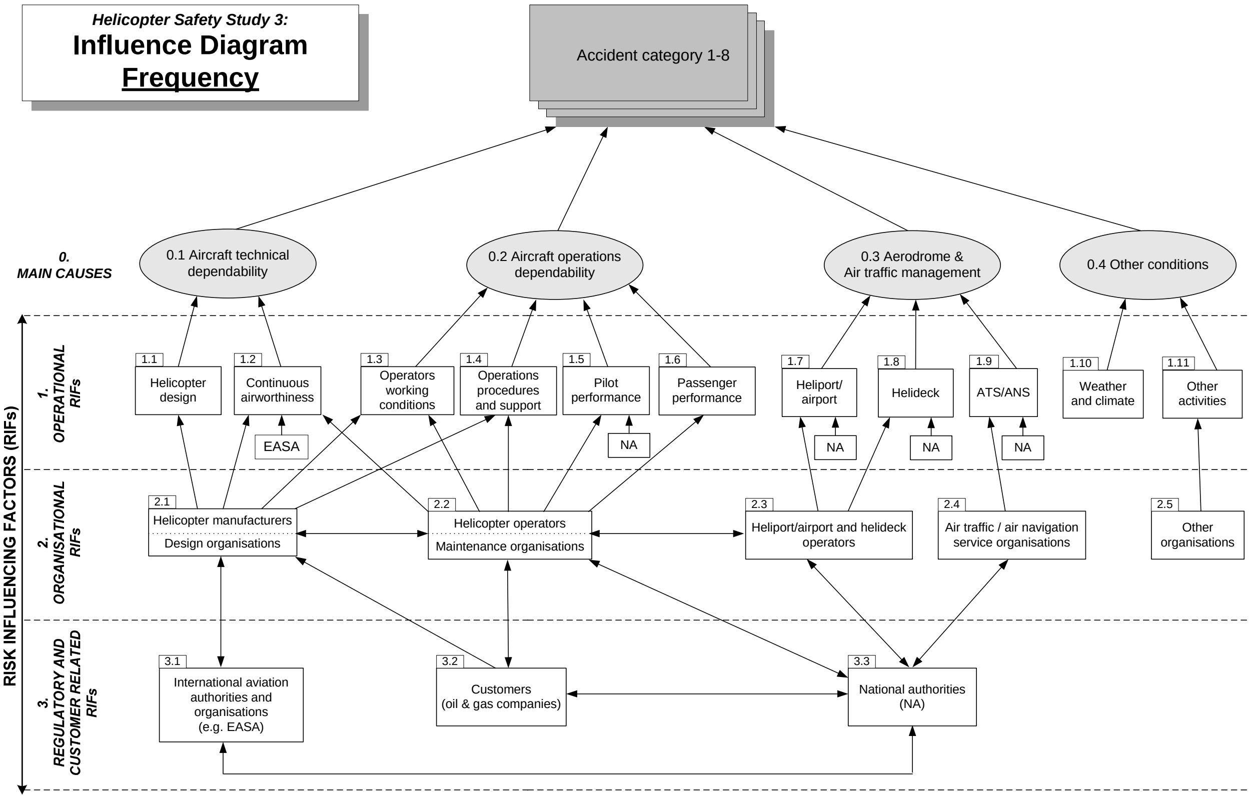


Figur 1.1 Influensdiagram frekvens.

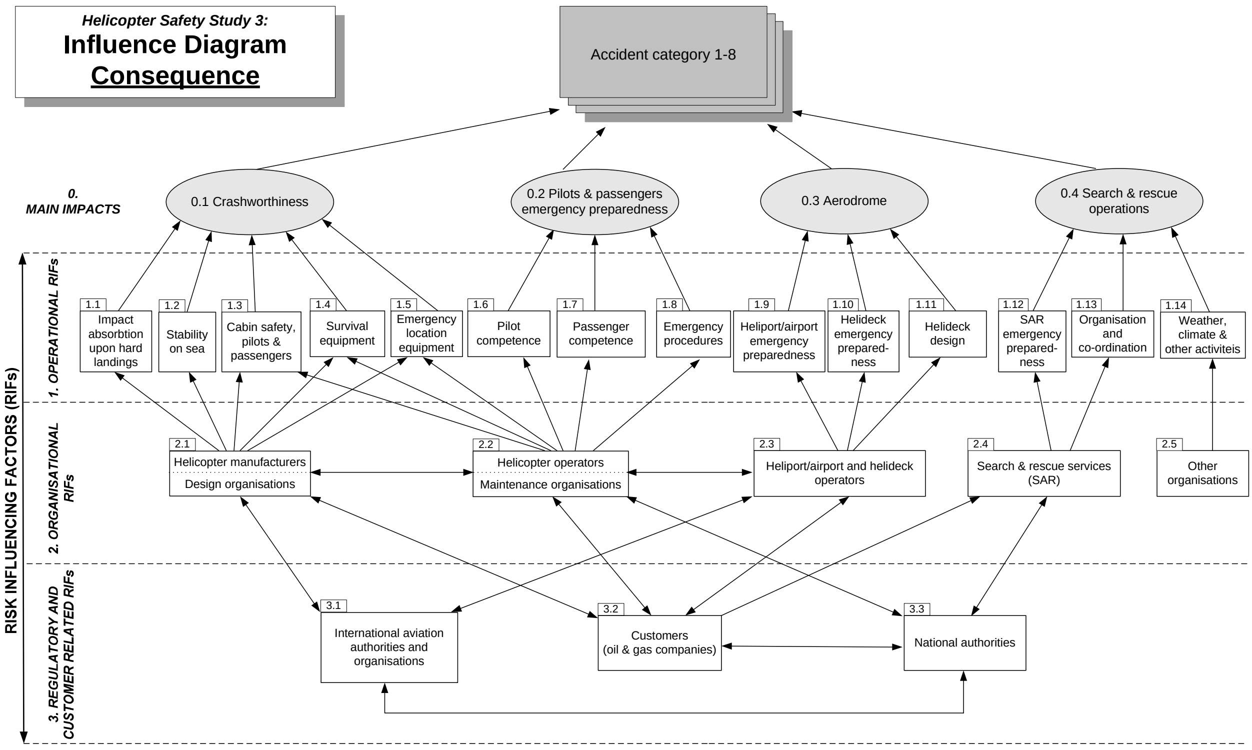


Figur 1.2 Influensdiagram konsekvens.

Under vises engelske versjoner av influensdiagram for hhv. frekvens og konsekvens. Se beskrivelse av RIFer i kapittel 2.



Figur 1.3 Influence diagram frequency.



Figur 1.4 Influence diagram consequence**.**

2 DEFINITIONS AND DESCRIPTIONS OF RIFS FOR FREQUENCY

Level 0 – Main causes
The main causes for the frequency of helicopter accidents are:

F 0.1 Aircraft technical dependability
(Flyteknisk driftssikkerhet)

F 0.2 Aircraft operations dependability
(Flyoperativ driftssikkerhet)

F 0.3 Aerodrome & Air traffic management
(Aerodrom og ATS/ANS)

F 0.4 Other conditions
(Andre årsaksforhold)

The four main causes are *not* RIFs, they represent a *grouping* of the operational RIFs on level 1.

Level 1 – Operational RIFs
Level 1 – Operational RIFs comprises the risk influencing conditions related to ongoing daily activities necessary to provide safe and efficient offshore helicopter *transport* on a day to day basis. The activities include conditions concerning aircraft technical dependability, state of aircraft operational dependability and provision of necessary external services.

There are 11 operational RIFs for frequency, described in detail below.

F 1.1 Helicopter design

<table>
<tr><td>Risk factor:
F 1.1</td><td colspan="2">**HELICOPTER DESIGN
(HELIKOPTERKONSTRUKSJON)**</td><td>Effect on:
Frequency</td></tr>
<tr><td>Definition</td><td colspan="3">*The suitability, quality and reliability of the aircraft design and equipment delivered from the manufacturer necessary for performing the intended operations at a defined/intended level of safety. Includes major repairs and modifications.*</td></tr>
<tr><td>Description</td><td colspan="3">The manufacturer's (type certificate holder's) contribution to *Design*:
• Aircraft airframe and systems reliability and quality with regards to type of operation for the individual aircraft. E.g. transmission reliability, damage tolerance in engine installations, flight controls and rotor systems, commonality of wires and connectors, avionics and communication systems.
• Quality of spare parts, material and maintenance documentation deliver to customers and quality of major design and modifications for individual aircraft

Note 1. User-friendliness of cockpit design and other elements pertaining to ergonomic design physical work environment are considered as part of RIF *1.3 Operations Working Conditions*.

Note 2: Aircraft Flight Manual and other operations documentation issued by the manufacturer are considered as part of RIF *1.4 Operations procedures*.

Note 3: Consequence reducing factors such as crashworthiness and emergency equipment are not considered as part of *Design* when categorising frequency influencing factors.

Note 4: Maintenance and repair is comprised by RIF 1.2, including maintenance procedures, working conditions etc.</td></tr>
<tr><td>Effects on other RIFs</td><td colspan="3"></td></tr>
<tr><td>Comments</td><td colspan="3"></td></tr>
<tr><td colspan="2"></td><td>Last update:</td><td>2009-04-03</td></tr>
</table>

F 1.2 Continuous Airworthiness

Risk factor: **F 1.2**	**CONTINUOUS AIRWORTHINESS (KONTINUERLIG LUFTDYKTIGHET)**	Effect on: Frequency
Definition	*The aircraft operator's and maintenance facility contribution to continuous airworthiness by maintaining and modify its aircraft fleet to a defined/intended airworthiness standard. Either by establishing its own maintenance organisation, or by contracting out maintenance and inspection to an approved maintenance organisation.*	
Description	The RIF comprises a) QUALITY OF SCHEDULED MAINTENANCE, e.g. activities related to tasks specified on maintenance program and maintenance manuals b) QUALITY OF UNSCHEDULED MAINTENANCE, e.g. organisation support for aircraft on ground (AOG) and access to spare parts and materials c) QUALITY OF GROUND INSPECTIONS BEFORE TAKE-OFF And .1 WORKING CONDITIONS (cf. RIF 1.3): Health and safety regulations (HMS), human factors in aircraft maintenance, working schedules etc. .2 PROCEDURES (cf. RIF 1.4): Maintenance Organisation Exposition (MOE), QA, follow-up of new regulations etc. .3 PERSONNEL PERFORMANCE/COMPETENCE (cf. RIF 1.5): Licensing of engineering staff, recurrent training etc.	
Effects on other RIFs		
Comments	By *maintenance* is here meant *any one or combination of overhaul, repair, inspection, replacement, modification or defect rectification of an aircraft or component, with the exception of pre-flight inspection.* (EASA Reg 2042/2003)	
	Last update:	2009-04-03

F 1.3 Operators working conditions

Risk factor: **F 1.3**	**OPERATORS WORKING CONDITIONS (OPERASJONELLE ARBEIDSFORHOLD)**		Effect on: Frequency
Definition	*The crew's ability to perform its assigned duties/operations (at an intended level of safety)*		
Description	The RIF comprises: .1 HELICOPTER PERFORMANCE: i.e. suitability, manoeuvring, etc. .2 PHYSICAL WORKING CONDITIONS: e.g. ergonomics, man-machine interface, temperature, noise vibrations .3 ORGANISATIONAL WORKING CONDITIONS: i.e. factors that influence the operational crew's ability to perform assign duties; such as working schedules, access to necessary equipment, resting shelters, clothing, etc.		
Effects on other RIFs	Influences the pilot performance (RIF 1.5)		
Comments			
		Last update:	2009-04-03

F 1.4 Operations procedures and support

Risk factor: **F 1.4**	**OPERATIONS PROCEDURES AND SUPPORT (OPERASJONELLE PROSEDYRER OG BRUKERSTØTTE)**		Effect on: Frequency
Definition	*Flight operations procedures that cover all aspects of flying an aircraft. (Other than maintenance and inspection procedures as part of RIF 1.2)*		
Description	The quality, updating of, access to and user-friendliness of the Operations Manual (ref. BSL JAR OPS 3.1045, Part A and Part B), including • Helicopter Flight Manual • Operational Flight Plan • Jeppesen's Manual • Checklists • Standard Operating Procedures		
Effects on other RIFs			
Comments			
		Last update:	2009-04-03

F 1.5 Pilot performance

Risk factor: **F 1.5**	**PILOT PERFORMANCE (PILOTENES KOMPETANSE)**	Effect on: Frequency
Definition	*Factors affecting the performance of flight crew.*	
Description	This RIF comprises: • Competence (incl. knowledge, skills, experience, training) • Attitudes (incl. motivation) • Individual psychological factors (e.g. stress tolerance, emotional state) • Individual physiological factors (e.g. fatigue, hunger, thirst discomfort) Note: Factors affecting this risk factor are e.g. selection and training (covered by RIF 2.2 Helicopter operators), work environment (covered by RIF 1.3 Operators working conditions) and operational procedures (RIF 1.4)	
Effects on other RIFs		
Comments		
	Last update:	2009-04-03

F 1.6 Passenger performance

Risk factor: **F 1.6**	**PASSENGER PERFORMANCE (PASSASJERENES OPPFØRSEL)**	Effect on: Frequency
Definition	*Performance of the passengers on the aircraft, both during flight, embarking, disembarking.*	
Description	The passenger's ability and willingness to adhere to procedures and norms for safe performance. Examples where passengers influence the risk of an accidents: • Passengers bringing personal belongings onto heliport/helideck that are loose. • Passengers open/close helicopter doors • Passengers walking near the tail rotor	
Effects on other RIFs		
Comments		
	Last update:	2009-04-01

F 1.7 Heliport/airport

Risk factor: **F 1.7**	**HELIPORT/AIRPORT (HELIPORT/FLYPLASS)**	Effect on: Frequency
Definition	*The characteristics of the heliport/airport location, layout, personnel performance, quality of procedures etc. while the aircraft is operating on or near the heliport/airport.*	
Description	The RIF comprises: .1 HELIPORT/AIRPORT OPERATING WORKING CONDITIONS, for heliport/airport personnel assisting during landing and take-off/landing (e.g. refuelling personnel) .2 QUALITY OF HELIPORT/AIRPORT OPERATING PROCEDURES .3 HELIPORT/AIRPORT PERSONNEL PERFORMANCE: The competence, skill and availability of personnel assisting during landing and take-off, incl. communication with helicopter crew. .4 HELIPORT/AIRPORT DESIGN, with respect to size, layout, lighting, marking .5 HELIPORT/AIRPORT LOCATION, in relation access, airflow, turbulence, obstacles and inference from other (ground) traffic Note 1: The competence, skill and availability of personnel performing inspections on heliport/airport, is covered by RIF 1.2 Continuous airworthiness. Note 2: Air Traffic control activities are covered by RIF 1.9 ATS/ANS.	
Effects on other RIFs		
Comments		
	Last update:	2009-04-27

F 1.8 Helideck

Risk factor: **F 1.8**	**HELIDECK (HELIDEKK)**		Effect on: Frequency
Definition	*The characteristics of the helideck location, layout, equipment, personnel performance etc. while the aircraft is operating on or near the helideck.*		
Description	The RIF comprises: .1. HELIDECK DESIGN, with respect to size, layout, access, railing, lighting, marking and mooring including, helideck location in relation to access, airflow, turbulence, exhaust and obstacles .2 HELIDECK OPERATING WORKING CONDITIONS, for helideck personnel assisting during take-off/landing (e.g. HLO and HFIS personnel) .3 QUALITY OF HELIDECK OPERATING PROCEDURES, e.g. housekeeping .4 HELIDECK PERSONNEL PERFORMANCE: The competence, skill and availability of personnel assisting during landing and take-off, incl. communication with helicopter crew and in relation to aeronautical weather information. .5 TYPE OF INSTALLATION, moving or stationary, i.e. helideck motion		
Effects on other RIFs			
Comments			
		Last update:	2009-04-27

F 1.9 Air traffic/navigation services (ATS/ANS)

Risk factor: **F 1.9**	**ATS/ANS (ATS/ANS)**		Effect on: Frequency
Definition	*The coverage and quality of various air traffic services (e.g. ATS, ATC, ANS, HFIS, NAVAIDS) and meteorological services.*		
Description	The coverage and quality of • Air traffic services (ATS) including air traffic control (ATC) and air navigation service (ANS) and their instruments • Flight information service (HFIS) and their instruments • Navigational Aids (NAVAIDS) • Radio and radar coverage • Meteorological services with respect to the operational needs and the traffic density and types of operations in the area. This RIF also comprises the extent of controlled versus not controlled airspaces. Note: Meteorological information, routine weather observations (METAR) and other information provided by helideck is covered by RIF 1.8 Helidecks.		
Effects on other RIFs			
Comments			
		Last update:	2009-04-27

F 1.10 Weather and climate

Risk factor: **F 1.10**	**WEATHER AND CLIMATE (VÆRFORHOLD OG KLIMA)**	Effect on: Frequency
Definition	*Climate, sea, and meteorological conditions affecting helicopter operation.*	
Description	Some examples are: • Wind, turbulence, snow, ice, waves, rain, lightning, darkness, emissions, salt, deposits, clouds, fog, temperature changes, polar lows Examples of how they may influence operations are: • Clouds, fog, precipitation, and/or darkness complicating navigation • Wind and turbulence hampering operations to and from helidecks • Aircraft performance degraded by ice build up on rotors and airframe • Lightning strikes damaging rotor blades and/or upsetting navigational equipment • High sea state endangering landing on water in an emergency	
Effects on other RIFs	May influence RIF 1.2 Continuous airworthiness, due to: • Increased erosion on rotor blades and engine compressors • Increased possibility of metal fatigue induced by extreme weather operations May influence RIF 1.8 Helidecks, due to: • Wind influences the helideck motion when helideck is located on a moving facility.	
Comments		
	Last update:	2009-04-27

F 1.11 Other activities

Risk factor: **F 1.11**	**OTHER ACTIVITIES** **(ANNEN VIRKSOMHET)**	Effect on: Frequency
Definition	*Surrounding activities, such as other air and sea traffic, that affect the helicopter operation.*	
Description	The relevant actors are: • Other helicopters, other air traffic and military air traffic, sea traffic in nearby area, other nearby rigs, except from the rig for take-off/landing, drones, birds Examples of how they may influence operations are: • Birds causing bird strikes (applicable for unmanned installations) • Increased air traffic increases the risk for mid-air collisions • During an emergency landing, nearby rigs/ships are preferred above landing on sea • Nearby rigs/ships drifting into approach or climb-out areas can be dangerous • Short distances between rigs increases the probability for landing on wrong rig	
Effects on other RIFs		
Comments		
	Last update:	2009-04-27

Level 2 – Organisational RIFs

Level 2 – Organisational RIFs are risk influencing factors related to the organizational basis, support and control of running activities in helicopter *transport*. These factors are related to helicopter manufacturers, helicopter operators, air traffic / air navigation services, heliport/airport and helideck operators and other organisations.

There are 5 RIFs on level 2 for frequency, described below.

F 2.1 Helicopter manufacturers / Design organisations

Risk factor: **F 2.1**	**HELICOPTER MANUFACTURERS / DESIGN ORGANISATIONS (HELIKOPTERFABRIKANTER / DESIGNORGANISASJONER)**	Effect on: Frequency
Definition	*The way the helicopter manufacturers or design organisation plan and carry out their business in general, to the extent that this has a direct or indirect influence on flight safety.*	
Description	This RIF comprises: • the manufacturer's financial situation, general income and market situation (demand for new helicopters) • the manufacturer's workforce, level of competence and experience • the manufacturer's quality policy, management practice and company/safety culture • the manufacturer's quality system • the quality and timeliness of safety related information from the manufacturer to the helicopter operators (and national authorities) • quality of follow up on customers and products	
Effects on other RIFs	The helicopter manufacturers have a direct or indirect influence on the following other RIFs: • F 1.1 Helicopter design • F 1.2 Continuous airworthiness • F 1.3 Operators working conditions • F 1.4 Operations procedures through the Flight Operation Manual • F 3.1 International aviation authorities and organisations	
Comments	A design organisation holds DOA, Design Organisation Approval. Production Organisation holds a Production Organisation Approval. These organisations are responsible for the design of aircraft, aircraft engines, propellers, or related parts and appliances or to build aircraft specific parts (EASA Part 21).	
	Last update:	2010-02-25

F 2.2 Helicopter operators / Maintenance organisations

Risk factor: **F 2.2**	**HELICOPTER OPERATORS / MAINTENANCE ORGANISATIONS (HELIKOPTEROPERATØRER / VEDLIKEHOLDSORGANISASJONER)**	Effect on: Frequency
Definition	*The way the helicopter operators or maintenance approved organisations plan and carry out their business in general, to the extent that this has a direct or indirect influence on flight safety.*	
Description	This RIF comprises: • the operator's financial situation, general income and market situation (demand for transportation services) • the operator's workforce, level of competence and experience • the operator's quality system and safety management system (SMS), ref. EU-OPS 1.035 • the helicopter operator's safety policy (willingness to pay for extra safety) • the operator's accident prevention and flight safety program, ref EU-OPS 1.037 • Flight data monitoring (FDM) programme • the planning and scheduling of flights • the operator's deviation control system • the accepted contractual conditions with the customer (economical compensation, regularity and punctuality requirements, obligation to satisfy customer's immediate needs as opposed to regularly planned flights, long term/short term contract period, penalties)	
Effects on other RIFs	The helicopter operators have a direct influence on the quality of the maintenance of the aircrafts (RIF 1.2), through the adjustments of the maintenance program prescribed by the manufacturer and the implementation of the program. The working conditions will influence on the crew's ability to perform their duties in a safe manner (RIF 1.3). The operations procedures (RIF 1.4) are issued and updated by the operators. The operator is responsible for the selection, training and retraining of the crew and other personnel involved in the operations (RIF 1.5). The passengers are briefed by the helicopter operators (RIF 1.6). There is also some “horizontal” influence from the helicopter operators on the heliport/airport and helideck operators (RIF 2.3). On level 3, the helicopter operators influence the customers (RIF 3.2) and the national authorities (RIF 3.3).	
Comments	This RIF includes Part M continuing airworthiness organisation, Part 145 aeronautical repair station having a maintenance organisation approval and helicopter operators functions related to the operational JAR-OPS-3.	
	Last update:	2010-02-25

F 2.3 Heliport/airport and helideck operators

Risk factor: **F 2.3**	**HELIPORT/AIRPORT AND HELIDECK OPERATORS (HELIPORT-/FLYPLASS- OG HELIDEKKOPERATØRER)**	Effect on: Frequency
Definition	*The way the heliport/airport and helideck operators plan and carry out their tasks in general, to the extent that this has a direct or indirect influence on flight safety.*	
Description	This RIF comprises: • the management having the authority to instruct the personnel • the quality system, including the procedures, information system and other factors having an influence on the safety during landing and take-off	
Effects on other RIFs	This Organisational RIF has a direct influence on Heliport/airport (RIF 1.7) and Helideck (RIF 1.8). There is also some "horizontal" influence from heliport/airport and helideck operators to helicopter operators (RIF 2.2), and to the national authorities (RIF 3.3) on level 3.	
Comments		
	Last update:	2009-03-11

F 2.4 Air traffic/navigation service organisations

Risk factor: **F 2.4**	**AIR TRAFFIC / AIR NAVIGATION SERVICE ORGANISATIONS (ATS/ANS SERVICEORGANISASJONER)**	Effect on: Frequency
Definition	*The way the ATS/ANS service organisations plan and carry out their tasks in general, to the extent that this has a direct or indirect influence on flight safety.*	
Description	This RIF comprises: • Training programs for ATS/ANS personnel • the follow-up of physical working conditions (e.g. ergonomics, man-machine-interface, temperature, light, noise) • the organisational working conditions (e.g. working schedules, work load, access to necessary equipment, resting shelters, clothing • the quality policy, management practice and safety culture/awareness of the ATS/ANS • the quality system, including deviation control of the ATS/ANS	
Effects on other RIFs	This organisational RIF is influencing the coverage and quality of the various meteorological and other air traffic services needed by the helicopter operators (RIF 1.9 ATS/ANS). This RIF also influences the national authorities (RIF 3.3)	
Comments		
	Last update:	2009-03-11

F 2.5 Other organisations

Risk factor: **F 2.5**	**OTHER ORGANISATIONS (ANDRE ORGANISASJONER)**		Effect on: Frequency
Definition	*The way other external organisations etc. plan and carry out tasks that can affect the helicopter operation, to the extent that this has a direct or indirect influence on flight safety.*		
Description	The relevant actors are: • The Air Defence (national and international) carrying out military exercises in the same airspace as helicopter activity takes place • Organisations responsible for ship traffic in areas where helicopters are flying • Organisations responsible for crane activities around heliports/airports • Fixed wing operators		
Effects on other RIFs	This RIF is primarily influencing the status of the surrounding activities (RIF 1.11).		
Comments			
		Last update:	2009-03-11

Level 3 – Regulatory and Customer Related RIFs

Level 3 – Regulatory and customer related RIFs are risk influencing factors related to the requirements and controlling activities by authorities and customers.

There are 5 RIFs on level 3 for frequency, described below.

F 3.1 International aviation authorities and organisations

<table>
<tr><td>Risk factor:
F 3.1</td><td>**INTERNATIONAL AVIATION AUTHORITIES AND ORGANISATIONS (INTERNASJONALE LUFTFARTSMYNDIGHETER OG LUFTFARTSORGANISASJONER)**</td><td>Effect on:
Frequency</td></tr>
<tr><td>Definition</td><td colspan="2">*The influence/effect of international authorities e.g. related to:*
• *safety regulations and design standards*
• *requirements on helicopter design and manufacture, operations and maintenance*
• *certification of aircrafts*
• *airworthiness*
• *licensing of personnel*
• *rules of the air*
• *meteorology and communication services*
• *navigation aids and air traffic control*</td></tr>
<tr><td>Description</td><td colspan="2">The international organisations comprised by this RIF are ICAO and EASA.

<u>1. *ICAO*</u>
The International Civil Aviation Organisation (ICAO) is UN's agency for civil air traffic. The basic objective of ICAO is the development of safe, regular, efficient and economic air transport. ICAO recognises nine geographical regions, and ICAO has seven regional offices to follow up the implementation of the Air Navigation Plans.

One of ICAO's chief activities is standardisation, the establishment of International Standards, Recommended Practices and Procedures covering the technical fields of aviation:
• licensing of personnel
• rules of the air
• aeronautic meteorology
• aeronautic charts
• units of measurements
• operation of aircraft
• nationality and registration marks
• airworthiness
• aeronautical telecommunications
• air traffic services
• search and rescue
• aircraft accident investigation
• aerodromes
• aeronautical information services</td></tr>
</table>

Risk factor: **F 3.1**	**INTERNATIONAL AVIATION AUTHORITIES AND ORGANISATIONS (INTERNASJONALE LUFTFARTSMYNDIGHETER OG LUFTFARTSORGANISASJONER)**	Effect on: Frequency
	• aircraft noise and engine emissions • security and the safe transport of dangerous goods When a Standard is adopted the more than 180 Contracting States of ICAO puts it into effect in its own territories. ICAO is conscious of the need to adopt in its specifications modem systems and techniques. It has undertaken extensive work e.g. in the areas of: • reporting aircraft accidents and incident data • all-weather operations • automation of air traffic services • the application of computers in meteorological services ICAO will perform a unifying influence for the development of a code of international air law. It is a function of ICAO to facilitate the adoption of international air law instruments and to promote their general acceptance. ICAO also produces manuals for the guidance of states in such areas as statistics, air traffic forecasting, airport and air navigation facility tariffs, the economic regulation of air transport. ICAO technical co-operation mission promotes civil aviation in developing countries. Assistance in general has consisted of advising on the organisation of government civil aviation department and on the location and operation of procurement of equipment. Large civil aviation training centres have been created or assisted by ICAO. *2. EASA (EU)* European Aviation Safety Agency (EASA) is an agency of the European Union (EU) which has been given specific regulatory and executive tasks in the field of civilian aviation safety. It was created in 2003 and has now taken over the functions of the JAA (Joint Aviation Authorities). While JAA provided recommendations that were adopted by JAA members, EASA provide harmonised regulations for Europe. EFTA countries have been granted participation in the agency (incl. Norway). The agency's responsibilities include: The main tasks of the Agency currently include: • Rulemaking: drafting aviation safety legislation and providing technical advice to the European Commission and to the Member States; • Inspections, training and standardisation programmes to ensure uniform implementation of European aviation safety legislation in all Member States; • Continuing airworthiness; • Safety and environmental type-certification of aircraft, engines and parts; • Approval of aircraft design organisations world-wide as and of production and maintenance organisations outside the EU; • Approval of modifications	

<table>
<tr><td>Risk factor:
F 3.1</td><td>**INTERNATIONAL AVIATION AUTHORITIES AND ORGANISATIONS (INTERNASJONALE LUFTFARTSMYNDIGHETER OG LUFTFARTSORGANISASJONER)**</td><td colspan="2">Effect on:
Frequency</td></tr>
<tr><td></td><td colspan="3">• Authorization of third-country (non EU) operators;
• Coordination of the European Community programme SAFA (Safety Assessment of Foreign Aircraft) regarding the safety of foreign aircraft using Community airports;
• Data collection, analysis and research to improve aviation safety. European Helicopter Safety Team (EHEST) is an EASA initiative to improve safety.

<u>3. EUROCONTROL</u>
European Organisation for the Safety of Air Navigation (Eurocontrol) is an international organisation, founded in 1963, whose primary objective is to harmonise and integrate air navigation services in Europe, aiming at the creation of a uniform air traffic management (ATM) system for civil and military users, in order to achieve the safe, secure, orderly, expeditious and economic flow of traffic throughout Europe, while minimising adverse environmental impact. This civil organisation currently has 38 member states (incl. Norway).

The goal for EUROCONTROL is to develop, coordinate and plan for implementation of pan-European air traffic management strategies and their associated action plans in an effort involving national authorities, air navigation service providers, civil and military airspace users, airports, industry, professional organisations and relevant European institutions. Its core activities involve all gate-to-gate air navigation service operations: strategic and tactical flow management, controller training, regional control of airspace, safety-proofed technologies and procedures, and collection of air navigation charges.

Eurocontrol have been delegated parts of the Single European Sky regulations by the European Commission. Eurocontrol is responsible for the drafting of related technical regulatory material and runs notably the formal consultation processes. The Safety Regulation Commission (SRC) undertakes Eurocontrol’s work in the field of ATM safety regulation and is responsible for the development of harmonised safety regulatory objectives and requirements, including the Eurocontrol Safety Regulatory Requirements (ESARRs) for the European air traffic management. The SRC advises the Eurocontrol Permanent Commission on all matters relating to the safety regulation of ATM.

ESARRs are incorporated in BSL A 1-9, “Forskrift om bruk av system for sikkerhetssytring innen flysikringstjenesten og bakketjenesten”.
Note: Other international organisations having an impact on helicopter operations are included in this RIF i.e. Federal Aviation Authorities (FAA) responsible for USA rule making i.e. FAR-29 for helicopter, International Helicopter Safety Team (IHST). IATA activities like IOSA audits will be considered.</td></tr>
<tr><td>Effects on other RIFs</td><td colspan="3">This RIF influences the helicopter manufacturers (RIF 2.1) and the national authorities (RIF 3.3).</td></tr>
<tr><td>Comments</td><td colspan="3"></td></tr>
<tr><td></td><td></td><td>Last update:</td><td>2009-04-27</td></tr>
</table>

F 3.2 Customers

Risk factor: **F 3.2**	**CUSTOMERS (KUNDER)**	Effect on: Frequency
Definition	*The way the customers (mainly the oil companies) plan and carry out their business in general, to the extent that this has a direct or indirect influence on flight safety.*	
Description	This RIF comprises: • the customer's financial situation, general income and market situation • the customer's quality and safety policy, management practice and safety culture, included their willingness to pay for extra safety • the contractual conditions imposed on the helicopter operator (economical compensation, regularity and punctuality requirements, obligation to satisfy customer's immediate needs as opposed to regularly planned flights, long term/short term contract period, penalties) • the customer's attention and follow-up on flight safety (flight safety report requirements, quality audits, • safety reviews, corrective action requirements)	
Effects on other RIFs	This RIF influences the helicopter operators (RIF 2.2) and the national authorities (RIF 3.3).	
Comments		
	Last update:	2009-03-26

F 3.3 National authorities

Risk factor: **F 3.3**	**NATIONAL AUTHORITIES (NASJONALE MYNDIGHETER)**	Effect on: Frequency

Definition	*The influence/effect of the (Norwegian) National Authorities by*
	• *issuing and enforcing safety regulations and standards*
	• *being a part of, or co-operating with International authorities and organisations*
	• *approval and survey of helicopter operators, heliport/airport and helideck operators and ATS/ANS organisations*
	• *approval and survey of*
	    o *modifications/repairs performed by operators,*
	    o *human competence*	

Description	Several Norwegian authorities have a influence or effect on different levels: The principal Authority is the Norwegian Civil Aviation Authority (CAA-N) (Norwegian: Luftfartstilsynet LT). The CAA-N oversees aircraft operators, maintenance organisations, production organisations, aviation training schools, aircrafts, licence holders in addition to all private aviation schools, heliports/airports and landing areas on the continental shelf. The overall goal for all civil aviation is to increase safety. This work is also done through an extensive international cooperation with among others the International Civil Aviation Organisation (ICAO) and the European Civil Aviation Conference (ECAC). Other relevant Norwegian Authorities/Institutions are: • The Norwegian Petroleum Directorate (Oljedirektoratet) • The Norwegian Petroleum Safety Authority (Petroleumstilsynet) • Accident Investigation Board Norway (Statens Havarikommisjon for Transport – SHT) • The Norwegian Labour Inspection Authority (Arbeidstilsynet) • The Norwegian Maritime Directorate (Sjøfartsdirektoratet) • The Norwegian Meteorological Institute (Det Norske Meteorologiske Institutt - DNMI)	
Effects on other RIFs	The national authorities are influencing: • *REGULATORY AND CUSTOMER RISK FACTORS* by issuing and enforcing safety regulations and standards (RIF 3.2), and by being part of or co-operating with International authorities and organisations (RIF 3.1) • *ORGANISATIONAL RISK FACTORS* by approval and survey of the Helicopter operators (RIF 2.2), Heliport/airport and helideck operators (RIF 2.3) and *ATS/ANS* organisations (RIF 2.4). • *OPERATIONAL RISK FACTORS* by approval and survey of modifications and repair (RIF 1.2), Pilot performance (RIF 1.5), Heliports/airports (RIF 1.7), Helideck (RIF 1.8) and ATS/ANS (RIF 1.9). The letter also includes weather information, ref. BSL-MET.	

Risk factor: **F 3.3**	**NATIONAL AUTHORITIES (NASJONALE MYNDIGHETER)**	Effect on: Frequency

These points are further elaborated below:

Effect on Regulatory and customer risk factors.
It is the responsibility of each NA to participate in the issuing and enforce national safety regulations and standards within their area of authority that, if complied with, facilitate acceptable risk levels. Drafting for regulation regarding design, production and maintenance are drafting by EASA. The effect of these regulations and standards should be regularly monitored and analysed. Adjustments of the regulations and standards should be made on a proactive basis, rather than as a reactive approach with regard to aircraft safety.

National regulations are usually founded on international standards. Within aviation, Norway is consecutively adopting the EASA regulations. It will be an increasingly important challenge for LT to try to influence on the development of these standards so that they also reflect the special aspects of offshore helicopter transport. Norway and UK have a common interest in this area. It would therefore be beneficial if both countries co-ordinate their work within EASA. Regulations of particular interest would be EASA-CS-29 (certification specifications for rotor aircraft) and JAR-29 (certification specification requirements for Joint Aviation Authorities), EASA Part-M (operator-continuous airworthiness), EASA Part-145 (maintenance organisation approval), EASA Part-66 (Certifying Staff, aircraft maintenance license), Part-147 (training organisation requirement, technical personnel), JAR-OPS 3 (provides rule and advisory material for helicopter flight in expected or actual icing conditions) JAR-OPS is currently transition to EASA regulations (Part-Ops, Part-FCL, flight crew licence), Eurocontrol regulation for air traffic management, airports and industry recommendations for heliport/airport.

Effect on Organisational risk factors
CAA-N is responsible for the approval and survey of the Helicopter Operators. The following approvals are issued to an operator after CAA-N has satisfied itself that the operator meets the applicable regulatory requirements explained above.

Helideck Operators on fixed installations are subject to formal approval and survey. The main responsibility for inputs with regard to safety issues seems, however, to be left to the helicopter operators.

Helideck Operators on floating installations are subject to formal approval and survey. The main responsibility for inputs with regard to safety issues seems, however, to be left to the helicopter operators.

Heliport/airport Operators are subject to formal approval and survey from CAA-N.

Effect on Operational risk factors
The effect on each RIF is treated separately:

RIF 1.2: Continuous airworthiness

<table>
<tr><th>Risk factor:
F 3.3</th><th>NATIONAL AUTHORITIES
(NASJONALE MYNDIGHETER)</th><th>Effect on:
Frequency</th></tr>
<tr><td></td><td colspan="2">The EASA and National Authority's direct contribution to continuous airworthiness by satisfying itself that the following conditions are met both prior to, and subsequent to, the issuance of an approval of a major modification or a major repair:
• The design organisation has the proper qualification to design the modification or repair. (The national equivalent to EASA Part 21 "DOA").
• The design organisation has performed the necessary analysis, calculations, tests, in order to ensure that the design meets the applicable design requirements (EASA CS-29) for its intended function.
• The design organisation has performed the necessary analysis, calculations, tests, in order to ensure that the design does not in any way adversely affect the airworthiness or safe operation of the aircraft in other areas.
• Proper instructions and drawings for parts production and installation/repair work have been made.
• The parts production and installation/repair work is performed by an approved/qualified organisation (Part M and Part 145 or Part 21 "POA", as applicable).
• A revision/addition to the aircraft maintenance program exists, that ensures the continuing airworthiness of the modification/repair.
• The applicable operators report in-service experience to the Authority

In addition, the Authority is responsible for distributing necessary continuous airworthiness information/instructions (Airworthiness Directives) related to the modification/repair to every national operator that has implemented the modification/repair. Furthermore this information must be conveyed to the authorities in other countries which have operators that have implemented the modification repair.

<u>NOTE: It is required to verify differences between EASA-CS-29 and JAR-29. We are not sure that both regulations are equal. This issue needs to be clarified with CAA-N and HO.</u>

<u>RIF 1.5: Pilot performance</u>
The National Authority's direct contribution to ensure that pilots are properly qualified, by satisfying itself that the following conditions are met prior to issuing and renewing a pilot's license/rating:
• The candidate having the theoretical knowledge meeting the requirements for the licence/rating (JAR FCL) *JAR-OPS under transition
• The candidate having the practical skills meeting the requirements for the licence/rating (JAR FCL)
• The candidate meeting the medical requirements for the licence/rating (JAR FCL)
• The candidate has no record of unsolved personal or professional conduct that may affect the confidence in the ability to perform his/her assigned duties.

The National Authority's indirect contribution to ensure that pilots are properly qualified, by reviewing and approving the operator's training system and</td></tr>
</table>

Risk factor: **F 3.3**	**NATIONAL AUTHORITIES (NASJONALE MYNDIGHETER)**	Effect on: Frequency

programs.

<u>NOTE: It is required to verify differences between EASA-CS-29 and JAR-29. We are not sure that both regulations are equal. This issue needs to be clarified with CAA-N and HO.</u>

<u>RIF 1.7: Heliport/airport</u>
The applicable National Authority's direct contribution to heliport/airport safety by:

- Providing heliports/airports, herein design, operating procedures and personnel. Provider: CAA-N
- Approval of heliport/airport design. Authority: CAA-N
- Approval of heliport/airport operating procedures and personnel. Authority: CAA-N

<u>RIF 1.8: Helideck</u>
The applicable National Authority's direct contribution to helideck safety by:

- Approval of helideck design for fixed installations. Authority: OD/CAA-N
- Approval of helideck operating procedures and personnel for helidecks on fixed installations. Authority: OD/CAA-N
- Approval of helideck design for floating installations. Authority: Sdir/CAA-N
- Approval of helideck operating procedures and personnel for helidecks on floating installations. Authority: Sdir/CAA-N

Note: The provider is only mentioned in cases where the organisation at the same time has a function as authority.

<u>RIF 1.9: Air traffic and navigational services (ATS/ANS)</u>
The applicable National Authority's direct contribution to ensure safe navigation, traffic separation, and communications by:

- Providing* Air Traffic Services in accordance with ICAO Annex 2, Annex 11, and additional national regulations. Herein a sufficient number of installations as well as a sufficient number of qualified personnel. Provider: CAA-N.
- Approving ATS installations and personnel. Authority: CAA-N.
- Providing HFIS installations and personnel on heliports/airports. Provider: CAA-N
- Approving HFIS/AFIS installations and personnel on heliports/airports. Authority: CAA-N
- Approving HFIS** installations and personnel on helidecks. Authority: CAA-N
- Providing Air Navigational equipment and services; and Information Services in accordance with ICAO Annex 4, Annex 9, Annex 15, and/or national regulations. Provider: CAA-N.
- Approving Air Navigational equipment and services; and Information Services in accordance with ICAO Annex 4, Annex 9, Annex 15, and/or national regulations. Authority: CAA-N.

Risk factor: **F 3.3**	**NATIONAL AUTHORITIES** **(NASJONALE MYNDIGHETER)**	Effect on: Frequency
	• Providing meteorological services in accordance with ICAO Annex 3 and/or national regulations. Provider: LT/DNMI • Approving the meteorological services. Authority: CAA-N *Note: The provider is only mentioned in cases where the organisation at the same time has a function as authority. **Note: Services on helidecks on floating installations do not meet ordinary HFIS/AFIS requirements, and are currently not subject to any approval. ***NOTE: It is required to verify differences between EASA-CS-29 and JAR-29. We are not sure that both regulations are equal. This issue needs to be clarified with LT and HO. In addition it is required to verify status of BSL D5-1 and BSL-MET*** In addition the national authorities influence the international authorities (RIF 3.1), the helicopter operators (RIF 2.2), the heliport/airport and helideck operators (RIF 2.3) and the ATS/ANS service organisations (RIF 2.3).	
Comments		
	Last update:	2009-04-01

3 DEFINITIONS AND DESCRIPTIONS OF RIFS FOR CONSEQUENCE

Level 0 – Main impacts
The main impacts on the consequence of helicopter accidents are:

C 0.1 Crashworthiness
(Redningssikkerhet)

C 0.2 Pilots & passengers emergency preparedness
(Beredskap, piloter og passasjerer)

C 0.3 Aerodrome
(Aerodrom)

C 0.4 Search & rescue operations
(Søk og redningsoperasjoner)

The four main impacts are *not* RIFs, they represent a *grouping* of the operational RIFs on level 1.

Level 1 – Operational RIFs
Level 1 – Operational RIFs for consequence concern:

- The ability of the heliport/airport or helideck to minimise/prevent further injuries or loss of life of persons that have survived the first impact of a helicopter accident on, or in the close vicinity of a heliport/airport or helideck, and to prevent injuries or loss of life of third persons by:
    1. Reducing the risk of any person being hit by rotors or flying debris immediately after an accident.
    2. Reducing the risk of an aircraft accident jeopardising the safety of third persons in any other way (for example: uncontrolled fires on an offshore helideck).
    3. Efficiently putting out or controlling any fires.
    4. Rescuing trapped or disabled persons from the wreckage or any other life threatening locations.
    5. Rescuing persons from the water.
    6. Give sufficient frrst aid treatment to injured persons as to assure that critical life functions are maintained and injuries are kept under control until the patient receives proper medical care.

- The ability of the heliport/airport or helideck to minimise/prevent further injuries or loss of life of persons that have been injured by a helicopter during normal operations (for instance; first aid to a person that has inadvertently walked into a running tail rotor).

There are 14 operational RIFs for consequence, described in detail below.

C 1.1 Impact absorption upon hard landings

Risk factor: **C 1.1**	**IMPACT ABSORPTION UPON HARD LANDINGS (STØTAPSORPSJON V/HARD LANDING)**	Effect on: Consequence
Definition	*Helicopter design with regard to protection of the occupants against impact trauma injuries and/or injuries from post-crash smoke, toxic fumes and fire after an emergency landing or a crash.*	
Description	Occupant restraint from static loads and protection against exposure to dynamic loads. /FAR §29.561 and § 29.562. (See also RIF 1.2). ***NOTE: It is required to verify differences between EASA-CS-29 and JAR-29. We are not sure that both regulations are equal. This issue needs to be clarified with LT and HO.***	
Effects on other RIFs		
Comments		
	Last update:	2009-03-11

C 1.2 Stability on sea

Risk factor: **C 1.2**	**STABILITY ON SEA (STABILITIET PÅ SJØEN)**	Effect on: Consequence
Definition	*The ability of the helicopter to remain afloat in an upright position for a sufficient duration after ditching on sea in any reasonably probable water conditions (sea states) en route.*	
Description	Helicopter stability on sea, which depends on: • helicopter design • cargo, and flotation equipment.	
Effects on other RIFs		
Comments		
	Last update:	2009-03-11

C 1.3 Cabin safety, pilots & passengers

Risk factor: **C 1.3**	**CABIN SAFETY, PILOTS & PASSENGERS (KABINSIKKERHET, PILOTER OG PASSASJERER)**	Effect on: Consequence
Definition	*Passenger cabin safety in addition to the occupant protection mentioned in RIF 1.1 Impact absorption upon hard landings.*	
Description	Passenger cabin safety as: • the resistance of the cargo holds and cabin interiors against the development of any fire while in the air or during emergency evacuation (fire suppression) • suppression of smoke and toxic fumes while in the air or during emergency evacuation • Facilitation of emergency evacuation both with the helicopter in an upright position, and with a submerged or sinking cabin (passenger briefing cards, markings and placards, escape ways, emergency egress lightning, emergency exits (including sufficient numbers and ease of operation). • facilitation of external assistance of emergency evacuation (markings and placards, operation of emergency exits from the outside)	
Effects on other RIFs		
Comments		
	Last update:	2009-03-11

C 1.4 Survival equipment

Risk factor: **C 1.4**	**SURVIVAL EQUIPMENT (OVERLEVELSESUTSTYR)**	Effect on: Consequence
Definition	*Survival equipment for passengers and crew inside/on helicopter.*	
Description	Adequate equipment/gear to protect crew and pax from: • drowning (survival suits, life wests, dingies, and other floatation equipment) • hypothermia • serious physical deterioration due to injuries, dehydration, or hunger (first aid equipment, emergency food and water rations)	
Effects on other RIFs		
Comments		
	Last update:	2009-03-11

C 1.5 Emergency location equipment

Risk factor: **C 1.5**	**EMERGENCY LOCATION EQUIPMENT (NØDPEILEUTSTYR)**		Effect on: Consequence
Definition	*Emergency location equipment for passengers and crew inside/on helicopter.*		
Description	Adequate equipment/gear to facilitate being detected by rescuers, i.e.: • emergency location transmitters Gettisonable type) on helicopter • emergency radios • flares • lightning on survival suits, life wests, dingies, or other floatation equipment • water dye • brightly coloured survival suits, life wests, dingies, or other floatation equipment • Modified Automatic Dependent Surveillance (M-ADS)		
Effects on other RIFs			
Comments			
		Last update:	2010-02-10

C 1.6 Pilot competence

Risk factor: **C 1.6**	**PILOT COMPETENCE (PILOTENES KOMPETANSE)**		Effect on: Consequence
Definition	*The ability of the crew to help minimise/prevent injuries or loss of life of persons when a helicopter emergency landing is unavoidable, and/or after an accident has occurred.*		
Description	This RIF comprises: • having briefed passengers before take-off (unless pax briefing cards is provided • warning passengers when an emergency landing/accident is imminent • evacuating the helicopter themselves • directing/assisting passenger emergency egress • directing/assisting passengers away from the helicopter in case of fire or fire hazard is present • directing/assisting passengers into dingies/floatation gear • knowing how to give first aid treatment to injured persons • knowing how to utilise any type of emergency equipment provided • establishing contact with rescue services • having knowledge of and being trained in any other applicable emergency procedure in addition to those specified above • crew performance in any reasonably conceivable emergency		
Effects on other RIFs			
Comments			
		Last update:	2009-03-26

C 1.7 Passenger competence

Risk factor: **C 1.7**	**PASSENGER COMPETENCE (PASSASJERENES KOMPETANSE)**	Effect on: Consequence
Definition	*The ability of the passengers to preserve their own lives, and to assist others, in case of a helicopter accident or emergency landing, including situations where the crew are incapacitated.*	
Description	This RIF comprises: • wearing personal protecting equipment (e.g. survival suits) as required, and ensuring that it is undamaged and properly worn (zipped up) • knowing how to operate all applicable types of emergency exits • knowing how to perform underwater escapes • knowing how to utilise dingies and other floatation gear • knowing how to give first aid treatment to injured persons • know how to utilise any type of emergency equipment provided • knowing how to establish contact with rescue services • having knowledge of and being trained in any other applicable emergency procedure in addition to those specified above • passenger performance in any reasonably conceivable emergency	
Effects on other RIFs		
Comments		
	Last update:	2009-03-26

C 1.8 Emergency procedures

Risk factor: **C 1.8**	**EMERGENCY PROCEDURES (BEREDSKAPSPROSEDYRER)**	Effect on: Consequence
Definition	*Having sufficient, easy accessible and understandable emergency procedures.*	
Description	Procedures/descriptions/directions, including markings and labels, for the use of every item of emergency equipment provided.	
Effects on other RIFs		
Comments		
	Last update:	2009-03-26

C 1.9 Heliport/airport emergency preparedness

<table>
<tr><td>Risk factor:
C 1.9</td><td>HELIPORT/AIRPORT EMERGENCY PREPAREDNESS (BEREDSKAP HELIPORT/FLYPLASS)</td><td>Effect on:
Consequence</td></tr>
<tr><td>Definition</td><td colspan="2">The preparedness for emergency activities of the ground crew to minimise/prevent injuries or loss of life. Including adequate equipment/gear available to the heliport/airport operator to handle any reasonably conceivable emergency situation in connection with helicopter operations.</td></tr>
<tr><td>Description</td><td colspan="2">The preparedness of the facility to minimise/prevent injuries or loss of life with regard to:

Organisation: The sufficiency and adequacy of plans, procedures, and number of designated personnel.
Competence: The ability and preparedness of designated personnel to deal with emergency situations (e.g. selection and training).
Availability: Sufficient readiness of emergency services during helicopter operations.
Alertness: The awareness and alertness of designated personnel with regard to immediately detecting and timely reacting to emergency situations.
General emergency preparedness: The ability and preparedness of personnel not directly involved in emergency/rescue work to avoid hampering such operations, while still being available to assist on request.
Assistance capability: Capacity to assist other facilities in emergencies
Emergency equipment: Adequate equipment/gear includes the quality and the accessibility/location e.g. of the following:

fire fighting equipment
cutting tools
oxygen masks
fire protective clothing (e.g. emergency suits, eye protection glasses)
stretchers
first aid equipment

</td></tr>
<tr><td>Effects on other RIFs</td><td colspan="2"></td></tr>
<tr><td>Comments</td><td colspan="2"></td></tr>
<tr><td></td><td>Last update:</td><td>2009-03-11</td></tr>
</table>

C 1.10 Helideck emergency preparedness

<table>
<tr><td>Risk factor:
C 1.10</td><td>**HELIDECK EMERGENCY PREPAREDNESS (BEREDSKAP HELIDEKK)**</td><td>Effect on:
Consequence</td></tr>
<tr><td>Definition</td><td colspan="2">*The preparedness for emergency activities of the helideck crew to minimise/prevent injuries or loss of life. Including adequate equipment/gear available to the helideck operator to handle any reasonably conceivable emergency situation in connection with helicopter operations.*</td></tr>
<tr><td>Description</td><td colspan="2">The preparedness of the facility to minimise/prevent injuries or loss of life with regard to:
• *Organisation:* The sufficiency and adequacy of plans, procedures, and number of designated personnel.
• *Competence:* The ability and preparedness of designated personnel to deal with emergency situations (e.g. selection and training).
• *Availability:* Sufficient readiness of emergency services during helicopter operations.
• *Alertness:* The awareness and alertness of designated personnel with regard to immediately detecting and timely reacting to emergency situations.
• *General emergency preparedness:* The ability and preparedness of personnel not directly involved in emergency/rescue work to avoid hampering such operations, while still being available to assist on request.
• *Assistance capability:* Capacity to assist other facilities in emergencies
• *Emergency equipment:* Adequate equipment/gear includes the quality and the accessibility/location e.g. of the following:
o fire fighting equipment
o cutting tools
o oxygen masks
o fire protective clothing (e.g. emergency suits, eye protection glasses)
o stretchers
o first aid equipment</td></tr>
<tr><td>Effects on other RIFs</td><td colspan="2"></td></tr>
<tr><td>Comments</td><td colspan="2"></td></tr>
<tr><td></td><td>Last update:</td><td>2009-03-11</td></tr>
</table>

C 1.11 Helideck design

Risk factor: **C 1.11**	**HELIDECK DESIGN (HELIDEKK-KONSTRUKSJON)**	Effect on: Consequence
Definition	*The design and layout of the helideck with regard to minimising/preventing injuries or loss of life.*	
Description	The design, quality and layout of the helideck: • Location of helideck, e.g. to have a safe distance to other vulnerable areas (as building quarters). • Nets to prevent capsized helicopters or fleeing personnel from falling off the deck. • Draining system (capacity and design) for spilled fuel from ruptured tanks. • Safe storage of any explosive, flammable, or otherwise hazardous liquids and material. • Personnel protection design measures (rescue nets, rails etc.) • Emergency exits	
Effects on other RIFs		
Comments		
	Last update:	2009-03-11

C 1.12 SAR Emergency preparedness

Risk factor: **C 1.12**	**SAR EMERGENCY PREPAREDNESS (BEREDSKAP SAR)**	Effect on: Consequence
Definition	*The organisation, competence, availability, capasity and alertness of the SAR services.*	
Description	This RIF comprises: • Organisation: the sufficiency/adequacy of plans, procedures, number of SAR units and their equipment, suitable localisation of the SAR units and number of designated personnel. • Competence: the ability and preparedness of designated personnel to deal with emergency situations. • Availability: the readiness and capacity of SAR services during helicopter operations. • Alertness: the awareness and alertness of designated personnel with regard to immediately detecting and timely reacting to emergency situations.	
Effects on other RIFs		
Comments		
	Last update:	2009-03-11

C 1.13 Organisation and co-ordination

Risk factor: **C 1.13**	**ORGANISATION AND CO-ORDINATION (ORGANISERING OG SAMORDNING)**	Effect on: Consequence
Definition	*The actual organisation and co-ordination of any given search and rescue operation.*	
Description	This RIF comrises: • Internal organisation (authority, responsibility and procedures) • External co-ordination/co-operation between SAR units, and between SAR services and any other related services and/or authorities	
Effects on other RIFs		
Comments		
	Last update:	2009-03-11

C 1.14 Weather, climate & other activities

Risk factor: **C 1.14**	**WEATHER, CLIMATE & OTHER ACTIVITIES (VÆRFORHOLD, KLIMA & ANNEN VIRKSOMHET)**	Effect on: Consequence
Definition	*The influence from the weather condition and the surroundings that affect the ability of the SAR services.*	
Description	Environmental conditions /surroundings, typical examples: • rough wind, rain, snow, fog, waves • extremely low or high temperatures • nearby ships • nearby SAR helicopters	
Effects on other RIFs		
Comments		
	Last update:	2009-03-11

Level 2 – Organisational RIFs

Level 2 – Organisational RIFs are risk influencing factors related to the organizational basis, support and control of running activities in helicopter *transport*. These factors are related to helicopter manufacturers, helicopter operators, air traffic / air navigation services, heliport/airport and helideck operators and other organisations.

There are 5 RIFs on level 2 for consequence:

C 2.1 Helicopter manufacturers / Design organisations

Reference is made to the corresponding RIF on frequency.

C 2.2 Helicopter operators

Reference is made to the corresponding RIF on frequency.

C 2.3 Heliport/airport and helideck operators

Reference is made to the corresponding RIF on frequency.

C 2.4 Search & rescue services

Risk factor: **C 2.4**	**SEARCH & RESCUE SERVICES (SØK OG REDNINGSTJENESTE)**		Effect on: Consequence
Definition	*The way the search & rescue services plan and carry out their business in general, to the extent that this has a direct or indirect influence on the organisation and co-ordination of any given search and rescue operation.*		
Description	Typical actors: • The Rescue Coordination Center (Hovedredningssentralen)		
Effects on other RIFs			
Comments	This RIF influences the emergency preparedness (RIF 1.12), the organisation and co-ordination (RIF 1.13) and the national authorities (RIF 3.3).		
		Last update:	2009-03-26

C 2.5 Other organisations

Reference is made to the corresponding RIF on frequency.

Level 3 – Regulatory and Customer Related RIFs

Level 3 – Regulatory and customer related RIFs are risk influencing factors related to the requirements and controlling activities by authorities and customers.

There are 3 RIFs on level 3 for consequence:

C 3.1 International aviation authorities and organisations

Reference is made to the corresponding RIF on frequency.

C 3.2 Customers

Reference is made to the corresponding RIF on frequency.

C 3.3 National Authorities

Reference is made to the corresponding RIF on frequency.

4 KVANTIFISERING I RISIKOMODELLEN

Innholdet i dette kapittelet er relevant for kapittel 6 i hovedrapporten.

4.1 Bidrag til ulykkesfrekvens fra operasjonelle RIFer

I risikomodellen brytes ulykkesfrekvensen ned på bidrag fra RIFer og ulykkeskategorier, jf. Tabell 6.1 i hovedrapporten. Utgangspunktet for denne kvantifiseringen er en tilsvarende tabell i HSS-2, gjengitt i Tabell 4.1 nedenfor. Merk at RIF-nummereringen ikke er identisk med nummereringen i HSS-3.

Tabell 4.1 Ulykker (i %) fordelt på RIFer og ulykkeskategorier i HSS-2. Merk at RIF-nummereringen ikke er identisk med nummereringen i HSS-3. Tallene er gjennomsnitt for perioden 1990–1998.

RIF		**Ulykkeskategori**								
		U1 Heliport	**U2** Helidekk	**U3** System-feil	**U4** Kollisjon luft	**U5** Kollisjon terreng	**U6** Person inni	**U7** Person utenfor	**U8** Annet/ ukjent	**Sum**
1.1	Design and cont. airworthiness	4,9	1,7	19,0	0,0	0,4	0,4	0,8	1,3	**28,4**
1.2	Operators maintenance	4,1	1,1	9,7	0,0	0,3	0,3	0,1	0,0	**15,6**
1.3	Modification and repair	0,2	0,1	2,0	0,0	0,1	0,1	0,0	0,0	**2,4**
1.4	Operations working cond.	0,1	0,2	0,5	0,0	1,9	0,0	0,0	1,0	**3,8**
1.5	Operations procedures	0,6	6,0	0,0	0,0	1,8	0,0	0,7	1,0	**10,0**
1.6	Human behaviour	0,9	6,6	2,6	0,2	3,0	0,0	1,0	0,5	**14,7**
1.7	ATS/ANS	0,5	0,0	0,0	0,6	1,3	0,0	0,0	0,0	**2,5**
1.8	Helidecks and heliports	0,0	9,3	0,0	0,2	0,9	0,0	1,1	1,3	**12,7**
1.9	Environment	1,1	2,0	4,2	0,0	0,9	0,0	1,2	0,5	**9,9**
Sum		**12,4**	**26,9**	**38,0**	**1,0**	**10,6**	**0,7**	**4,8**	**5,5**	**100,0**

RIF-modellen har gjennomgått en del endringer siden HSS-2, bl.a. har RIFer både fusjonert og fisjonert og ellers fått nytt innhold, samtidig som helt nye RIFer har kommet til. Det har derfor vært nødvendig å transformere tabellen og tilpasse den til HSS-3. I tillegg har noen celler blitt noe modifisert basert på ny informasjon og ekspertvurderinger. Tabell 4.1 viser en *gjennomsnittlig* ulykkesfrekvensfordeling for HSS-2-perioden. Man har i HSS-2 også estimert en endring i frekvens for de ulike RIFene innad i perioden. Basert på dette kan man beregne frekvens-fordelingen ved utgangen av perioden (1998). Denne brukes som en inngangsfordeling til HSS-3-perioden (1999–2008). Tabell 4.2 viser denne inngangsfordelingen, som da blir gyldig for 1999.

Tabell 4.2: Ulykker (i %) fordelt på RIFer og ulykkeskategorier. Tallene er for 1999.

RIF		Ulykkeskategori								
		U1 Heliport	**U2** Helidekk	**U3** System-feil	**U4** Kollisjon luft	**U5** Kollisjon terreng	**U6** Person inni	**U7** Person utenfor	**U8** Annet/ ukjent	**Sum**
1.1	Helikopter-konstruksjon	1,7	4,2	19,0	0,0	0,4	0,4	0,8	1,3	**27,7**
1.2	Kontinuerlig luftdyktighet	1,2	4,3	11,7	0,0	0,4	0,4	0,1	0,0	**18,1**
1.3	Operasjonelle arbeidsforhold	0,1	1,0	0,5	0,0	1,1	0,0	0,0	1,0	**3,8**
1.4	Operasjonelle prosedyrer	0,6	6,0	0,0	0,0	1,8	0,0	0,7	1,0	**10,0**
1.5	Pilotenes kompetanse	0,9	6,6	2,6	0,2	3,0	0,0	1,0	0,5	**14,7**
1.6	Passasjerenes oppførsel	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,0	**0,3**
1.7	Heliport	0,3	0,0	0,0	0,0	0,0	0,0	0,6	0,6	**1,5**
1.8	Helidekk	0,0	9,3	0,0	0,0	0,0	0,0	0,6	0,6	**10,5**
1.9	ATS/ANS	0,5	0,0	0,0	0,6	1,3	0,0	0,0	0,0	**2,5**
1.10	Værforhold og klima	1,1	2,0	4,2	0,0	0,9	0,0	1,2	0,5	**9,9**
1.11	Annen virksomhet	0,1	0,0	0,0	0,2	0,9	0,0	0,0	0,0	**1,2**
Sum		**6,6**	**33,3**	**38,0**	**1,0**	**9,8**	**0,8**	**5,0**	**5,5**	**100,0**

Basert på ekspertvurderinger har man estimert *endringer* i ulykkesfrekvens innad i perioden 1999–2009 med den samme nedbrytingen i RIFer og ulykkeskategorier (Tabell 4.3).

Tabell 4.3: Endringer (i %) i ulykkesfrekvens innad i perioden 1999–2009. (Jf. Tabell 6.3 i hovedrapporten)

RIF		Ulykkeskategori								
		U1 Heliport	**U2** Helidekk	**U3** System-feil	**U4** Kollisjon luft	**U5** Kollisjon terreng	**U6** Person inni	**U7** Person utenfor	**U8** Annet/ ukjent	**Totalt**
1.1	Helikopter-konstruksjon	-7	-12	-10	-23	-12	0	-10	-15	**-10**
1.2	Kontinuerlig luftdyktighet	-12	-12	-12	0	0	0	0	0	**-11**
1.3	Operasjonelle arbeidsforhold	-20	-17	0	-37	-30	10	0	0	**-14**
1.4	Operasjonelle prosedyrer	0	-10	0	-10	-25	0	0	0	**-10**
1.5	Pilotenes kompetanse	-15	-15	-10	0	-5	0	0	0	**-10**
1.6	Passasjerenes oppførsel	0	0	0	0	0	0	0	0	**0**
1.7	Heliport	0	0	0	0	0	0	0	0	**0**
1.8	Helidekk	0	-30	0	0	0	0	-20	0	**-28**
1.9	ATS/ANS	0	-10	-10	-60	-10	0	0	-10	**-20**
1.10	Værforhold og klima	0	0	0	0	0	0	0	0	**0**
1.11	Annen virksomhet	0	0	0	-70	0	0	0	0	**-12**
Totalt		**-6**	**-17**	**-9**	**-49**	**-11**	**0**	**-4**	**-3**	**-11**

Kombinasjonen av Tabell 4.2 og Tabell 4.3 gir en tilsvarende tabell med frekvensfordelingen ved utgangen av HSS-3-perioden (2009). Man kan da beregne en gjennomsnittlig frekvensfordeling for HSS-3-perioden (Tabell 4.4).

Tabell 4.4: Ulykker (i %) fordelt på RIFer og ulykkeskategorier. Tallene er gjennomsnitt for perioden 1999–2009. (Jf. Tabell 6.1 i hovedrapporten)

RIF		Ulykkeskategori								Sum
		U1 Heliport	**U2** Helidekk	**U3** System-feil	**U4** Kollisjon luft	**U5** Kollisjon terreng	**U6** Person inni	**U7** Person utenfor	**U8** Annet/ ukjent	
1.1	Helikopter-konstruksjon	1,7	4,1	18,7	0,0	0,4	0,4	0,7	1,2	**27,2**
1.2	Kontinuerlig luftdyktighet	1,2	4,2	11,4	0,0	0,4	0,4	0,1	0,0	**17,7**
1.3	Operasjonelle arbeidsforhold	0,1	0,9	0,5	0,0	0,9	0,0	0,0	1,0	**3,4**
1.4	Operasjonelle prosedyrer	0,6	5,9	0,0	0,0	1,6	0,0	0,7	1,0	**9,9**
1.5	Pilotenes kompetanse	0,9	6,5	2,7	0,2	3,1	0,0	1,1	0,5	**15,0**
1.6	Passasjerenes oppførsel	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,0	**0,3**
1.7	Heliport	0,3	0,0	0,0	0,0	0,0	0,0	0,6	0,7	**1,6**
1.8	Helidekk	0,0	9,0	0,0	0,0	0,0	0,0	0,6	0,7	**10,3**
1.9	ATS/ANS	0,5	0,0	0,0	0,4	1,1	0,0	0,0	0,0	**2,0**
1.10	Værforhold og klima	1,2	2,3	4,8	0,0	1,1	0,0	1,4	0,6	**11,3**
1.11	Annen virksomhet	0,1	0,0	0,0	0,1	1,0	0,0	0,0	0,0	**1,2**
Sum		**6,7**	**32,9**	**38,1**	**0,7**	**9,7**	**0,8**	**5,4**	**5,7**	**100**

4.2 Antall omkomne per ulykke

Tabell 4.5 viser resultater fra ekspertvurderinger rundt andelen fatale ulykker og andelen omkomne gitt en fatal ulykke. Dette kombineres til å gi estimater for antall omkomne i en hvilken som helst ulykke.

Tabell 4.5: Konsekvensvurderinger av ulykker. (Jf. Figur 6.3 i hovedrapporten)

	Ulykkeskategori							
	U1 Heliport	**U2** Helidekk	**U3** Systemfeil	**U4** Kollisjon luft	**U5** Kollisjon terreng	**U6** Person inni	**U7** Person utenfor	**U8** Annet/ ukjent
Ulykker								
Antall	20	4	5	1	4	5	2	10
Fatale	1	1	1	1	3	1	1	1
Andel	0,05	0,25	0,2	1	0,75	0,2	0,5	0,1
Fatale ulykker								
Om bord	17	17	17	17	17	17	17	17
Omkomne	1,5	9	12	30	15	8	4	14
Andel	0,09	0,53	0,71	1,76	0,88	0,47	0,24	0,82
Omkomne per ulykke								
Per kategori	0,1	2,3	2,4	30,0	11,3	1,6	2,0	1,4
Totalt	3,2							

4.3 Viktighet av operasjonelle RIFer for konsekvens

Tabell 4.6 viser endring i konsekvens (antall omkomne gitt en ulykke) for alle kombinasjoner av RIFer og ulykkeskategorier i perioden 1999–2009. Tabell 4.7 viser tilsvarende for neste periode (2010–2019). Tallene er basert på ekspertvurderinger.

Tabell 4.6: Endring (i %) i konsekvens innad i perioden 1999–2009. (Jf. Tabell 6.3 i hovedrapporten)

RIF		Ulykkeskategori								Totalt
		U1 Heliport	**U2** Helidekk	**U3** System-feil	**U4** Kollisjon luft	**U5** Kollisjon terreng	**U6** Person inni	**U7** Person utenfor	**U8** Annet/ ukjent	
1.1	Støtabsorpsjon	-23	-28	-28	0	-8	0	0	-8	**-17,2**
1.2	Stabilitet på sjøen	-5	-33	-33	0	-8	-5	0	-8	**-19,8**
1.3	Kabinsikkerhet	-15	-18	-18	0	-13	-10	0	-5	**-13,6**
1.4	Overlevelsesutstyr	-5	-18	-18	0	-10	-3	0	-5	**-12,7**
1.5	Nødpeileutstyr	-5	-15	-20	-5	-10	-3	0	-5	**-13,2**
1.6	Pilotenes kompetanse	-10	-10	-10	-10	-15	0	0	0	**-11,1**
1.7	Passasjerenes kompetanse	-10	-13	-13	0	-5	-8	-5	-8	**-8,7**
1.8	Beredskaps-prosedyrer	-5	-5	-5	0	-5	-5	-5	-5	**-4,7**
1.9	Beredskap heliport	-10	-10	0	0	-5	-10	-10	-10	**-4,7**
1.10	Beredskap helidekk	0	-18	0	0	0	0	0	0	**-4,1**
1.11	Helidekk-konstruksjon	0	-23	0	0	-15	0	-15	0	**-10,9**
1.12	Beredskap (SAR)	0	-5	-20	-20	-20	-5	0	-15	**-15,6**
1.13	Organisering, samordning	0	13	0	0	8	0	5	0	**5,7**
1.14	Vær/klima, annen virksomhet	0	-5	5	0	0	0	0	5	**0,4**
									Totalt	**-9,7**

Tabell 4.7: Endring (i %) i konsekvens innad i perioden 2010–2019. (Jf. Tabell 6.3 i hovedrapporten)

RIF		Ulykkeskategori								Totalt
		U1 Heliport	U2 Helidekk	U3 System-feil	U4 Kollisjon luft	U5 Kollisjon terreng	U6 Person inni	U7 Person utenfor	U8 Annet/ ukjent	
1.1	Støtabsorpsjon	-18	-18	-18	0	-13	-5	0	-8	**-13,7**
1.2	Stabilitet på sjøen	-10	-35	-35	0	-23	-10	0	-13	**-26,4**
1.3	Kabinsikkerhet	-18	-18	-18	0	-15	-8	0	-10	**-14,6**
1.4	Overlevelsesutstyr	3	-13	-13	0	-13	-5	0	-5	**-11,0**
1.5	Nødpeileutstyr	0	-10	-13	-13	-15	-5	0	-5	**-12,1**
1.6	Pilotenes kompetanse	-5	-10	-10	-10	-10	0	-5	0	**-9,53**
1.7	Passasjerenes kompetanse	0	-5	-5	-5	-5	0	0	0	**-4,67**
1.8	Beredskaps-prosedyrer	-5	-5	-5	-5	-5	0	0	0	**-4,68**
1.9	Beredskap heliport	-5	-5	0	0	0	0	0	0	**-1,18**
1.10	Beredskap helidekk	0	-8	-5	0	0	0	-5	-5	**-3,49**
1.11	Helidekk-konstruksjon	0	-20	-10	0	0	0	-18	0	**-8,15**
1.12	Beredskap (SAR)	-5	-15	-15	-13	-15	0	0	-5	**-13,98**
1.13	Organisering, samordning	5	10	8	5	5	3	0	3	**6,65**
1.14	Vær/klima, annen virksomhet	5	5	5	-10	-5	0	0	0	**0,21**
									Totalt	**-9,0**

4.4 Endring i risiko

Innholdet i dette avsnittet er relevant for kapittel 6.5 i hovedrapporten.

4.4.1 Endring i risiko *innad* i perioder

Risiko beregnes som produktet av frekvens og konsekvens:

$$R = f \times K$$

Gitt en relativ endring i frekvens Δf og en relativ endring i konsekvens ΔK, blir den nye frekvensen f^* og konsekvensen K^* hhv.

$$f^* = f \times (1 + \Delta f)$$
$$K^* = K \times (1 + \Delta K)$$

Oppdatert risiko R^* blir

$$R^* = f^* \times K^*$$

Relativ *endring* i risiko ΔR finnes da vha. følgende formel:

$$\Delta R = \frac{R^* - R}{R} = (1 + \Delta f) \times (1 + \Delta K) - 1$$

Endringen i risiko er altså uavhengig av *verdiene* (nivåene) for frekvens, konsekvens og risiko, og avhenger kun av de relative *endringene* i hhv. frekvens og konsekvens.

Eksempel: Med en reduksjon i frekvens på 10 % og en økning i konsekvens på 5 %, blir relativ endringen i risiko $\Delta R = (1-0{,}10)\times(1+0{,}05)-1 = -0{,}055$, dvs. en reduksjon på 5,5 %.

4.4.2 Endring i risiko *mellom* perioder

Når man har et estimat for risikoen i starten av en periode og et estimat for endring i risiko innad i perioden, kan man beregne risikoen ved utgangen av perioden. Dette kan videre anses som en ”inngangsrisiko” til *neste* periode, og gitt en endring i risiko for den neste perioden, kan man beregne en ”utgangsrisiko” for denne perioden også. Dersom det antas en jevn (lineær) utvikling av risikoen i hver periode, kan gjennomsnittlig risiko i hver periode lett finnes, og man kan da beregne en endring i risiko mellom disse gjennomsnittsnivåene. Denne endringen vil være uavhengig av estimatene for risiko*nivå*, og kun avhenge av estimatene for risiko*endring*. Formlene for denne prosedyren vises i Tabell 4.8.

Tabell 4.8: Fremgangsmåte for å regne ut relativ endring i risiko mellom (gjennomsnittsnivå i) to perioder.

Periode 1	
Risikonivå i starten av periode 1	$R1^{start}$
Relativ endring i risiko i periode 1	$\Delta R1$
Risikonivå i slutten av periode 1	$R1^{slutt} = R1^{start} \times (1+\Delta R1)$
Gjennomsnittlig risiko i periode 1	$R1 = (R1^{start} + R1^{slutt}) / 2$
Periode 2	
Risikonivå i starten av periode 2	$R2^{start} = R1^{slutt}$
Relativ endring i risiko i periode 2	$\Delta R2$
Risikonivå i slutten av periode 2	$R2^{slutt} = R2^{start} \times (1+\Delta R2)$
Gjennomsnittlig risiko i periode 2	$R2 = (R2^{start} + R2^{slutt}) / 2$
Endring	
Relativ endring i risiko *mellom* periode 1 og periode 2	$\Delta R = \frac{R2 - R1}{R1} = \frac{\Delta R1 + \Delta R2 + \Delta R1 \times \Delta R2}{2 + \Delta R1}$

5 DEFINISJONER OG KATEGORISERING AV HENDELSER

I dette kapittelet gis definisjoner av hendelseskategorier basert på BSL A 1-3. Merk at enkelte av definisjonene ble justert 1. juli 2007 ved innføring av ny BSL A 1-3. Disse endringene er illustrert i Figur 5.1.

Luftfartsulykke
En uønsket begivenhet som inntreffer i forbindelse med bruk av et luftfartøy fra det tidspunkt en person går om bord i fartøyet med flygning som formål, til alle har forlatt fartøyet, såfremt

a) noen avgår ved døden eller påføres slik alvorlig skade[1] som følge av
    - å være i luftfartøyet,
    - direkte kontakt med en del av luftfartøyet, herunder deler som er løsnet fra det, eller
    - direkte virkninger av eksosstrøm fra motor(er), og/eller luftstrøm fra propell(er) og rotor(er)

   med mindre dødsfallet eller skaden skyldes naturlige årsaker, er selvpåført eller påført av andre personer, eller er påført en blindpassasjer som har gjemt seg på et sted som normalt ikke er tilgjengelig for passasjerer eller besetningen; eller
b) luftfartøyet utsettes for skade som nedsetter strukturens styrke eller fartøyets yteevne eller flygeegenskaper, og som normalt nødvendiggjør større reparasjon eller utskifting av angjeldende del eller komponent. Unntatt er motorsvikt eller -skade, såfremt skaden er begrenset til motoren, dens deksler eller tilbehør. Unntatt er videre skade begrenset til propeller, vingespisser, antenner, dekk, bremser, glatt kledning, små bulker eller små hull i fartøyets kledning; eller
c) luftfartøyet er savnet eller fullstendig utilgjengelig.

Luftfartshendelse (benyttet før 1.7.2007)
Uønskede begivenheter, som ikke karakteriseres som en ulykke, men som har eller vil kunne ha ugunstige innvirkninger på sikkerhet i luftfarten.

Luftfartshendelse (etter 1.7.2007)
Et driftsavbrudd, en feil, eller annen uregelmessig omstendighet, som har eller kan ha påvirket flysikkerheten, men som ikke har medført en luftfartsulykke. Med **alvorlig luftfartshendelse** menes en luftfartshendelse der omstendighetene tilsier at det nesten inntrådte en luftfartsulykke.

Driftsforstyrrelse (inntil 1.7.2007)
Unormal operativ hendelse samt enhver teknisk feil og skade av betydning for luftdyktigheten, enten den oppstår under flyging eller oppdages på bakken (også under vedlikeholdsarbeid) og som ikke klassifiseres som luftfartsulykke eller luftfartshendelse.

Lufttrafikkhendelse
En trafikkrelatert luftfartshendelse som f.eks. en nærpassering (*aircraft proximity*), alvorlige vanskeligheter som oppstår fordi fartøysjefen eller lufttrafikktjenesten unnlater å følge gjeldende fremgangsmåte eller avviker fra gjeldende *procedure* samt alvorlige vanskeligheter forårsaket av

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[1] Med *alvorlig skade* menes en skade en person har pådratt seg i forbindelse med en ulykke og som:
a) krever innleggelse på sykehus innen 7 dager etter at skaden ble pådratt og har varighet mer enn 48 timer, eller
b) resulterer i brudd i et hvilket som helst ben (unntatt enkle benbrudd i fingre, tær eller nese), eller
c) omfatter sår som medfører alvorlig blødning, nerve-, muskel- eller seneskade, eller
d) omfatter skade på et hvilket som helst indre organ, eller
e) omfatter andre- eller tredjegrads forbrenning, eller hvilken som helst forbrenning som dekker mer enn 5 prosent av kroppens overflate, eller
f) omfatter bekreftet kontakt med smittefarlige stoffer eller stoffer som avgir skadelig stråling.

mangler eller feil ved bakkeinstallasjon eller hjelpemiddel (*facility*). Med **alvorlig lufttrafikk-hendelse** menes en lufttrafikkhendelse der omstendighetene tilsier at det nesten inntrådte en luftfartsulykke.

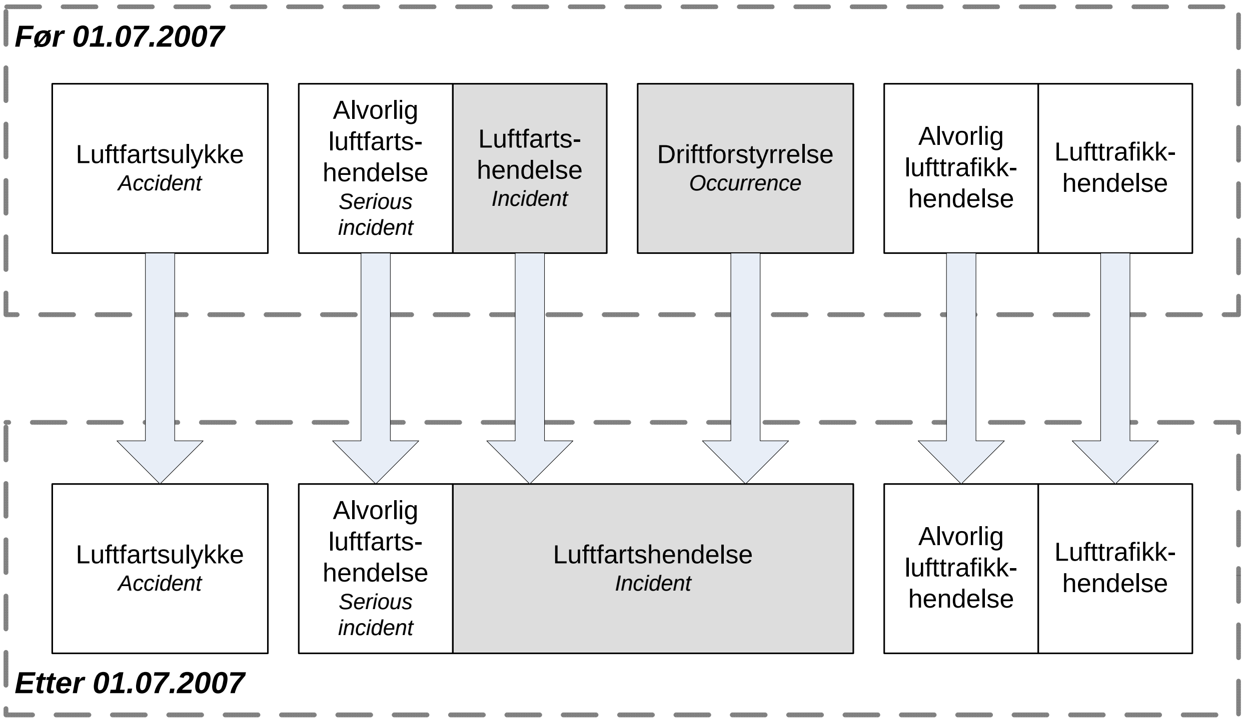
***

Kommentarer
I denne studien brukes ofte *hendelse* som en fellesbetegnelse på luftfartsulykker, luftfarts-hendelser, lufttrafikkhendelser og driftsforstyrrelser.

Norge implementerte EUs rapporteringsdirektiv gjennom ny rapporteringsforskrift 1. juli 2007. Den nye forskriften øker kravene til innrapportering og utvider definisjonen av *luftfartshendelse* til også å omfatte hendelser der sikker drift av luftfartøyet ikke ble satt i fare. Eksempler på slike "nye luftfartshendelser" kan være funn av teknisk feil under vedlikehold, mangler ved lys eller instrumenter på en lufthavn uten at et luftfartøy er involvert, eller en intern hendelse innen lufttrafikktjenesten som tilfeldigvis ikke påvirket sikkerheten til operasjon av et luftfartøy.

Definisjonen av *luftartsulykke* er ikke endret, den følger ICAOs standard og innebærer enten dødsfall, alvorlige personskader og/eller større materielle skader på luftfartøyet.

Som nevnt forsvant begrepet *driftsforstyrrelse* og definisjonen av *luftfartshendelse* ble endret med innføringen av ny BSL A 1-3 fra 1. juli 2007. Generelt kan man si at tidligere driftsforstyrrelser i dagens forskriftsverk er luftfartshendelser. Figuren nedenfor viser en oversikt over hendelses-kategoriserier før og etter 1. juli 2007.



Figur 5.1: Kategorisering av hendelser i norsk luftfart før og etter 1. juli 2007.

6 RESILIENCE ENGINEERING AND INDICATORS

SINTEF	MEMO
SINTEF Technology and Society Safety Address: NO-7465 Trondheim, NORWAY Location: S P Andersens veg 5 NO-7031 Trondheim Telephone: +47 73 59 27 56 Fax: +47 73 59 28 96 Enterprise No.: NO 948 007 029 MVA MINES ParisTech	MEMO CONCERNS **Helicopter Safety Study 3: Functional Resonance Analysis Method & Proactive Safety Indicators** DISTRIBUTION Project group

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504170	2009-06-17	Ivonne Herrera, Erik Hollnagel (ARMINES- Mines ParisTech), Eduardo Runte (ARMINES-Mines ParisTech)	24

This memo presents a status related to the application of the Functional Resonance Analysis Method and identification of leading safety indicators relevant for helicopter operations in the Norwegian Continental Shelf.

6.1 Introduction

Several initiatives have been applied on the Norwegian Continental Shelf to improve the safety of helicopter operations offshore. The first Helicopter Safety Study, HSS-1, (1966–1990), the second Helicopter Safety Study, HSS-2, (1990–2000), the NOU 2001: 21 Helicopter Safety – Organizing of the public authorities, and the NOU 2002: 17 Helicopter safety – Trends and specific measures. These initiatives as well as international helicopter activities have led to specific measures to improve helicopter operations. Although no major accidents have occurred in the Norwegian Continental Shelf since 2001, the industry is well aware that this is neither necessarily a good indication of the safety status, nor an indication that safety is high. A new HSS-3 study has therefore been initiated to assess current risk level, propose indicators to monitor safety, and identify safety measures for further improvement.

Both HSS-1 and HSS-2 were carried out using the established approach to risk influence modelling. This approach, which has been adopted as the unofficial standard by most industrial domains, basically assumes that accidents and incidents can be described as the result of cause-effect relations, sometimes as a single cause-effect chain but more often as a combination of multiple cause-effect chains. (A typical representation of this is the fault tree, which was developed in 1961.) The basic idea is that incidents and accidents can be explained by finding out what has failed or gone wrong, and that it is possible to calculate the risk that this may happen. (What fails or goes wrong can, of course, be either a single or a composite event.) In the 1990s, it was accepted that dormant or latent conditions might combine with active failures and thereby change the risk analysis picture. Although the main effect of this was the development of new approaches top accident, it clearly also has consequences for how the risks are determined.

The established approaches commonly represent the risks using the graphical form of a tree or a network. One example of that is the risk model in the HSS-2 study shown in Figure 1 below. While this clearly is an efficient way of communication, it does mean that the representation – the risk picture – is a static rendering of proposed causal pathways. When used as a basis for identifying ways to improve safety and reduce risks, it leads to a focus on individual rather than systemic risks and to a focus on 'negative' or unwanted outcomes. This is clearly demonstrated by the recommendations in the HSS-2 for indicators that can be used to monitor risk, which were:

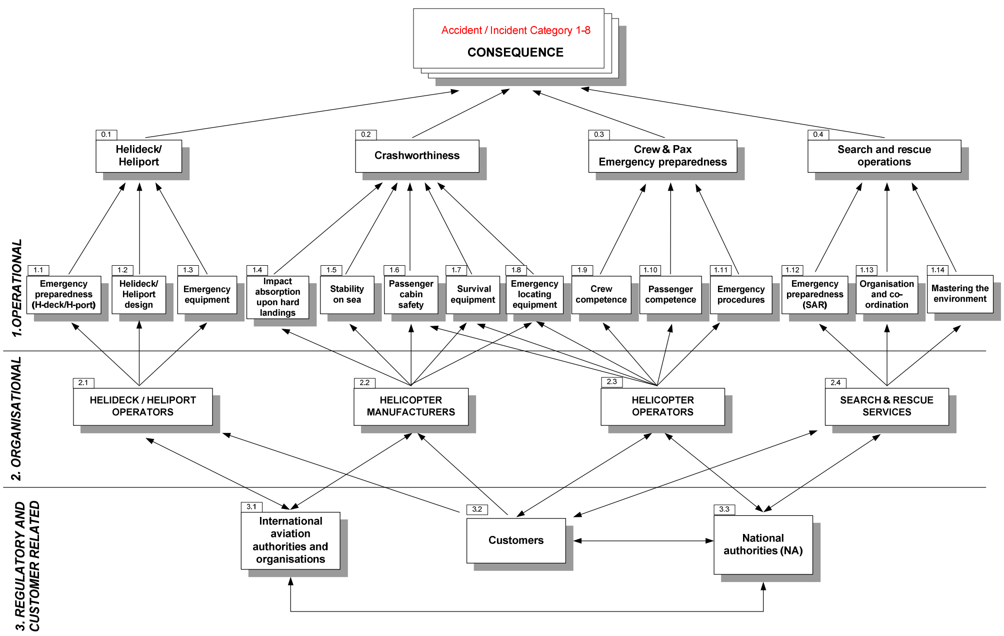

Figure 6.1: Risk Influence Model HSS-2.

a) number of deaths per million flight hours;
b) number of accidents per million flight hours;
c) number of deaths per year due to helicopter transport;
d) number of serious accidents and incidents per year or million flight hours;
e) number of occurrences per year or million flight hours;
f) number of technical and operational reports per year or per million flight hours; and
g) subjective risk.

Resilience Engineering has been proposed as a way to overcome some of the known difficulties with the established approach to risk modelling. Resilience Engineering does not require that established methods and models are abandoned, but rather proposes that issues of safety and risk are seen from a different perspective. More concretely, Resilience Engineering is based on the following four principles:

- Performance conditions are always underspecified. Individuals and organisations must therefore always adjust their performance to match current demands and resources; because resources and time are finite, such adjustments will inevitably be approximate.

- Many adverse events can be attributed to a breakdown or malfunctioning of components and normal system functions, but many cannot. These events can be understood as the result of unexpected combinations of the variability of normal performance. Another way of expressing this is by noting that failures are the flip side of successes.

- Safety management cannot be based on hindsight, nor rely on error tabulation and the calculation of failure probabilities. Safety management must be proactive as well as reactive.

- Safety cannot be isolated from the core (business) process, nor vice versa. Safety is the prerequisite for productivity, and productivity is the prerequisite for safety. Safety is achieved by improvements rather than by constraints.

Resilience can more concrete be defined as the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions. The aim of Resilience Engineering is to develop tools and methods that can help organisations increase their resilience, i.e., their ability to operate in a robust and flexible way. From a Resilience Engineering perspective, linear (causal) accident models are unable to represent the complex dynamics and interdependencies commonly observed in socio-technical systems (Amalberti, 2001; Dekker, 2004; Hollnagel, 2004; Leveson, 2004; Perrow, 1984; Rochlin, 1999; Woods & Cook, 2002). The emphasis of Resilience Engineering is congruent with the emphasis of recent systemic models and methods that propose that a system is considered as a whole and that emphasize the interaction of system functions rather than the causal connection among system structures.

In the HSS-3 project, a Resilience Engineering approach will be used in parallel to the traditional way of describing Risk Influence Modelling. Two aspects from the Resilience Engineering perspective will in particular be addressed by the project. The first aspect concerns the need to use models that can represent the dynamics of the system being described, and that do not require complete specifications (i.e., 'underspecified' models). This will make it possible to account for non-linear interactions and dependencies among functions, as well as take into account developments and changes without a need to completely rebuild the models. The second aspect concerns the safety indicators. Most indicators in aviation, as well as in other domains, refer to adverse events that have taken place, and therefore mainly allow an organisation to respond or act after the fact. There is, however, also a strong need of indicators that allow an organisation to act prior to an event, i.e., to be proactive. One reason is that this may actually prevent certain classes of adverse outcomes from occurring. Another is that it usually is better to prevent than to cure. The Functional Resonance Analysis Method (FRAM) illustrates a practical way of applying Resilience Engineering, and is therefore used by the HSS-3 project to develop a complementary risk model of helicopter operations.

This memo provides an interim report of this work and of the results obtained so far. The current status and needs to safety performance indicators are summarised. A short description of FRAM is included. The starting point for HSS-3 is the risk model developed by the HSS-2 project, including the approach by which it was developed. This risk model is complemented by a functional model using FRAM. The description produced by FRAM represents a generic functional view of helicopter operations that is related to HSS-2 level I description. In accordance with the principles of Resilience Engineering, the FRAM approach emphasises both normal operations (things that go right) as well as failures (things that go wrong). A specific scenario – landing on helideck – is used to illustrate the how a risk model can be developed from this basis.

6.2 Approach

6.2.1 Leading indicators for HSS-3?

This section summarize relevant findings from literature review on safety performance indicators detailed on Appendix A.1.The discussion starts with the observation that fatality rate is unsuitable as an indicator for safety performance.

In the case of aviation, we need to look for accident precursors in order to be able to assess safety performance. In general, leading indicators are defined as conditions, events or measures that precede and have some value in predicting the future occurrence of an event. These indicators could be seen as accident precursors.

The several interpretations regarding the definition and use of indicators lead to confusion. Therefore, it is necessary to establish the definition and characteristics that we will use in the HSS-3 study. The helicopter study uses two safety perspectives, risk influence modelling and Resilience Engineering. These perspectives are based on different models of safety. Therefore, we propose the following definition:

> *Leading indicators are precursors based on a model of safety, indicating the possibility of future events having an impact on safety or performance. (Adapted from Herrera & Hovden, 2008)*

Because a leading indicator refers to something that may happen in the future, the value of the indicator at the time it is noted may be different from the value of the indicator at the point in the future where the indicated event is supposed to happen.

Based on a literature review, indicators should possess the following characteristics:

- Be an “objective” measure
- Be easy to understand
- Indicate improvement or deterioration
- Collected from existing data.

Since a leading indicator is an interpretation of a measurement (or set of measurements) at the present, it is not meaningful to discuss whether the indicator is objective or not. Instead the criterion of intersubjective verifiability can be used. This simply means that if two or more observers interpret the indicator in the same way, then this agreement can be seen as support for the appropriateness of the indicator. Leading indicators are in practice selected based on a consensus between experts and decision makers. They may refer to single measurements or to a combination of multiple measurements. The indicators may be used to identify different emergent patterns and unintended interactions. Leading indicators should provide indications, giving guidance on actions and information about future performance.

Organisational, human and technical indicators have been identified in the literature review. Recent developments include a systemic view; rather than decomposition into single factors, the coupling between humans, technology and organisation is taken into account.

6.2.2 Functional Resonance Analysis Method

Resilience Engineering provides a practical basis for the development of systemic models in order to describe the characteristic performance of a system as a whole. It can therefore also be used as the starting point for developing a systemic or functional risk model (FRM). The purpose of a systemic model is to describe the dynamic and non-linear nature of interactions within a system. This should be seen as a complement to the traditional view where accidents are described either as sequences or as concatenation of latent conditions. Hollnagel (2004) presented a new method to perform accident investigation and safety assessment, called the Functional Resonance Analysis Method (FRAM). The Functional Resonance Analysis Method is based upon the following four principles.

The principle of equivalence of success and failures

Resilience Engineering represents a way of thinking about safety that emphasises a systems perspective. Whereas established risk management approaches normally are based on hindsight and emphasise error tabulation and calculation of failure probabilities, Resilience Engineering looks for ways to enhance the ability of organisations to create processes that are robust yet flexible, to monitor and revise risk models, and to use resources proactively in the face of disruptions or ongoing production and economic pressures. In Resilience Engineering failures do not stand for a breakdown or malfunctioning of normal system functions, but rather represent the converse of the adaptations necessary to cope with the underspecification that is a consequence of real world complexity. Individuals and organisations must always adjust their performance to the current conditions; and because resources and time are finite it is inevitable that such adjustments are approximate. Success is a consequence of the ability of groups, individuals, and organisations to anticipate the changing shape of risk before damage occurs; failure is simply the temporary or permanent absence of that. Adopting this view means that there is a need for models that can represent the variability of normal performance and methods that can use this both to provide more comprehensive explanations of accidents and to identify the possible risks.

The principle of approximate adjustments

In a systemic perspective, the variability of a system's normal functioning is due to two facts. First, that the operating conditions usually are underspecified, hence rarely, if ever, as imagined or as prescribed. Second, that the operating conditions are dynamically changing in a more or less orderly manner. This variability exists throughout the lifetime of the system, from the beginning of the life cycle to the very end. To get anything done humans must therefore adjust their performance to the current conditions. Humans are fortunately extremely adept at finding effective ways of overcoming problems at work, and this capability is crucial for safety. Indeed, if humans always resorted to follow rules and procedures rigidly in cases of unexpected events, the number of accidents and incidents would be much larger. Human performance can therefore at the

same time both enhance and detract from system safety. Assessment methods must be able to address this duality.
Because resources and time are finite, it is inevitable that such human adjustments are approximate. If inadequate adjustments coincide and combine to create an overall instability this can become the reason why things sometimes go wrong. To the extent that performance variability has been considered, it has primarily been used to understand operations that have gone wrong (operational failures). But it can equally well be applied to design, construction, testing, maintenance, modification, and decommissioning. Design failures and latent conditions, for instance, can be seen as an outcome of performance variability at the respective stages of the system's life.

The principle of emergence
The variability of normal performance is rarely large enough in itself to be the cause of an accident or even to constitute a malfunction. But the variability of multiple functions may combine in unexpected ways, leading to consequences that are disproportionally large, hence produce a non-linear effect. Both failures and normal performance are emergent rather than resultant phenomena, because neither can be attributed to or explained only by referring to the functions or malfunctions of specific components or parts. Socio-technical systems are intractable because they change and develop in response to conditions and demands. It is therefore impossible to describe all the couplings in the system, hence impossible to anticipate more than the most regular events.

The principle of functional resonance
As a systemic approach, FRAM offers an alternative to commonly used methods by focusing on the relationships between the system's functions and by replacing the traditional cause-effect relation by the principle of resonance. This means that the variability of a number of functions every now and then may resonate, i.e., reinforce each other and thereby cause the variability of one function to exceed normal limits. (The outcome may, of course, be advantageous as well as detrimental, although the study of safety for natural reasons has focused on the latter.) The consequences may spread through tight couplings rather than via identifiable and enumerable cause-effect links, e.g., as described by the Small World Phenomenon (Travers & Milgram, 1969). The resonance analogy emphasises that this is a dynamic phenomenon, hence not attributable to a simple combination of causal links. This principle makes it possible to capture the real dynamics of the system's functioning (Woltjer & Hollnagel, 2007), hence to identify emergent system properties that cannot be understood if the system is decomposed in isolated components.

Using the Functional Resonance Analysis Method

In its present form, the method comprises the following five steps.

1. The first step is the definition of the purpose of the analysis since FRAM has been developed to be used for both accident investigation (looking at past events) and safety assessment (looking at future events).
2. The second step is the identification and description of system functions. The result of the second step is the model. Every function can be characterised by six basic aspects:

- Input (I, that which the function uses or transforms),
- Output (O, that which the function produces),
- Preconditions (P, conditions that must be fulfilled to perform a function), resources (R, that which the function needs or consumes),

- Time (T, that which affects time availability), and
- Control (C, that which supervises or adjusts the function)

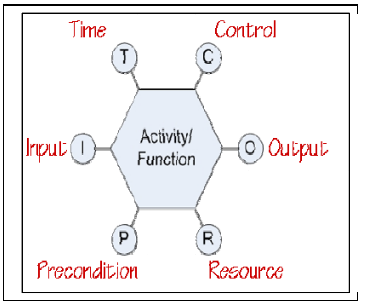

Figure 6.2: A FRAM function.

3. The third step is the assessment and evaluation of the potential variability for each singular function. One way of doing that is to use an *a priori* assessment of a set of Common Performance Conditions (CPCs) that have an influence on the function's performance variability (Hollnagel, 1998). Another way is to describe management and organisational functions. This evaluation should be integrated with the retrospective information extracted from accident databases to the extent that data are available.

4. Step four is the identification of functional resonance. The aim of this step is to determine the possible ways in which the variability from one function could spread in the system and how it may combine with the variability of other functions. This may result in situations where the system loses its capability safely to manage variability. The propagation may be both direct via the output from a function, and indirect via the effects that the variability may have on the CPCs.

5. The fifth and last step to perform a FRAM analysis is the identification of effective countermeasures or barriers that can be introduced in the system. In FRAM, prospective countermeasures aim at dampening performance variability in order to maintain the system in a safe state. But it is consistent with the principle of Resilience Engineering to consider also measures that can sustain or amplify functional resonance that leads to desired or improved outcomes. Besides recommendations for countermeasures or barriers, FRAM can also be used to specify recommendations for the monitoring of performance and variability, in order to be able to detect undesired variability at an early stage. Performance indicators may thus be developed for individual functions and for the links or couplings among functions.

6.2.3 Build generic FRAM model

The Functional Resonance Analysis Method was chosen for this project because it facilitates the modelling of the impact of variability in normal, everyday operation. A FRAM model assists the analyst in the task of identifying and explaining how multiple factors affect the manner in which the functions of a system are carried out, as well as how the outputs of different those same functions combine to result either in successful system performance or in failure.

The process of creating a FRAM model follows five steps (cf. above). The purpose of the model was, in accordance with the first step, to develop a functional representation of the Risk Influencing Factors (RIFs) elaborated in the course of the HSS3 Project in terms of functions and their dynamic interdependencies. This definition of the purpose of the model logically led to a selection of functions largely based on the RIFs and complemented by the technical literature available. The selection was then refined and checked, and a preliminary model was proposed. The process of selecting the relevant functions and building the model is summarized below.

- The description of the Operational RIFs (Annex 2 of the HSS2 Final Report) was read by two analysts. Keywords were highlighted and re-phrased as Functions.

  For example, from RIF 1.1, Design and Continuous Airworthiness, the following ten functions were initially defined: 1) Development, design and production, 2) Selection of helicopter, 3) Selection of equipment, tools and spare parts, 4) Certification, 5) Supply of equipment, tools and spare parts, 6) Design of modification and repairs, 7) Execution of modification and repairs, 8) Issue of service bulletins, service letters, 9) Production of operation and maintenance documentation, and 10) Support helicopter operators.

- A corpus of 60+ functions of potential interest to the project was developed. Three analysts then filtered this corpus and selected 30+ main functions. These functions describe in generic fashion offshore helicopter operations from the design of aircraft to its day-to-day operation. Examples of these functions are “Development, design and production” to “Support helicopter landing”. The granularity of the descriptions is based on the HSS-2 RIF model.

- Each function was then characterised in terms of the six aspects as appropriate. These six aspects are Input, Control, Precondition, Resources, time and Output, (I, C, P, R, T and O). The aspects help the identification of couplings and dependencies among functions. Table 6.1. illustrates an example of aspects for the function “Execution of modification and repairs”

Table 6.1: Aspects description of function “Execution of modifications and repairs”.

1.1.7	**Function**	**Execution of modifications and repairs**
Input		Request from Helicopter Operators
Output		Helicopter modified and/or repaired
Preconditions		Helicopter available
Resources		Engineers, technicians, tools, equipment
Time		
Control		Engineering work orders

- A consistency check was then performed on the list of High Level Functions. Following FRAM modelling logic, each function is made of 6 aspects (I, C, P, R, T, and O). The check consisted in assuring that each individual function was described with enough level of detail, and that no elements were orphaned.

- The consistency check revealed the need for some additional functions, including “dummy functions” that were considered to be out of the scope of the model, but that were either the source or the destination of an aspect of one of the FRAM functions retained for analysis.

- Finally, a preliminary generic model of offshore helicopter operations was proposed

As indicated above, the model proposed offers a generic overview of offshore helicopter operations. The model is multi-layered, and the generic model corresponds to the highest layer. In that sense, it must be completed by individual scenarios that look at the interaction of functions at a level closer to the operational level.

6.2.4 Scenario - Landing on helideck

The generic model is the basis for the functional risk model, which therefore represents an instantiation of the generic model. In order to demonstrate how the FRAM generic model is to be used, an operational scenario was selected. A critical operation is helicopter landing on helideck. This scenario, chosen by consensus among the researchers involved in the project, is described as:

> *Approach and landing of a Helicopter on the helideck of a fixed platform, during day-time, with clear weather and no unusual events.*

Considering the need for guidance when collecting field data for FRAM models, two analysts proposed a modified version of the Recent Case Walkthrough interview schedule (Hoffman, et al. 2008)

A professional pilot, currently flying for a Norwegian helicopter operator was invited to participate in the data collection phase. Following a brief exchange of e-mails, in which the purpose of the project was explained to him, a telephone (conference call) interview was scheduled.

The interview took place with the three participants (two analysts and the pilot) in their respective homes. The interview began at approximately 9h00, when the pilot was asked to narrate a recent experience of an operation conforming to the scenario proposed. While the pilot described his experience, the analysts took notes and posed occasional questions.

At approximately 10h20, the pilot finished his description. At this point, the pilot was given a one hour break, during which period the analysts constructed a timeline of the operation based on a comparison of the notes taken. The computer file, containing the timeline built by the analysts, was presented to the pilot when he came back. The timeline was read aloud to him, and his remarks were used to improve the timeline. The interview ended at approximately 12:30 and arrangements were made for a follow up interview.

The analysts used the revised timeline, supplemented by technical literature and personal experiences (both analysts have flown as offshore helicopter passengers in several occasions), to build an Approach and Landing Model. In similar fashion to the process used for the development of the Generic Model, the following was done:

- Keywords were extracted from the revised timeline and phrased as functions. The following functions were identified:

Table 6.2: Functions Helicopter landing on helideck.

Id	Function Scenario 1: Landing on helideck
FS1.1	Approach planning
FS1.2	Update weight & balance calculations
FS1.3	Fix approach on GPS
FS1.4	Do prelanding preparations
FS1.5	Arrive to ARA (airborne Radar Approach)
FS1.6	Approach to minimum descend
FS1.7	Continue descend to offset installation point (OIP)
FS1.8	Request if deck is clear for landing
FS1.9	Approach near by obstruction
FS1.10	Establish visual at OIP
FS1.11	Turn 10 degrees in the missed approach direction (away from rig)
FS1.12	Continue approach to missed approach point
FS1.13	Perform a missed approach
FS1.14	Decide approach type

FS1.15	**Move along site deck**
FS1.16	**Land**
FS1.17	**Perform landing check list**
G.1.8.2	**Support helicopter landing**
G.1.5.3	**Provide flight operation procedures**
G.1.1.1	**Development, design and production**
G.1.1.4	**Certification**
G.1.1.7	**Execution of modifications and repairs**
G.1.2.1	**Execute scheduled maintenance - preventive**
G.1.2.2	**Execute unscheduled maintenance - corrective**
Functions from generic model	

- The scenario description used a combination of functions from the generic description with other more detailed functions required to describe the concrete scenario. The descriptions of the functions were checked to eliminate inconsistencies due to spelling mistakes or alternative phrasings of the same issue. Other functions that were considered important, but which were not mentioned in the timeline, were added. The functions descriptions were developed to a level of detail necessary for the description of the scenario. At the same time it is necessary to maintain a high level description for other functions.
- According to the FRAM method description a set of six aspects were described for each function. Table 6.3 illustrates aspects related to the function "Approach planning"

Table 6.3: Aspects description of function "Approach planning"**.**

1.1.7	**Function**	**Decide approach type**
Input		Rig report: weather, fule and nav aids inf
Output		Approach type IFR/Manual
Output		Decision Pilot Flying/Pilot Monitoring
Preconditions		Helicopter airworthy
Resources		Jeppesen charts
Time		15 min (longer if bad weather)
Control		OPS MAN A&B 1 hour before departure

- A consistency check was carried out. The 6 elements for each individual function have been identified, either as part of the Approach and Landing Model itself or as part of the Generic Model;
- The links between the two models were identified and made explicit (as illustrated in Table 6.2);

A preliminary Approach and Landing Model was then proposed

The FRAM model may be read sequentially, that is, with each function corresponding to a "step" in the operation of the helicopter during the approach and landing process. However, its primary objective is to illustrate how functions interact in practice, therefore impacting how each of them is actually performed. A clear identification of these interactions is needed for the subsequent steps in a FRAM analysis.

6.3 Preliminary results and further work

The purpose of this Memo has been to present a status of the application of the Functional Resonance Analysis Method to the Helicopter Safety Study. This has been done with two aims. The first aim, described in detail in this report, is to develop a Functional Risk Model (FRM) as a complement to the existing risk model developed in HSS-2. The second aim, partly begun in the work reported here and partly to be continued, is to propose leading (or proactive) safety indicators for helicopter operations in the Norwegian Continental Shelf on the basis of the two models.

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The work has comprised the following steps, as detailed above.

- First, the existing risk model was analysed with the purpose of identifying a corpus of functions that were relevant to characterise the safety of helicopter operations. As described in Section 2.3, this was done by going through the description of the Operational RIFs, sometimes supplemented by the study of additional background information, in order to see which functions were described. This resulted in a number of functions, which represented the contents (or meaning) of the RIFs without necessarily maintaining their structure or organisation. Since this first set of functions was derived from the generic risk model, the outcome can be characterised as a generic set of functions. (In this context 'generic' means that the risks and/or functions refer to helicopter operations in general, without being applied to specific scenarios or situations.)

- Second, the functions included in the generic set were described according to the principles of FRAM. This meant that each function was characterised with regard to its input(s) and output(s) and, if relevant, also with regard to the four other aspects of timing, control(s), precondition(s), and resource(s). The information needed to characterise the aspects of the functions was taken from the available background material, primarily the from the HSS-2 project. After the aspects had been described, a consistency check was performed. This is necessary to ensure that the aspects are uniformly described, so that possibly spelling mistakes do not play a role. It also ensures that all aspects have an 'origin,' i.e., that they do not come out of nothing.

- Third, the generic FRM was then instantiated by comparing it with a specific scenario. This serves two purposes. The first is to see if the scenario requires functions that are not part of the FRM. If that is the case, it should be considered whether additional functions need to be included in the FRM. (It should be kept in mind that the scenario represents a specific case, whereas the FRM represents the generic case. There is therefore not impossible that some of the functions required by the scenario are particular to this event, but of such a nature that they need not be included in the generic model. The generic model should in principle be applicable to all scenarios, without necessarily being able to describe every scenario in complete detail.) The second purpose is to see if there are functions in the FRM which do not apply to a set of representative scenarios. If that is the case, it should be considered whether such functions should be removed from the generic FRM. This purpose was not served in the present case, since we only have looked at a single scenario. In principle, the generic FRM should be compared to a representative set of scenarios. This will establish prima facie evidence for the appropriateness of the generic FRM, and serve as a replacement for a more formal validation. Such a validation is likely to be very extensive and costly.

- The fourth step, yet to be carried out, is to reconcile or combine the two risk models, i.e., the one produced by HSS-2 (with possible updates) and the generic FRM. This will lead to a combined risk model which will be more complete than either. The two models will also complement each other in different ways. The 'classical' risk model, being in the form of a tree, will provide well-defined links between various Operational RIFs, hence support a quantitative expression of risks. The FRM, being in the form of a set of generic functions rather than a set of risk factors, will provide ways of reasoning about the links in the classical model, as well as ways of possibly recognising additional links, for instance if the risk model is applied to a specific scenario or if it is used to evaluate the consequences of technological or organisational changes.

In the present study, the third step was done by remote interviews with a helicopter pilot, as described above. While this served its purpose at the moment, it is clear that the telephone interview was too demanding for all parties involved. Although interviews over the telephone may be useful for gathering data for the initial phase of a modelling project, it is strongly recommend that future interviews be conducted face-to-face, at least until a more refined questionnaire is developed. Another concern was that very limited “deepening” was possible, in part due to the analysts' lack of experience with the questionnaire used (since it had been specially developed for this interview) and in part due to the constraints posed by telephone communication. However, as noted above, a follow up interview was arranged to complete the scenario description at a later time.

Further work
Several lines of work remain open for the future.

- One line of work is to check the generic FRM by developing more concrete scenarios. Although this is a time consuming thing to do, and therefore outside of the scope of the current project, it is strongly recommended as a practical way of calibrating or verifying the model.
- A second line of work is to use the FRM, possibly together with the classical risk model, to identify relevant leading safety indicators. The FRM provides a very useful basis for that since it describes the functions that are required to accomplish a specific activity (or mission), including the ways in which these functions dynamically depend on each other. It can therefore, in accordance with the principles of FRAM, be used to analyse how specific unwanted situations may develop, and how reliable precursors may be found. This line of activity will be carried out in this project, at least to the extent that the principal steps of a method or step-by-step approach will be described.

6.4 Abbreviations

ATA	Air Transport Association
BASIS	British Airways Safety Information System
BP	British Petroleum
ETOPS	Extended-range Twin-engine Operational
ETTO	Efficiency-Thoroughness Trade-Off
HRO	High Reliability Organization
HSE	Health Safety and Environment
ICAO	International Civil Aviation Organization
MESH	Managing Engineering and Safety Health
OECD	Organisation for Economic Co-operation and Development
SMS	Safety Management System
TGRE	Task Group on Regulatory Effectiveness

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Appendix: Leading indicators concepts & studies

1. Introduction

The measure of safety performance in aviation is traditionally based on lagging indicators such as accident rates. In aviation these accident rates have been further decomposed into different categories to identify particular safety issues. Examples of accident categories for helicopter are CFIT (controlled flight into terrain) and LOC-I (loss of control in flight). This categorisation of accidents has enabled several improvements on specific issues. However, there is a growing concern that this information does not provide the required basis for the prevention of future accidents. The absence of an accident does not necessarily prove that everything is going well (Van Steen, 1996). Several other indicators may therefore be needed to provide a better understanding of the current state of the system or process. In addition it is also necessary to propose indicators of possible future events or changes. Many companies have introduced the use of leading and lagging indicators into their Safety Management System to track safety performance. The International Civil Aviation Organization (ICAO) recommended the establishment of an effective Safety Management System (SMS). However, despite the benefit of a proactive SMS, in general the aviation industry is still focused on reactive part of safety management.

Reactive monitoring is based on the identification, reporting and investigation of incidents and accidents (HSE, 2006; Baker, 2007). It provides a feedback in relation to safety performance and allows the identification of deficiencies associated to specific incidents or trends. This monitoring is based on indicators of after-the-fact performance, such as tallies of various types of adverse outcomes. The indicators therefore refer to the past. In contrast to that, proactive monitoring looks at the present state and interprets that to make predictions about possible future events. Therefore, leading indicators should attempt to measure variables that provide an indication of future safety performance. Adapting a definition from economy to safety, a leading indicator may provide a reliable indication that a specific change in risk level is about to occur.

This implies a need to recognize early signals before an accident occurs to improve safety. In this paper, it is explored the identification of leading indicators in aviation maintenance. **The focus on this section is to review leading indicators to identify specific indicators for helicopter operations as basis to look forward in the monitoring safety performance.** Since the main problem is to address the proactive part of safety management of maintenance, the memo is limited to leading indicators. The development of lagging indicators and integration of leading and lagging indicators for evaluating of safety performance is outside the scope of this memo. The leading indicators are limited to risk elements that have impact on major accidents.

2. Concepts on safety indicators

Performance indicators serve three main purposes: *i)* monitoring the level of safety in the system; *ii)* deciding where and how to take actions and *iii)* motivating those in a position to take a necessary action take it (Hale, 2008). Performance indicators are use to measure performance, to benchmark performance, to measure efficiency and effectiveness, to improve activities and to communicate (Hollnagel, 2007).

> *An indicator is a measurable/operational variable or characteristic that can be used to describe the condition of a broader phenomenon or aspect of reality [adapted from Øien].*

A safety indicator is an observable characteristic of an operational unit, presumed to bear a positive correlation with the safety of the system (Adapted from Holmberg, 1994).

The safety science community has different understandings of the distinction between leading and lagging indicators. Table 1 provides an overview of different definitions of these indicators.

Table A.1: Different definitions and application of leading and lagging indicators.

No.	Leading indicators	Lagging indicators	Ref.
1	Type of accident **precursors** are conditions, events or measures that precede an undesirable event and have some value in predicting the arrival of an event. Are associated with proactive activities that identify hazards and will assess, eliminate, minimize and control risk.	Measures of a system that are taken after undesired events have occurred. Will measure outcomes and occurrences.	(Construction Owners Association of Alberta, 2004)
2	Defined as a form of **active monitoring.** Focused on few control systems and on process or inputs.	Provides information when the safety outcome has failed. Focused on outcome.	HSE, 2006
3	"Activity" indicators, showing whether the organisation is taking actions believed to reduce the risk.	"Outcome" indicators, showing whether the actions lead to reduced risk; example: reduction of injuries and fatalities from chemical accidents.	OECD, 2003
4	Measure variables that are believed to be **indicators or precursors** of safety performance, so that indications of current/future(?) safety outcome is achieved .	Historical indicators that show the past achievement of the safety performance.	Baker, 2007
5	Use present and past information to give an status and to **predict future performance**; relies on the validity of the model.	Based on performance in the past, aggregated.	Hollnagel, 2007
6	Focused on the **input** and tell how to achieve improvement on safety performance.	Focused on the output and provide measure how well the system performed	Erikson, 2008
7	Address the need **to predict and act before** the accident event occurs.	Address the "fix and fly" approach, meaning acting after the event	Hale, 2008

Grote (2008) argues that it is very difficult to establish good precursors that have sufficient predictive validity. Woods (2008) points out the need to monitor and maintain a balance between safety and performance to meet production, quality and efficiency.

3. The ideal characteristics of indicators

Previous work on indicators indicates some key characteristics that are summarized in Table 2.

Table A.2: Overview of characteristics for indicators identified in the literature review.

No.	Characteristics of good performance indicators	Ref.
1	SAFETY Suitable for the purpose intended and **measurable**, **Useful for communicating** within the regulatory body and with its stakeholders, Capable of identifying undesirable trends to trigger actions by the regulator, Helping to focus and prioritise the regulator's activities, Providing a stimulus to the regulatory body to improve its performance.	IAEA, no date
2	SAFETY Provide an objective **indication of safety performance**; **Easily understandable**;,Data needed should be easily obtained **from existing data collection** systems	TGRE, 2004
3	SAFETY Relevant to the organisation strategies; Clearly defined **easy to understand and collect**; **Measurable in an objective way**; Acceptable, perceived as fair by staff and managers; Comparable, i.e. allow comparisons over time with other organisations; Unambiguous; **Indicate improvement or deterioration** of performance; Attributable, management action will have impact on results; Statistically valid; Timely, representing current performance; **Cost effective.**	OECD, 2003
4	MAINTENANCE Have Diversity and be complementary like financial(?), Operational, **Objective and accurate**, Informative, provide basis for decision making, Benefits should overcome costs of collection, Reflect	Parida, 2006

No.	Characteristics of good performance indicators	Ref.
	system causality, Relate to the strategy of the organisation, Motivate improvements, Improve decision making.	
5	SAFETY, LEADING: Simple, close **connectivity to the outcome/results**, Measured objectively and reliably, Interpreted by different groups in the same way, Broadly applicable across company operations, Easily and accurately communicated.	DuPont [2]
6	SAFETY: Administrative feasible and efficient, the return of investment is consistent with cost involved, **Quantifiable** and constant units of measurement, Sensitive enough to detect changes, Reliable, giving the same result if same situation is presented, Stable meaning, so if the process does not change, the measure remain unchanged, Valid, provide **information that is representative**, Robust against manipulations, Transparent and easily understood.	Tarrant (1980) and Kjellen (2000)
7	SAFETY: Objective, obtained from observable and non-manipulative sources, **Quantitative measured** and trended be aware when changes(?), Available from existing sources, Simple to understand, represent a valuable goal, Related or **compatible with other programs.**	Wreathall, 2006, 2007
8	GENERAL **Objective, Easy to measure**, Relevant, Provide immediate and reliable indication of the level of performance, Cost efficient in relation to data collection, **Understood and** owned by group whose performance is measured LEADING PERFORMANCE INDICATORS **Relation between indicator(?) and outcomes**, Reasons behind indicators and benefits are easy to understand, Provide information that **guide future actions**, Related to activities that are **important for future performance**, Reinforce willingness to intervention, Provide clear indications of means to improve performance.	Sefton, Step Change [3]
9	GENERIC LIST FOR MEASURING SYSTEMS: **Valid**: does it measure what we want it to measure? Is correlation enough, or do we need the link to be causal? This includes using rates which take account of exposure when counting things such as accidents. **Reliable**: does it give the same measurement when used by different people on the same situation, or on different occasions by one person on that same situation? **Sensitive**: does it respond to changes in what it is measuring with sufficiently large changes in the indicator to become statistically significant over a reasonably short time? **Representative**: does the set of KPIs cover all of the aspects which are relevant? **Openness to bias**: can it be manipulated to show a better score without changing the underlying situation it is supposed to be measuring? **Cost-effectiveness**: does it cost more to collect the data than would be lost without the indicator to assist decisions.	Hale, 2008
10	GOOD MEASURE OF SAFETY PERFORMANCE Quantifiable and permitting statistical inferential procedures, Valid or representative of what is to be measured, Provide minimum variability when measuring the same conditions, Sensitive to change in environmental or behavioural conditions, Cost of obtaining and using measures is consistent with the benefits, Comprehended by those in charge with the responsibility of using them.	Rockwell, 1959

None of these documents discussed the reasons behind the selection of the characteristics. As a general conclusion the following characteristics seem to be repeated across the literature:

- objective measure,
- easy to understand,
- indicate improvement or deterioration and
- collected from existing data.

There is not a single measure that will meet all the characteristics mentioned in Table 3. A combination of measures can provide a reasonable compromise, (Tarrant, 1980). The literature review reveals a strong tendency to quantitative indicators. Hollnagel (2007) pointed out the importance to go behind the indicators, and study causes and reason behind the indicators, rather than treating indicators as signals.

The following pitfalls on indicators were identified to be taken into account when using indicators (IAEA):

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2 http://www2.dupont.com/Consulting_Services/en_US/news_events/article20070921.html

3 http://stepchangeinsafety.net/stepchange/News/StreamContentPart.aspx?ID=1517

- Conclusions can not be based on indicators alone
- Some indicators can not be defined unambiguously
- Result may be misleading if the indicator is seen as measure of the safety level rather than as measure of a particular performance
- Indicators can be manipulated
- Use of aggregated indicators could mask trends of specific systems, one good trend could override a bad trend.

4. What can we learn from other studies?

4.1. Indicators within aviation

One approach for leading indicators looks for data both at working level and in organisational behaviours, (Wreathall and Merrit, 2003). This approach uses the 8-12 work place and tasks factors identified by Reason (1998). These factors have been assessed in the organisation proactively. In this specific case a web tool has been developed to have samples from workers on periodic basis.

In the aviation industry, ***MESH (Managing Engineering and Safety Health)*** is an example of the identification of situational factors having adverse effect on performance of maintenance. MESH was developed in early 1990s and use rating instead of indicators. MESH assesses local and organizational factors. Collectively, these measures were designed to give an indication of the safety of the system (Reason, 1998; Reason and Hobbs, 2003). The aviation industry has been using performance indicators and information from databases for incident reporting systems. In addition, confidential reporting systems have been established to record incidents not reported elsewhere.

The ***Civil Aviation Authorities in New Zealand***[4] developed a prototype for risk indicators in 2000, and a re-evaluation of the system started in 2005. The result of this exercise was the adoption of several new risk indicators, the development of a system to assess as many risk indicators as possible automatically, and the development of word pictures to help assess those indicators that were not suitable for automation.
The risk profile was designed to highlight aspects of an operation that may involve increased risks to safe operation. It required the CAA to assess a client's organisational culture and internal functioning in many areas and rate performance against a standard scale.
Risk profiles could be generated and changed by any staff member having interaction with a client during routine and non-routine surveillance and certification. In addition to this direct human assessment, routine automatic evaluation of client information was carried out.
The risk profile assessed an organisation in about 30 areas. Tailored risk indicators were developed for each certificate type and therefore their number varies according to the certificate type held. About half of the indicators were assessed by CAA staff during interactions with clients, and the remainder were assessed automatically by the monitoring of changes to the CAA database.

Another example of development of performance indicators in the aviation sector is the ***BASIS*** (British Airways Safety Information System). This is an incident reporting system, started at British Airways in 1990. BASIS system is used by several operators. BASIS operators use the system to enter reports from flight crew and maintenance engineers, and performance outside a defined threshold from a flight data recorder is reported. Associated with this database, the regulator has a requirement that the operators must maintain certified records, which ensure that the aircraft is in an airworthy condition. Technical records are related to aircrafts, engines,

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[4] http://www.caa.govt.nz/surveillance_system/the_risk_indicators.htm

components and maintenance training. Permanent records include modifications and inspections (mandatory and not mandatory), major repairs and test flight reports. Continuous records are updated according to airline operation at any time, including time in service, time limits, life limit parts limits, time in service since last inspection, logbook (flight, maintenance and cabin), and engine and auxiliary power unit records. Repetitive records shall reflect the regular checks, transit and letter checks.

The data collection in aviation is extensive and provides information to the reliability and engineering departments on the effectiveness of the maintenance programs. An interesting aspect is that focus is on those items that have failed. The data that is normally collected is:

- Flight times and cycles for each aircraft, the majority of the statistical calculations are rates, based on flight hours or cycles.
- Cancellations and delays; these data is used to build dispatch rates, normally delays over 15 minutes. Cancellations and delays are related to different activities such as maintenance.
- Unscheduled component removal; the maintenance program specifies when the “hard time” components are removed. The rate depends on systems and operation but after analysis of data rate that is not acceptable require improvement measures.
- Unscheduled removal of engines; this information is the same as unscheduled removal of components but due to the amount of resources involved is treated separately.
- During flights, shutdowns of engines are probably one of the most serious failures in aviation, particularly under Extended-range Twin-engine Operational Performance Standards (ETOPS). ETOPS operation allows twin-engine commercial air transports to fly routes that, at some points, are farther than a distance of 60/180 minutes flying time away from an emergency or diversion airport with one engine inoperative. This has an impact on route planning and operation, i.e. it sets limitations to the nearest airport for refueling or in case of failure. This kind of failures required a more intensive investigation.
- Pilots, maintenance and cabin reports (write-ups) are about malfunctions that are identified by maintenance or the flight crew. The systems and subsystems in the aircraft are tracked by specific Air Transport Association ATA number; this allows the analyst to track down problems to specific areas.
- Maintenance check findings; after scheduled maintenance failures found in checks are reported.
- Components failures are recorded, and findings from the maintenance repairs are stored
- Air-ground communication systems can also deliver on-line operational data. In case of problems some aircraft can send real data to maintenance facilities. Operational data is also collected from the flight data recorder (FDR). Safety programs have been built based on this information like the Flight Operations Quality Assurance (FOQA). Helicopters have a similar system called Vibration Health Monitoring (VHM, previously Health and Usage Monitoring System, HUMS). These programs analyse FDR data to monitor normal conditions and for accident investigation. Helicopters use these data to determine if the aircraft is airworthy. Due to the amount of data collected by the FDR, software programs have been developed for the analysis. Events can be examined to determine causes and possible measures.
- Cockpit indications when systems have failed. These indications are displayed in accordance to the criticality of the events.

When an aircraft enters into service manufacturer and experience data is combined as an initial set of data for problem detection and alert levels. After operational experience is collected this original data is adjusted. Data is gathered and compared on monthly, quarterly and yearly basis. Normally, reliability reports are originated where the hard data is reported and follow-up actions are included. A maintenance review board meets usually monthly to discuss the overall status of the maintenance reliability and to discuss items that are over the alert levels. Problems and solutions are discussed.

Human error in maintenance can be reported using different taxonomies such Boeing's ***Maintenance and Error Decision Aid (MEDA), Human Factors Analysis and Classification Systems (HFACS)*** and ***ICAO ADREP***. However, is has been pointed out that the analysis of the information stored in databases is limited by the lack of information on the context within which the event has occurred (Gosling, 1998).

A set of **indicators for measuring safety in aviation** was developed in cooperation with the Swedish and Norwegian Aviation Authorities (Tinmannsvik, 2005). These indicators were developed to identify the consequences of changes that could have a safety impact. The safety indicators selected in the study were outcome-based and activity indicators based on Kjellen (2000). The outcome-based indicators included were accident and incident rates, discrepancies reported and absence due to sickness. The activity indicators were defined in groups, i) external-internal audits, ii) competence training and experience, iii) maintenance, and iv) financial investments. The indicators were classified in accordance with their importance for the monitoring of safety trends, as high importance, average importance and minor importance, (Herrera and Tinmannsvik, 2006). After selection of indicators, quantification is normalized by the amount of flight hours, when required.

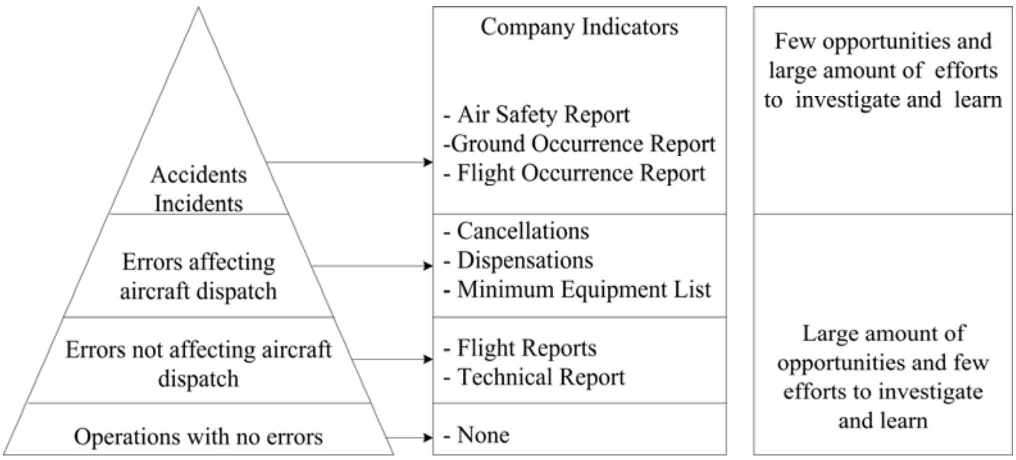

Figure A.1: Company safety indicators (Herrera et al., 2007).

The study showed that there is a strong focus on learning from rare accidents; and as shown in Figure 1 there is no tradition to analyze successes, (normal operations with no delays, or when the organization recovers from a failure that could have a safety impact). This trend has changed for flight operations and air traffic management with the introduction of Line Operations Safety Audit (LOSA) and Normal Operations Safety Survey (NOSS) respectively. These safety management tools are still based on managing errors and threats.

An additional aspect in the study was the reliance on objective measures, this can be illustrated with the number of external audits, and the quality aspect of the audits is not reflected in the objective measure. The indicators in this study provide a static picture of a dynamic system, so we need indicators that capture dynamics and provide indication of the current safety performance.

4.2. Early warnings studies and status on selected major hazard industries

One of the major challenges is to allow the organisation to know the current state of safety. Studies have started to identify the development of leading indicators, (Wreathall, 2006; Wreathall and Merrit, 2003, Grabowski et al. 2007).

Table 3 illustrates the leading indicators identified in major studies. The studies use different terms like *factors*, *indicators* and *themes*. A common trend is that indicators are associated with the performance at individual level (sharp-end) and at organisational level. Aviation safety depends on the safe operations of many actors, and a comprehensive set of safety performance indicators for the entire aviation field will include elements from each. Further work is needed to define the necessary safety performance indicators and the means for monitoring them. It is recommended that a set of performance indicators should be established based on the model, described previously, but which combines both technical failures and human errors.

Table A.3: Overview over leading and other relevant indicators.

No.	Indicators	Ref.
1	LEADING: ORGANIZATIONAL Management commitment, Just culture, Learning culture, Opacity, Awareness, Preparedness, Flexibility.	Wreathall & Merrit 2003
2	ORGANIZATIONAL Organizational structure, People management, Provision and quality of equipment, Training and selection, Commercial and operational pressures, Planning and scheduling, Maintenance of buildings and equipment, Communication. INDIVIDUAL Knowledge, skills and experience, Morale, Tools, equipment and spares, Support, Fatigue, Pressure, Time of day, Environment, Computers, Paperwork and manuals procedures , Personal safety features.	Reason, 1998
3	LEADING ORGANIZATIONAL Organisational structure, Prioritizing for safety, Effective communication. INDIVIDUAL Empowerment, Individual responsibility, Anonymous reporting, Individual feedback, Problem identification, Vessels responsibility.	Graboski et al., 2007
4	TECHNICAL Flight times and cycles, Delays and cancellations, Unscheduled component/engine, Removal, In flight shutdowns, Write-ups, lMaintenance findings after checks, Components failures, Occurrence reports, Reports from regular monitoring and inspections, Data from flight data recorder.	Aviation

The ***Organisation for Economic Co-operation and Development, (OECD, 2005)*** recommended the use of performance indicators for the chemical industry, giving guidelines regarding the selection and use of safety performance indicators. The set of indicators proposed are activity indicators and outcome indicators. The outcome indicators should indicate if the organisation has increased risk of accident(?). The activity indicators would allow the organisation to identify whether the organisation is taking measures believed to lower risks. The indicators should be adapted and defined for each organisation. The guidance provides activity and outcome indicators for all principal activities in the organisation from the overall policy, personnel, procedures, technical issues through reporting and learning from experience. The selection of indicators is based on a questionnaire. The selected indicators are then quantified, weighted and aggregated. It is recommended that the indicators and metrics are periodically reviewed and evaluated.

Health and Safety Executive (HSE) developed a guide for the developing of process safety indicators (HSE, 2006). The purpose of the guide is to measure performance as an early warning prior to a catastrophe. The guide is based in the use of leading as well as lagging indicators for each control safety system. The HSE document defines leading indicators as active monitoring of critical control and safety systems, and these indicators are measures of process or inputs that are essential to deliver the desired function. This approach uses barriers indicators as leading indicators, and the overall performance of the barrier constitutes and indicator.

5 Models and indicators

Leading indicators are interpreted differently in the various safety models. In situations where the domino model for failure applies, the leading indicators consist of single elements. Upon failing, one of these elements may subsequently lead to catastrophic failures. Indicators related to the Swiss cheese model monitor performance of safety barriers.

The systemic approach looks into the dynamics of safety. This approach looks at the socio-technical interaction in which human; organisations and technology all play a role. The systemic view is based on models for functions rather than structures, and can therefore account for a non-linear propagation of events. The Functional Resonance Accident Model (FRAM, Hollnagel, 2004) explains failures and successes as a result of adaptations to cope with complexity. Two forms of monitoring have been identified the monitoring of performance variability at function level, and the utilization of FRAM to understand system's status in relation to resilient characteristics at system level, (Herrera, 2008). The performance variability is monitored. Examples of indicators at a function level are i) Availability of personnel and equipment, ii) Training, preparation, competence; iii) Communication quality; iv) Human-machine interaction, operational support; v) Availability of procedures; vi) Working conditions; vii) Goals, numbers and conflicts; viii) Available time; ix) Circadian rhythm, stress; x)Team collaboration. At system level, Woods (2006) identified themes including buffering capacity, flexibility, margin, and tolerance and cross-scale interactions. Mendoça (2008) measures these themes by triangularization of observation, using quantitative and qualitative data.

7 INTERNASJONALT SIKKERHETSFREMMENDE ARBEID

Internasjonalt pågår også sikkerhetsfremmende arbeid og identifisering av tiltak innenfor helikoptervirksomhet. En gruppe i EHEST har analysert 186 helikopterulykker (både innenlands og offshore) fra perioden 2000–2005 i Europa. Basert på denne analysen har de kommet frem til følgende liste over de viktigste ”Intervention Recommendations Categories”:

1. Trening og instruksjon.
2. Flyoperasjonelle forhold og sikkerhetsstyring.
3. Myndigheter og regulering.
4. Data og informasjon
5. Vedlikehold
6. Teknisk utstyr og systemer
7. Helikopterkonstruksjon
8. Fabrikasjon
9. Forskning
10. Infrastruktur (heliport/flyplass, helidekk, innretninger, ATC, osv.)

Forutsetningene om konsolidering av eksisterende krav og teknologi og innføring av allerede planlagte endringer dekker de fleste av punktene over (jf. kapittel 10.1 i hovedrapporten). Nedenfor gis en kort status og de viktigste tiltak (og forutsetninger) relevante for norsk sektor for hvert av de ti punktene over.

<u>1. Trening og instruksjon</u>
Eksempler på tiltak fra EHEST er bedre trening på spesifikke operasjoner og under spesifikke forhold og krav til trening for involvert personell utenom pilotene (f.eks. helidekkpesonell). Trening for piloter og krav til simulatorer er i denne rapporten foreslått som et eget tiltak.

<u>2. Flyroperasjonelle forhold og sikkerhetsstyring</u>
Eksempel på tiltak fra EHEST er innføring av SMS og bruk av FDM. Både SMS og FDM er allerede innført som krav og vil videreutvikles kontinuerlig. I forbindelse med sikkerhetsstyring har det også vært en forbedret rapporteringskultur i bransjen de siste årene, men det er mer å hente i forhold til læring av hendelser og bruk av proaktive indikatorer.

<u>3. Myndigheter og regulering</u>
Den viktigste forutsetningen for anbefalingene om tiltak i HSS-3 er opprettholdelse av norske tilleggskrav. Dessuten anbefaler rapporten at OLF benyttes som anerkjent norm, bedre oppfølging hos organisasjoner ved endrede interne rammebetingelser samt forbedret tilsynsaktivitet.

<u>4. Data og informasjon</u>
Opprettholdelse av norske tilleggskrav gjelder blant annet HUMS og FDM. Her ligger det, som beskrevet tidligere, en forutsetning om konsolidering av systemene.

<u>5. Vedlikehold</u>
Innenfor vedlikehold er det også, som for piloter, identifisert behov for bedre og mer relevant trening.

<u>6. Teknisk utstyr og systemer</u>
Bruk av siste generasjon utprøvd teknologi er et av de prioriterte tiltakene, og er i ferd med å implementeres, se beskrivelse av innfasing av nye helikoptre i kapittel 3.1.

7. Helikopterkonstruksjon

Siste generasjon utprøvd teknologi er et av de prioriterte tiltakene. Innenfor helikopter-konstruksjon har innfasingen av nye helikoptre bidratt til å redusere konsekvensen av ulykker pga. blant annet bedre støtabsorpsjon.

8. Fabrikasjon

Innenfor fabrikasjon fremmer rapporten et behov for grundigere kritikalitetsanalyser (FMECA) og andre analyser for å avdekke potensielle risikomomenter før innfasing av nye helikoptre. Rapporten har også identifisert et tiltak som innebærer at piloter og teknisk personell med erfaring fra forhold i Nordsjøen er med i designfasen.

9. Forskning

De siste årene har det pågått forskning innenfor flere tema relevant for offshore helikopterflygning, særlig i regi av CAA UK. Av forskningsprosjekter fremover anbefaler HSS-3 et samarbeidsprosjekt mellom Norge og UK for å unngå lyntrigging og lynnedslag.

10. Infrastruktur (heliport/flyplass, helidekk, innretninger, ATC, osv.)

Med hensyn til utforming av helidekk og krav til helidekkpersonell har det de siste årene vært en forbedring, blant annet gjennom innføring og oppdatering av OLF helidekkmanual. Identifiserte tiltak innenfor helidekk viser at det er mer å hente på bedre værobservasjoner, rapportering av utstyr og opplæring av helidekkpersonell. Innenfor ATS/ANS er det særlig et behov for videreutvikling/erstatning av M-ADS.

8 RELEVANT LITTERATUR

Litteratur og rapporter fra en rekke forskjellige kilder er gjennomgått:

- Samarbeidsforumets statusrapporter i prosjektperioden for HSS-3
- Relevante SINTEF-rapporter
- Hovedrapporter fra RNNS/RNNP Fase 1–7
- Rapporter fra EHEST og IHST
- Rapporter fra CAA UK
- Granskningsrapporter fra AAIB
- Granskningsrapporter fra SHT/HSLB
- Diverse annen relevant litteratur

8.1 Oversikt over norske tilleggskrav

Tabellen gir en oversikt over spesielle tilleggskrav og status for operasjoner på norsk kontinentalsokkel.

Tabell 8.1: Spesielle tilleggskrav og anbefalte retningsliner.

Organisasjon	Tittel	Status 01.02.2010
EASA	EASA PART-OPS høring med innspill for helikopter operasjon. Det er spilt inn tre forslag: - Behov for egne bestemmelser for offshoreflygninger - Behov for trening - Behov for system for angivelse av helikopter posisjon	EASA vil utarbeide et revidert forslag til nytt regelverk basert på kommentarene til høringsutkastet.
Luftfartstilsynet	Forskrift om kontinentalsokkelflyging - ervervsmessig luftfart til og fra helikopterdekk på innretninger og fartøy til havs (BSL D 5-1)	Publisert i 2007 Ikrafttredelse: 2008-01-01
Luftfartstilsynet	Forskrift om vibrasjonsovervåkningssystemer for helikopter (BSL D 1-16)	Publisert i 2005 Ikrafttredelse: 2005-07-01
Luftfartstilsynet	Forskrift om flyværtjeneste (BSL G 7-1)	Publisert i 2008 Ikrafttredelse: 2008-07-01
Luftfartstilsynet	Forskrift om bruk av modified automatic dependant surveillance (M-ADS)-utstyr i sivile helikopter (BSL D 2-10, lå tidligere under BSL D 1-15)	Publisert i 2004 Ikrafttredelse: 2004-07-01
Luftfartstilsynet	Krav til norsk operasjonstillatelse (AOC)	Generelle bestemmelser for sertifisering (AOC) JAR-OPS 3.175
Oljeindustriens Landsforening	OLF 066 - Anbefalte retningslinjer for flyging på petroleumsinnretninger	Publisert 2000 siste rev.2007
Oljeindustriens Landsforening	Helideck Manual	Siste revisjonsdato 31.12.2008
Oljeindustriens Landsforening	OLF retningslinje 074 – Anbefalte retningslinjer for helikopter personell: Pkt. 9 helikopterdekk; bemanning og kompetanse	Publisert i 2002. Siste revisjon i 2002
Andre studier	NOU 2001: 21 og NOU 2002: 17	I referanseliste i hovedrapporten

8.2 Utvalgte luftfartsstudier fra CAA UK 2001–2007

Tabellen gir en oversikt over FoU-prosjekter som er analysert nærmere for å avgjøre om de er relevante for HSS-3.

Tabell 8.2: Utvalgte luftfartsstudier fra CAA UK 2001–2007.

Referanse	Tittel	Dato
Helikopterspesifikk		
CAA Paper 2009/06	Hazard Analysis of the Use of GPS in Offshore Helicopter Operations	February 2010
CAA Paper 2008/05	HUMS Extension to Rotor Health Monitoring	23 March 2009
CAA Paper 2008/03	Helideck Design Considerations - Environmental Effects	1 July 2009
CAA Paper 2008/02	Offshore Helideck Environmental Research	1 May 2009
CAA Paper 2008/01	Specification for an Offshore Helideck Status Light System	1 July 2008
CAA Paper 2005/06	Summary Report on Helicopter Ditching and Crashworthiness Research	16 December 2005
CAA Paper 2005/01	Enhancing Offshore Helideck Lighting - Onshore Trials at Longside Airfield	30 April 2005
CAA Paper 2003/06	Specification for an Offshore Helideck Status Light System	November 2004
CAA Paper 2004/12	Final Report on the Follow-on Activities to the HOMP Trial	October 2004
CAA Paper 2004/03	Helicopter Turbulence Criteria for Operations to Offshore Platforms	22 September 2004
CAA Paper 2004/02	Helideck Design Considerations - Environmental Effects	30 January 2004
CAA Paper 2004/01	Enhancing Offshore Helideck Lighting - NAM K14 Trials	30 January 2004
CAA Paper 2003/07	Effect of Helicopter Rotors on GPS Reception	December 2003
CAA Paper 2003/01	Helicopter Tail Rotor Failures	November 2003
CAA Paper 2002/02	Final Report on the Helicopter Operations Monitoring (HOMP) Trial	25 September 2002
CAA Paper 1999/04	Research on Offshore Helideck Environmental Issues	22 November 2002
Luftfart		
CAA Paper 2009/05	Aircraft Maintenance Incident Analysis	1 July 2009
CAA Paper 2003/02	DGPS Guidance for Helicopter Approaches to Offshore Platforms	9 June 2003
CAA Paper 2007/06	RNAV (GNSS) Non-Precision Approach – Flight Trials Analysis Report	21 September 2007
CAA Paper 2006/05	The Completeness and Accuracy of Birdstrike Reporting in the UK	November 2006
CAA Paper 2005/03	A Benefit Analysis for Aircraft 16G Dynamic Seats Configured without Enhancements to Head Injury Criteria	October 2005
CAA Paper 2004/10	Flight Crew Reliance on Automation	22 December 2004
CAA Paper 2004/08	Delivering Safety in the Context of Environmental Restrictions; Aviation Expert and Research Review	July 2004
CAA Paper 2003/09	GPS Integrity and Potential Impact on Aviation Safety	April 2004
CAA Paper 2004/04	Cabin Air Quality	February 2004
CAA Paper 2003/11	Safety Health of Aviation Maintenance Engineering (SHoMe) Tool: User Guide	25 November 2003
CAA Paper 2003/10	Safety Health of Aviation Maintenance Engineering: Project Description	25 November 2003

Referanse	Tittel	Dato
CAA Paper 2003/14	Wakefulness on the Civil Flight Deck: Evaluation of a Wrist-worn Alertness Device	14 November 2003
CAA Paper 2003/13	Preliminary Study of the Implementation and use of Emergency Breathing Systems	24 October 2003
CAA Paper 2003/12	Introduction to the Safety Health of Maintenance Engineering (SHoMe) Tool	12 September 2003
CAA Paper 2002/05	Methods used to Evaluate the Effectiveness of Flightcrew CRM Training in the UK Aviation Industry	23 June 2003
CAA Paper 2003/03	Effects of Interference from Cellular Telephones on Aircraft Avionic Equipment	30 April 2003
CAA Paper 2002/06	Work Hours of Aircraft Maintenance Personnel	March 2003
Andre		
CAA Paper 2007/05	The Effect of JAR-FCL on General Aviation Safety	6 July 2007
CAA Paper 2004/05	Report on the Testing and Systematic Evaluation of the airEXODUS Aircraft Evacuation Model	15 April 2005
CAA Paper 2003/04	Dealing with In-Flight Lithium Battery Fires In Portable Electronic Devices	30 July 2003
CAA Paper 2003/05	On Track - A Confidential Airspace Infringement Project	11 July 2003
CAA Paper 2002/04	A Benefit Analysis for Cabin Water Spray Systems and Enhanced Fuselage Burnthrough Protection	7 April 2003
CAA Paper 2002/07	A Study into the Response of Aircraft Fuel Tanks to Rapid Decelerations	November 2002
CAA Paper 2002/01	A Benefit Analysis for Enhanced Protection from Fires in Hidden Areas on Transport Aircraft	6 September 2002

8.3 Utvalgte studier fra *International Helicopter Safety Team* (IHST)

- US JHSAT 2000 Report
- JHSAT Helicopter Back-Up Reports
- Summary Report on Helicopter Ditching and Crashworthiness Research UK CAA Safety Regulation Group
- Aviation Safety Review - 2005 (CAP-763 UK CAA)
- Investigation of Visual Flight Cues for Timing the Initiation of the Landing Flare Stephen Palmisano, et al. School of Psychology, University of Wollongong, AU TSB
- Wire-strike Accidents in General Aviation: Data Analysis 1994 to 2004 AU TSB
- Lessons Learned from TSB Investigation of Helicopter Accidents (1994 - 2003) Joel Morely, PhD and Brian MacDonald, TSB Canada
- Safety Performance of Helicopter Operations in the Oil and Gas Industry - 2000 Data International Association of Oil & Gas Producers
- Review of Confidential Human Factors Incident Reporting Programme (CHIRP) Data For the JAA/FAA Rotorcraft Human Factors Study Group D. A. Howson, UK CAA Research Management Dept.
- Helicopter GASIL Special UK CAA
- Ego-Motion and Optical Cues Applied to Helicopter Flight: A Review of Civil Accident Cases Involving Degraded Visual References (Unclassified) M. T. Charlton, G. D. Padfield, A. M. Kimberley and J. R. McLean, UK CAA
- U.S. Civil Rotorcraft Accidents, 1963 Through 1997 F. D. Harris, L. Iseler and E. Kasper, NASA
- Analysis of US Civil Rotorcraft Accidents from 1990 to 1996 and Implications for a Safety Program L. Iseler and J. De Maio, NASA

- ASRS Rotorcraft Incident Study - Draft Data Summary Aviation Reporting System, NASA
- The Final Report of the Helicopter Accident Analysis Team Hart, et al. NASA
- History of Helicopter Safety
- Roy G. Fox, Bell Helicopter Textron, Inc.
- Interim Safety Recommendations to the International Helicopter Safety Team Presented at Carmel IHST Meeting, November 2006 Mark Liptak, et al., JHSAT
- Accident Analysis Process for a Joint Helicopter Safety Analysis Team September 2007 Mark Liptak, et al., JHSAT

8.4 Utvalgte studier og data fra *International Association of Oil & Gas Producers* (OGP)

Tabell 8.3: Studier og statistikk fra OGP.

Referanse	Tittel	Dato
Studier		
403	Managing major incident risks – Workshop report	Apr 2008
387	Travel Guide - a guide to health & safety for the oil & gas professional	Mar 2007
386	Health & Safety Incident Reporting Users' Guide - 2006 data	Jan 2007
390	Aircraft management guidelines	Apr 2007
343	Managing health for field operations in oil & gas activities	May 2003
Statistikk		
402	Safety performance of helicopter operations in the oil & gas industry – 2006 data	Nov 2007
401	Safety performance of helicopter operations in the oil & gas industry – 2005 data	Nov 2007
371	Safety performance of helicopter operations in the oil & gas industry – 2004 data	Jan 2006
366	Safety performance of helicopter operations in the oil & gas industry – 2003 data	Feb 2005
354	Safety performance of helicopter operations in the oil & gas industry – 2002 data	Jul 2004
341	Safety performance of helicopter operations in the oil & gas industry – 2001 data	Apr 2003

8.5 Utvalgte ulykkesgranskningsrapporter

- UK AAIB Bulletin No: 12/2000
- UK AAIB Bulletin No: 10/2001
- UK AAIB Bulletin No: S4/2001; Aircraft Accident Report 3/2004
- UK AAIB Bulletin No: 08/2003
- UK AAIB Bulletin No: S3/2002; Aircraft Accident Report 1/2005
- Norway AIBN: SL REP 27/2005
- Dutch Safety Board: preliminary report; intermediate report 2007
- UK AAIB Bulletin No: S1/2007; Aircraft Accident Report 7/2008
- UK AAIB Bulletin: 9/2008; 22 Feb 2008; lightning damage on rotor blades
- UK AAIB Bulletin: 7/2008; 9 March 2008; helicopter’s tail struck the guardrails of crane
- UK AAIB Bulletin: S3/2009 fatal accident 18 Febrary 2009
- UK AAIB initial report EW/C2009/01
- UK AAIB initial report 2 EW/C2009/04/01

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