2017:00079 – Unrestricted

Report

Helicopter Safety Study 3b

A limited update of HSS-3 focusing on the period 2010–2015

Authors
Tony Kråkenes
Tor Erik Evjemo, Solfrid Håbrekke, Åsa S. Hoem

SINTEF Technology and Society
Safety Research

2017-05-31

SINTEF

SINTEF Teknologi og samfunn
SINTEF Technology and Society

Address:
Postboks 4760 Sluppen
NO-7465 Trondheim
NORWAY

Telephone:+47 73593000
Telefax:+47 73592896

ts@sintef.no
www.sintef.no
Enterprise /VAT No:
NO 948007029 MVA

KEYWORDS:
Safety
Helicopter
Helicopter safety
Flight safety

Report

Helicopter Safety Study 3b

A limited update of HSS-3 focusing on the period 2010–2015

VERSION
1.0

DATE
2017-05-31

AUTHORS
Tony Kråkenes
Tor Erik Evjemo, Solfrid Håbrekke, Åsa S. Hoem

CLIENT
Norwegian oil and gas

CLIENT'S REF.
Lars Petter Lundahl

PROJECT NO.
102012164

NUMBER OF PAGES
115

ABSTRACT

The overall objective of the *Helicopter Safety Study 3b* (HSS-3b) is to contribute to improved safety in helicopter transport of personnel on the Norwegian Continental Shelf. The study is a limited update of the *Helicopter Safety Study 3* (HSS-3) published in 2010.

The report describes main developments in helicopter safety in the period 2010–2015, but also looks into the period after 2015. Relevant statistics on accidents/incidents and transport activity are presented, and a special review is made of recent accidents in the study period. Compared to HSS-3, two new topics are introduced in the HSS-3b study; the British safety study CAP 1145 is assessed in relation to a Norwegian context, and so are the new European rules for offshore helicopter flight operations (HOFO). The report concludes in a series of safety recommendations as well as important prerequisites to maintain the current level of safety.

The Turøy accident (29 April 2016) is outside the time scope for this report. Nonetheless, the accident is still considered and reflected in the different parts of this report.

PREPARED BY
Tony Kråkenes

SIGNATURE
Tony Kråkenes

CHECKED BY
Lars Bodsberg

SIGNATURE
Lars Bodsberg

APPROVED BY
Roar Norvik, Research Director

SIGNATURE
Roar Norvik

REPORT NO.
2017:00079

ISBN
978-82-14-06718-7

CLASSIFICATION
Unrestricted

CLASSIFICATION THIS PAGE
Unrestricted

Document history

VERSION	DATE	VERSION DESCRIPTION
1.0	2017-05-31	Final report

Front page:
Photo courtesy of Sikorsky.

Preface

This report is the result of very good cooperation between the petroleum industry, the helicopter industry, labour unions, the authorities and research in a joint effort to improve the safety of helicopter transport on the Norwegian Continental Shelf. We hope our recommendations will be of use to the community, and that the industry and the aviation authorities follow up our recommendations for concrete measures.

The study is a limited update of *Helicopter Safety Study 3* (HSS-3) from 2010, hence labelled "3b". The study is to be considered as an additional "in-between study" awaiting the expected new and more comprehensive HSS-4.

The helicopter accident at Turøy 29 April 2016 occurred after the study was initiated, and has therefore not influenced the study mandate. The accident has had a great impact on the Norwegian helicopter community during the last year. Even though the accident is outside the time scope for this study (2010–2015), it has nevertheless been considered and reflected in the different parts of this report.

We thank all contributors for their openness and valuable input.

This report is a translation of the original report in Norwegian, issued in February 2017.

Trondheim, May 2017

Tony Kråkenes

Table of contents

Executive summary

General

The main purpose of the *Helicopter Safety Study 3b* (HSS-3b) is to contribute to improved safety in helicopter transport of personnel to and from fixed and mobile offshore oil and gas installations on the Norwegian Continental Shelf (NCS). The study is a limited update of the *Helicopter Safety Study 3* HSS-3 from 2010, which in turn was following up on the previous helicopter safety studies HSS-1 and HSS-2.

The report describes main developments in helicopter safety in the period 2010–2015, but also looks into the period after 2015. Relevant statistics of accidents and incidents are presented together with data describing the total transport activity. The most recent accidents are assessed in particular. Compared to HSS-3, two new topics are introduced in the HSS-3b study; the British safety study CAP 1145 is assessed in relation to a Norwegian context, and so are the new European rules for offshore helicopter flight operations (HOFO). The report concludes in a series of safety recommendations as well as important prerequisites to maintain the current level of safety.

The Turøy accident (29 April 2016) is outside the time scope for this report. Nonetheless, the accident is still considered and reflected in the different parts of this report.

Main conclusions

The main conclusions of the Helicopter Safety Study 3b are as follows:

1. <u>Accident statistics</u>

- The statistics for accidents and fatalities in helicopter transport on the Norwegian Continental Shelf (NCS) have been very good for many years. Even when considering the Turøy accident, the NCS statistics are far better than the total North Sea average.
- For the period 2010–2015 there have been no helicopter accidents on the NCS. Looking at the extended period 1999–2015, there has been one accident and no fatalities. If one were to include the Turøy accident (13 fatalities) in this period, this would have given a rate of **1,0** fatalities per million person flight hours.
- For the British sector in the same period (1999–2015) the rate is **4,0** fatalities per million person flight hours. The rate is based on 15 accidents of which 4 were fatal with a total of 38 fatalities.

2. <u>Main development features</u>

- The petroleum business area is currently going through large changes and the future prospects are uncertain. A downturn in the business may result in an increased pressure on safety through downsizing and a strong focus on economy, both with the oil companies and the helicopter operators. There is not a one to one relation between economics and the level of safety, but the safety margins may erode over time due to decreased redundancy, loss of competence, longer maintenance intervals, etc.
- The helicopter fleet operating on the NCS has been the newest proven technology available. The Turøy accident created a new situation where a large part of the operating fleet (H225) is no longer available for passenger transport or SAR. It is uncertain how long this situation will last and whether the H225 will come back into service at all. Introduction of new helicopter types may be a result in order to keep a robust transport solution for the NCS.
- The opening of the Barents Sea for oil exploration is introducing new and potentially bigger challenges for offshore transport by helicopter due to long flying distances and a harsh environment.

SINTEF

3. <u>Potential threats to helicopter safety</u>

The most important potential threats to helicopter safety in the coming period are mainly the same as those identified in the HSS-3 study. Many of these threats now seem reinforced:

- Lack of the possibility to maintain established Norwegian additional requirements for offshore flights, or that it will not be possible to introduce new requirements adapted to the conditions on the NCS
- Exemption from offshore special requirements and deviation from recommended guidelines
- Unwanted consequences from changes implemented by the helicopter operators and other players in this area
- Reduced competence among technicians and pilots in the helicopter companies due to the retirement of existing personnel
- Lack of competence and resources regarding offshore helicopters in the Civil Aviation Authority – Norway (CAA-N)
- Too much focus on cost and revenue by the different players on the NCS

4. <u>The new EASA regulation (HOFO) and the Norwegian Oil and Gas guideline 066 (Norog 066).</u>

- The introduction of new European regulations for offshore helicopter operations (HOFO) from 2018 is creating general uncertainty as the full implications of the regulations are still unclear. As a rule, the European Economic Agreement (EEA) does not apply to the NCS outside Norwegian territorial waters (12 nautical miles). However, it is uncertain whether Norway will be able to – or even wish to – maintain this limitation.
- Threats to safety identified in HSS-3 are becoming more relevant by the introduction of HOFO. A new regulation that may decrease or all together remove the possibilities for special Norwegian regulations for offshore helicopter operations, will be a setback for the current Norwegian safety efforts.
- Norog 066 reflects the development and practical safety efforts established on the NCS trough several decades. This standard is viewed by many as world leading, and the main Norwegian stakeholders consider the guideline to be an important document that needs to be preserved and further developed.
- Overall, the Norog 066 guideline represent a higher safety standard than the HOFO regulation. The guidelines are used voluntarily in the current contracts between the oil companies and the helicopter operators, and this may also be the case for future contracts under HOFO. However, there is a concern that Norog 066 may become diluted and loose its position over time because of economic pressure in the industry and divergent priorities by new (or existing) actors under HOFO.

5. <u>The British CAP 1145 safety study</u>

- The British CAP 1145 safety study is viewed as a natural and very understandable reaction to the recent helicopter accidents in the British sector. The study contains a lot of relevant information and a set of actions and recommendations that seem to cover a particular British need following the accidents.
- The CAP 1145 study has received some critique from different Norwegian stakeholders; this is mainly related to: a) the recommendations are seen as reactive; b) the study is trivializing the differences between the British and the Norwegian sectors relating to accidents; c) the study seems to be somewhat rushed; d) the Norwegian contributions to the study were downgraded.
- The Norwegian approach is to maintain the established focus (e.g. from the previous HSS studies) on the *prevention* of accidents rather than reducing the consequences of accidents. The industry in Norway has a strong belief in this focus and wish to preserve and develop this as it has given robust safety results thus far. It is not a given that rational recommendations for the British sector will work equally well in the Norwegian sector, and vice versa.
- Many of the CAP 1145 recommendations are already more or less in place in Norway. The most relevant recommendations are mentioned in this report.
- Particularly, this study concludes that three controversial recommendations from CAP 1145 – relating to wave height limitations, breathing system and passenger marking – should not be introduced uncritically in the Norwegian sector (see "Recommendations" below).

a) Wave height limitations may have a risk reducing effect in certain situations with the helicopter in the sea; however, the probability of such situations is seen as remote, and the total risk reduction associated with wave height limitations is considered to be marginal.
b) A Cat A breathing system (pressurised air) may have a risk reducing effect in certain situations with the helicopter in the sea; however, the probability of such situations is seen as remote, and the total risk reduction associated with a Cat A breathing system is considered to be marginal.
c) A regime with categorising and marking passengers by body size may have an effect in an actual evacuation; however; the total risk reduction associated with such a regime is considered to be marginal. Moreover, there are logistical, economical and ethical sides to such measures.

- Work is in progress on the development and certification of equipment that will prevent the helicopter from inverting after landing on the water. If this work proves successful, the need for reactive measures like the three measures mentioned above will in large part be eliminated.

Recommendations

This study confirms that the majority of the recommendations from HSS-3 are still relevant today. This shows that effort and focus over time is needed to be able to implement improvements.

Several of the recommendations in the HSS-3b study builds on important prerequisites about the continuation of the current regime and practice. For instance, it is presumed that implemented and planned measures from HSS-3 (and earlier) are not halted or reversed. Some of the HSS-3 recommendations have been implemented in the Norog 066 guideline, but full implementation will need to take some time.

Based on a coarse cost-benefit assessment the most important safety recommendations are (not in prioritised order):

- AIS in helicopters, integrated in navigational displays
- ADS-B, ATC services and communication coverage in the Barents Sea
- Stronger focus on communication to improve learning from incidents
- Unified practise concerning contracts and the use of penalties
- Improved training of technical personnel
- Stricter competency requirements for leaders in the helicopter companies
- Strengthening of capacity and competence in the Norwegian CAA

It is emphasized that the selection of candidate measures for inclusion in the cost-benefit assessment is based on *both* the cost and benefit dimensions; hence, some measures that hold a relatively large risk reduction may not be included in the analysis for various reasons (excessive cost, low realism, wrong timing, etc.). Likewise, the analysis may include measures that hold a relatively *low* risk reduction if the associated cost is also low.

Recommendations related to CAP 1145

Recommendations for Norway related to the three specific CAP 1145 measures that are discussed the most in the Norwegian community (i.e. relating to wave height limitations, breathing system and passenger marking), are as follows:

- Before possibly introducing flight limitations related to wave height, it is recommended to carry out a broad risk assessment also including possible indirect effects on other areas than the helicopter transport.
- It could be considered to introduce wave height limitations for night operations. This will be a step towards reducing night operations in bad conditions without giving any significant logistical implications. Any limitation pertaining to wave height should not be strictly formulated, but rather be seen as part of

the evaluation of the complete meteorological situation. Exemptions should be made for passing areas of high waves en route. A thorough evaluation of this arrangement should be made before considering the introduction of any daytime limitations related to wave height.
- As per today Norway should not introduce requirements for a Cat A breathing system on own initiative. It is recommended to await the coming HOFO introduction.
- Should the introduction of the HOFO regulation allow Norway to *choose* breathing system, a thorough assessment should be undertaken before any change is made. Risks associated with use both in training and in real evacuation situations – as well as cost and logistics – should all be considered.
- As per today Norway should not introduce requirements for categorising and marking passengers by body size on own initiative. It is recommended to await the coming HOFO introduction.
- Norway should support and follow up on the development of so called "air pocket" solutions as this is seen to largely eliminate the need for many of the reactive measures described above (i.e. wave height limitations, breathing system and passenger marking).

<u>Recommendations related to HOFO and Norog 066</u>

Recommendations related to the EASA HOFO regulation and the Norog 066 guideline are as follows:
- Norway should not implement the HOFO regulation on the NCS outside Norwegian territorial waters (12 nm). HOFO represents a possible realisation of key threats to offshore helicopter safety as identified in HSS-3. From a safety perspective, HOFO should not be considered implemented before it can be documented that there are no significant negative safety effects.
- Work should continue to seek legal formalisation of the Norog 066 guideline. As per today Norog 066 is just a *guideline* utilised by the oil companies through contracts with the different helicopter operators. A formalisation of Norog 066 into Norwegian law will strengthen the position of Norog 066 for the future.

<u>Recommendations for continued work</u>

Important recommendations for further work are as follows:
- Maintain the current practice of conducting regular safety studies of the helicopter activity on the NCS. Such safety studies have proven to be effective means to establish a common understanding and cooperation on the implementation of prioritised safety measures.
- Implement a special study of helicopter safety in the Barents Sea. Increased activity in the northern region represents new challenges related to helicopter transport.
- Study helicopter safety in recession conditions with low oil price and low activity. Both oil companies and helicopter operators struggle to make profit in today's market, and there is a strong focus on cutting costs. This situation may increase pressure on safety margins. It is also interesting to study helicopter safety during periods of significant business growth.
- Examine identified causes and implemented measures related to gearbox incidents, and consider seeking influence on gearbox development, including design, modification, maintenance and condition monitoring. There have been several serious gearbox incidents the last few years, drawing attention to the vulnerability of this critical part.
- Examine to what extent recent accidents and incidents – especially the Turøy accident – affect the perception of risk in helicopter transport. HSS-3 discussed perceived risk in depth as per 2010, but having an updated picture is considered important.
- Perform a broad comparative study of helicopter activities in the British and Norwegian sectors. At first glance there are many similarities between the sectors, like helicopter types, operators, environmental conditions, history, culture, etc. A deeper analysis may uncover important differences that we could take learning from. Anecdotes and hearsays exist about alleged differences between the two sectors, but this has never been studied or documented. Such a study must have participants from both sectors with an emphasis on learning.

The recommendations given in this report should be followed up by the relevant stakeholders in the business. *Norwegian Oil and Gas* and the *Committee for Helicopter Safety on the NCS* seem to be the most natural arenas for this work.

1 Introduction

1.1 Background

In the recent years we have observed some important developments and also particular events related to offshore helicopter transportation:

- There have been several serious incidents, especially in the British sector. In April 2016, a fatal accident occurred in the Norwegian sector; the previous fatal accident in Norway was back in 1997.
- CAA UK has issued the CAP 1145 safety study, with safety recommendations especially related to the three accidents in the British sector in 2012 and 2013.
- EASA is preparing a common regulation for offshore helicopter operations, under the EU regulation 965/2012. This regulation may have a profound impact on the helicopter operations.

Norwegian Oil and Gas (Norog) has tasked SINTEF to do a limited update of the Helicopter Safety Study 3 (HSS-3) from 2010, with a particular focus on the before mentioned events and developments.

SINTEF has previously carried out three comprehensive studies on the safety of helicopter transport on the Norwegian Continental Shelf (NCS) and the North Sea:

- The Helicopter Safety Study (HSS-1) for the period 1966–1990 was released in 1990. A/S Norske Shell and Statoil took the initiative and commissioned the study. One of the main conclusions was that the biggest potential for improvement of safety in the next 10–15 years, was of a technical nature, for example through implementation of the technical surveillance system HUMS (Health and Usage Monitoring System).
- The Helicopter Safety Study 2 (HSS-2) for the period 1990–1998 was released in 1999. Shell and Statoil were still initiators, but this time BP Amoco, Elf Petroleum Norge AS, Norsk Hydro ASA, Phillips Petroleum Company Norway, Saga Petroleum ASA, and the Civil Aviation Authority also contributed to finance the study. The study concluded, among other things, that despite a considerable risk reduction measured in the number of fatalities, there was still much room for improvement.
- The Helicopter Safety Study 3 (HSS-3) for the period 1999–2009 was completed in March 2010. Nine oil companies and the CAA-N had the financial backing. A main issue in HSS-3 was to verify whether the calculated risk reduction made in HSS-2 had been achieved, and in addition to estimate the risk for the coming ten-year period (2010–2019). Further, HSS-3 should map trends and give recommendations to improve or sustain the safety of helicopter operations on the NCS.

Following the HSS-2 study the oil companies and the authorities started a series of initiatives. The most significant contribution from the authorities was the completion of two Official Norwegian Reports (NOU):

- *NOU 2001: 21 Helicopter safety on the Norwegian Continental Shelf. Part 1: The structure and organisation of the official public engagement*
- *NOU 2002: 17 Helicopter safety on the Norwegian Continental Shelf. Part 2: Developments, goals, risk influencing factors and prioritised recommendations*

The two NOU's listed a lot of recommendations. One of the main recommendations was to create a collaborative forum for helicopter safety, and The Committee for Helicopter Safety on the NCS was established in 2003. The committee was tasked to be the driving force in relation to the authorities and different stakeholders, in such a way that the given recommendations could be implemented. The committee has been an active player in the offshore helicopter community since its foundation.

1.2 The organising of this study

The petroleum industry through Norog has issued the task for the HSS-3b-project. The financing of this project is a multi-client effort consisting of an owners' group of 16 oil companies, as well as Industri Energi (trade union) and the CAA-N. The governing of this project has been by a steering committee with representatives from the oil companies, trade unions and the authorities. Table 1.1 presents the owners' group and the steering committee. Please note that there has been changes to some of the oil companies' names during the running of this project. The table depicts the current names of the companies, but the names at project start-up are also given.

Table 1.1: Owners group and Steering Committee (SC) for HSS-3b.

Owners' group	Representative	Comments
Statoil ASA	Erik Hamremoen Erling Munthe-Dahl	Until Dec. 2016. SC lead until Dec. 2016 From Dec. 2016
ConocoPhillips	Øystein Petterson	
Aker BP ASA	John Arild Gundersen Geir H. Mathisen	Former BP Norge AS. SC lead from Dec. 2016 Former Det Norske
Repsol Norge AS	Øyvind Hebnes	
ENGIE E&P Norge AS	Vibeke Mowatt	Former GDF SUEZ E&P Norge AS
Eni Norge AS	Rune Meinich-Bache	
ExxonMobil E&P Norway AS	Norunn A. Strand	
Lundin Norway AS	Jan Vidar Markmanrud	Not in the SC
OMV (Norge) AS	Svein Olav Drangeid	
AS Norske Shell	Arnt Olsen Jan Erik Sandven	 Former BG Group
Total E&P Norge AS	Steinar Hviding Olsen	
VNG Norge AS	Rolf Håkon Holmboe	
Wintershall Norge AS	Bjørn Stein	
Maersk Oil Norway AS	Dean Antink	Not in the SC
Industri Energi	Henrik S. Fjeldsbø	
CAA-N	Ørnulf Lien	
	Roy Erling Furre	SAFE (trade union)
	Bryn Arild Kalberg	Petroleum Safety Authority

During the project, several workshops with different topics have been completed. A number of experts from different parts of the offshore helicopter business have attended these workshops. In addition to some members of the steering committee, this includes helicopter pilots, technicians, authotities etc.

1.3 Project scope

The HSS-3b study constitutes a limited update of central parts of the HSS-3 study (2010), with a focus on the following areas:

- An overview of important developments over the last 5 years
- Important developments for the coming 5–10 years (including the HOFO regulation)
- Relevant statistics (accidents, incidents and activity)

- Review of recent accidents in the British sector
- Assessment of the CAP 1145 in a Norwegian context
- Recommendations for increased safety

Topics form the HSS-3 report *not* covered in this report are:

- A general literature study
- An update of the analysis model (the "Helicopter Model")
- The quantification of risk levels by the Helicopter Model
- Indicators for helicopter safety
- Perceived risk
- The completion of goals as defined in the NOU 2002:17

Given the close relation between HSS-3 and HSS-3b, the reader will find similarities in the report both in structure and content.

1.4 Conditions and limitations

Use of the results from this study shall take place at the user's own risk, and neither SINTEF nor the commissioning party are responsible vis-à-vis other parties or third parties regarding consequential loss(es).

In addition to verifiable statistical data, the report builds upon SINTEF's analysis of information and viewpoints, which have emerged from the petroleum industry, the helicopter environment in general, labour unions, and users of helicopter transport. These viewpoints have largely been discussed in the report, but SINTEF is solely responsible for the report's recommendations and proposed measures.

SINTEF does not consider as its duty to determine which respective agencies should be responsible for carrying out the presented recommendations. In general, this will be evident given the nature and content of the recommendation.

Other conditions and limitations are mentioned in chapter 8.

1.5 Abbreviations

A	Accident category (A1–A8)
AAIB	Air Accidents Investigation Branch (UK)
ACAS	Airborne Collision Avoidance Systems
ADS	Automatic Dependent Surveillance
ADS-B	ADS-Broadcast
AIBN	Accident Investigation Board Norway
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
AIS	Automatic Identification System
AltMoC	Alternative Means of Compliance
AMC	Acceptable Means of Compliance
ANS	Air Navigation Service
AOC	Air Operator's Certificate

ARA	Airborne Radar Approach
ATC	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Service
AWOS	Automated Weather Observing System
BaSEC	Barents Sea Exploration Collaboration
BSL	Bestemmelser for sivil luftfart (Norwegian civil aviation regulations)
C	The consequence contribution to risk (as per definition R=F*C)
CA	Canada
CAA UK	Civil Aviation Authority, UK
CAMO	Continuing Airworthiness Management Organisation
CAP	Civil Aviation Publication
CFIT	Controlled Flight Into Terrain
CHC	Canadian Holding Corporation
CRM	Crew Resource Management
CTA	Control Area
EASA	European Aviation Safety Agency
EBS	Emergency Breathing System
ECCAIRS	European Coordination Centre for Accident and Incident Reporting Systems
EEA	European Economic Agreement
EPAS	European Plan for Aviation Safety
EEA	European Economic Area (Norway, Iceland, Switzerland and Lichtenstein)
EU	European Union
F	The frequency contribution to risk (as per definition R=F*C)
FAA	Federal Aviation Authority (USA)
FAR	Federal Aviation Regulations
FDM	Flight Data Monitoring
FiFi	Fire-Fighting
FMECA	Failure Modes, Effects and Criticality
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
HFIS	Helicopter Flight Information Service
HLO	Helicopter Landing Officer (on offshore helideck)
HMS	Helideck Monitoring System
HOFO	Helicopter Offshore Flight Operations (EASA)
HSLB	Accident Investigation Board for civil aviation and railroad (now AIBN)
HSS	Helicopter Safety Study
HUMS	Health and Usage Monitoring System (cf. VHM)
ICAO	International Civil Aviation Organisation
IOGP	International Association of Oil & Gas Producers
JAR-OPS	Joint Aviation Requirements – Operations
MAC	Mid-Air Collision
M-ADS	Modified Automatic Dependent Surveillance
MET	Meteorologisk institutt (Norwegian meteorological institute)
MGB	Main gearbox
MSG	Maintenance Steering Group
MSL	Mean Sea Level

N	Norway
NCS	Norwegian Continental Shelf
NO	Norway
Norog	Norwegian Oil and Gas
NOU	Norges offentlige utredninger (Official Norwegian Reports)
NVG	Night Vision Goggles
PC2e	Performance Class 2 enhanced (flight performance with one engine operating)
PMA	Parts Manufacturer Approval
PSA	Petroleum Safety Authority
R	Risk
RIF	Risk Influencing Factor
RIPS	Rotor Icing Protection System
RNNP	Risikonivå i norsk petroleumsvirksomhet (Trends in risk level in the petroleum activity)
SAR	Search and Rescue
SC	Steering Committee
SMS	Safety Management System
SOP	Standard Operating Procedures
TCAS	Traffic-alert and Collision Avoidance System
UK	United Kingdom
VHM	Vibration Health Monitoring (cf. HUMS)

1.6 Report structure

This report is structured as follows:

- In **chapter 2** we describe the methodological approach and how this relates to the previous safety studies.
- In **chapter 3 and 4** we describe the general development features from 2010 and forward towards 2020, including the introduction of HOFO.
- In **chapter 5** we present statistics on accidents, incidents and activity volumes, and put these results in a longer time perspective.
- In **chapter 6** we assess relevant accidents in the UK and NO sectors, as well as Canada
- In **chapter 7** we document the results from the assessment of CAP 1145 in a Norwegian context with focus on selected recommendations.
- In **chapter 8** we discuss concrete measures identified in the study, and provide a systematic review of the recommendations given in HSS-3.
- In **chapter 9** we present the main conclusions and recommendations from the study, sorted by the different focus areas for this report.

2 Method

2.1 Literature and sources

The study has used several publicly available sources, including scientific studies and reviews, accident investigation reports, letters and statements concerning specific topics, meeting minutes, news reports and other information available on the internet.

2.2 Inputs by experts

The SINTEF project group has a wide field of knowledge within the helicopter safety area, mainly acquired from the previous HSS studies. Still, the study has depended heavily on active consultation of experts working within the offshore helicopter business today, i.e. helicopter operators, maintenance organisations, oil companies, authorities, etc. Many experts have in this respect given their contributions in form of their experience and knowledge. The information from the experts has been obtained through interviews, workshops, email correspondence and phone conferences.

The content of the report refers primarily to the information gathered from the different contributors to the study. SINTEF has subjected this information to evaluation and analysis – notably by use of the so-called Helicopter Model (cf. section 2.4) – to be able to make the conclusions and give the recommendations in this report.

The informants (experts) are from different parts of the helicopter business and thereby holding different opinions and attitudes. In spite of this, there seems to be a common agreement on the main present and future challenges. For some areas, we observe differences in opinion among the experts. For these areas SINTEF have made own conclusions and in addition obtained advice from other experts within the relevant areas. In cases where challenges or problems have not been concluded, a balanced representation is offered.

The experts contributing to this study are from the following companies/institutions:

- Norwegian Oil and Gas (Norog)
- Statoil
- CHC (Norway)
- Bristow (Norway)
- Norsk Helikopterservice
- Avinor (ATC provider)
- The committee for helicopter safety on the NCS
- Industri Energi (trade union, offshore workers)
- SAFE (trade union, offshore workers)
- Norsk helikopteransattes forbund (trade union, helicopter technicians)
- Norsk flygeforbund (trade union, helicopter pilots

2.3 The identification and assessment of recommendations

The procedures for identifying and prioritising the different recommendations are depicted in Figure 2.1.

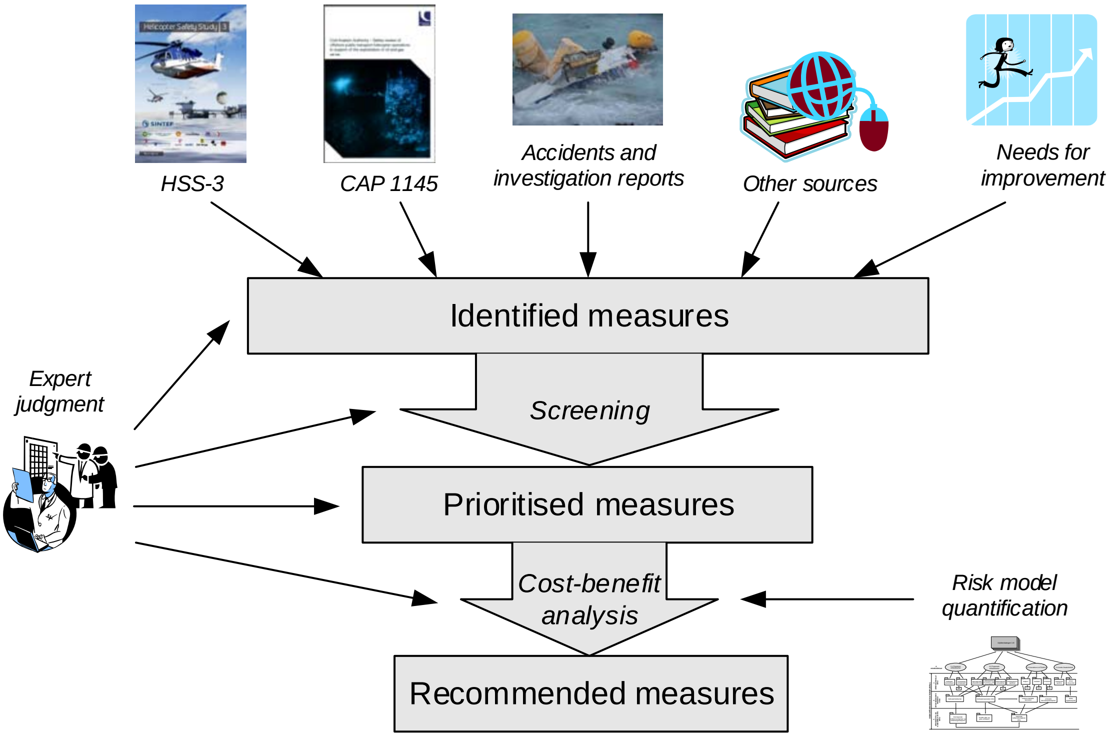


Figure 2.1: Procedure for the identification and recommendations of safety measures.

2.3.1 The identification of measures

The possible measures for improving helicopter safety described in this report stem from many different sources. Specifically, the actions from the HSS-3 study have been re-evaluated. The different stakeholders were invited to suggest measures through the workshops and interviews, as well as by email contributions. An evaluation of accident reports and other relevant documents (for example CAP 1145) has also been made in order to identify possible measures.

2.3.2 Initial prioritisation of measures

For the measures presented in the HSS-3 and the HSS.3b studies, an initial overall evaluation was made based on feasibility and expected utility represented as risk reduction for the coming 5 years (2016–2020). All of the open measures have been prioritised through expert evaluations and given one of the following grades:

- **HIGH:** The measure is seen as important to implement given a reasonable cost-benefit effect.
- **MEDIUM:** The measure is seen as useful and should be evaluated by cost-benefit in the coming period.
- **LOW:** The measure is seen as "nice to have", has a small risk reducing effect an/or an unreasonable cost attached.

The measures given a “HIGH” priority have been evaluated further by a cost-benefit assessment for further prioritisation.

2.3.3 Cost-benefit assessment of measures with HIGH priority

Most of the suggested measures are associated with a large uncertainty regarding the estimation of related costs. Therefore, we have chosen to use three cost classes for both investment costs and annual operating costs (Table 2.1). The operating costs include all costs associated with normal operations, including repairs, spare parts, maintenance, salaries, etc.

Table 2.1: Cost classes given in million NOK (estimated representative values for each class in parentheses).

Code	Class	Investment cost (I) [mill. NOK]		Annual operating cost (O) [mill. NOK]	
1	Low	0–10	(5)	0–1	(1)
2	Medium	10–100	(30)	1–10	(3)
3	High	>100	(150)	>10	(13)

The estimated representative values within the different classes of cost, rest on assumptions on how the cost of the different measures are distributed within each cost class. For the class *Low* the mean value of the interval is used for the investment cost (I), while the maximum value is (conservatively) used for the operating cost (O). For the class *Medium* (both I and O) we assume that the distribution is such that most of the measures will fall into the lower part of the interval, yielding a representative value somewhat lower than the mean value for the class. For the class *High* (both I and O) there is no upper limit, and the representative value is set based on a discretional judgement.

The actual limits and representative values of the cost classes are seen as secondary, and are utilised only as a tool to make coarse comparisons of the measures.

The expected utility of the measures, i.e. the expected contribution to risk reduction in the form of a relative reduction in the number of fatalities, is based on the Helicopter Model. The risk contribution from the defined RIFs and accident categories defined in the model, are quantified based on a distribution established in the HSS-3 report. The measures are linked to one or more RIFs and accident categories. The expected effect of a particular measure is estimated by evaluating the improvement for relevant RIFs and the reduction of risk for the relevant accident categories. We assume that the measures are implemented completely, i.e. that they have maximum effect. The classification of effect for the frequency and consequence reductions, respectively, and examples thereof, are described below.

Table 2.2: Classification of frequency-reducing effect.

Code	Effect	Percentage reduction in number of accidents for the relevant RIFs and accident categories
1	Low	0–20 %
2	Medium	20–40 %
3	High	40–80 %

Example: Measure on improvements in training for technical personnel.
The measure affects the frequency contribution to accidents, RIF 1.2 Continuous airworthiness and on all accident categories. We must ask the question: “Given a number of hypothetical accidents wholly or in part

related to continuous airworthiness – what portion of these accidents can be avoided by improving training of technical personnel in line with the suggested measure?" This percentage will then constitute the frequency-reducing effect of the measure. Her one needs to assess the influence of technical training on the continuous airworthiness, and to what extent training may improve.

Table 2.3: Classification of consequence-reducing effect.

Code	Effect	Percentage reduction in number of fatalities for the relevant RIFs and accident categories
1	Low	0–20 %
2	Medium	20–40 %
3	High	40–80 %

Example: Measure on introducing limitations to passengers' body size.
The measure affects the consequence contribution to accidents for all accident categories. For the consequence of accidents, the recommendation will affect RIF C1.7 Passenger behaviour (i.e. ability to evacuate the helicopter). We must ask the question: "Given a number of hypothetical accidents related to the passenger behavior – how large would the percentage reduction in the number of fatalities be, given the introduction of body size limitations?" This percentage will then constitute the consequence-reducing effect of the measure. Here one needs to assess e.g. the portion of fatal accidents requiring window evacuation.

The effects for frequency and consequence are evaluated separately; subsequently we find the effect on the total risk. The effect of the measure within the RIF, compared to other relevant factors for the RIF, must be considered. If the effect of the measure cannot be categorized within neither RIFs nor the accident categories, the effect on the total risk will have to be estimated directly This is applicable for measures at level 2 and 3 in the Helicopter Models' risk influence diagrams (cf. section 2.4 and Figure 2.3).

The representative values for the three effect categories are used when estimating the expected risk reduction, respectively 10 % (L), 30 % (M) and 60 % (H). The relative contribution to the total risk from the relevant RIFs and accident categories, is then considered based on the quantifications in the RIF model used in the HSS-3 report.

In Figure 2.2 we provide two examples of finding the effect on the accident frequency for a given measure. First, we consider the combination of RIFs and accident categories. Example 1, in the figure shows that this contribution is 17,7 % of the total risk, given that the recommendation will affect RIF 1.2. Then you consider the effect of the recommendation (low, medium or high). Suppose we anticipate a medium effect on RIF1.2 (i.e. 50 % reduction in frequency). The expected reduction of frequency will then be; 0,5 x 0,177 = 8,9 %.

Let us further assume that the same recommendation is expected to reduce the consequence of accidents by 3 %. The expected risk reduction if introducing the recommendation will then be:

$(1-0{,}089)\times(1-0{,}03)-1=-0{,}12$, i.e. a 12 % reduction of the total risk.

Example 1: RIF 1.2, all accident categories. The total contribution equals the sum of the contributions from RIF 1.2 for all accident categories, i.e. the total contribution equals 17.7 %.

RIF		Accident category A1 Heliport	A2 Helideck	A3 System failure	A4 Collision air	A5 Collision terrain	A6 Person inside	A7 Person outside	A8 Other/ unknown	Total
1.1	Helicopter design	1.7	4.1	18.7	0.0	0.4	0.4	0.7	1.2	**27.2**
1.2	Continuous airworthiness	1.2	4.2	11.4	0.0	0.4	0.4	0.1	0.0	**17.7**
1.3	Operational working conditions	0.1	0.9	0.5	0.0	0.9	0.0	0.0	1.0	**3.4**
1.4	Operational procedures	0.6	5.9	0.0	0.0	1.6	0.0	0.7	1.0	**9.9**
1.5	Pilot competence	0.9	6.5	2.7	0.2	3.1	0.0	1.1	0.5	**15.0**
1.6	Passenger behaviour	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	Helideck	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	Weather conditions and climate	1.2	2.3	4.8	0.0	1.1	0.0	1.4	0.6	**11.3**
1.11	Other activity	0.1	0.0	0.0	0.1	1.0	0.0	0.0	0.0	**1.2**
Total		**6.7**	**32.9**	**38.1**	**0.7**	**9.7**	**0.8**	**5.4**	**5.7**	**100**

Example 2: The RIFs 1.4 and 1.5 for accident category A5. The total contibution equals the sum of the contributiosn from fra RIF 1.4 and RIF 1.5 respectively, for accident category A5, i.e. the total contribution equals 4.7 %.

Figure 2.2: Two examples of the contribution to accident frequency for given RIFs and accident categories.

2.4 The Helicopter Model

Central to the HSS studies is the so-called "Helicopter Model" which has been developed in the course of the project series. The model is an aid in in structuring and quantifying an array of *risk influencing factors* (RIFs) in a way that facilitates:

- structured discussions in workshops
- thematical presentation of results
- quantification of risk and changes in risk

The model has not been further refined in this study, but it has been utilised as depicted below:

- framework and structuring of the experts workshops on developments (chapter 3 and 4) and thematical sorting of measures (chapter 8)
- presentation of accident and incident data distribution on risk factors (RIFs) and accident categories (chapter 6)
- quantification in the cost-benefit assessment of measures (chapter 8)

The Helicopter Model is further described in the HSS-3 report and in various published scientific articles.

Figure 2.3 depicts the RIF hierarchy including risk factors affecting the *frequency* of accidents. The RIFs are organised in 3 levels: 1) operational RIFs, 2) organisational RIFs, 3) authorities and customer related RIFs. There is a similar diagram for RIFs affecting the consequential part of risk. Both diagrams are presented in Appendix A (with higher resolution).

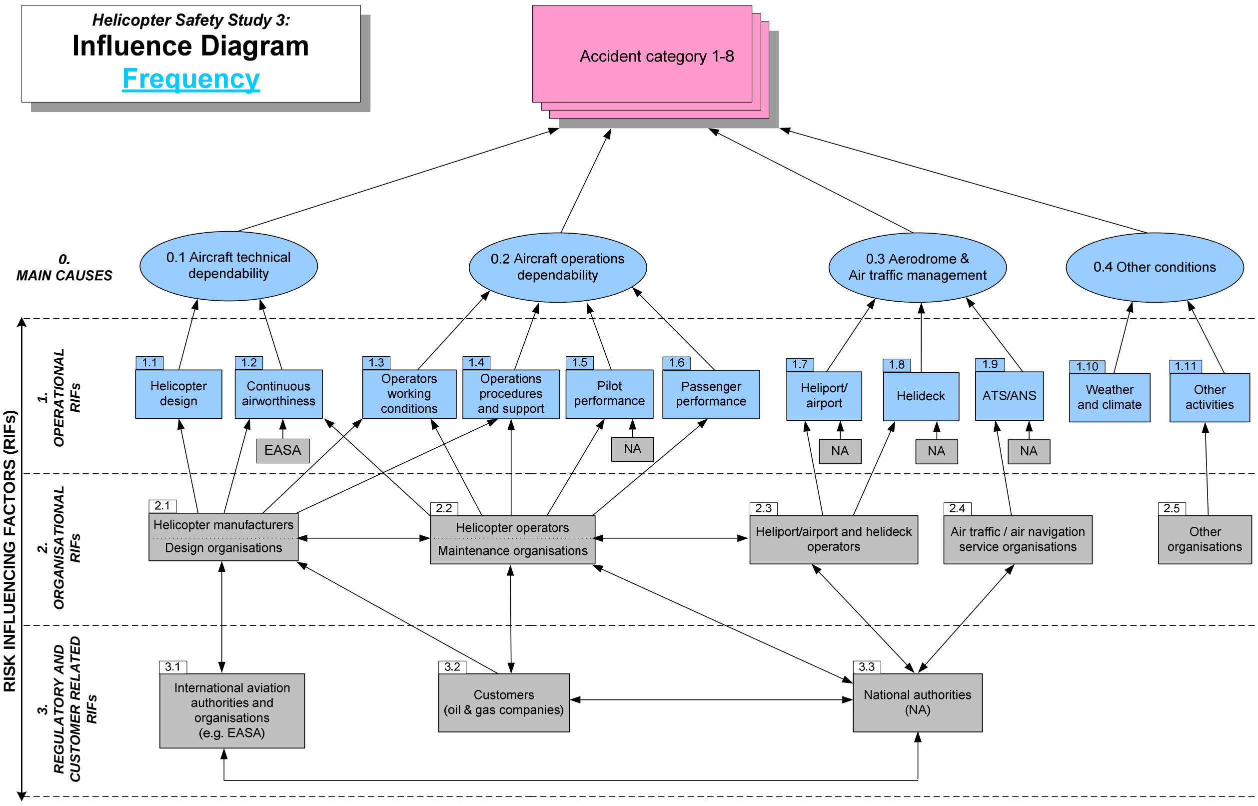


Figure 2.3: Influence diagram for the frequency dimension of accidents. A similar diagram exists for the consequence dimension (see appendix A).

The helicopter Model operates with eight different accident categories, listed below. Shorter names for the accident categories for use in figures and tables are included in brackets.

- **A1: Accident during take-off or landing at heliport/airport [Heliport]**
  Accident which occurs after passengers have boarded the helicopter and before TPD (*Take-off Decision Point*), or after LDP (*Landing Decision Point*) and before passengers have left the heliport/airport.

- **A2: Accident during take-off or landing on helideck [Helideck]**
  Accident which occurs after passengers have boarded the helicopter and before TDP (*Take-off Decision Point*) or after LDP (*Landing Decision Point*) and before passengers have left the helideck.

- **A3: Accident caused by critical failure in helicopter during flight [System failure]**
  Accident caused by critical system failure in the helicopter after TDP (*Take-off Decision Point*) and before LDP (*Landing Decision Point*), for example in the main rotor, tail rotor, engine, gearbox, etc. When a critical system failure occurs, the craft (pilots/passengers) can only be saved through a successful emergency landing.

- **A4: Collision with another aircraft [Mid-air collision]**
  Collision with another aircraft during flight, without any critical failure occurring. (*Mid-Air Collision*; MAC)

- **A5: Controlled flight into terrain, sea or building [Terrain collision]**
  Accident caused by collision into terrain, sea, or building after TDP (*Take-off Decision Point*) and before LDP (*Landing Decision Point*), without any critical failure occurring. (*Controlled Flight Into Terrain, sea or building*; CFIT)

- **A6: Accident with risk for persons in the helicopter [Person inside]**
  Accident involving danger to persons (pilots/passengers) located in the helicopter, for example caused by toxic gases due to a baggage or cargo fire**.**

- **A7: Accident with danger for persons outside helicopter [Person outside]**
  Accident involving danger to persons (pilot/passengers) located outside the helicopter, for example the tail rotor striking a person.
  (Note that danger to other persons than helicopter pilots and passengers, for example helideck personnel, is not included.)

- **A8: Accident caused by weather conditions, surrounding environment, or other [Other/unknown]**
  Accident caused by weather conditions (for example lightning strike), surrounding environment (for example collision with a vehicle at the heliport/airport), or other (for example an act of terror), in addition to accidents with unknown causes.

3 Developments in the period 2010–2015

This chapter provides an overview of identified changes and trends in the period 2010–2015. The developments have been categorized as follows:

- Technical development
- Operational development
- Development in helideck operations
- Development in Air Traffic Management
- Organisational development
- Development related to authorities and customers
- Development in emergency preparedness

3.1 Technical development

Helicopter types

The Sikorsky S-92 (in use from 2005) and the Airbus H225LP (former Eurocopter EC225, in use from 2008) have been the main helicopter types in use on the Norwegian Continental Shelf (NCS) in the period 2010–2015. The customers specify for a large part what type helicopter to be used trough the tender requirements. Following the Turøy accident in April 2016 all H225 (and AS332L2), including the SAR helicopters, were grounded. EASA has now released the H225 for operations, but the CAA-N is still maintaining a formal grounding of the helicopter and it is uncertain when this will end. It is also uncertain if the customers would want to bring the H225 back in operation. Per December 2016, only the S-92 operates in passenger transport on the NCS.

The two largest helicopter operators on the NCS, CHC and Bristow, operated 30 S-92 machines before the Turøy accident, while the smaller operator NHS had two S-92 in its fleet. All S-92 were used for passenger transport. When it comes to the H225, CHC operated 12 machines and Bristow 5. CHC used the H225 mainly for SAR but also passenger transport, while Bristow used the H225 for SAR only. After the Turøy accident the H225 SAR have been replaced with S-92 or older types Super Pumas (AS332L or L1). More S-92 are now in service on the NCS due to the reduced capacity for passenger transport following the H225 grounding.

Both the H225 and the S-92 have experienced "teething troubles" after the introduction, as described in the HSS-3 report. For instance, incidents related to the deicing systems (RIPS) and engine fire warnings were common. Particularly for the S-92, many pan-pan and may-day calls were made due to false alarms during the first couple of years in operation. There are still technical challenges with the S-92, but these are largely familiar issues and under control as such.

The H225 also have had its share of running-in problems, for example fault indications related to the emergency lubrication system for the main gearbox. Before the Turøy accident, the H225 performed well; for instance, improvements to the de-icing system have been made and the autopilot is considered to be very responsive and precise. The H225 is a technically advanced helicopter that needs a lot of maintenance. Delays and regularity issues were not uncommon. This was linked to both real and false faults/alarms. Lack of information related to "hidden safety features" in the H225 electronics has also been a part of this picture.

It is worth noting that compared to the S-92, the confidence in the H225 is lower among offshore workers. This scepticism is for a large part due to the accidents in the British sector in 2012 and 2013. The S-92 is perceived as safer and more comfortable than the H225. According to the trade unions SAFE and IE, the perceived risk among the passengers is higher for the H225, and this perception has been amplified by the Turøy accident. The relatively low confidence in the H225 is also related to the narrow cabin and the seating arrangement, as well as noise levels and vibrations. The trade unions report that some individuals refuse to travel with the H225.

In addition to the S-92, a few machines of older versions of the Super Puma are also in operation on the NCS today. One AS332L1 AWSAR is operating out of Heidrun. There are three AS332L in operation, whereof two in SAR roles (LIMSAR at Oseberg and AWSAR at Stavanger airport, Sola) and one used for shuttling (at Valhall). The limited size of some of the offshore hangars is the main reason for the use of the older Super Pumas.

Several AS332L2 was in operation on the NCS in 2010, but they are now phased out. Following the accidents in 2012 in the British sector – after which the H225 was grounded for almost one year – the AS332L2 was heavily utilised on the NCS.

HUMS and current status

The system used to monitor the technical status of the helicopter (HUMS – Health and Usage Monitoring System) is in continuous development. Today, the downloading and analysis of data are done after each flight at the onshore bases. This high frequency of downloading and analysis was formalised in Norog 066 of 2015, but operators have practiced such a regime for some time already. Data from the helicopter are stored in a flash memory card and downloaded to a laptop with the proper software. Any exceedance or warning will be displayed immediately. Long-term trending of data is also a part of the HUMS capabilities, but this requires more time to analyse. Deviations in HUMS are treated as any other technical deviation. Downloading data as often as between flights is considered as a step in the right direction. CHC is running a HUMS centre at Stavanger airport, servicing data from contracted operators worldwide. Bristow downloads HUMS data locally and sends the data externally (to the producer) for further analyses.

From M-ADS to ADS-B

The mandatory implementation of the M-ADS system through regulation of 1999 (BSL D 2-10) is described in HSS-3. M-ADS was a GPS based system utilising satellite communication (INMARSAT) for the surveillance of helicopters (down to sea level) outside radar coverage. The system has now been decommissioned, partly due to difficulties in providing new units and spare parts. The last flight with M-ADS signals was conducted in July 2014. M-ADS consisted of three electronic units mounted in the helicopter tail section. In comparison, the new ADS-B (Automatic Dependence Surveillance Broadcast) utilises the transponder on board the helicopter. ADS-B calculates the aircraft's position via GPS and broadcasts this via VHF-AM base relays to the ATS. A limitation of ADS-B compared to M-ADS is that the former does not provide a landing message to the ATS; M-ADS featured such a message triggered by the nose landing gear proximity switch. Furthermore, ADS-B does not have coverage down to sea level. ATS representatives state that both these features will be missed.

Anti-collision systems

HSS-3 described two versions of airborne anti-collision systems (ACAS – Airborne Collision Avoidance System) in use on the NCS, either SkyWatch or TCAS (Traffic Alert and Collision Avoidance System). SkyWatch has now been replaced by TCAS following the phase-out of the older helicopter types AS332L and L1. The TCAS system comes in different versions. TCAS I provides traffic information and alarms on potentially conflicting traffic, a so-called *Traffic Alert (TA)*. TCAS II gives an additional *Resolution Advisory* (RA) instructing the pilots of recommended maneuvers in the vertical plane. It is worth noting that the RA function does not operate below 1000 feet, and that there are often traffic conflicts at 1000 feet in relation to approach and departures from offshore installations. TCAS I is the current standard on the NCS, but TCAS II is getting more common. Bristow and CHC have 4 and 6 helicopters with TCAS II, respectively (before the Turøy accident). The Norog 066 guideline recommends TCAS II.

Other equipment

Rotor de-icing systems are operational and functioning on both the H225 and the S-92. EGPWS (Enhanced Ground Proximity Warning System) is standard equipment today, but this system seems to have a certain potential for improvements in simulator training.

3.2 Operational development

Utilisation of FDM

The purpose of FDM is to proactively identify, quantify and assess the degree of risk (ref. CAP 739) related to the pilots' handling of the helicopter and its systems. The recorded data are used statistically to identify deviations from the standard operating procedures (SOP) in time and space defined by different levels (1, 2 and 3). A breach of level 3 is defined as critical, containing a violation of one or more procedures. The purpose is to utilise the FDM system for learning, thereby improving pilot performance. The data relate to particular incidents and individual pilots, and must be processed respecting the protection of privacy. An example of an improvement based on FDM level 1 deviations, is the identification of a tendency to have a too low nose attitude on departure, exceeding SOP specifications. In such cases of identifying negative trends at an early stage, FDM is a powerful tool. One of the challenges of FDM is defining the different levels in a useful way. This has proven particularly challenging in the multinational companies where the opinions differ across the internal cultures on how FDM should be utilised. The levels defined by multinational helicopter operators internationally are sometimes perceived as being too “narrow” by Norwegian operators.

Rules, standardisation and new approach procedures

The new basic regulation EASA-OPS (965/2012) was published in 2012 and implemented in 2014. This regulation covers in principle all aspects of most types of air operations, and contains requirements to how the helicopter companies' Safety Management Systems (SMS) should be structured. Rulemaking task 0409 in EASA prepared HOFO (ref. section 4.1). The Committee for Helicopter Safety on the NCS appointed a work group to assess the possible consequences of a HOFO implementation in Norwegian legislation with a particular focus on the EU term “level playing field”.

Procedures for operating in the Norwegian sector used to be published in Jeppesen for CHC and Bristow. They are now published in the AIP manuals for common use.

Training aspects

In 2010 the requirement for simulator training for pilots increased from 12 hours per year to 16 hours per year (8 hours each 6 months). This increase is related to customer requirements defined in Norog 066. SAR pilots must do an additional 4 hours in the simulator per year. The simulator standard is also defined in Norog 066, as level D should be utilised if available (worldwide). The authorities' requirement for simulator standard is simply “approved simulator”. Norog 066 also defines simulator training for technicians on the aircrafts' technical systems (systems trainer). The following simulators are currently available for training:

- CAE S-92 and H225 Level D, Oslo
- Flight Safety S-92 Level D, Stavanger

- Thales H225 Level D, Stavanger
- 2 x H225 and S-92, Aberdeen

The development of autopilot capabilities from the AS332L2 to the H225 has been very positive. According to the helicopter operators, a significant amount of training is conducted on the utilisation of the autopilot. This training is important, as operating an automated system is intuitively different than operating the helicopter manually. As an example incident, a fully functioning H225 was nearly flown into the sea due to lack of knowledge on the functioning of the autopilot, as the crew attempted to operate the helicopter manually "fighting" the autopilot and its automatic modes. Another focus in training is the transitioning from using autopilot to manual mode, and using the autopilot to aid in the completion of standard procedures. The helicopter operators underline that they also train explicitly on so-called "hidden safety features". Utilising FDM data as input to pilot training is also an important aspect. As an example, pilots have trained on performing departures with nose attitude less than 20 degrees (as mentioned in the FDM section above). The pilots are required to do an evaluation of their training and suggest inputs to new or revised procedures according to CRM (Crew Resource Management) requirements.

When it comes to recruiting new pilots, there are some changes compared to HSS-3. Previously, we observed a generation shift among the pilots. Today, due to the general downturn in the petroleum business, there are skilled offshore helicopter pilots available for companies seeking to expand their activities. Quality of pilots and relevant experience is still highly valued, and pilot profile should fit with the existing company culture. The focus in the Norwegian sector is to undertake thorough selection processes of new pilots. This implies testing in simulators and extensive interviews with psychologists.

Technical maintenance

After HSS-3, the helicopter companies have modernised different tools for increasing the efficiency of maintenance. There are challenges related to this type of change. One company has introduced a new IT-system that is perceived as rigid in use. There is a point being made that harmonisation through the introduction of global systems in multinational companies is viewed as a challenge for the good maintenance culture that exists in Norway. In this respect, concerns have been raised over how the helicopter companies' management seem to take a more active part in such processes than before. This is exemplified by instructions given from the management on what not to write in incident reporting. It is also pointed out that there have been some changes in the technical management in the helicopter companies.

Informants use terms like "fixed culture" linked to a decrease of transparency in the sense that the principle of reporting without repercussions is being challenged. It is claimed that there have been instances of technicians choosing not to report incidents as a result.

Some maintain that they experience that the standard of maintenance has been reduced in Norway, while the impression is that it could be improving in other countries. It is also pointed out that the number of procedures to adhere to is somewhat unclear. There is uncertainty related to which procedures the Norwegian authorities have approved and which are not approved. The maintenance personnel stress that it is important to recognize the risk related to working alone on a helicopter, for example during the daily inspection. In that respect there are concerns raised related to the fact that things might be overlooked, and that there is insufficient documentation of the work being done. Challenges related to parts and their approval are underlined.

An increasing focus on cutting costs has resulted in downsizing in the helicopter companies, and that the economic pressure also causes reductions and changes in maintenance. The maintenance structure has been changed by relocating more of heavy maintenance abroad (Poland, Scotland is being considered). The trade unions underline that a relocation is likely to result in reduced competence nationally due to less recruitment and lower activity. It is worth mentioning that the helicopter industry in general is viewed as an industry with high professional pride and work ethics. The trade unions are concerned with the current cost focus and they fear that the joy and enthusiasm of working in the business shall disappear. This in turn may influence the quality of for example helicopter maintenance. As an example, young and inexperienced technicians are reportedly being pressed on time to get the work done.

The introduction of electronic maintenance manuals instead of paper manuals is seen as positive. This will secure having updated manuals at any given time. This is a large improvement from the former paper manuals with lagging manual revisions. However, some of the electronic manuals are perceived as tricky to navigate, and the system has been characterized as low cost.

3.3 Development in helideck operations

The design and operations of helidecks are regulated by BSL D 5-1. This regulation is currently under revision. Operations on helidecks are viewed as one of the most challenging areas of offshore helicopter flights. As mentioned in HSS-3, this is reflected in the focus on helideck safety both nationally and internationally. Statoil has studied turbine emissions in relation to helidecks. The main purpose was to investigate how turbine emissions from the installation, could affect helicopter performance near the helideck, especially focusing on the helicopter engines and problems related to engine stalls (due to sudden variations in inlet air temperature and flow). Both the temperature over the helideck and the wind are considered. Some restrictions have been introduced for a few installations as a consequence of this study, like weight limitations or change of approach profile in certain wind conditions. In some cases, no-fly zones have also been established.

Helideck monitoring systems (HMS) were implemented around year 2000. These systems function as intended (mostly adjustments of settings) and a defined steering group is revising the related procedures.

Considering the formal audit of the offshore helideck and related systems, the CAA-N seems to have limited capacity due to age retirement of inspectors. (See also section 3.6.)

Bird strike in proximity to offshore installations is a hazard. Bristow and CHC have totally a two-digit number of incidents per year. Initiatives exist to reduce the risk of bird strike, but so far no solutions have been implemented.

3.4 Development in Air Traffic Management (ATS/ANS)

Air Traffic Management consists of:

- *Air Traffic Service* (ATS)
- *Air Navigation Service* (ANS)
- Communication
- Weather service.

Controlled airspace

Following the closing of the Oseberg HFIS (Helicopter Flight Information Service) in 2009, the remaining HFIS are located at Tampen and Ekofisk. The HFIS provides local flight information service up to 1500 feet and is not coordinated with Avinor's control area service. The ATC controller would like to be in radio contact with the helicopter as much as possible, arguing that both positive radar contact and direct communication is a prerequisite for providing an adequate ATC service. There has been a discussion whether Avinor should take over for the Tampen HFIS, but it has been decided to leave Tampen HFIS as is. The Ekofisk HFIS are being fed surveillance images of the ADS-B system from Avinor. This has led to an improvement of the service rendered by the Ekofisk HFIS. The pilots experience a reduction in radio communication as a result. This reduces the cockpit workload in critical phases of flight, like landing or taking off offshore.

The introduction of ADS-B has led to the establishment of controlled airspace from 1500 feet up to flight level 085 for the southern North Sea in the Norwegian sector. The area comprises both Ekofisk (2015) and Balder (2016). The ADS-B area (airspace class G) will still be under the respective control areas (CTA) from MSL to 1500 feet. There has been challenges related to this, especially concerning the certification of some equipment with EASA. Avinor is underling that the introduction of controlled airspace is an improvement of safety, especially for Ekofisk, where there are a substantial number of helicopter movements per day.

The long-term plan is to introduce ADS-B for all of the NCS. ADS-B is now being set up at Statfjord C (for the Tampen area), and there exist concrete plans for the Norwegian Sea and the Barents Sea, including a corridor towards Svalbard (Spitzbergen). It should be noted that Avinor has experienced some challenges with cooperation at a few offshore installations concerning installation of ADS-B equipment.

Controlled airspace by radar coverage is currently still the case at Oseberg, Tampen and Heidrun. The radar at Tampen (Gullfaks C) is quite old and will be replaced by ADS-B. The radar installed at the Heidrun platform will not be replaced. The reason for this is that the area around Heidrun is used for training by the military, and all military aircraft may not be tracked by the ADS-B system (but by radar). Avinor also points out that the Finnmark coastline (towards the Barents Sea) has low radar coverage.

Improvements in weather reporting

The recent improvements in weather reporting have been significant. For example, there has been a large increase in the number of local (automatic) observation posts. This has been achieved by introducing:

- Automatic Weather Observation and Reporting (AWOS)
- The enabling of improved forecasting for defined geographical sections (by the AWOS data)

There are some limitations related to the measuring of cloud base and cloud coverage. The AWOS does not have lightning/static discharge forecast capability, but data form AWOS (as one of several sources) are used in the newly introduced (2016) Norwegian system for lightning forecasting. The former system in use had some challenges related to accuracy and caused some unnecessary disturbances in flight regularity (see also safety measure M03 in section 8.1).

3.5 Organisational development

The introduction of EASA OPS

EASA OPS (basic regulation 965/2012) was introduced in October 2018 and made applicable for all actors on the NCS. The main areas in this regulation are the authority’s oversight and the organisation of the operators' work on safety and quality. The main tool for this is the Safety Management System (SMS). The following SMS requirements have been made explicit through the EASA regulation:

- Root cause analyses of reported incidents
- Risk assessment of changes and unknown aspects
- Management of change for larger changes (in organisation or operation)

The term "compliance monitoring" replaces parts of the former quality system. According to the CAA-N, there was some initial uncertainty regarding the interpretation and use of the regulation, both with the helicopter operators and the authorities. This related particularly to the management system area. Although the situation has improved, the CAA-N states that the regulation still needs some clarification.

The CAA-N is working on the introduction of the so-called "state safety program". This includes a clarification of the role for the Ministry of Transport and Communications, and the functioning of the structure including all the different entities regulating Norwegian air operations. The state safety program is an ICAO standard (Annex 19, 2013) and is currently discussed by EASA.. The proposed program for Norway is on public review until March 2017.

European Plan for Aviation Safety (EPAS) concerns measures and priorities for EASAs work on regulatory issues. The helicopter portion of EPAS has not been developed sufficiently, and the completion of this is an EASA priority.

The EASA area of responsibility has widened over the last few years, encompassing e.g. certification, airports and air traffic services.

Incident reporting

All reporting of accidents and incidents to the CAA-N and AIBN is done via the public portal Altinn. The helicopter operators express a wish to be more proactive in their reporting. This has been a focus area with the helicopter operators internally. One example of a proactive approach is mentioned by Avinor and relates to an incident where lack of radio contact between a helicopter and ATC was an issue.

Organisation and ownership (helicopter companies)

After HSS-3 (2010), CHC has been restructured from two to five regions globally. The CHC ownership has also changed from First Reserve to Clayton, Dubilier and Rice (CD&R) (both investment companies). It could be noted that CD&R is a General Electric (GE) company, and that GE also owns the Milestone Aviation Group, which is a major player in the helicopter leasing market. As for Bristow, there have been no major changes.

3.6 Development related to authorities and customers

CAA-N

The CAA-N helicopter section is going through a generations shift as many experienced inspectors have retired. Replacements are about to be completed. The helicopter operators are questioning the current capacity in the CAA-N. The revision of BSL D 2-2 and 5-1 are both delayed; the revision of BSL D 5-1 by three years at least. On the other hand, improvement is seen in the processing of issues related to training and certification. The helicopter operator underline the open communication they have with the authorities. The helicopter companies report that they cooperate well with each other. Avinor is experiencing some issues with the CAA-N, especially related to challenging formal processes and available competence within the CAA-N. The trade unions in the helicopter operators see the CAA-N as somewhat unclear and passive, as the CAA-N traditionally has trusted the clients (oil companies) to impose sufficient safety requirements and conduct oversight with the customers (helicopter operators). The CAA-N now seems to take a more active role in this respect.

The oil companies are required to inspect their own helidecks according to current regulations. The helicopter operators are in turn obligated to do verifications of the oil companies' helidecks, including internal audits, operation and maintenance. The Petroleum Safety Authority (PSA) has the formal oversight responsibility for helidecks on fixed installations. However, the CAA-N does the helideck verifications on behalf of the PSA, since the CAA-N has the best competence related to flight operations, including helidecks. As mentioned, the CAA-N has capacity issues, also related to the inspection of helidecks.

New companies operating on the NCS

Information related to e.g. offshore helidecks has not been available to new operators as CHC and Bristow historically has accumulated this information on their own, and the CAA-N has not utilised the AIP system for this type of information. Avinor is now updating the AIP publications to include maps and pictures of offshore routes and installations, including helideck information. As regards new helicopter operators on the NCS, Blueway became part of the Dutch company NHV in 2014. Norsk Helikopterservice (NHS) has previously (2012) operated for Bond Helicopters in the British sector. Per December 2016 NHS has no permanent contracts on the NCS and one S-92 in ad-hoc operations. A new company named Vici Helicopter is in the process of establishing required permits to operate. Vici has Norwegian management and owners, and plan to operate 2 AW189 out of Bergen.

Contracts, prices and competition

According to the helicopter companies, it is “buyers' market” for the time being, and it is difficult to make profit with the current contracts. The low oil price has led to a reduction in the overall activity and consequently a reduction in the need for helicopter transport. The oil companies also have a strong focus on cutting costs. The penalty regimes (fines for disruptions of agreed services) are practiced in a more stringent manner than before. The contract terms are also formulated more stringently (less slack) in new contracts, and in general the market power held by the oil companies is being exercised. The trade unions express safety concerns in this relation. The trade unions also express concern over how the different helicopter operators are managed, the increasingly stringent contractual terms and how the business as such seems to handle different challenges. As an example the trade unions refer to the new contract type for operations from Bergen and Florø, where notably the turn-around time for helicopters is proposed reduced from one hour to 30 minutes.

This may lead to undue pressures and stress causing bad decisions. Necessary activities like HUMS data downloading, refuelling, inspection of the helicopter etc. can be made in parallel by different persons, and normally 30 minutes should suffice (for comparison, fixed-wing operators are down to 20 minutes turn-around time). However, in practice there will not be a full 30 minutes available for these tasks, when this also comprises crew change and preparations for start-up. The stress levels may increase if something unforeseen should occur which in turn could induce errors and mishaps. The CAA-N has a focus on this issue, which has been discussed in meetings with the oil companies and operators. The CAA-N is expressing concern over this development.

3.7 Development in emergency preparedness

Since 2010 the main changes to the oil companies’ emergency preparedness has been an upgrade of the SAR helicopters and the establishment of the onshore SAR base at Stavanger airport. Before the Turøy accident the SAR helicopters in use were mainly of the H225 type, which performed well in this role. After Turøy and the grounding of H225, both older type Super Pumas and S-92s are utilised as SAR helicopters. The current SAR response time is 15 minutes (20–30 minutes at night). Table 3.1 presents the SAR bases and types of helicopter in use before and after the Turøy accident.

Table 3.1: Operational SAR helicopters and bases.

Base	Before Turøy	Today (Dec. 2016)	Comment
Hammerfest	H225	S-92	On "wet lease" from USA
Heidrun	AS332L1	AS332L1	
Statfjord B (Tampen)	H225	S-92	
Oseberg	H225	AS332L	LIMSAR
Sola	H225	AS332L	Planned replaced by S-92
Ekofisk	H225	S-92 (2 aircraft)	One S-92 is backup

Concerning the public rescue services via the 330 squadron, the currently used Sea Kings have a great deal of challenges due to ageing. The new AW101 SAR helicopters are to be delivered in the period 2017–2020. In the meantime, a civil operator (CHC) will serve the Florø base from September 2017. The plan is to move the SAR helicopter at Heidrun to Florø, and station a AS332L at Heidrun.

4 Developments in the coming five years (2016–2020)

This chapter describes expected developments relevant to offshore helicopter safety for the coming five-year period (2016–2020). We describe the following areas, where the introduction of the HOFO regulation is the main topic:

- New EASA regulation (HOFO)
- Technical equipment
- Operational issues
- Revised reporting scheme

4.1 New EASA regulation (HOFO)

Since 2011 EASA has been working on a new regulation for offshore helicopter operations (HOFO). The regulation was passed in July 2016 through Commission Regulation 2016/1199 and shall be fully implemented by July 2018.

CAA-N can issue national rules for offshore operations given the same or higher safety standard than implied by EASA regulation 965/2012. The HUMS requirement from BSL D 1-16 is an example of such a rule. Further, two main factors are seen as central concerning the helicopter safety on the NCS:

- Compliance to the industry guideline Norog 066
- The requirement for an operator to hold a Norwegian AOC

The Committee for Helicopter Safety on the NCS is concerned that the Norog 066 guideline may come under pressure in the coming years. The guideline is the responsibility of the *Aviation Forum* (helicopter expert group) under the *Norwegian Oil and Gas* (Norog) organisation. According to the CAA-N, this guideline is central in keeping an important focus on specific safety-related themes.

The Norog guideline is reflected in current contracts between the oil companies and the helicopter operators. Being a guideline and not a regulation, it can not be taken for granted that current or new oil companies will adhere to and specify the use of the guideline in future contracts. Some have requested that the Norog 066 guideline should be formalised through legislation, but this has yet to materialise. The realism and rationality of turning the guideline in its entirety into regulation is questionable. It is not seen as optimal for the cooperative safety work that one stakeholder (i.e. the oil companies via Norog) alone should have the possibility to form a regulation. Others argue that the guideline – and its possible formalisation – could be governed by a tripartite cooperation, like in the Committee for Helicopter Safety on the NCS. An argument against such a cooperation is the probable weakening of the guideline through dilution and compromises between diverging priorities of the different stakeholders. The most sensible solution seems to be to maintain the current roles of the stakeholders in a balanced relationship where the Norog 066 guideline remains the oil companies' “regulatory” tool. In general, the tripartite cooperation (oil companies, trade unions and the authorities) – e.g. through the Committee for Helicopter Safety on the NCS – is considered by all three parties as a key success factor for the helicopter safety work.

Norog 066 specifies that all helicopter operators operating on the NCS must be based in Norway and have a certification (AOC) issued by the CAA-N. This implies that the CAA-N can maintain a holistic oversight over each individual operator and consider the specific operational environment when evaluating the operator's operational procedures. It is not clear whether a holder of a foreign AOC could operate on the NCS given an implementation of the HOFO regulation in Norwegian legislation. Many Norwegian stakeholders fear this to be a realistic future scenario. According to the HOFO regulation, an operator is responsible towards its national CAA only. Consequently, given the implementation of the HOFO regulation, foreign operators will not have to relate to the CAA-N when operating on the NCS. The main concern is lack of competence and experience related to the special and sometimes difficult conditions on the NCS. This may increase the accident risk. The multinational companies operating in Norway (CHC and Bristow) might also restructure to have a common European AOC in another country, rendering the same effects related to the CAA-N lack of oversight of the operations.

The Ministry of Transport and Communications is pointing out that the current national regulation for offshore helicopter transportation has its shortcomings. However, since the oil companies themselves have a well-defined safety focus through the Norog 066 guideline, the ministry has not seen the need for further regulatory instruments.

The proposed HOFO regulation is met with a great deal of scepticism in Norway. All operations form the Mediterranean to the Barents Sea will be regulated through this, and the fear is that a regulation with an obvious generic nature will not be specific enough for certain types of challenges, for example harsh climatic conditions in Norway. If decided, HOFO will be mandatory form July 2018. As a result, article 6.4 in EASA basic regulation 965/2012 will no longer be valid, meaning that no additional national requirements can be made. This is one of the reasons why the trade unions called for a consequence assessment of the proposed HOFO regulation. They are concerned that the tripartite cooperation model will come under pressure and the Committee for Helicopter Safety on the NCS may become diluted and weakened as a result.

Cost pressure and rationalisation is also seen as negative factors for the Norog 066 guideline. Commercial pressure may result in a reduction of the guideline's status and defined safety levels over time. The developments within the fixed-wing business related to internationalisation and globalisation may also be adopted in the helicopter business. It is uncertain how this may affect the safety of offshore helicopter operations.

The HOFO regulation has been distributed for public hearing and there are contradictory views on the regulation. The trade union NHF (mostly helicopter technicians) lists three specific challenges related to not operating under a Norwegian AOC:

- The role of the CAA-N will change dramatically, as it loses the possibility to conduct oversight and initiate sanctions when the operators no longer have to relate to the CAA-N.
- The level of competence related to offshore operations may decrease if helicopter operators and maintenance organisations with little or no previous offshore experience are allowed to operate on the NCS.
- As a passenger, you will depend on your company choosing a safe operator, given that there are no other possibilities for offshore transport than by helicopter.

The following points illustrate the complexity related to the interpretation of the proposed regulation and the subsequent safety challenges for offshore helicopter operations:

- Non-commercial operators may operate complex helicopters offshore, as the regulation in principle opens for this type of operation. In theory, singe operators (e.g. drill rig owners, seismic vessel operators, etc.) may operate their own helicopter without the same competence as a commercial operator.
- The Norog 066 guideline is leading but not mandatory for NCS operations. The CAA-N has been criticized or leaving important parts of the regulations to commercial companies. There are uncertainties related to the legal status of the Norog guideline given a HOFO implementation.

- The helicopter operators in Norway are subsidiaries of global companies. The implementation of HOFO opens for centralisation of the European operators onto one single AOC outside Norway. This will reduce the income for the CAA-N and in general reduce the CAA-N's activities on the offshore helicopter area.

The CAA-N has recently compared HOFO with the current regulation including the Norog guidelines with the purpose of identifying main differences. Table 4.1 presents this comparison; note that the selection of themes is not exhaustive.

Table 4.1: Important changes related to equipment and training given the introduction of the HOFO regulation.

HOFO	Current regulation EASA/JAR-OPS	Norog 066	CAA-N comments
A non-commercial operator having declared its activity in accordance with Part-ORO.	**N/A**	**N/A**	Not included in previous regulation. Non-commercial operators (e.g. private persons and firms) would hardly be permitted with the previous regulation. HOFO opens for operations at the oil companies' own discretion, i.e. without AOC.
The operator shall, prior to performing operations from a Member State other than the Member State that issued the approval under (a), inform the competent authorities in both Member States of the operation.	A Norwegian AOC is mandatory to perform offshore helicopter operations on the NCS (from Norway).	The helicopter operator's main office and organisation shall be located in Norway and shall be a Norwegian registered company. The helicopters in operation shall be registered by the helicopter operator.	How the CAA-N's formal oversight shall be performed has not been decided. EASA is working on a scheme for cooperative oversight across national borders. The economic effects for the CAA-N are uncertain. The Norog 066 mandatory requirement for having a Norwegian AOC may be in conflict with the HOFO regulation related to discrimination; if so the Norog requirement cannot be continued.
All persons on board shall carry and be instructed in the use of emergency breathing systems.	N/A	N/A	This has a potential for incurring significant additional costs, and the effect on the total risk is uncertain. This must be investigated and an AltMoC must be made if other solution are decided.
An opening in the passenger compartment should be considered suitable as an underwater escape facility if the following criteria are met: *(5) For the egress of passengers with shoulder width greater than 559 mm (22 inches), openings should be no smaller than 480 mm x 660 mm (19 x 26 inches) or be capable of admitting an ellipse of 480 mm x 660 mm (19 x 26 inches).*	N/A	N/A	This AMC introduces a separation of passengers by shoulder width (above 56 cm).
Passengers with shoulder width greater than 559 mm (22 inches) should be identified and allocated to seats with easy access to an emergency exit or opening that is suitable for them.	N/A	N/A	The idea is that large passengers shall be sorted, marked and placed close to the larger emergency exits. This may add significant extra cost and administration.
N/A	No operational requirements for ACAS/TCAS in EASA OPS or JAR-OPS 3.	TCAS 2 integrated in pilots' flight display is required.	No change. This is explicitly stated in Norog 066 and can be continued as a requirement. It should be evaluated whether this should be taken in as a national requirement in the formal regulation.

The HOFO regulation seems likely to be introduced in Norwegian legislation. However, it is uncertain what area of validity it will have, i.e. whether it will be valid for the NCS, which is not included in the EEA agreement. The consequences in general are also uncertain. The Ministry of Transport and Communications has recently (December 2016, via the consultant Safetec) published a consequence study of the introduction of HOFO. The report concludes in a moderate negative effect on flight safety in the long-term perspective, which seems to coincide with the general consensus in the Norwegian aviation community.

4.2 Technical equipment

Future helicopter fleet

There are currently two helicopter types contracted in use on the NCS: the Sikorsky S-92 and the Airbus H225. Due to customer requirements on capacity, these have been the only useful alternatives. Following the Turøy accident, the future use of the H225 in Norway is uncertain. The uncertainty also applies to the established practice of having two different helicopter types in operation on the NCS. The reason for this practice is to have redundancy in case of occurring issues and contribute to competition between the helicopter manufacturers. The H225 is formally approved for operations by the EASA given that certain conditions are satisfied. For the time being, both the British and the Norwegian CAA are still upholding the grounding of this helicopter. The Norwegian CAA is awaiting the AIBN report on the Turøy accident.

Controlled airspace

The long-term plan is to implement ADS-B on the entire NCS. In the Brønnøysund/Norne area the radio coverage is sometimes suboptimal, and according to Avinor it will take 2–3 years before an ADS-B system will be in place. After Norne/Brønnøysund, the Barents Sea and Hammerfest will be next up for ADS-B implementation (the Goliat ADS-B project is already underway). In the medium term, Avinor would like to establish an ADS-B corridor between Tromsø and Svalbard, given the bad radar coverage in general for the Finnmark coastal areas. ADS-B for Svalbard is being planned, and a project has been initiated. Avinor is pointing out that the eastern Barents Sea will be a particularly challenging area for the establishment of controlled air space.

Anti-collision systems

TCAS I is still the standard in Norway, but TCAS II is coming with the latest helicopters being delivered, and helicopters are also being upgraded form TCAS I to TCAS II. Norog 066 has TCAS II as a requirement. A "TCAS III" can be imagined by combining TCAS II and ADS-B to give lateral advice in addition to the existing vertical advisory from TCAS II.

Other technical developments

The downloading and analyses of HUMS data are continuously improving. Nevertheless, helicopter operators have requested systems for improved connectivity in the helicopters, enabling the transfer of real time data from the helicopter to analysts on land. In general, there is a need to have better integration of live data, both on board and toward onshore bases. A system giving live data from helideck monitoring systems (HMS) will be operational from mid-2017, by Bristow initially.

Tail-mounted cameras (giving information to the cockpit) and possibly also cockpit cameras are considered as new requirements in the Norog guidelines.

The introduction of new light systems for helidecks is under consideration. The idea is that helideck lights can change colour to indicate a clear or closed helideck. This is a requirement in the British sector.

4.3 Operational issues

Climatic and operational factors are changing, and a new type of operational challenges will be experienced in the Barents Sea. The framework conditions for operating helicopters are also changing, particularly contractual terms like shorter onshore turnaround times for helicopters and the use of penalties for delays or cancellations.

4.4 New reporting scheme

The EU regulation 376/2014 (July 2016) concerns mandatory reporting to the authorities. It contains requirements regarding the operators' processing of reports, including risk classification, root cause analysis and information to the authorities about internal investigations of incidents. Requirements for the authorities' analysis and utilisation of this type of data is also specified. The purpose of the regulation is to better exploit the experience data produced by the operators. All reporting of accidents and incidents in Norway is done through the electronic reporting system Altinn. The helicopter operators are diligent in their reporting. Some challenges have been experienced exploiting this data base, for example related to the classification of incidents.

Concerning the mandatory reporting of incidents and accidents, the CAA-N points out the low quality existing in parts of the European database (ECCAIRS). This must be seen in relation to the system for classification, where one observes great variation in the reporting. A revised system for classification is under development and the reporting in itself will be simplified.

The CAA-N also points out that access to international incident data of high quality is a challenge. This is mainly due to the international practice of making all data available, requiring that incidents are anonymized, often beyond recognition.

5 Statistics

This chapter gives an overview of relevant statistics for helicopter safety focusing on the NCS for the period 1999–2016. The information presented here can be seen as an extension of the material found in the HSS-3 report. The following sources have been used for obtaining new data post HSS-3:

- Traffic volumes on the NCS from CAA-N
- Reported incidents to CAA-N
- Investigation reports from AIBN
- Investigation reports from AAIB UK

5.1 Summary of incidents on the NCS 1999–2015

There have been no accidents on the NCS for the period 2010–2015, but two incidents have been classified as "serious". Considering the extended period from 1999, one accident and 12 serious incidents have been registered. Table 5.1 gives an overview of accidents/incidents for the period.

Table 5.1: Accidents and serious incidents on the NCS for 1999–2015/16. Accidents are depicted in boldface.

No.	Date	Helicopter	Accident category	Description
1	01.03.2000	AS332L2 LN-OHG / S-61N LN-OSJ	A4 Mid-air collision	Loss of separation for departing and approaching helicopters at Bergen airport
2	26.06.2001	AS365N2 LN-ODB	A5: Terrain collision	Loss of visual references and control when attempting landing at the HOD platform in fog
3	**05.11.2002**	**AS332L2 LN-ONI**	**A3: System failure**	**Damage to main rotor blade during approach to Stavanger airport, emergency landing on ship**
4	19.08.2002	S-76C+ LN-ONZ / AS332L LN-OLB	A4 Mid-air collision	Loss of separation between two helicopters near Heimdal (installation)
5	08.01.2004	AS332L2 LN-ONI	A2 Helideck	The tail rotor guard caught the helideck net during take-off from Transocean Searcher (installation)
6	13.05.2004	AS332L G-TIGV	A3 System failure	Inspections hatch detached and damaged tail rotor in flight, emergency landing at Grane (installation)
7	09.07.2004	AS332L2 LN-ONI	A4 Mid-air collision	Approach to Stavanger airport, loss of separation to a helicopter in test flight (AS332L2 LN-OHK)
8	21.01.2005	AS332L LN-OLB	A1 Heliport	Near collision with obstructing crane during landing at Kristiansund Airport
9	10.06.2006	AS332L2 LN-ONH	A2 Helidekk A7 Person outside	Tail rotor close to personnel and obstacles during take-off (hover) from Snorre B (installation)
10	21.04.2007	S-76C+ LN-ONZ	A1 Heliport	Blocking of pedals for yaw control during landing at Stavanger airport

No.	Date	Helicopter	Accident category	Description
11	28.04.2009	Bell 214ST LN-OMM	A3 System failure	Exhaust pipe detached during shuttling at Tampen area, minor damage to tail rotor
12	01.04.2010	S-92 LN-OQE	A3 System failure	Pilot's seat became detached during approach to Gullfaks B (installation)
13	12.01.2012	H225 LN-OJE	A3 System failure A2 Helideck	Partial loss of hydraulics, emergency landing at Åsgard B platform, loss of wheel brakes on helideck
14	***29.04.2016***	***H225 LN-OJF***	***A3 System failure***	***Crash at Turøy after main rotor detachment, 13 fatalities***

Note: Complete data for 2016 are not available at the time of publication.

The table above refers to the different accident categories described in section 2.4. A distribution of the accidents/incidents based on accident categories are presented in Figure 5.1. Note that those events (9 and 12) that are placed in two categories also count as double in the presentation below, thus the total is not accurate. This is subordinate since the purpose is to describe frequency/importance among the accident categories themselves.

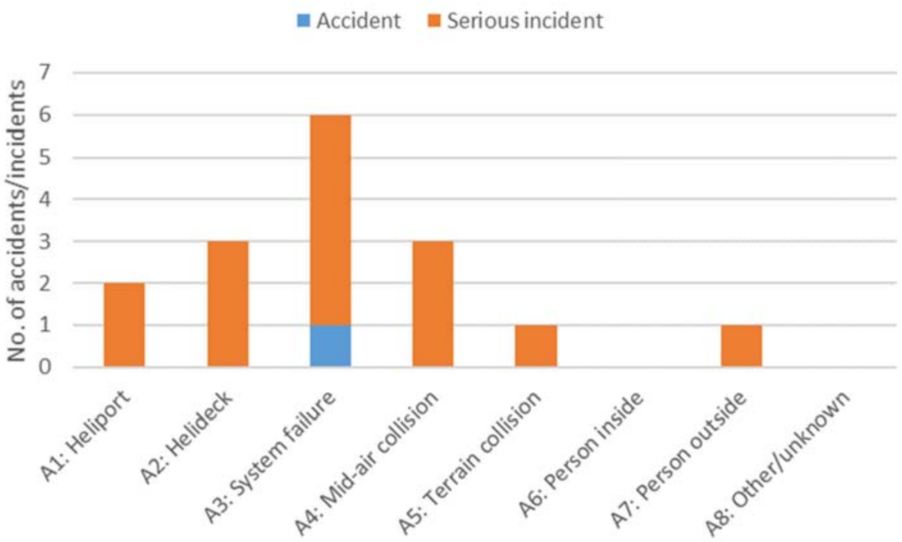


Figure 5.1: Distribution of accidents and serious incidents based on accident category; NCS 1999–2015.

We observe a slight reduction of serious incidents over the last years. On the other hand, there has been an increase in the number of "major incidents", which have a lower degree of severity. This may to some extent be related to how reporting and classification have been adjusted during the period. All incidents categorized as "major" are in fact air traffic incidents where the helicopter has come too close to other traffic (i.e. accident category A4 Mid-air collision). A couple of the serious incidents are also of this type. Figure 5.2 presents how accidents and incidents (both serious and major) are distributed per year for the period.

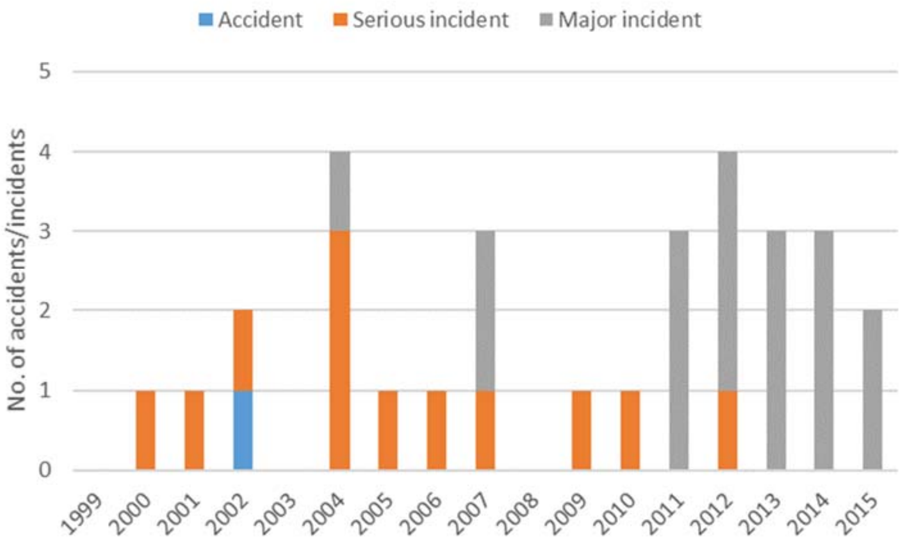


Figure 5.2: Accidents and serious/major incidents per year on the NCS for the period 1999–2015.[1]

5.2 Traffic volume

Table 5.2 and Figure 5.3 presents the traffic volume for passenger transport on the NCS for the period 1999 – 2008, based on data from CAA-N. The data relate to regular passenger transport, hence training, testing, cargo flights, medevac and rescue operations are not included. Similar data for the British sector are presented for comparison. The data are also used for calculating the accident statistics in Table 5.4 below. Note that some data are missing; these data have been estimated and put in italics.

Table 5.2: Traffic volumes in the Norwegian and British sectors for 1999–2015. Number in italics are. estimates.

Year	Norwegian Sector				British Sector	
	Passenger transport	Shuttle	Flight hours	Person flight hours	Flight hours	Person flight hours[d]
1999	37 912	4 840	42 752	707 543	*78 208*[c]	*570 133*
2000	39 887	5 352	45 239	727 134	78 208	*570 133*
2001	40 670	5 692	46 362	775 708	82 180	*599 088*
2002	38 016	5 140	43 156	725 063	81 537	*594 401*
2003	38 877	5 356	44 233	705 953	73 139	*533 180*
2004	36 269	5 517	41 786	697 807	69 674	*507 920*
2005	38 280	5 279	43 559	720 368	76 919	*560 736*
2006	39 207	5 608	44 815	659 076	71 884	*524 031*
2007	39 848	5 092	44 940	671 337	76 254	*555 888*
2008	38 115	4 566	42 681	725 790	76 900	*560 597*

[1] Note that there are small deviations from the overview presentation in the HSS-3 report due to a later reclassification of incidents.

2009	47 110	121[a]	47 231	717 541[b]	71 865	*523 893*
2010	46 299	4 352	50 651	709 587	72 557	*528 937*
2011	49 132	4 730	53 862	747 186	77 611	*565 781*
2012	53 095	4 065	57 160	759 862	86 134	*627 913*
2013	56 422	3 246	59 668	859 000	77 257	*563 200*
2014	58 178	2 346	60 524	879 000	78 984	*575 790*
2015	44 805	1 100	45 905	690 818	69 052	*503 386*

Note a: Shuttle volume in 2009 is low due to missing reporting. The total number of flight hours is assumed to be correct.
Note b: The number for NCS in 2009 is estimated as the average of 2008 and 2010.
Note c: Flight hours for the British sector for 1999 is estimated to be the same as for 2000.
Note d: Person flight hours for the British sector in 2010–2015 is estimated based on the same seat utilisation as for the period 1999–2009.

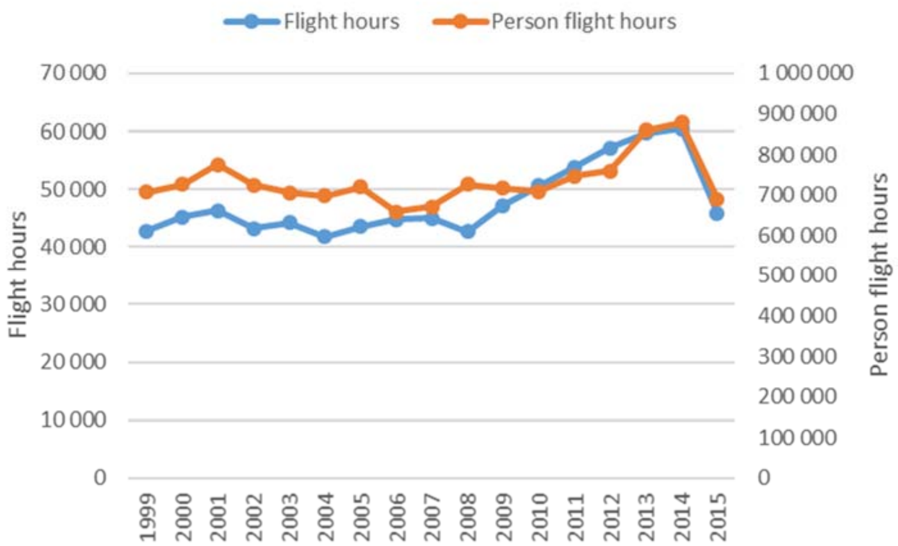


Figure 5.3: Traffic volume for the NCS 1999–2015.

Figure 5.3 depicts a relatively stable traffic level for the first part (1999–2009) of the period, after which it increases steadily and peaks in 2014. For 2015 there is a considerable drop in volume back to the same level as before the increase. This coincides with the business downturn in 2015.

Moreover, Table 5.2 shows that the British sector has significantly more flight hours compared to the NCS, but at the same time far fewer person flight hours. This implies a lower average number of passengers on British flights, which may be explained by more frequent use of smaller helicopters and a lower seat utilisation (due to e.g. more extensive use of shuttling).

5.3 Accidents in the North Sea 1999–2015

In the period 2010–2015 there have been three accidents in the North Sea, all in the British sector. Looking at the whole period from 1999, there are in total 16 recorded accidents in the North Sea; 15 of these accidents occurred in the British sector and only one on the NCS. The accidents are summarised in Table 5.3. Note that the Turøy accident is also included in the overview. A more detailed presentation and analyses of the accidents are presented in chapter 6.

Table 5.3: Accidents in the North Sea 1999–2015/16 (not complete for 2016).

No.	Date	Helicopter	Place	Fatalities	Survivors
1	2000-02-15	AS332L	UK	-	-
2	2001-07-12	S-76A	UK	-	-
3	2001-11-10	AS332L	UK	-	-
4	2002-02-28	AS332L	UK	-	-
5	2002-07-16	S-76A	UK	11	0
6	2002-11-05	AS332L2	NO	-	-
7	2006-03-03	AS332L2	UK	-	-
8	2006-10-13[a]	AS332L	UK	-	-
9	2006-12-27	SA365N	UK	7	0
10	2008-02-22	AS332L2	UK	-	-
11	2008-03-09	SA365N	UK	-	-
12	2009-02-18	H225	UK	-	-
13	2009-04-01	AS332L2	UK	16	0
14	2012-05-10	H225	UK	-	-
15	2012-10-22	H225	UK	-	-
16	2013-08-23	AS332L2	UK	4	14
17[b]	*2016-04-29*	*H225*	*NO*	*13*	*13*

Note a: Accident no. 8 was not included in the HSS-3 report as the investigation report from the AAIB was not published and the classification not set.
Note b: Accident no. 17 is outside the period focused in HSS-3b, but is included due to its importance.

In Table 5.4 accident data and traffic data for both the Norwegian and British sectors are summarised for the period 1999–2009 (HSS-3), 2010–2015 (HSS-3b) and the extended period 1999–2015 (HSS-3 and 3b). There are no quality data for traffic volume for 2009 for the NCS, so this number is estimated as an average of the, 2008 and 2010 data. For the British sector, data for 1999–2009 stem from the HSS-3 report, while data for 2010–2015 are estimated based on registered flight hours and an average number of persons per flight equal to that of the previous period (1999–2009). Since some (the lesser part) of the traffic data are estimated, parts of the statistics in Table 5.4 are to some degree uncertain. These numbers are in italics.

The number of fatalities per million person flight hours is **0** for the NCS for the extended period 1999–2015, as there were no accidents with fatalities during that period. For the North Sea in total (i.e. NO and UK sectors) there were **0,5** fatalities per million person flight hours for the period 2010–2015. This is a reduction from the period covered by HSS-3 (1999–2009) where **2,4** fatalities per million person flight hours were registered. For the combined period 1999–2015, the average is **1,7** for the North Sea in total. For the British sector, **1,2** fatalities per million person flight hours are registered for the period 2010–2015 (based on one fatal accident), compared to **5,6** for the period 1999–2009 (based on three fatal accidents). For the combined period 1999–2015, the average fatality rate is **4,0** for the British sector.

Table 5.4: Traffic and accident statistics for the Norwegian and British sectors 1999–2015. Numbers in italics are estimates.

Parameter	**HSS-3: 1999–2009**			**HSS-3b: 2010–2015**			**HSS-3/3b: 1999–2015**		
	NO	UK	NO+UK	NO	UK	NO+UK	NO	UK	NO+UK
Million person flight hours	*7,8*[a]	6,1	*13,9*	4,6	*3,4*[b]	8,0	*12,5*	9,5	*21,9*
Number of accidents	1	12	13	0	3	3	1	15	16
Number of fatal accidents	0	3	3	0	1	1	0	4	4
Rate of fatal accidents	0	0,25	0,23	0	0,33	0,33	0	0,27	0,25
Number of fatalities	0	34	34	0	4	4	0	38	38
Accidents per mill. person flight hours	0,13	1,97	*0,93*	0	*0,89*	0,89	*0,08*	1,58	*0,73*
Fatalities per accident	0	2,8	2,6	0	1,3	1,3	0,0	2,5	2,4
Fatalities per mill. person flight hours	**0**	**5,6**	***2,4***	**0,0**	***1,2***	**0,5**	**0,0**	**4,0**	***1,7***

Note a: The number for NCS in 2009 is estimated based on 2008 and 2010.

Note b: Person flight hours for the British sector in 2010–2015 are estimated based on the same average number of persons per flight as in the previous period (1999–2009).

Figure 5.4 illustrates the development in the number of fatalities per million person flight hours over the various HSS periods in the Norwegian and British sectors, as well as the North Sea combined. In the figure the column groups a)–c) are results from the three previous HSS studies, as reported in HSS-3, while column group d) expands HSS-3 to also include HSS-3b. Finally, column group e) depicts hypothetical results for the expanded HSS-3/3b period if the Turøy accident is included in that period.

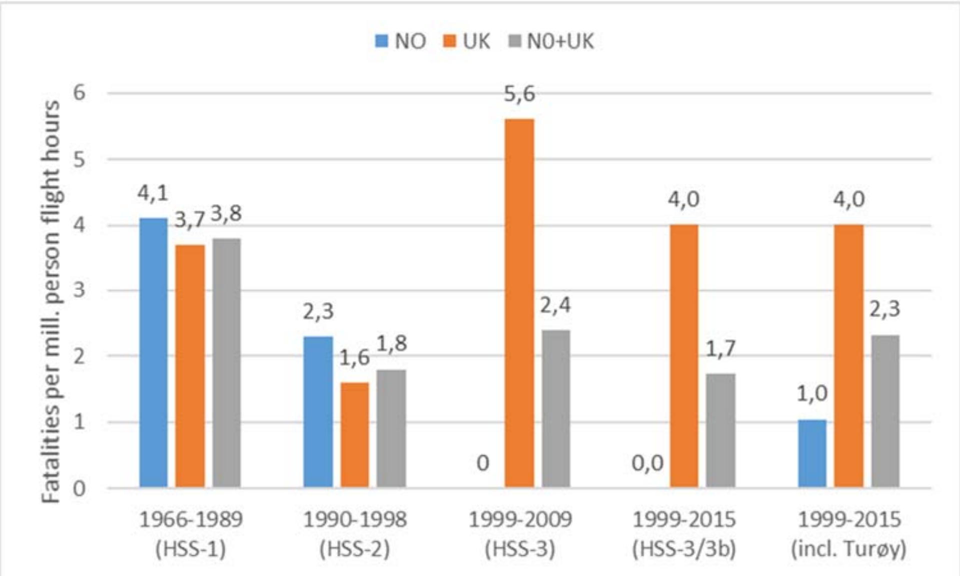


Figure 5.4: The number of fatalities per million person flight hours on the Norwegian and British sectors and combined. Results are shown for the different HSS periods: a) HSS-1 1966–1989; b) HSS-2 1990–1998; c) HSS-3 1999–2009; d) extended HSS-3/3b 1999–2015; e) extended HSS-3/3b 1999–2015 hypothetically including the Turøy accident.

If the Turøy accident had occurred in 2015 instead of 2016, the number of fatalities per million person flight hours would have increased from zero to **2.8** for the NCS in the period 2010–2015 (not depicted). For the extended period 1999–2015, the increase would be from zero to **1,0** for the NCS (Figure 5.4). This is still well below the average for the North Sea as a whole.

Furthermore, Figure 5.4 demonstrates the following relations:

- The statistical risk for the NCS shows a clear positive trend through the HSS periods, to zero for HSS-3 and 3b.
- Even if the Turøy accident is included in the data for the extended HSS-3/3b period (1999–2015), the statistics shows a halving of statistical risk for the NCS between each of the three HSS periods.
- There is no particular trend in the development of statistical risk in the British sector.

The statistical risk as calculated here is highly sensitive to single fatal accidents like e.g. the Turøy accident. Hence, great caution must be taken when attempting to draw conclusions based on such a thin data material.

Figure 5.5 depicts a 5-year moving average for the number of fatalities per million person flight hours for the North Sea (NO+UK) for the period 1975–2013. A large and stable improvement after around 1990 is indicated, with some variation from 2004 and onwards. The global trend from the 1970-ies is showing a notable reduction.

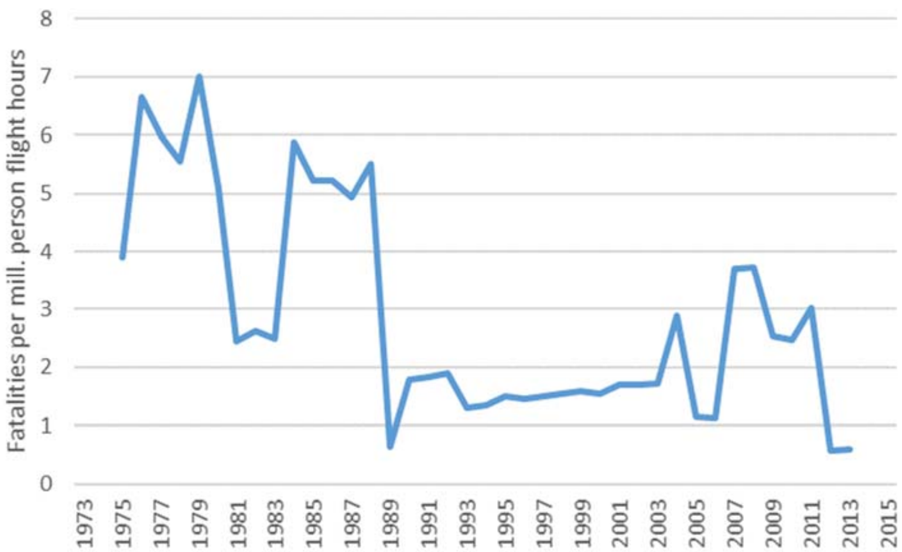


Figure 5.5: The number of fatalities per million person flight hours in the North Sea (NO and UK sectors) for the period 1975–2013; 5-year moving average.

6 Accident analyses

In this chapter, we have analysed the accident picture for offshore helicopter transport on the Norwegian and British sectors, as well as Canada. The main purpose is to investigate what can be learned and what we already have learned from these accidents. We also discuss, hypothetically, what preventive measures may have prevented similar accidents in the Norwegian sector. Further, this is a basis to discuss future focus areas for accident prevention.

There have been several accidents in the British sector and Canada in the period 1999–2015, with the same type of helicopters that are used in Norway and under comparable conditions. It is therefore relevant to discuss to what extent these accidents could have occurred on the NCS. In 2016 we had a fatal accident in the Norwegian sector with obvious similarities to a UK accident in 2009 – the accident in Norway is included in presentations and discussions in this chapter.

6.1 Overview of the accidents

Table 6.1 lists the accidents that are registered for offshore helicopter transport in the North Sea for the period 1999–2015. In addition, we have also included the Turøy accident due to its relevance. Furthermore, one accident in Canada from 2009 is also included. Canada is relevant because the same helicopters are used as in the North Sea, and the weather conditions are also comparable to the North Sea. For each accident, the course of events, contributing factors, and the extent of damage are described in brief, based on excerpts from investigation reports and interviews with pilots and technicians. The final investigation reports are available for all accidents, with the exception of the Turøy accident.

The accidents are classified in relation to the accident categories A1–A8, which are used in the Helicopter Model. An assessment has also been conducted of which RIFs for frequency are the most important factors for each accident. SINTEF has based its assessments on expert judgments regarding the accident's relevance for the Norwegian sector, both at the time of the accident and for the current situation (2016). For each of the accidents we have raised the following questions:

- **A.** Could the accident have occurred in the Norwegian sector at the same time?
- **B.** Could the accident have occurred in the Norwegian sector today (2016)?

For each of the questions we have the following possible answers:

- **Yes**: Could have occurred in the Norwegian sector, with approximately the same probability
- **Yes***: Could have occurred in the Norwegian sector, but with a substantially lower probability
- **No**: Could probably not have occurred in the Norwegian sector

The comments column in Table 6.1 elaborates on whether the accident could have occurred in the Norwegian sector at the same time or today, what the industry may have learned from the accident, and which barriers are in place in the Norwegian sector which could reduce the probability or limit the consequence of a similar accident.

Table 6.1: Overview of helicopter accidents in the North Sea (and Canada) for the period 2009–2015/16 (incomplete for 2016).

No.	Date	Place	Heli-copter	Course of events	Contributing causal factors	Extent of loss/damage	RIF	Acc. cat.	Same time? (A)	Today? (B)	Comments (A/B)
1	2000-02-15	UK	AS332L	Lightning strike. No errors in instruments or other systems.	The captain saw a cumulus cloud, contacted Scatsta and received a message that there was no lightning activity at that time.	No fatalities	1.10	A8	Yes	Yes*	Lightning strike. Improved system for forecasting lightning/discharge conditions.
2	2001-07-12	UK	S-76A	The captain decided that the mate should turn the helicopter 90 degrees so it would be easier for the passengers to embark. After the helicopter had been turned, the pilot was not paying attention and pulled the wrong lever (not the parking brake, as he should have done). The helicopter was lifted rapidly and the pilot pulled the lever back at once. The helicopter landed tail first.	Human factors. Unfortunate placement of lever for parking brake.	No fatalities	1.5 1.3	A7	Yes	**No**	Human factors and cockpit HMI design (for S-76). Would probably not have occurred on the NCS today due to new design and improved CRM training (*Crew Resource Management*).
3	2001-11-10	UK	AS332L	The helicopter on the drill ship West Navion fills fuel while the rotors are running. The captain remains on-board while the mate assists the helideck personnel with the disembarking. Five minutes after landing, the ship's DP system changes to MANUAL. The ship starts rotating and the helicopter tips over.	The rig's DP system changes to MANUAL and the ship starts to rotate. Big change in relative wind gave strong aerodynamic power which had an effect on the helicopter and made it fall easier. In addition the ship had "roll" movements. Lack of procedures: -for the ship crew to transfer change in emergency preparedness status to the pilots; -for the pilots on-board, if the control of the ship is lost/weakened.	One person seriously injured (the mate, who was the only person outside the helicopter on the helideck was seriously injured by flying parts from the helicopter's main rotor, which had been damaged in connection with the collision with the helideck.	1.8	A7	Yes	Yes	Somewhat better procedures today, but similar incidents could happen again. A system has been developed which measures "pitch" , "roll" and "heave" on floating helidecks and provides a *Motion Severity Index* (MSI); an indicator of movement on the helideck.
4	2002-02-28	UK	AS332L	Bad weather (waterspout). During landing, the tips of the tail rotor blades touched the tail pylon.	Waterspout/tornado not visible to the deck personnel. Even though it was relatively far away and the pilots avoided the bad weather, there was severe turbulence.	No fatalities	1.10	A2	Yes	Yes	Could happen anytime, anywhere as long as the waterspout is not registered on the radar.

No.	Date	Place	Heli-copter	Course of events	Contributing causal factors	Extent of loss/damage	RIF	Acc. cat.	Same time? (A)	Today? (B)	Comments (A/B)
5	2002-07-16	UK	S-76A	While the helicopter is approaching, people on the platform hear a loud bang, and then see the helicopter fall into the sea. A witness also saw the main rotor head with the blades fall into the sea after the helicopter had hit the sea.	Loss of separation between the rotor blade sections led to imbalance and to the gearbox falling off.	11 fatalities (out of 11)	1.1 1.10	A3	Yes	**No**	Approach to offshore installation during reduced visibility (see separate chapter). This accident type has been incorporated in the newest generation proven helicopter technology and would probably not have occurred with the H225 or S-92.
6	2002-11-05	NO	AS332L2	During the descent to 1,000 feet for visual approach to Sola, severe vibrations occurred. The pilots sent a MAYDAY signal and informed Sola that they set course for two ships they saw near land. They landed on the helideck of the ship nearest land.	Loss of engine power as a result of fatigue in an axle for vibration damping. Weakness in the certification data for design. Other corresponding cases with this type of helicopter. The design for vibration damping is now modified.	No fatalities. Destroyed main rotor blade.	1.1 1.2	A3	Yes	**No**	Introduced new maintenance procedures and the newest generation proven helicopter technology which prevents this type of incident from happening.
7	2006-03-03	UK	AS332L2	Lightning strike. No vibration or damage visible for the pilots, but there was a temporary disturbance on the instrument screens. Hydraulic system failure occurred, but the helicopter landed safely.		No fatalities. Damage to a main rotor blade and a tail rotor blade.	1.10	A8	Yes	Yes*	Lightning strike. Improved system for forecasting lightning/discharge conditions.
8[a]	2006-10-13	UK	AS332L	During departure from Aberdeen a loud bang followed by large vibrations was observed. Take-off was aborted and the helicopter lowered safely to the runway.	Crack in one of the spindle attachments due to wear and incorrect torque of a bolt.	No fatalities	1.1 1.2	A3	Yes	**No**	New procedures issued from manufacturer for maintenance of spindle.
9	2006-12-27	UK	SA365N	During approach to the North Morecambe platform at night and in poor weather conditions, the mate loses control of the helicopter. The helicopter flies past the platform and crashes into the sea and sinks.	No correct transfer of control between mate and captain. The approach profile gave the wrong angle.	7 fatalities (out of 7)	1.10 1.5 1.4	A5	Yes*	Yes*	Approach to offshore installation during reduced visibility. The probability for occurring on the NCS is considered lower due to training and improved CRM training (*Crew Resource Management*).
10	2008-02-22	UK	AS332L2	Lightning strike during flight. No system failures or impact to the helicopter's performance.		No fatalities. Damage to main rotor blade.	1.10	A8	Yes	Yes*	Lightning strike. Improved system for forecasting lightning/discharge conditions.

No.	Date	Place	Heli-copter	Course of events	Contributing causal factors	Extent of loss/damage	RIF	Acc. cat.	Same time? (A)	Today? (B)	Comments (A/B)
11	2008-03-09	UK	SA365N	During landing on a helideck, the helicopter's tail hits a crane.	Choice of approach profile, limited performance ability of helicopter, approach technique and possible fatigue.	No fatalities	1.5 1.8 1.1 1.2 1.4	A2	Yes*	Yes*	On the NCS the requirement for helideck diameter is 1.25D (compared to 1.0D in the UK sector). A larger diameter provides better visual reference and clearance for obstacles, especially for large helicopter types and on installations with much turbulence and difficult flight conditions. The accident could happen on the NCS, but with less probability because of greater helideck diameter.
12	2009-02-18	UK	H225	Collision with sea during approach to the ETAP platform in the dark and poor visibility.	Poor visibility, more clouds and fog than forecasted. No automatic warnings in cockpit that the helicopter was close to the ground. This was because the pilot had disconnected the auto warning function.	No fatalities	1.10 1.4 1.5	A5	Yes	Yes*	Approach to offshore installations during reduced visibility. In this case several human errors were committed. Would most likely not have occurred on the NCS today due to new design and improved CRM training (*Crew Resource Management*).
13	2009-04-01	UK	AS332L2	The helicopter crashed on the way from the Miller platform to Aberdeen.	An error in the main rotor's gear box led to the main rotor head loosening from the helicopter and that the helicopter and rotor blades destroyed the pylon and tail boom.	16 fatalities (out of 16)	1.1 1.2	A3	Yes	Yes	Even though procedures or maintenance practices are different in the UK and Norway, it is not likely that the same type of technical error would have been discovered in Norway, not even for new machines. The Turøy accident is an example of this.
14	2012-05-10	UK	H225	The helicopter made a safe emergency landing on the sea 34 nm east of Aberdeen following an alarm on the main gearbox lubrication and emergency lube system.	The vertical shaft in the main gearbox cracked due to fatigue in the welding between the two sections of the shaft. (the shaft is driving both MGB oil pumps). The manufacturers FE model underestimated max tension in the weld. Bad design and welding of shaft plus some corrosion (due to moisture).	No fatalities	1.1	A3	Yes	**No**	After 2009 HUMS data are checked between flights. This was not the case with the accident helicopter. The shaft itself has been reinforced. It is claimed that cruise power outtake is lower in the NO sector than in the UK, implying less wear on dynamic components. This failure is specific for Super Puma helicopters.
15	2012-10-22	UK	H225	The helicopter made a safe emergency landing on the sea 32 nm southwest of Sumburgh following an alarm on the main gearbox lubrication system and emergency lube system. (Same as accident 14)	Same as accident 14	No fatalities	1.1	A3	Yes	**No**	Same as accident 14

No.	Date	Place	Heli-copter	Course of events	Contributing causal factors	Extent of loss/damage	RIF	Acc. cat.	Same time? (A)	Today? (B)	Comments (A/B)
16	2013-08-23	UK	AS332L2	Controlled flight into the sea during approach to Sumburgh Airport.	Low cloud layer and fog. Autopilot mode Alt.A (altitude acquire and hold) was not used according to procedure.	4 fatalities (out of 18)	1.4 1.5 1.10	A5	Yes*	**No**	Not followed SOP in relation to use of autopilot during approach, possibly due to complexity of system. It is claimed that procedures are more rigorously followed in the Norwegian sector. L2 not in use on the NCS today, and new helicopters have improved technology for approach.
17[b]	*2016-04-29*	*NO*	*H225*	*Helicopter crashed at Turøy on approach to Bergen airport.*	*Probable cause: a failure in the main gearbox caused the main rotor to separate from the aircraft.*	*13 fatalities (out of 13)*	*1.1* *1.2*	*A3*	*Yes*	*Yes*	*The accident investigation is still ongoing.*
CA[c]	*2009-03-12*	*CA*	*S-92*	*The helicopter crashed into the sea southeast of Newfoundland on the way to the Hibernia oil rig.*	*Broken titanium bolts in the main gear box led to an oil leak in the gear box. An emergency landing should have been conducted but this was not part of the applicable procedure.*	*17 fatalities (out of 18)*	*1.1* *1.2* *1.4*	*A3*	*Yes*	***No***	*Under the same conditions this could have happened in Norway but the consequence could have been less severe. This is because in Canada they flew at 9000 feet (higher than in the Norwegian sector) and therefore spent more time getting to the sea surface. As a result of the accident, the design and procedures are changed and the accident will not happen again. The same type of accident would not have happened with an H225, as this helicopter can fly for 30 minutes without oil pressure in the gearbox.*

Note a: Accident no. 8 was not included in the HSS-3 report as the investigation report from the AAIB was not published and the classification not set.
Note b: Accident 17 is not within the time scope for HSS-3b, but is included due to its importance.
Note c: The Canadian accident in 2009 is included due to relevance to Norwegian operations.

We have identified and assessed a total of 18 accidents in the period 1999–2015/16. There are several aspects of the data material worth attention:

- Most of the accidents (15 of 18) occurred in the British sector. The traffic volumes are comparable for the UK and Norwegian sectors.
- Different versions of the Super Puma have been involved in most of the accidents (13 of 18). This type of helicopter is also utilised the most in this period.
- One third of the accidents (6 of 18) were fatal with 68 fatalities in total. In the fatal accidents all or almost all on board perished (5 of 6 fatal accidents).
- Almost half of the accidents have a technical root cause. Most of these accidents occurred towards the end of the period (5 of the 6 most recent accidents have a technical root cause; all are linked to failures in the main gearbox).
- It is not very uncommon that the main rotor to detach from the helicopter (accident no. 5, 13 and 17).
- For the remaining 10 accidents which do not have a technical root cause, we find the following distribution:
    - Lightning strike / static discharge / extreme weather: 4 accidents (no. 1, 4, 7, 10).
    - Collision with sea: 3 accidents (no. 9, 12, 16).
    - Helideck conditions: 3 accidents (no. 2, 3, 11).

We emphasize that the categorization made above in "technical" and other accidents is very simplified, since normally several factors contribute to an accident. Human factors as such play an important role in many types of accidents. For example, a relatively harmless incident with a technical root cause can develop into an accident following an unsuitable human response (put to the point, the accident in Canada is an example). Human judgment and decisions also play a role in accidents related to landing/parking on helideck, although it is often easy to point at causes related to external physical conditions (obstructions, weather, etc.). For collision accidents with sea, human factors obviously have a dominating role, but technical factors (like man-machine interface) may be influential, and weather conditions may act as a triggering factor. For example, lightning strike is an external factor, but the decision to fly in areas with risk of lightning is obviously of human nature. Further, lightning or static discharge may sustain permanent non-visual structural weaknesses that may later develop into a technical failure.

Concerning the two questions whether the accidents could have occurred in Norway at the same time or today, the analysis gives the following answers:

A. All the accidents could in principle have occurred in Norway at the time. However, the *probability* for the different accidents occurring is not necessarily the same for the British and the Norwegian sectors. For a minority of the accidents (3 of the 16 accidents outside Norway) we consider the probability to be significantly lower in the Norwegian sector.

B. In the current situation (2016) we assess that 8 of the 18 accidents will not occur again in Norway, and that an additional 6 accidents have a significantly lower probability than at the time of the accident. The improvement is mainly due to technical developments and learning form the accidents.

Figure 6.1 gives a visual summary of central information and assessments of the accidents.

Those accidents that are likely to reoccur are grouped as follows:

- Lightning strike / static discharge / extreme weather (4 accidents)
- Visual approach to offshore installations in reduced visibility (2 accidents)
- Helideck conditions (2 accidents)
- Technical failure in the main gearbox (2 accidents)

For these types of accidents there are measures that may be implemented to reduce the probability of an accident. Each of the accident types are discussed below.

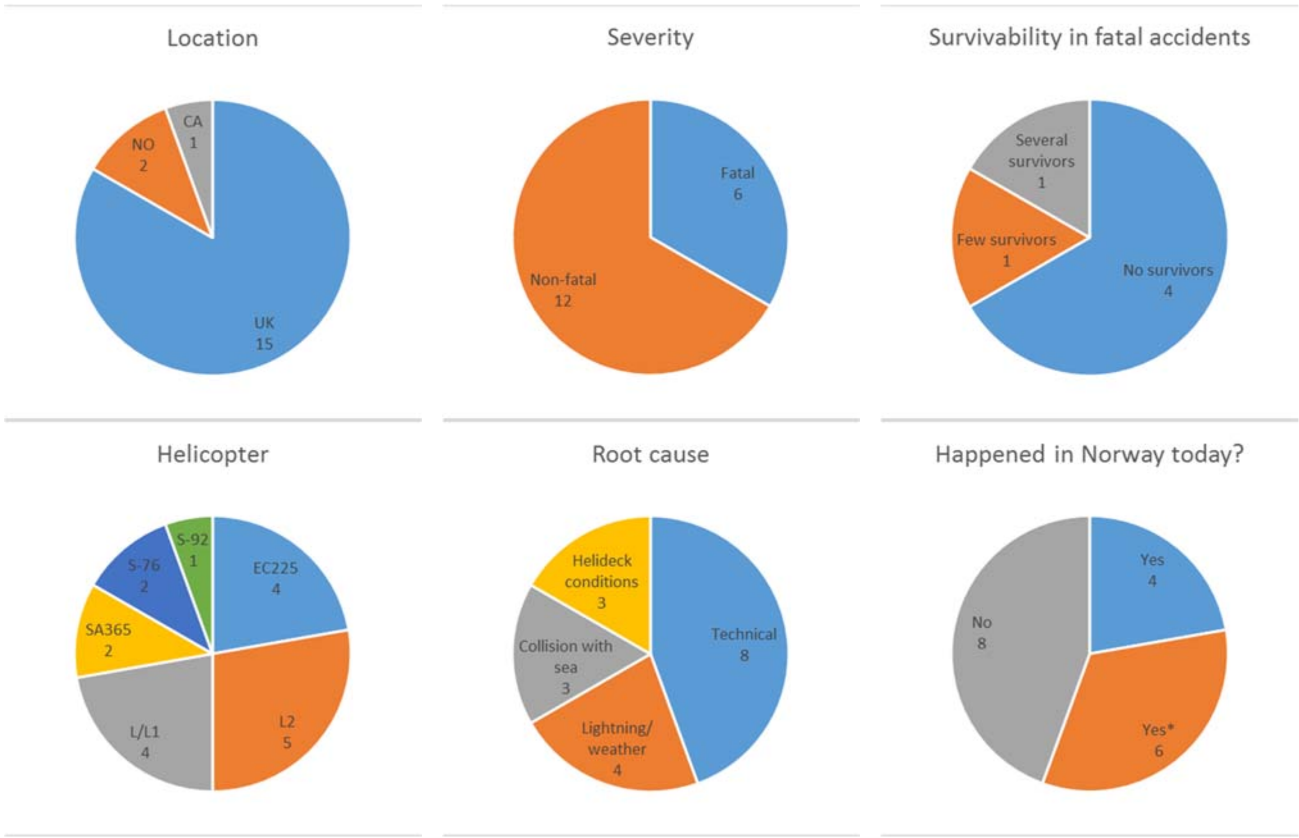


Figure 6.1: Visual summary of information about accidents in the North Sea (and Canada) for the period 1999–2015/16.

6.2 Discussion of accident types

7.1.1. Accidents caused by lightning strike/discharge/extreme weather

Three of the accidents in Table 7.2 are related to lightning strike, a phenomenon which is just as likely to occur in the Norwegian sector as in the British sector. Helicopters will always be exposed to this type of risk, and there is currently no satisfactory method to detect lightning or static discharge conditions to such an extent that they may be avoided completely. There are systems in place registering lightning strikes, but these are reactive and do not warn of the *threat* of lightning. The helicopter can also accumulate a static charge and trigger a discharge with the environment itself. The only way of avoiding lightning is to avoid exposed areas (e.g. snowy weather, cumulus and cumulonimbus clouds and areas with a temperature from -3 °C to +3 °C).

The extent of damage caused by a lightning or discharge may have increased after the introduction of composite materials in blades and parts of the airframe. Composite materials are not very good conductors compared to metal; therefore, different bonding issues may occur as a consequence. Rotor blades are also more prone to damage due to delamination of the composite materials and deice heating blankets when subjected to large electrical currents. The technology needs to be developed further, also concerning hidden damages. The helicopters should be designed more resilient to lightning/discharge. There are no accidents related to lightning/discharge in the Norwegian sector for the period covered (1999–2015). On average, there are 2–3 reported lightning incidents per year. A possible explanation to the absence of lightning or discharge accidents in the Norwegian sector, may that flying in unfavourable conditions to a greater extent is avoided.

6.2.1 Accidents during visual approach to offshore installations in reduced visibility

Four of the accidents in Table 6.1 are related to approach to helideck (accidents no. 5, 9, 12) or airport (accident 16) in reduced visibility conditions (darkness, fog or bad weather). This accident type is considered likely to occur in the Norwegian sector as well. There have been incidents in the Norwegian sector where the helicopter came too close to the sea during approach, and collision was avoided due to the warning system (GPWS). Pilots, like most people, tend to trust and act based on what they can see with their own eyes (which in some situations can be misleading due to lack of visual cues) instead of trusting what the instruments show.

The Crew Resource Management concept (CRM) has been given an increased focus in the recent years. Norwegian pilots perform a high quality training scheme in both monitoring and challenging the other pilot. How the CRM concept is utilised during flying and the methods for training air crew properly in the CRM concept is seen as one factor that might separate the British and the Norwegian sectors. The Norwegian culture supports a non-hierarchical cockpit where it is encouraged to challenge the captain (or the other crewmember) if something seems to be wrong. Accident reports indicate that cockpit relations might differ between the two sectors, as some British accidents indicate that the co-pilot has (obviously) failed in challenging the captain when he should have.

Aside for robustness in CRM training, the introduction of automatic approach procedures is another important risk reducing factor for this type of accidents. These procedures will reduce the risk of errors during the approach. Other risk reducing measures are to reduce night operations and increase the amount of simulator training in night/bad visibility conditions.

6.2.2 Accidents caused by critical failures in the main gearbox

As many as five of the six most recent accidents (Table 6.1) are related to technical failures in the main gearbox. Three of these accidents (no. 14, 15 and the Canadian accident) have led to technical improvements (new design features and strengthening of components) that will most likely prevent the exact same type of accidents. For the remaining two accidents (no. 13 and 17), no particular modifications or improvements have been made to prevent any reoccurrence. These two accidents look very similar, featuring a failure in the second stage planet gear. However, detectable metal chips were present in the gearbox prior to the 2009 accident, while no chips were found before the 2016 accident.

6.3 Analysis of the accidents

Figure 6.2 depicts the distribution of accidents by categories. The distribution is for the British and Norwegian sectors (and Canada) for the period 1999–2015.

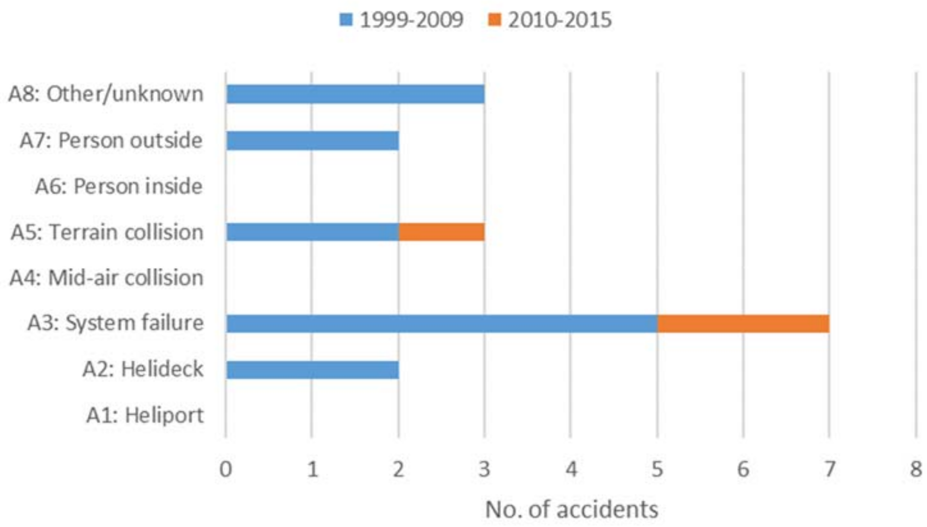


Figure 6.2: Accidents in the North Sea (and Canada) 1999–2015 by accident category.

From Figure 6.2 we observe the category A3 *Accident caused by critical failure in helicopter during flight* are dominating with 7 accidents. However, the analysis shows that 5 of the 7 accidents could have been prevented today.

Figure 6.3 presents all the accidents distributed by the defined RIFs for the two periods. We observe that the RIFSs *Weather and climate* and *Helicopter design* hold the largest contribution to accidents since 1999. The accidents linked to *Helicopter design* are for a large part type *A3 System failure*, and the reduction of this type of accidents will also result in a decrease in this RIF's contribution.

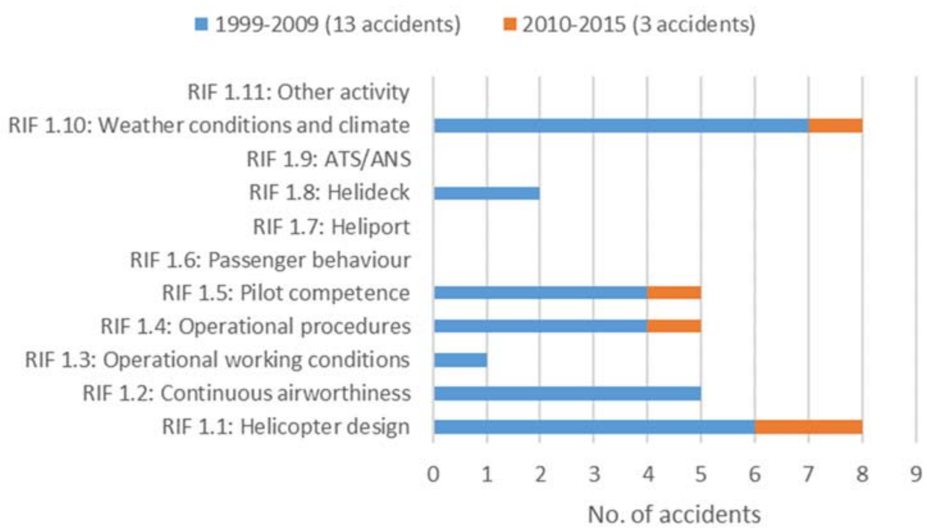


Figure 6.3: Accidents in the North Sea (and Canada) 1999–2015 by RIFs for frequency.

In HSS-3 the biggest contribution to risk was from RIF 1.10 *Weather and climate*. HSS-3 predicted that RIF 1.10 together with RIF 1.2 *Continuous airworthiness* would see a reduction in the period 2009–2019 due to the introduction of new helicopter types, last generation proven technology and new maintenance procedures. Furthermore, a reduction in RIF 1.4 *Operations procedures and support* and RIF 1.5 *Pilot performance* was also predicted based on new procedures and automated approaches. The few accidents occurring after 2009 do not support this prediction, so further studies are needed to possibly verify this expected improvement.

For a number of the accidents (especially those in 2009 and 2012 that had a technical cause), the root causes have been addressed and improvements have been implemented in order to prevent reoccurrence. The assessment of recent accidents shows that it is important to learn from accidents seen over a long time-span, and not only act on the most recent ones. This is especially true when the same type of accident has occurred several times.

7 Assessment of CAP 1145

7.1 Introduction

There were five accidents in the British sector over a relatively short time span in the period 2009–2013. Shortly after the latest accident in August 2013, a safety study was initiated by the British authorities. The report “Safety review of offshore public transport helicopter operations in support of the exploitation of oil and gas", also known as “CAP 1145", was published in February 2014.

CAP 1145 contains many measures and recommendation aimed towards the authorities (CAA and EASA), the helicopter business (manufacturers, operators, maintenance and training) and the players in the petroleum business (i.e. oil companies). All the recommendations in CAP 145 are reproduced in Appendix C of this report.

In this report, we have evaluated some of the recommendations in the CAP 1145 report, and collected experiences from the process of making CAP 1145.

7.2 Norwegian reactions to CAP 1145

The CAP 1145 report documents a relatively comprehensive work, executed over a short time span involving many persons. The report contains a lot of interesting material and presents many reasonable recommendations aimed towards different players in the helicopter transport business. Some of the recommendations can also be found in the HSS-3 and HSS-3b reports. In particular, three of the CAP 1145 recommendations have been caused some controversy and sparked discussions in Norway:

- Wave height limitation at sea state 6
- Cat A breathing system (pressurised air)
- Marking of large passengers

These recommendations are treated separately in the following chapters.

The main points of criticism from different stakeholders in Norway can be summarized as follows:

- **Focus on reactive measures.** It is a recognised and sound principle to spend resources on the *prevention* of accidents rather than reducing the consequences of accidents. All accidents cannot be prevented, hence a focus on both proactive and reactive measures is important. The CAP 1145 report contains more proactive recommendations than reactive, but the criticism raised in Norway has suggested that an even greater emphasis on preventive measures should have been given. However, it seems that the emphasis on reactive measures is deliberate in CAP 1145, focusing on post-ditching measures and water impact survivability. This is a natural and understandable focus considering the nature of the triggering accidents.
- **Claiming insignificant differences.** Comparing the accident statistics between UK and Norway, the numbers are strikingly different. However, this difference is not given much attention in CAP 1145. The report simply states that the differences are not *statistically* significant – which seems correct – but this leaves the impression that no differences exist between the British and Norwegian sectors. Rigid statistical tests of the significance of differences are very strict, and should not constitute the complete basis for such a discussion.
- **The report being rushed**. The safety study was initiated on a short notice and completed over a short time span. This does not necessarily affect the quality of the results. However, it seems that some of the

proposed recommendations have not been adequately assessed in relation to total risk and possible effects on other areas. An example of this is the recommendation on wave height limitation (discussed in section 7.3).

- **Lack of attention towards Norwegian contributions.** CAP 1145 is partially presented as a collaboration between British and Norwegian resources, but Norwegian contributions and comments are to a small extent reflected in the report. The Norwegian contributors have not agreed to all of the conclusions or the material presented. For this reason, the CAA-N chose not to sign the report.

7.3 Wave height limitations

One important recommendation in CAP 1145 is the introduction of an operating limit linked to wave height (recommendation A5 and A6, Appendix C). This prohibits operations of the helicopter over waves exceeding the certification of the helicopter for "minimum ditching performance" (EASA certification). Most heavy helicopters are certified to sea state 6, which equals a significant wave height of maximum 6 meters. Both the Norwegian and British sectors use some helicopters certified to sea state 4 (2,5 meters significant wave height). On the Norwegian sector, this is the AS332L type currently used as SAR helicopter from Stavanger and Oseberg, as well as shuttle helicopter at Valhall.

Advantages
A wave height limitation contains several safety features. First, in case of ditching – controlled or uncontrolled – there will be a higher probability that the helicopter will stay afloat and not capsize or sink. This will allow an orderly evacuation of the helicopter through the doors, thereby increasing safety. Second, the perceived safety for the passengers will increase, knowing that the flight is not conducted in the worst conditions, since high waves are often associated with strong wind and bad weather in general. Third, this would also introduce a more defined standard for operating, easing the exchange of personnel and aircrafts for those companies operating on both sides of the North Sea. It should be noted that the HOFO regulation contains no wave height limitations.[2]

Disadvantages
Seen in isolation, the introduction of a wave height limitation will certainly give a reduction in risk. However, it may have negative impacts on other aspects of the offshore business, including safety aspects. This recommendation will of course incur cost as it will be disruptive to traffic regularity in periods with bad weather. Considering safety, a postponement of transport for a short period of time (a few days) should not be a problem. However, challenges arise when waves remain high for days and weeks, which is not that uncommon on the NCS, particularly in the Norwegian Sea.

- **No rotation of personnel.** When helicopters are grounded for longer periods due to wave height limitations, offshore personnel will not be exchanged. Still, production needs to continue, which will disturb established shifts, extend work periods, reduce rest, etc. The increased workload may yield tired and inattentive workers, thereby possibly increasing the risk for accidents and incidents.
- **High utilisation of helicopter resources.** After periods of bad weather, there will be a large and simultaneous demand for helicopters for the exchange of offshore personnel. This will result in heavy utilisation of aircraft and crew, with possible consequences such as reduced rest and less time for inspections and small maintenance. Doing catch-up can of course be done within the legal frames, but with a potential for decreasing safety margins.

[2] From EASA, the need to consider such flight restrictions is formalised through the two airworthiness directives EASA AD 2014-0188R1 and 2014-0244.

- **Increase in night operations.** A sudden increase in demand for helicopter resources for a limited time may also increase the hours of operating at night. This will increase risk, as flying at night gives few visual cues, thereby reducing situational awareness. Rescue operations are also more demanding at night. Furthermore, the relation between high waves and darkness is especially relevant since bad weather periods are more likely to occur during autumn and winter, and more likely in the north (Norwegian Sea) than in the south (North Sea).

Assessment

It seems only reasonable to consider the sea condition when planning a helicopter flight. However, using wave height as a strict criterion is questionable. The total weather situation should be assessed considering wind, precipitation, lightning/discharge, icing conditions etc. – not wave height alone. Considering waves, additional features like choppiness, direction and wind are of importance.[3] Therefore, utilising wave height as an isolated criterion seems unreasonable. As a minimum, a wave height criterion should be understood and practiced in such a way that the total weather situation is considered.

A wave height limitation is likely to reduce the consequences of landing on or colliding with water. At the same time, such a limitation will introduce other risks given a high sea state over longer periods, which is not that uncommon on the NCS. The effect on the total risk is therefore uncertain.

A possible way to introduce wave height limitations in the worst conditions while still maintaining regularity, is to introduce the limitation for night operations only. Reducing operations in darkness in challenging weather conditions is considered risk reducing. Such a limitation should also include the possibility to grant exceptions for crossing defined (limited) areas with sea state above the limitations. Exceptions should also be considered for extended bad weather periods in order to exchange personnel.

Another consideration is that the SAR coverage in the Norwegian sector is better that in the British sector, due to SAR helicopters based offshore. This gives a reduced response time despite greater distances, which again may reduce the consequences of a ditching.

Given an introduction of sea state limitations, there must be a defined standard for measuring and reporting sea state, giving all helicopter operators the same basis for planning the operations. Situations where one operator decides to fly and another does not, based on different information, should be avoided, as this will introduce unwanted competitive factors for the helicopter operators.

It should be noted that a possible limitation associated with wave height would be unique to offshore helicopter operations. Helicopter transportation over land does not have any similar limitations regarding the possibility for making a safe landing in all situations. Nor does ordinary fixed-wing passenger transport consider the conditions at the sea surface. On this basis, it can be argued that it would be strange to claim this limitation for offshore transportation. It must be said that this comparison is not completely fair, since design, equipment and operating conditions are very different for offshore helicopters, onshore helicopters and fixed-wing. Still, it highlights the principal question of discriminating between these three areas of air transportation.

Conclusion

- Wave height limitations may have a risk reducing effect in certain situations with the helicopter in the sea; however, the probability of such situations is seen as remote, and the total risk reduction associated with wave height limitations is considered to be marginal.

[3] HeliOffshore is currently conducting substantial work in this area.

- Before possibly introducing flight limitations related to wave height, it is recommended to carry out a broad risk assessment also including possible indirect effects on other areas than the helicopter transport.
- It could be considered to introduce wave height limitations for night operations. This will be a step towards reducing night operations in bad conditions without giving any significant logistical implications. Any limitation pertaining to wave height should not be strictly formulated, but rather be seen as part of the evaluation of the complete meteorological situation. Exemptions should be made for passing areas of high waves en route. A thorough evaluation of this arrangement should be made before considering the introduction of any daytime limitations related to wave height.

7.4 Compressed air breathing systems

Another important recommendation in the CAP 1145 report is the introduction of an emergency breathing system that can be deployed under water, a so-called "Cat A" (Category A) breathing system (recommendation A8 and A10, Appendix C). This recommendation implies that everyone on board must have a pressurised air unit available in the survival suit. In the Norwegian sector today, a so-called "rebreather" is used, which is an external mechanical air repository that is initially filled exhaled air from the user. This system requires certain preparations before use. The Cat A system, however, can be put to use with no prior preparation; one simply inserts the mouthpiece and starts breathing. Still, proper training is essential for this type of equipment to be effective and useful, particularly on how to get rid of water in mouth and nose if the system is deployed under water.

Advantages
The obvious advantage of using pressurised air is that the system can be used without preparation at any time during an evacuation. The greatest value will be in situations where the helicopter submerges suddenly and the persons on board are conscious. Knowing that there is air available for breathing under water is seen as positive by many users, and might contribute to reducing stress in real situations. A rebreather requires preparations before use, and the correct procedure must be followed for the equipment to be effective. This is practised in training, but training is done only every fourth year, which is too seldom to automatize the use of the rebreather.

The general value of standardizing equipment and procedures – especially among neighbours in the North Sea – applies for breathing systems as well. It would be unfortunate to maintain different regimes in the different sectors or between companies, since many offshore workers tend to change workplace over time. Cat A breathing systems will be a HOFO requirement, and this may lead to a common introduction regardless.

Disadvantages
There are several uncertainties and potential negative effects related to an introduction of a pressurised emergency breathing system. Different aspects are summarised below:

- **Wrong usage**. Experiences from diving in cold water demonstrates that correct use of the breathing system is the most challenging issue, i.e. opening the valve and breathing normally. This requires adequate training. Inexperienced persons, especially when put in a stressed situation, will try to fill the lungs to maximum capacity and breathe heavily. This might induce pulmonary embolism (the pressure difference is largest for the first meter). This may also lead to the available air being consumed too quickly. Furthermore, starting to use the breathing device too early, may result in running out of air under water.
- **Lack of training**. The current training in the use of pressurised breathing systems is inadequate. The training is not done in a realistic environment (i.e. submerged/capsized helicopter) – it is not even

conducted in water. Training is only done on land due to the risk of erroneous use and potential for causing harm, especially for persons with embolic issues. Dry training is not able to mimic a realistic situation with cold water, possible disorientation, stress and the importance of timing the use of the breathing device. A regulatory requirement may be imposed on training in water. However, since there is relatively little experience with this type of training and the related risks have not been adequately mapped, such a regulation will not be seen any time soon. The training frequency (every 4th year) also seems to be too low to get properly familiarised with the use of the system.

- **Health certification.** Given a requirement to train realistically in water, a health certification will be required for the use of pressurised air. Some of the offshore workers will not pass such a certification and will in practice be denied working offshore if the training requirement is upheld very strictly. Persons more likely not to pass such a certification are older workers; hence, such a requirement may lead to a temporary loss of experienced personnel. It is questionable whether this is a desired development given the low probability for situations where pressurised breathing systems may make a difference.
- **Load on the pilots.** A pressurised container will significantly increase the weight of the life jacket carried by pilots, notably around the neck and shoulder areas. This represents a potential health hazard for the pilots and the possible consequences have not been properly investigated. The breathing system can possibly be mounted as a part of the helicopter instead of being carried as personal equipment. This will require another type of certification and maintenance of the equipment.
- **Compressed air.** Transporting pressurised containers aboard a helicopter (cabin or cockpit) is a hazard in itself. Transferring these containers onto an offshore installation will transfer the risk to that installation.
- **Systems design.** Some challenges exist related to the design of Cat A breathing systems, like developing a mouthpiece that fits all persons, avoiding the air hose to catch on objects, etc. The number of manufacturers of such systems is limited, and so far no system presented stands out.

I addition there will be investment costs and maintenance costs associated with introducing a new and considerably more advanced breathing system. A regime for regular inspection will be required to ensure that the functionality is intact, including pressure tests. If a requirement for increased training is put in effect, increased costs will be incurred for the oil companies, and the risk for the users (related to training and certification) will increase.

Assessment

A pressurised breathing system will be most efficient in situations where the helicopter is capsizing after a ditching and a minimum of preparations can be made. In an emergency landing at sea – controlled or uncontrolled – the passengers will have time to prepare and a rebreather will give the same function as a pressurised breathing system. Ideally, the helicopter shall not capsize after a controlled landing as long as the certified wave height limitation is respected (ref. section 7.3). If there is a crash or a controlled flight into the sea (CFIT), the situation will be chaotic and the probability of capsizing is large; however, in these scenarios passengers may be injured or unconscious and incapable of evacuating anyway (as pointed out in accident investigations after CFIT accidents). Overall, there seems to be a relatively limited need for the extra functionality offered by a Cat A breathing systems. The effect on safety seems marginal at best, and the value of introducing such a system is uncertain considering the many drawbacks described above.

Some of the downsides related to the introduction of a pressurised breathing system are linked to lack of experience and comfort in using such systems, as well as immaturity in the development of equipment. The introduction of a new system will also introduce new risks; these can be compensated by training, but the training needs to be realistic and sufficiently frequent, which is not the case today. The uncertainty will be most noticeable in a transition phase, but after the system has been established and the training brought to an adequate level, pressurised systems are likely to be perceived as safer.

Cat A breathing systems will be a requirement in HOFO. Should HOFO be introduced on the NCS, such systems will be compulsory, unless alternative solutions can be justified (AltMoC).

Figure 7.1: Example of two current breathing systems: Apeks PSTASS (left) and Hansen Protection SeaAir EBS (right). (Source: Falck Nutec)

Conclusion

- A Cat A breathing system (pressurised air) may have a risk reducing effect in certain situations with the helicopter in the sea; however, the probability of such situations is seen as remote, and the total risk reduction associated with a Cat A breathing system is considered to be marginal.
- As per today Norway should not introduce requirements for a Cat A breathing system on own initiative. It is recommended to await the coming HOFO introduction.
- Should the introduction of the HOFO regulation allow Norway to *choose* breathing system, a thorough assessment should be undertaken before any change is made. Risks associated with use both in training and in real evacuation situations – as well as cost and logistics – should all be considered.

7.5 Marking of large passengers

A third controversial recommendation in CAP 1145 is the marking of large passengers and the reservation of specific seats in the helicopter cabin for these passengers (recommendation A9, Appendix C). "Large" is here defined as persons with a shoulder width exceeding 559 mm (22 inches), which corresponds to the smallest cabin window size measured in the diagonal. The purpose of this recommendation is to secure evacuation of large persons and avoid potential blocking of emergency exits.[4]

Advantages

The main advantage of introducing restrictions based on passenger body size is to make evacuation more efficient in case of an emergency. This will largely eliminate situations where passengers try to escape through too narrow windows, possibly blocking these exits. A system of marking both passengers and seats makes it explicit who may sit where in the cabin, and this may contribute to improve the perceived safety for those passengers that fear being blocked in during evacuation (as discussed in the HSS-3 study).

[4] Very large persons that do not fit the seat belts, cannot fly. There used to be seat belt extensions available, but these have now been removed.

Disadvantages

Regarding safety, there are no evident downsides to a body size limitation, except for those cases where large persons are fit and well trained as opposed to slow and overweight. Large, strong persons might be a considerable asset in case of an emergency and contribute positively to perceived safety. Some other issues (not safety-related) associated with passenger marking are discussed below.

- The marking of large passengers can be a stigma for the individuals in question and contribute to pressure large persons out of offshore work. Furthermore, such practice will seem strange to the prevailing Norwegian “equality culture”.
- There will be logistical challenges with the establishment and practise of such a system. All relevant seats must be marked, and body measurements must be standardised and the quality assured. In the UK, a dedicated course is required to qualify for taking measurements.

Assessment

The measuring and marking of large passengers and seats seem to have little effect on safety. It is seen more as a logistical challenge. The requirement will affect relatively few individuals. In 2015, a count made in the British sector showed that ca. 3 % of 12 000 persons would require marking, i.e. ca. 3–400 persons.

Measuring shoulder width alone may not be representative for the widest area of the body. The waist area is more flexible than the shoulders, but may be considerably wider on some individuals. The shoulder width is fairly constant, but the waist measure may vary and actually be the real limiting factor. However, measuring the waist seems less practical and more controversial, and shoulder width is generally accepted as the limiting body dimension when passing through narrow openings.

In addition to the practical aspects of this recommendation, there are also problematic ethical sides to body measuring and marking of individuals. Measuring shoulders instead of waist probably reduces the stigma to some extent, but avoiding to address waist size blurs the issue of evacuation capability.

Marking of large passengers will be a requirement in HOFO. Should HOFO be introduced on the NCS, such a practice will be mandatory.

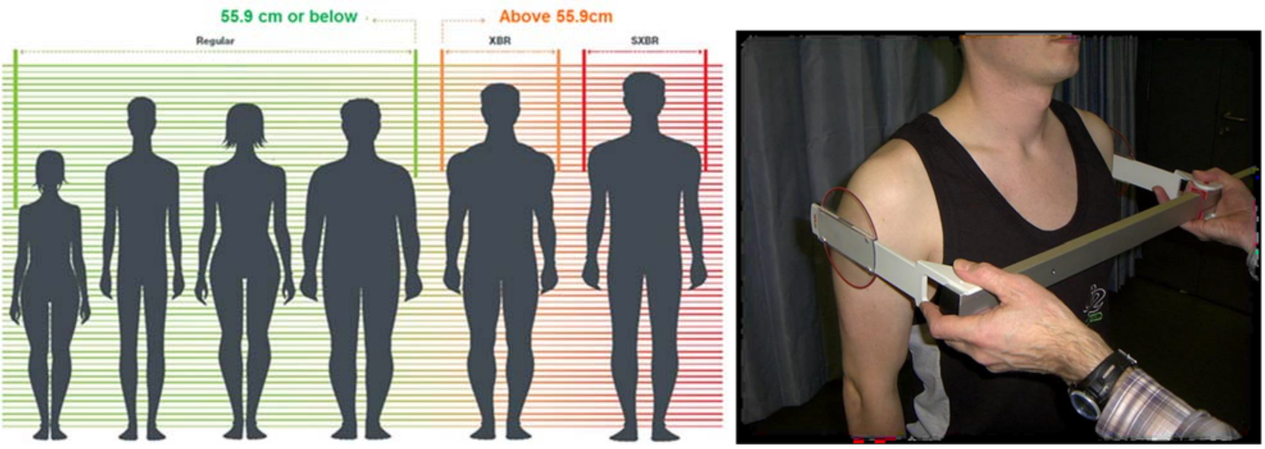


Figure 7.2: Shoulder width exceeding 22 inches (559 mm) are categorised as "extra broad" (XBR). Both the measuring procedure and tools are standardised. (Source: Step Change in Safety)

Conclusion

- A regime with categorising and marking passengers by body size may have an effect in an actual evacuation; however; the total risk reduction associated with such a regime is considered to be marginal. Moreover, there are logistical, economical and ethical sides to such measures.
- As per today Norway should not introduce requirements for categorising and marking passengers by body size on own initiative. It is recommended to await the coming HOFO introduction.

7.6 Side floating device

Offshore helicopters are equipped with inflatable emergency floating devices with the purpose of keeping the helicopter afloat and stable given an emergency landing on water (this equipment is not designed for CFIT or uncontrolled landings). The helicopters are certified ("ditching performance") to stay afloat in certain sea conditions (e.g. 6 m significant wave height for the S-92 and the H225). The probability of capsizing increases with wave height, and in given circumstances the helicopter may capsize in wave heights below the certified limitation.[5] The floating devices are attached to the lower part of the helicopter. To avoid capsizing the devices should rather be attached higher on the helicopter ("side floating device"). With a side floating device the helicopter will be less prone to capsizing and only partially submerged. This will create an air pocket inside the cabin for use during emergency evacuation.

Figure 7.3: Floating devices preventing capsizing will reduce the need for reactive measures (consequence reduction). Picture from the Sumburgh accident in 2013. (Source: The Shetland Times).

Finding solutions for attaching the floats higher on the helicopter has been discussed for some time. The technology is not yet properly developed, but several development initiatives exist, and acceptable solutions may be presented in the future. One of the challenges is to secure that an untimely inflation of the floats does

[5] A shortcoming of the current certifying regime is that it is all done on paper and not in practical demonstrations. It is therefore uncertain that the helicopter meets the approved certification in practise. The ability to stay afloat is not only related to wave height, but also to wave choppiness and direction, as well as wind conditions.

not compromise the safety of the flight. Potential physical contact between the rotors and the flotation gear is the main concern, as this could be disastrous during flight. It is of course important not to introduce new risks when developing systems. A current initiative in Australia shows great promise, where a large number of smaller floats provides the same buoyancy (as few and larger floats), and mounted on the side of the helicopter they cannot physically interfere with the rotors when inflated.

Given a successful introduction of floats that will keep the helicopter afloat in high seas, this will reduce the need for reactive measures aimed at reducing the consequences of capsizing. All the three controversial recommendations discussed above (wave height limitation, breathing system and passenger marking) will fall into this category, and therefore become less relevant. Norwegian players should support and follow up the development of air pocket solutions.

7.7 Relevant recommendations for the Norwegian sector

Many of the recommendations given in CAP 1145 are already in place in Norway, partly due to HSS-3. Other recommendations have little relevance for different reasons. The recommendations that seem to be most relevant for the Norwegian sector are:

- **Safety indicators based on FDM (A2).** FDM produces a large amount of data that may be used for trending purposes. Current FDM data are not much exploited, so the potential for a better utilisation of the system is considerable.
- **Establishment of an FDM user group (A4).** The establishment of such a forum has been decided, but has yet to materialize. It is natural that the CAA-N takes lead on this initiative.
- **Wave height limitations (A5/A6).** See discussion in section 7.3.
- **Cat A breathing system (A8/10).** See discussion in section 7.4.
- **Marking of large passengers (A9).** See discussion in section 7.5.
- **Offshore communication and control from an ATC-perspective (A15).** The Norwegian sector has started using ADS-B and is well ahead of the British sector in this field. A lot of work related to this is still to be completed, particularly in the northern parts of the NCS (from the Brønnøysund/Heidrun area).
- **Training on instrument flying (A16/17).** The recommendations are aiming to strengthen and assure the quality of training programmes related to instrument flying.
- **Support R&D initiatives concerning helideck lights, moving helidecks, helideck approach and HTAWS (A32).** These are all important areas that still need dedicated effort and development.

8 Suggested measures

This chapter contains suggestions for safety promoting measures which have been identified through the data collection for HSS-3b and the results from HSS-3. We refer to section 2.3 for details on the method for finding data and assessing measures.

Note that by *measure*, in this case, we mean measures which neither have been introduced nor planned as of today, and which would be realistic to introduce within a reasonable amount of time (up to 5 years). In the two studies HSS-3 and HSS-3b, both frequency-reducing and consequence-reducing measures have been identified, including measures related to organisations, authorities and customers. All measures presented in HSS-3 have been re-assessed regarding status and prioritisation. The status for these measures is classified in the following categories (Table 8.1):

Table 8.1: Classification of measures given in HSS-3.

Not relevant	The measure is outdated, outside the scope for HSS-3b, or not seen as having any safety-relevant effect at this time
Closed	The measure is properly implemented
Open	The measure has not been initiated, or is implemented only to a small degree

Both for the measures given in HSS-3 (numbered M01–M42) and the new additional measures from HSS-3b (numbered B01–B46), a holistic evaluation have been made regarding feasibility and expected utility in the form of risk reduction in the coming five-year period (2016–2020). Through the aid of expert assessments all open measures have been classified according to the following order of priority:

- **HIGH:** The measure is seen as important to implement given a reasonable cost-benefit effect
- **MEDIUM:** The measure is seen as useful and should be assessed with respect to cost-benefit in the coming period
- **LOW:** The measure is seen as "nice to have", has little risk reduction and/or an unreasonable cost

Note that even though some of the measures have been given a low or medium priority, they still may hold a positive effect on safety. However, they are not considered to be among the measures that will give the highest risk reduction in the coming years. For the measures listed as high priority, coarse cost estimates and cost-benefit assessments have been made.

The measures from HSS-3 classified as "Closed" are assumed not to be reversed in any way. Hence, these closed measures act as prerequisites for the other proposed measures. Several of the closed measures are today reflected as requirements in the Norog 066 guideline. The most important prerequisites are:

- Maintaining the current requirements from the authorities, including the continuation of the special Norwegian requirements and the requirement for AOC approved by CAA-N
- Maintaining Norog 066 as the recognised norm (M39), including:
    - Requirement for using the latest proven helicopter technology for passenger transport (M04)
    - Traffic advisory (minimum TCAS I) in all helicopters (M01).
    - Continued development and increased utilisation of HUMS
    - Continued development and increased utilisation of FDM, adapted to helicopter operations
    - Increased level of automation for approaches (M11)

The final recommendations mainly reflect those measures – in addition to the prerequisites given above – that have the best effect on safety and are cost effective. Cost-effectiveness implies a relatively low cost for a relatively large percentage reduction of risk (the method is described in section 2.3).

The process of identifying measures and recommendations are illustrated in Figure 8.1.

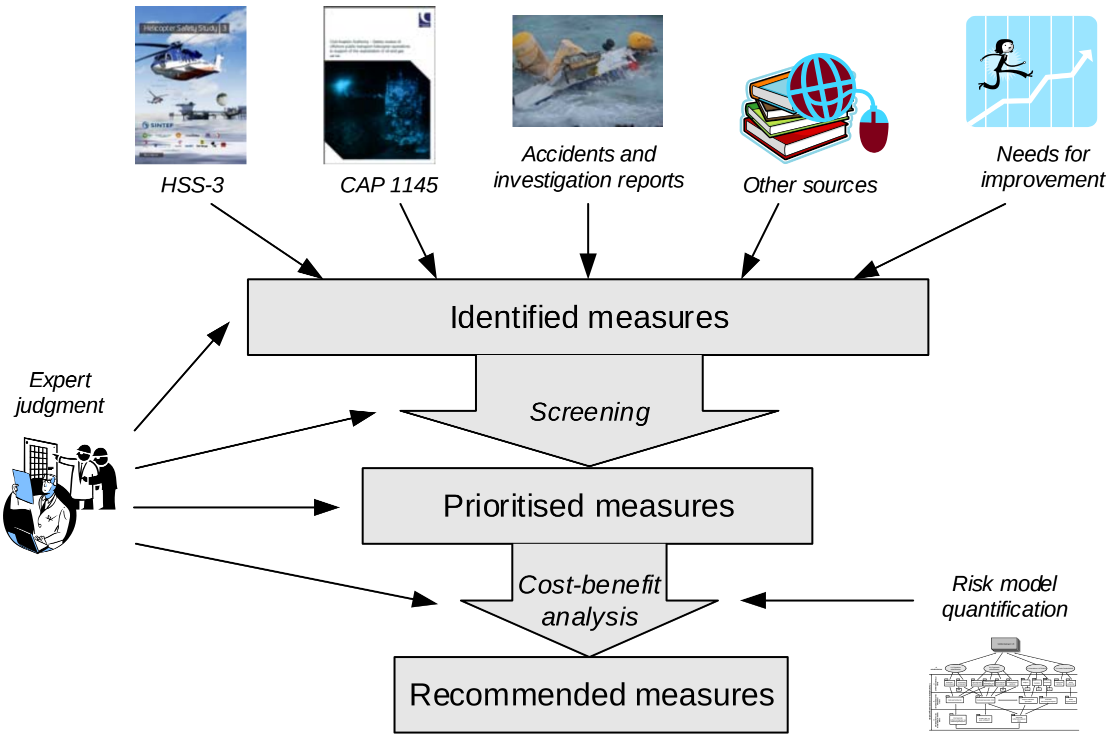


Figure 8.1: The process of identifying measures and recommendations.

For the three levels of measures (Figure 8.1) the following apply:

- *Identified measures* (total 88) is the sum of measures from HSS-3 (42 measures) and HSS-3b (46 additional measures).
- Prioritised measures (total 12) are the measures remaining after being sorted by possibility for implementation and expected risk reduction, and then the measures are evaluated by cost-benefit effects.
- *Recommended measures* (total 7) are those measures with the highest score from the cost-benefit assessment.

Note that in addition to the list of recommendations presented at the end of this chapter, the report (section 9.6) also contains a range of recommendations that are detached form the cost-benefit assessment.

8.1 Measures from HSS-3

In the following we present the measures from HSS-3 including status, priority, description and coarse assessments about cost and effect. The measures are numbered the same way as in HSS-3. Note that title and content for some of the measures have been updated or defined more precisely than in HSS-3; however, the *intention* of each measure is unchanged. In those cases where measures have been renamed, the original name is also provided alongside the new name. For a few measures the content has been changed to such a degree that the measure has been closed in its original form and reformulated as a new HSS-3b measure (section 8.2).

M01 – Requirement for TCAS I in all helicopters

Not relevant

TCAS I provides a warning for the danger of collision with another aircraft. TCAS II (se measure M02) has replaced TCAS I in new helicopters. As per today, all helicopters used for passenger transport are TCAS (I or II) equipped. TCAS II is a requirement in Norog 066.

M02 – Requirement for TCAS II in all helicopters and flight simulators

Previously: Requirement for TCAS II in all helicopters

Priority: MEDIUM

TCAS II gives advisory on actions in addition to the collision warning itself (resolution advisory, RA). An audio warning is given as either ”*descend, descend*” or «*climb, climb*”. The TCAS II requirement should be for both helicopters and flight simulators. A requirement for TCAS II in simulators should be formulated in Norog 066.

TCAS II is standard for the H225. Fully integrated TCAS II is now also available for the S-92, but due to cost considerations (seen in relation to expected risk reduction) it is not retrofitted to all operating helicopters.

<u>EFFECT:</u> Compared to TCAS I, TCAS II is expected to give a further reduction in the frequency of collision accidents. However, the improvement by going from TCAS I to TCAS II is seen as marginal since most of the collision risk reduction is attributed to TCAS I. In addition, the implementation of controlled airspace also make anti-collision systems less important.

M03 – Research project: Lightning protection

Closed

Both lightning strike and triggered lightning seem to be more risky for helicopters than for fixed-wing aircraft. The rotating parts on a helicopter can induce a rapid static build up and the rotor blades are smaller and less robust than the wings of a passenger airplane. Even though helicopters are constructed to withstand high electrical loads, the damages in such cases may be costly. Lightning strike/discharge incidents occur about 1–3 times per year on average on the NCS. In the British sector, during the period 1999–2009, three accidents have been registered caused by lightning. So far, lightning has only caused material damage to the helicopters. None of the incidents have caused loss of lives, but lightning is seen as a risk factor which should be controlled in a better way After every lightning strike/discharge, a thorough inspection must be performed to identify visible and possible hidden damage; this is often followed by costly repairs.

The CAA-UK and the UK Met Office finished in 2011 a project for the forecasting of lightning strike/discharge areas. The project was financed by Oil & Gas UK, CAA-UK, CAA-N, CHC and seven petroleum companies. The system was on trial for two winter seasons in 2011–2013, and is now established in the British sector. The same system has also been used in the Norwegian sector for the last couple of years, but is has been deemed necessary to develop a system adapted to the Norwegian climate using Norwegian met data. This has been done in cooperation with the Norwegian meteorological institute (MET). The upgraded system is today comprised of the lightning registration system "Lyn-i-dag (SINTEF) and "Triggered lightning" (MET). The system covers all of the NCS including (soon) the Barents Sea, and is operational from the autumn of 2016. A significantly increased precision in the forecasting for the NCS is expected, and this will contribute to improve both safety and regularity. The system will be subjected to continuous improvement; an element of this is the transfer of relevant forecast data to the helicopter during flight (ref. measure B03, section 8.2). Given the current status, no further measures are proposed in this area.

M04 – Requirement of latest generation of proven helicopter technology for all helicopters performing personnel transport

Closed

All helicopters performing commercial personnel transport offshore should, as a minimum, be maintained and updated in accordance with given updates of FAR 29 / EASA CS 29, so as to satisfy the latest generation of helicopter technology without non-conformities. Satisfying such a demand requires customer participation. In practical terms, this means only utilising the latest generation of proven helicopter technology. The latest proven technology incorporates more redundancy, improved impact absorption and improved fire resistance, etc.

Norog 066 specifies that helicopters operating on the NCS should be the latest proven technology. There is only one aircraft in operation today (used for shuttling) that does not meet this requirement. Efforts are in process for replacing this machine.

M05 – Continuous transfer of status data from helicopter

Previously: Continuous transfer of status data from helicopter and infrastructure

Priority: MEDIUM

The measure deals with the continuous transfer of status data (e.g. HUMS data and status of critical elements) via satellite from helicopter to land.

EFFECT: This system is expected to reduce the probability of several accident types by detecting dangers at an early stage and avoiding development into an accident. Such a regime must include an update of the emergency checklists to include HUMS systems warnings. It also requires dedicated personnel on land for the monitoring and evaluation of incoming data, possibly including necessary feedback to the helicopter crew. An evaluation must be done concerning what type of information that needs to be fed back, and what can wait until landing offshore or at the heliport.

The measure must be seen in relation to B03 concerning continuous data transfer to helicopters.

M06 – Stricter regime for independent inspections offshore and on land bases

Priority: LOW

Independent inspection, in connection with maintenance of critical components, must be performed by two independent and qualified technicians, both offshore and on land bases. Today, interpretations of the

Norwegian regulations allow technicians to do the “independent” inspection after completing the work themselves. In reality, this is only done offshore where normally only one technician is available. Current requirements under EASA are more restrictive and non-conformities from M.A.402 relating to independent inspection should be avoided, despite the fact that EASA 145.A.65(b)3 provides opportunities for non-conformities. Exemptions should only be given in exceptional cases.

This requirement of independence is also specified in Norog 066, with exemptions made for permanent offshore SAR bases, where pilots with relevant training may do a limited inspection of the main rotor. The regime as such seems sufficiently strict, but there are improvement points in interpretation and compliance. Offshore maintenance of critical components is still performed without two certified technicians; this is largely accepted, where the trained pilot is the second person assisting. Solutions for remote inspection via video (e.g. web cam) could be a way to partly ensure independent inspection in those cases where only one certified technician is available.

EFFECT: The measure will reduce the risk contribution from RIF 1.2 *Continuous airworthiness* in those cases where technicians have performed work offshore or on land. However, compared to the total amount of maintenance performed, the measure is considered to have little effect.

M07 – Improved training for technical personnel

Priority: HIGH

Technicians still express that both the basic training and the recurrent training are not comprehensive enough and do not put enough focus on specific equipment. The helicopters in use have more accessories and is more complex than previous models, especially regarding avionics. To maintain competence, there is a need for an increased focus on the content of training. The following improvements are suggested for basic training and continuation training, respectively:

- *Basic training / Type courses:* There is a need for both increasing and “focusing” the training (more relevant content) to be able to train on the relevant helicopters/specific equipment that the technicians are actually servicing, not just the “base case” helicopter or equipment. There is also a need for training which provides an overall systems understanding; both for the operation and troubleshooting of the equipment. The type-courses (specific for a particular helicopter type) must provide the students with an understanding of the system’s purpose, operation and error indications. Furthermore, the courses should provide training in navigating, reading and understanding manuals, forms, tables and procedures. The type-course instructor must have daily contact with the operative work day.
- *Continuation training / Periodic training:* There is a need for systemising retraining where the training is quality-assured before and during training, where goal is developing the technical staff. The training should contain both theory and practice (e.g. classroom teaching, CBT – *Computer Based Training*, simulator).
- *Requirements for instructors:* The measure also sets requirements for instructors concerning their knowledge and in-depth competence, practical application and the ability to provide the students with system understanding. Such requirements should also be included in Norog 066.

Courses given with a systems trainer (graphical simulator) have been very well received. The latest simulators offer a quality and learning that enables in-depth training on troubleshooting – given competent instructors. This type of training should be increased. The current requirement for systems training (in a systems trainer) is two hours (Norog 066). We suggest to increase this substantially and evaluate the experiences after some time. Relevant requirements should be specified in Norog 066. Finally, this should also be put forward as a global initiative through organisations like HeliOffshore and IOGP.

EFFECT: The measure will further reduce the probability of maintenance errors, and thereby the probability for maintenance related accidents (continuous airworthiness issues).

COST: Investment costs are low, and related to the evaluation of current requirements. Running costs will increase due to necessary training etc. Increased systems knowledge and sequential systematic troubleshooting may give a more efficient maintenance, and thereby reduced operational costs.

M08 – Improved availability of spare parts

Closed

During periods of growth, or when new helicopter types are introduced, it may be challenging to maintain the stock of spare parts at a reasonable level. Timely access to spare parts is important to avoid so-called “cannibalising" of parts, i.e. that working parts are taken form unserviceable helicopters and put on serviceable helicopters. This may increase the workload and induce stress, which may contribute to increased risk. The connection between lack of spare parts and risk is not clear, however.

The spare parts availability has improved over the last few years. There is an active approach towards the helicopter manufacturers to have more spare parts made available. However, the new situation of operating only one helicopter type may prove challenging in this respect, due to the sudden increase in utilisation of this type. A spare parts location for the S-92 was established in Stavanger in 2016, the first of its kind in Norway. This is expected to improve spare parts availability for this helicopter. The spare parts situation should be monitored, but no specific measures are suggested regarding spare parts.

M09 – Paperless cockpit

Closed

Increased automation and electronic solutions have gradually removed flight manuals and reduced the paper work in the cockpit. The cockpit has for all practical purposes become paperless. Reduced workload in the cockpit is an improvement, as this reduces stress and allows more time to focus on safety-related tasks. Systems reliability and pilots' systems knowledge are new challenges. The removal of loose items in the cockpit gives a positive effect on perceived risk.

Electronic solutions for the cockpit are under constant development. Improvements can still be made concerning the presentation of information during flight (e.g. weather, lightning forecast, helideck information, etc.). See measure B03 concerning continuous data transfer to helicopters.

M10 – Moving map in all helicopters

Priority: LOW

The moving map technology is available and in use in many different modes of transport. It is also possible to introduce this in offshore helicopters. Moving maps will increase situational awareness and will be particularly useful for SAR helicopters and flights over land.

EFFECT: The introduction of moving map will not have a very large safety gain in itself. Other proposed measures like AIS in helicopters (M24) and automatic approaches (M11) cover much of the purpose of moving maps, and will have a considerably larger effect than the introduction of moving map.

COST: Investment costs are estimated to NOK 5–7 mill. per helicopter (40–50 helicopters in passenger transport in Norway), and this will include GPS, map database, communication, training etc.

M11 – Automatic approach procedures / standardised approach

Closed

Of the 16 accidents registered in the North Sea during the period 1999–2015, four occurred during approach to helideck/airport in reduced visibility. Incidents have also occurred in the Norwegian sector where the helicopter came too close to the sea during approach, but the situations were corrected due to the 100 foot warning (GWPS).

More automated approaches to helidecks and airports has been a long-term target. An increase in automation will reduce the pilot workload and increase the monitoring capacity. This will reduce the potential for human errors during this critical phase of flight. Automated approaches will also reduce noise levels on the ground because automated approaches allow a more elevated approach profile. A 100 % automated approach is not possible because it will increase the risk of hitting obstacles (derricks, cranes, antennas, etc.) close to the helideck. The wind direction must also be taken into account during final approach and landing.

The helicopter manufacturers have developed systems for the automation of precision approaches, i.e. ARA-approaches to offshore installations and RNAV approaches on land. Norog 066 specifies this requirement, and it is expected that the necessary equipment and procedures will be implemented in helicopters. The measure is thereby closed.

M12 – Proactive updating of manuals

Priority: LOW

Proactive updating of manuals entails that a risk analysis is performed *before* significant changes to procedures. This in contrast to the current reactive practice where changes are made after faults have been identified.

Both Sikorsky and Airbus Helicopters have ongoing projects to publish Flight Crew Operating Manuals (FCOM), like manufacturers also do for fixed-wing. This means that the manufacturers will be responsible for both normal and emergency procedures, as opposed to the current practice where individual operators make these procedures by themselves based on the current Flight Manual (FM). This will simplify the manuals and promote standardisation between the different operators; for example, it will make it easier to set common FDM limitations and compare incident data. HeliOffshore is a promotor for this work.

EFFECT: Expected risk reduction is limited, and this work is already in process.

M13 – Reduce the number of flights to ships during night conditions and reduced visibility

Closed

Flying at night and during reduced visibility (dense rain, snow or fog) is demanding and associated with far greater risk than flying in daylight and in good visibility. This is especially valid for approaches to helideck and in particular approaches to ships. Limitations for landings on ships during night is implemented in Norog 066 and the measure may be closed. It is specified that exceptions from Norog 066 can be made based on risk assessments. There is an expected increase in night operations with the coming Barents operations. It must be taken into consideration that increased use of automated approaches (measure M11) will improve safety for approaches to helideck at night.

Similar limitations as for night flying may be introduced for approaches to ships in reduced visibility (dense rain, snow or fog). It should be noted that the Norog requirement for 90 day currency on night operations does not apply to ship landings. HOFO (170b) will also specify requirements for regular night landings. It could also be mentioned that all types of rescue operations are easier in daylight.

M14 – Improved training and exercises for pilots and requirements for simulators

Closed

The latest simulators are of high quality and are now available in Norway. They are also adapted to a Norwegian environment (cockpit layout and NCS installations) and reflect relevant situations (e.g. landing on moving helidecks). The Norog requirement for simulator training has been increased to 16 hours per year.

A more digitalised cockpit requires more training to obtain adequate systems knowledge. Analogue cockpits gave direct information on different parameters. The digital cockpit presents the same information, but how this information is processed is important to understand for example in relation to system failures and other related emergencies. It is still necessary to increase the quality of training related to the new technology in the helicopters. An increase in automation may reduce manual flying skills and this must be addressed. An increased standardisation of operational patterns also narrows the general knowledge on non-standard operations. For example, most of the pilots have not been training on landing anywhere else than on a helideck and on a runway. It is important that the training shall further develop the skills of the individual pilots and crews. CAP 1145 also focuses on harmonisation of training and procedures and improvements as to how the pilots function as a crew (ref. Appendix C).

The measure is closed based on the strengthening of the requirement for simulator training in Norog 066, and the requirement for automated approaches (M11). Nonetheless, there are many aspects of training (volume, quality, specificity) that still needs a continued focus.

M15 – Standardising procedures at the heliport/airport

Not relevant

The measure comprises a standardisation of the procedures for ground operations at the airports, like we have for fixed-wing. The current procedures as seen as adequate and the measure is therefore not considered relevant.

M16 – Increased priority for helicopter operations at airports

Previously: Risk analyses for labelling at the heliport/airport

Priority: MEDIUM

Airports for offshore helicopter activity have both fixed-wing and helicopter operations. There seems to be an impression that the helicopter activity at airports is secondary to fixed-wing – both in traffic volume and priority. The helicopter activity should be given more attention in the form of increased surveillance (ATS), systematic mapping of obstacles and improved ground markings. As an example, Bergen airport seems to have better markings than Stavanger. There have been incidents where markings have been a factor.

The measure implies that the helicopter operators secure the involvement of Avinor in order to give the helicopter activities increased attention. Risk assessments should be made in relation to the helicopter activities at the different airports; both operational and technical personnel should be involved in these assessments.

EFFECT: Increased focus on the helicopter operations at the airports, including improvements related to obstacles and markings, is expected to have a positive effect on safety.

M17 – Clearer requirements for lights on the helideck

Closed

The requirements in BSL D 5-1 is being updated and clarified in relation to CAP 437, regarding requirements for lighting and its quality.

M18 – Different lighting for prepared and unprepared helidecks

Priority: LOW

There have been cases of helicopters landing on a different helideck than intended. This can happen when installations are located close to each other and pilots fail to identify the correct one as a part of the before-landing checklist. The introduction of status lights on the helidecks may prevent such incidents. Examples of possible solutions are:

- Status light in yellow indicating that it is not dangerous to land and red if it is dangerous to land.
- Traffic light in yellow indicating that the helideck is neither closed nor cleared for landing, red if the deck is closed/dangerous and green when the deck is cleared for landing. The traffic light may be included in the deck H, the perimeter lights or in the friction net.

In the British sector the use of status lights is a requirement (CAP 437), but there are no solutions that functions satisfactorily. There is currently no such requirement for operations in Norway, but this may be implemented in the coming BSL 5-1 update. The subject is also discussed in IOGP and HeliOffshore. It seems clear that an international approach and standardisation is preferable over separate national solutions that may differ, as both pilots and rigs tend to move across borders. Hence, the measure is given low priority.

EFFECT: As mentioned, several landings on uncleared helidecks have occurred. Even though none of the incidents have been characterised as serious, landing on an uncleared deck is holding a large potential risk. The helideck approach is a critical phase of the flight, and an unprepared installation may for example have ongoing crane operations, people in endangered locations, etc. Other measures like improved light systems (M17) and use of AIS (M24) may contribute to reduce the probability of landing on uncleared helidecks. Overall, the safety effect of this measure is seen as marginal, and can even be counter-intentional if the status lights are not operated as intended (due to technical or human error) or if the lights may be confused with other lights on the installation.

COST: There are available technologies for helideck lighting, and the cost will depend of type of solution. In addition to the implementation itself, there will be some costs related to agreeing on the standard to be implemented.

M19 – Handheld communication for pilots moving about the helideck

Priority: HIGH

The measure involves the pilots utilising handheld communication when located on the helideck outside the helicopter, with connection to the cockpit and the helideck crew. A similar arrangement is implemented for inland operations for the cargo supervisor on ground during sling-load operations.

The measure requires pilots to carry a separate radio that must be charged at all times. In general, the community is sceptic to adding more equipment (weight, loose cockpit items etc.), especially equipment that will almost never be used. However, this should be solvable. The measure is given high priority due to its simplicity and low cost, and considering previous incidents. The measure may also be considered for inclusion in Norog 066.

<u>EFFECT:</u> There have been several incidents where the pilot on deck could have used radio communication to either warn or be warned about dangers. It is uncertain to what degree these incidents could have been avoided given that such radio communication had been available.

<u>COST:</u> Relatively low investment and running costs related to purchase, certification and maintenance.

M20 – Training in English helideck phraseology

Priority: LOW

The measure is about the communication between pilots and helideck personnel taking place in English (the technical language). This requires training in English helideck terminology. Communication in English should be the norm, but the current practice is that the communication is in Norwegian, as there is usually always at least one Scandinavian speaking pilot in the crew. This may change in the future, and it is advantageous that to have a common standard for language. There is a need for training and practise if communication shall be done in English.

<u>EFFECT:</u> Absence of English in the communication is not seen as a big problem. Going forward it is expected that English will be more common as younger generations are employed as HLOs. This issue may at all times be approached by selecting persons with good English knowledge as HLO's.

M21 – Requirements for weather observation equipment

Priority: MEDIUM

The quality of the current AWOS is considered to be good and the development of the system continues. However, the system has its limitations. This measure is suggesting to evaluate better systems for more accurate and reliable registration of weather conditions. This is particularly relevant for isolated installations. The measure includes building the necessary competence in using new equipment. BSL G 7-1 contains requirements for the weather services offshore.

<u>EFFECT:</u> There will still be limitations regarding the prediction of fog. Moreover, some manual observations (in addition to automatic systems) must still be accepted, particularly on central installations. One should consider whether a direct video feed form the installations should be made available for pilots.

M22 – Radio communication course

Not relevant

The measure in HSS-3 involved requiring a radio communication course (beyond radio certification) for all HLOs, heli guards and radio guards on facilities outside HFIS zones where Avinor could not communicate all the way down to the helideck. Today Avinor can communicate all the way down to the helideck, except in the Barents Sea. This has not been a priority by Avinor, and the need for courses has not been completely covered. The measure has low impact on safety and is not asked for by relevant players in the business.

M23 – Improved routines for reporting safety-related faults

Priority: LOW

The reporting culture among helideck personnel has traditionally been inadequate pursuant to the regulatory requirements in BSL D 5-1 (regulations relating to flying on the NCS) and BSL G 7-1 (regulations relating to aviation weather services). This applies to both technical equipment and other safety-related conditions. The reporting has improved significantly over the last years due to increased attention on the importance of reporting. RNNP has identified this as a challenge particularly for drilling rigs, while the reporting for fixed installations is seen as satisfactory.

The trade unions are reporting a growing tendency for under-reporting in the business in general. This is being related to fear for own jobs when faced with changing management culture, downsizing, use of temporary labour etc. This should have a focus going forward.

The utilisation of the data generated form the reporting is a bigger concern than the reporting itself. A lot of data are gathered by the CAA-N, but there very little information being returned in the form of published analyses and status reports. Over time this can be demotivating for the personnel reporting, and the additional reporting directly to the CAA-N may be seen as futile. One should seek to obtain a reasonable level of reporting, and to utilise the reports in a transparent manner.

<u>EFFECT: </u>Reporting on technical faults with equipment offshore has improved and is seen as a relatively small problem today. The additional effect of further reporting improvements is assumed to be low.

M24 – AIS in helicopters, integrated in navigational displays

Previously: Automatic Identification System (AIS) / Improved map database for mobile facilities

Priority: HIGH

All larger ships and offshore installations on the NCS shall be equipped with AIS transmitters. Having an AIS receiver on board the helicopters will thus allow the identification of ship traffic, potential obstacles and the correct destination. AIS will largely prevent collisions between a helicopter on approach and any vessel in its path. It will also reduce the likelihood of mixing up installations and landing on the wrong helideck. Given the need for landing as soon as possible, the AIS may also identify suitable vessel in the vicinity for landing.

If there is a possibility for data transfer to the helicopter in flight from an onshore facility (measure B03), the AIS information may be channelled directly, rendering an AIS installation in the helicopter obsolete.

EFFECT: Integrating AIS information in the navigational displays reduces the likelihood of landing on the wrong installation, and thereby reduces the risk associated with wrong landings. This will also reduce the danger of collision with vessels and other obstacles during approach.

COST: Even though AIS is an available system, it will be very costly to integrate AIS into the helicopter navigational displays. The operating costs will be low.

M25 – ADS-B, ATC services and radio coverage in the Barents Sea
Previously: Introduction of ADS-B / controlled airspace, air traffic service during the complete en route phase and communication coverage
Priority: HIGH

ADS-B / controlled air space
ADS-B coverage of the entire NCS will give an extended surveillance and alarm service in non-controlled areas. This is particularly important for the areas in the north with long distances between shore and the installations. Currently ADS-B is established at Ekofisk (2015) and Balder (2016). ADS-B is further planned for Statfjord (2016), Heidrun (2017) and the Barents Sea (2017+). ADS-B requires equipment to be installed on an offshore facility. In the medium term the Johan Castberg facility may be an alternative for ADS-B. Having ADS-B installed on moveable rigs is not feasible.

Air Traffic Services
Controlled flights are primarily relevant for the south and mid parts of the NCS due to traffic density. *Iridium tracking* is a designation for flight following systems that are used by both helicopter operators and some customers (oil companies) to monitor the flight operations. Iridium tracking gives good coverage regardless of position. The most commonly used systems is *Skytrac*. This system is not accepted nor can it be utilised by Avinor due to responsibility issues and the fact that it is a web-based system. Tracking systems in general must be integrated with the standard Avinor systems in order to be utilised properly. Such an integration will require a certification process. If Avinor should need information from a flight following system, this would have to be requested from the Skytrac (or similar) users. The measure is about integration of Iridium technology in Avinor's systems. The preferred solution seems to be to link ADS-B with satellite data. Iridium tracking is a Norog requirement.

Radio communication
The measure is about two-way communication by VHF between helicopters and ATC wherever there is helicopter transport on the NCS. With the establishment of Ekofisk and Balder CTA there is now a satisfactory two-way radio communication in the North Sea and the Norwegian Sea. This challenge was identified in the public paper NOU 2002:17 (ref. section 5.4.5 in the NOU), and functioning radio communication was established in 2013–15 in line with the given recommendations. However, radio communication between helicopters and ATC in the Barents Sea is not satisfactory. One planned improvement is to install a VHF repeater on the Goliat installation in 2017–2018, bettering communication between Hammerfest and Goliat. Further improvements to the VHF coverage in this area will depend on the helicopter base establishment eastwards along the Finnmark coastline.

EFFECT: Introducing ADS-B/controlled airspace was set to contribute to a 50–100 % reduction of the risk for mid-air collisions (MAC) in HSS-3. Improved air traffic services and radio communication will also reduce MAC risk, in addition to improving efficiency in the ATC services and the air traffic in general. Overall for the NCS, the reduction of MAC risk from the en route phase was estimated in HSS-3 to be between 90–100 %. Considering the Barents Sea only, the reduction will be less than that, but given the implementation already in place for the rest of the NCS, the effect of the measure will still be high (since a hypothetical MAC will have the largest probability for happening in the Barents Sea). Note that this measure will also be very relevant for the reduction of the consequences of accidents. This is particularly important in the Barents Sea due to longer distances and response times.

COST: The investment costs will be biggest for the ADS-B introduction. Since ADS-B is already planned for the Barents Sea, this cost is not included in the analysis. Concerning air traffic services and communication coverage, there are additional costs related to integration in the helicopters and in the Avinor systems. The cost will depend on the solution chosen (from simple laptop with Iridium tracking at Avinor, to full systems integration).

M26 – Continuation/replacement of M-ADS

Not relevant

M-ADS was a unique system which, among other things, ensured that the helicopter could be located immediately following an accident. One important advantage of M-ADS compared to, for example, ADS-B or radar, was that coverage extended down to the surface of the sea. The M-ADS requirement has been removed from Norog 066 and the regulations, while the ADS-B establishment on the NCS continues. Iridium tracking (Norog requirement) is an alternative to M-ADS, giving complete position coverage regardless of altitude (ref. M25).

M27 – Air traffic service on the land bases

Priority: MEDIUM

The airports that do not offer air traffic services (only flight information services) are the same as in HSS-3, i.e. Florø, Brønnøysund and Hammerfest. The helicopter share of the total traffic volume at the bigger airports Stavanger and Bergen is relatively low (ca. 15 %); at the land bases without air traffic services the helicopter share of the traffic volume is somewhat higher.

EFFECT: The lack of air traffic services at the three landbases mentioned is not a big issue, as these airports are small with a modest total traffic volume. The potential for traffic conflicts is therefore quite small, and there is also TCAS in the helicopters that will provide warnings in real conflict situations. Moreover, the flight information service may also give relevant information about other traffic. The measure is more realistic in the long term and when Avinor has sufficient manning.

M28 – Transfer HFIS tasks to Avinor

Not relevant

The measure involved transferring the HFIS unit at Tampen and Ekofisk to the Stavanger ATC Centre, to avoid interfacing between the HFIS and the surrounding airspace. The measure was given low priority since a practical solution was hard to find. Besides, Tampen was satisfied with keeping status quo. The situation has not changed since HSS-3. If HFIS is relocated the sector (ATC) must be split, which would require more ATC controllers. The safety effects of relocating the HFIS could be discussed. There is still a need to keep trained personnel at the offshore sites doing manual weather observation, as well as some necessary flight information service and light logistics work. Currently a possible decommission of offshore units for manual weather observations is planned, including the transfer of SAR coordination to land. A transfer of SAR coordination will reduce todays service by increasing the response time. A risk assessment will be required before relocating these services to onshore locations.

M29 – Quality assurance and standardising of emergency preparedness procedures between companies

Not relevant

We assume that any related challenges are handled by the oil companies themselves and the Petroleum Safety Authority.

M30 – Evacuation procedures for passengers

Priority: LOW

The teaching at the safety courses must correspond with the procedures followed by the pilots. The teaching should also represent realistic situations. For example, there is no training on the evacuation of a helicopter landing on sea, while still floating and without capsizing.

In relation to training on helicopter capsizing, no exemptions should be allowed. Every passenger must be able to exit a capsized helicopter. If a person sitting by a window cannot get out, due to body size or other physical limitations, this complicates the situation for the person sitting next to him/her. Requirements for the passengers' ability to evacuate in an emergency situation should be considered.

<u>EFFECT:</u> Aspects related to this measure are cowered by the measures on compressed air breathing systems (B16, cf. section 7.4) and marking of large passengers (B17, cf. section 7.5). Beyond this, the measure is considered to have a marginal effect.

M31 – Requirement for full hangar offshore for SAR helicopters

Priority: LOW

"Full hangar" implies a permanently stationed, temperature-controlled hangar offshore which would make folding and spreading rotor blades unnecessary. A full hangar contributes to reducing risk related to folding and spreading. Ageing mechanisms are also reduced, especially corrosion. In addition to a full hangar, a hangar with a repair shop for simple offshore repairs could be considered. The offshore SAR helicopter locations without full hangar today are Oseberg A and Heidrun. Full hangars are available at Ekofisk and Statfjord, and is planned for Johan Sverdrup.

<u>EFFECT:</u> The measure will improve SAR operations and thereby reduce the consequences of incidents. Low priority is given due to high cost and that the SAR services are functioning satisfactorily as is. Even though having a full hangar is not seen as cost-effective (if an investment to current arrangements is needed), the practise of having SAR helicopters at offshore bases is seen as very useful and also essential to meeting emergency response requirements. The offshore SAR helicopters have a very high rate of utilisation.

M32 – Night vision goggles for SAR-pilots

Priority: MEDIUM

Night vision goggles (NVG) enable pilots to observe the surroundings visually in darkness. This is not a priority for normal passenger transport (they operate IFR regardless of conditions), but SAR crews may benefit greatly from using NVG. Operations in the Barents Sea are often done in bad lighting conditions, and BaSEC recommends NVG for SAR helicopters. As an initial implementation, one could start in the Barents

Sea and then evaluate the possible use of NVG in operations further south. Eventually one should consider introducing NVG for ordinary passenger transport.

EFFECT: This is expected to have a limited effect. The investment costs are relatively high, approximately NOK 6 mill. for one SAR helicopter, training included. The running costs are low. There are potential negative safety aspects using NVG which will require added training – on CRM in particular.

M33 – Improved fire preparedness / automatic fire fighting system on unmanned facilities

Priority: LOW

Operating on unmanned helidecks will be covered by the revised BSL D 5-1. An alternate approach to reduce risk for such operations is to have a FiFi vessel alongside the installation in question, but this is a high cost solution. Guidelines and recommendations for this type operations are found in CAP 437 and 1145.

EFFECT: Unmanned facilities make up a small part of the total number of facilities on the NCS, and a small number of total take-offs/landings.

M34 – New rescue helicopters

Not relevant

The current challenges with an ageing fleet of rescue helicopters and reduced access to spare parts, contribute to increased risk for potential SAR operations. New helicopters will be introduced from 2018, so no further assessment is made here.

M35 – More thorough criticality analyses (FMECA)

Not relevant

FMECA or equivalent analyses during the engineering phase should be improved, and also have the potential for improvement. An example of a possible improvement is to introduce precise requirements for the analysis and its content. By performing an FMECA on a helicopter before it is put in service, faults and potential dangers can be identified which earlier would only have been discovered during operation or in connection with an incident/accident. More thorough FMECAs should also be performed for larger modifications. This measure should be considered especially when new helicopter types are introduced, and is therefore less relevant today. A scenario where the H225 is replaced by a new type may make this measure relevant again. Designing new helicopters types include a so-called MSG-3 analysis.

This measure is linked to M41 concerning active involvement in the design phase form personnel with North Sea operations experience.

M36 – Evaluating the "Committee for Helicopter Safety on the Norwegian Continental Shelf"

Previously: Revitalising technical helicopter cooperation

Priority: LOW

The "Committee for Helicopter Safety on the Norwegian Continental Shelf" was established pursuant to a recommendation in public report NOU 2002: 17. The purpose was for the committee to have representatives from all relevant stakeholders in Norway and to function as the driving force for implementing those risk reducing measures chosen to be carried out following the NOU report, and promote safety in helicopter transport on the NCS in general. The committee has been in operation since 2003, and has contributed to exploring and/or implementing several of the recommendations in public reports NOU 2001: 21 and NOU 2002: 17. The committee has also been driving the processing of the recommendations given in HSS-3.

In HSS-3 one suggestion was to transform the committee into a knowledge centre for helicopter operations, but this is no longer recommended. The committee is functioning as intended, but a revitalising has been suggested by many individuals within the community. The committee should be given a greater authority for making decisions, and more time should be spent on work outside the ordinary meetings. Initially the functioning of the committee could be evaluated internally. As part of the evaluation, the committee's past accomplishments and future development should be included – as seen by the committee members.

EFFECT: Such an evaluation is both realistic and cost effective compared to a complete revitalisation and establishment of a knowledge centre. The measure is considered to have a limited effect.

M37 – Strengthening of capacity and competence in the Norwegian CAA
Previously: Improved supervisory activity

Priority: HIGH

There is a still need for a more active supervision of the helicopter operators. The CAA-N should promote positive change processes with the helicopter operators. According to previous studies, the CAA-N should consider putting greater emphasis on system-oriented holistic and risk-based supervision, and develop/recruit personnel with relevant expertise – particularly focusing change processes with the helicopter operators. One relevant activity could be to review procedures for reporting and classifying organisational non-conformities, i.e. highlight the non-conformities in relation to their actual risk contribution.

The CAA-N should be strengthened with resources, competence and capacity to be able to provide a high quality service. Currently there are few or no specific competency requirements for the helicopter supervisory personnel There is a particular need within the technical area. CAA-N personnel very rarely inspect helicopters themselves; this is done by approved airworthiness review personnel on behalf of the CAA-N.

EFFECT: This measure is still highly relevant. By intensifying the supervisory efforts, chances increase to uncover deviations. At the same time, it will be educational for the helicopter operators. The risk reducing effect is estimated to be the same as in HSS-3.

COST: Some operational cost given an increase in activity, new positions and heightened competence.

Note that the transfer of helideck supervision to the CAA-N is a separate measure (B05).

M38 – Increased focus on communication to learn from incidents

Priority: HIGH

How is learning from incidents in focus today? How does one learn from FDM data and communicate this learning? Currently the CAA-N does simple categorisation and statistics but no quantitative assessments of accidents and incidents reported by the helicopter operators (through the Altinn system). The operators do a lot of reporting, but express a lack of return from the CAA-N in the form of relevant analyses that could encourage learning. The missing feedback is in part due to lack of capacity in the CAA-N and considerations on confidentiality. It is probably too ambitious to try to develop Altinn into a system that sorts, analyses and presents information in a quality-ensured manner, giving sensible feedback to the operators. Hence, the measure is not about improving the reporting system as such, but rather about what can be done to improve cooperation by proper exploitation of existing information. As an example, some internal analyses by the CAA-N (such as safety statistics and indicators) could be sent as information to the operators. The Altinn data are also supposed to be utilised in a risk-based supervision, where the CAA-N should draw attention to particular risk-prone areas (based on the analyses) and do specific inspections etc. for those areas.

In order to improve the learning from accidents/incidents and improve related communication between the CAA-N and the operators (also internally for operators, nationally and internationally) the following recommendations and focus areas are suggested:

- Introduce requirements in the guidelines on quality and deadlines for the processing of incidents and deviation reports. Processed reports should be forwarded to customers (oil companies) and the authorities (a lot of this is covered by EASA 376/2014).
- Closer and more systematic follow-up of safety recommendations from the AIBN. The Committee for Helicopter Safety on the NCS may be a natural arena for this.
- Implemented measures related to helicopter design following accidents and incidents, should be evaluated with respect to quality. The dialogue between the helicopter operator and the manufacturer is important.
- Focus on how “just culture” is practised with the helicopter operators (including CAMO). There is currently a requirement for this, but examples exist where persons involved in incidents have not received a fair treatment. There is a perception (in Norway) that the mother company management tend to have a different view on what is just culture than the Norwegian part of the companies.
- Focus on the exchange of information between the helicopter operators concerning technical malfunctions, lightning activity, weather etc. This is largely done today, but there is a potential for improving the cooperation, and possibly formalise it in some way.

Prerequisites for this to function properly are good internal communication with the operators and well defined organisational structure, responsibilities and reporting lines.

It could be mentioned that CAP 1145 advocates an increase in information exchange between manufacturers, operators and the authorities.

<u>EFFECT:</u> The CAA-N is positive to collaborating on what should be fed back to the operators. A better utilisation of all the reports flowing into the CAA-N will give a positive contribution to safety and enable all operators to learn across company boundaries. This type of communication and harmonisation will proactively reduce the probability of accidents, for example through the exchange of hazard registers and generic risk assessments. Improved communication and knowledge with the individual operator will also contribute to a more uniform company culture. Increasing the processing quality – e.g. by notifying the reporter that the report has been processed – will also encourage reporting. The effect is estimated similar to HSS-3.

<u>COST:</u> Some investment costs related to establishing requirements, as well as developments in Altinn. Low running costs once the measure is established. Operators may need to increase their capacity to obtain a meaningful improvement.

M39 – Norog's guidelines as the recognised norm
Previously: OLF's guidelines as recognised standard

Priority: HIGH

The Norog guidelines (particularly Norog 066) are not general requirements for flying on the NCS. However, adherence to Norog 066 is specified in contracts, making the guideline a de-facto requirement for the helicopter operators. The Norog guidelines have an important function as a supplement to formal regulations, through the specification of more detailed safety requirements beyond the high-level functional requirements found in formal legislation. The guideline is seen as the sum of all experience from decades of operation on the NCS, where important and necessary technical, operational and organisational requirements are collected.

Today, Norog 066 is specified in all helicopter contracts, but the guideline is not binding as such, and some oil companies may in principle chose to disregard the guidelines completely. To avoid a situation where the individual oil companies define their own set of rules, and to safeguard the guideline from economical variations in the business, and finally to reduce the possible impact of the upcoming European rules (HOFO), Norog 066 should strengthen its position through formal legislation. The current guideline must in case be reformulated and reshaped, where the key point is to transfer the important *principles* in the guideline that all may view as sensible and safety promoting.

There are a couple of issues to consider against a formalisation of the guideline. First, a single interest group (Norog) should not alone define the content of public legislation. The process of establishing such legislation must therefore involve different players. Second, in formalising the guideline the current flexibility for quick updates will be lost, as experience shows that changing legislation is a cumbersome process.

The measure implies that the authorities in some way secure that all oil companies on the NCS still require that the helicopter operators must adhere to *Norog 066: Recommended guidelines for flights to petroleum installations*. In this picture lies a request for the PSA to work for a legislative fixation of the guideline.

EFFECT: The measure will be increasingly relevant as more helicopter operators start operating on the NCS, and especially if the NCS-specific requirements (legislative) should be removed due to new European rules. Per today, this measure has no safety effect since Norog 066 already is the recognized norm among the players on he NCS. The continuation of this situation is one of the main prerequisites in this study.

COST: Some of the requirements in Norog 066 are costly and may therefore come under pressure in times of economic downturn. Note that the costs associated with this measure are related to upgrading beyond the expected use of latest helicopter technology (as specified in Norog 066).

M40 – Unified practise concerning contracts and the use of penalties
Previously: Review of the penalties scheme

Priority: HIGH

The helicopter operators claim that some customer contracts contain penalty clauses of considerable size (fine in the event of non-fulfilment of contractual requirements, especially regarding punctuality). Such an arrangement may be negative for safety in the sense that operational personnel (technicians, pilots, ground handling, etc.) may be pushed into taking shortcuts due to time constraints in relation to the set departure time for a flight. Today we observe a strong safety culture with the operators and therefore hold such effects as unrealistic. This might change with increasing pressures on the economy in the companies, the establishment of new operators, outsourcing of services, etc.

Obviously, an operator must accept to be measured on performance. A better model than penalising individual flights might be to evaluate monthly performance statistics and indicators, and possibly penalise based on this. The penalty framework may also be varied between contracts and between locations.

The bidding process for the different contacts are becoming increasingly shorter in time. The helicopter operators feel that the oil companies should use more time on these processes for making necessary analyses and considerations. Currently there is an intense focus on cost cutting and effectiveness. This may lead to stress and deviations, and it is claimed that it is hard to achieve the projected savings without compromising safety. Concerns are raised concerning prices in contracts, and there is a common attitude among the helicopter companies that cost-cutting and increased expectations towards subcontractors in general, are also compromising safety and the present safety culture within the helicopter companies. The contract terms must make it possible for an operator to run the operation in a safe manner without any undue pressures.

This measure on unified practice concerning penalties implies that the oil companies and the helicopter operators should evaluate the current penalty regime for non-fulfilment of contractual requirements. The claim is that this scheme may cause undue stress for those responsible for the operation, i.e. operations centre, pilots and maintenance personnel. Such stress can propagate in the organisation and cause errors. The measure therefore also includes that the operators' management is aware of – and has a strategy for – how any criticism from the customers is communicated internally.

The measure on contract review implies assessing the possible consequences of the cost-cutting and efficiency measures currently imposed or planned in the business. The penalty regime is seen a natural part of this picture.

EFFECT: There must be a balance between the requirements for delivering flights and operating in a safe manner. A predictable framework for operating safely is a must. The measure will reduce the risk of decisions being made unduly influenced by economic factors, and secure the correct focus for the personnel directly involved in the operations.

COST: Low.

M41 – Active inclusion in the engineering phase of helicopter personnel with experience operating in the North Sea

Not relevant

Helicopter personnel (pilots and technicians) with experience from helicopter operations in the North Sea should be involved in the engineering phase for new helicopters. There are technical challenges unique to the North Sea and the Norwegian Shelf, e.g. icing and corrosion. With regards to the pilot's working conditions in the cockpit, it has been pointed out that lights, window size and ergonomic design can be improved toward reducing the danger of fatigue. In addition to the engineering phase for new helicopters, competent operative personnel should be included in helideck design. This would contribute to optimising the design and placement of the helideck as regards take-off and landing. Such participation by relevant personnel can typically be obtained through a "Customer advisory board".

New helicopter types are not expected to be put in operation on a large scale for the coming ten-year period. The measure is therefore not so relevant for the time being. If the H225 should be replaced, the measure will be more relevant for consideration.

This measure is linked to M35 on more thorough criticality analyses (FMECA).

M42 – Monitoring safety though systematic use of indicators

Priority: HIGH

Safety monitoring is part of EASA OPS requirements for SMS. HSS-3 identified a set of leading and lagging indicators for monitoring safety within the helicopter operators. Active use of these implies not only recording observations, but also following up and implementing measures based on the information provided by the indicators. Indicators are pointless if the organisation is not capable of making decisions, acting and implementing safety improvements in time, i.e. before an accident occurs, which could have been predicted. The suggested indicators only reflect a limited number of the factors influencing safety. Therefore, a periodic review and reassessment of the indicators is recommended.

CAP 1145 recommends a standardisation of safety indicators for the business, including indicators based on FDM and the establishment of an FDM user group. Downsizing within the helicopter operators is currently preventing them to run such a forum, and it seems natural that the CAA-N takes this initiative. With a healthy reporting culture as a basis, an array of quality indicators may be agreed and established, and an exchange of this information between different organisations may be developed.

Through a Norog initiative a common set of key performance indicators has been introduced for the operators in Norway. These indicators could form the basis for a further international collaboration by for example HeliOffshore.

EFFECT: The follow-up of a set of proactive and reactive indicators will contribute to an increased safety focus, and the monitoring of such indicators may prevent future accidents. The effect is estimated similar to HSS-3.

COST: Costs will depend on the scope. Investment costs will be low as most of the information is already available in the organisations. There will be some modest running costs linked to the utilisation of the information in proactive safety work. Some costs will be related to the establishment and operation of an FDM forum and establishing a system for making observations and give related training.

8.2 Further recommendation identified in HSS-3b

HSS-3b has identified a series of new measures in addition to the measures from HSS-3. The measures have emerged from several sources and perspectives:

- Recommendations from CAP 1145 (cf. chapter 7)
- Recommendations from investigation reports of the most recent accidents (cf. chapter 9)
- Miscellaneous written documents such as reports, presentations, meeting minutes, web pages etc.
- Expert meetings and interviews
- Invited suggestions from relevant players in the business

Table 8.2 depicts all *new* suggested measures identified in HSS-3b, i.e. measures not already presented in HSS-3. Especially the last point above generated an array of measures on various levels; these measures vary greatly in scope and complexity, and are referred in this report largely as they were presented to us. Some of the suggestion will therefore appear as incomplete, unrealistic or narrow. Nevertheless, they are still included to make visible all the different suggestions we received and to preserve the ideas for later occasions. Note that many of the received suggestions were repetitions of measures given in HSS-3, and these are not included in the table below.

All measures are given a priority (Low–Medium–High). The measures with high priority are given a more thorough description below the table, and coarsely assessed with respect to safety effects, cost and practicality in implementation.

Note that all new measures identified in HSS-3b are numbered with prefix “B” to separate them from the HSS-3 measures, which have the prefix “M”.

Table 8.2: List of *new* measures identified in HSS-3b.

Ref.	Measure	Priority
B01	Improved maintenance systems and -manuals	High
B02	Agreement between operators and customers on a reasonable turn-around time	High
B03	Online data transfer to helicopters	High
B04	Stricter competency requirements for leaders in the helicopter companies	High
B05	Transfer of supervisory responsibility for helidecks to the CAA-N	Medium
B06	Strengthening of the dialogue between helicopter operators and manufacturers to drive changes and development of systems	Medium
B07	Design review by Type Certificate Holder following failures of components and systems on the production line, and implementation of relevant remedial actions	Medium
B08	Requirements to get a "satisfactory" share of B1/B2 support staff, and that responsible C technician shall be attending heavy maintenance	Medium
B09	Depicting rig name on derrick	Medium
B10	Secure 100 % ATC radio communication coverage down to 1000 ft	Medium
B11	Coordination between oil companies to avoid company specific requirements	Medium
B12	Stricter competence requirements to aviation safety advisors	Medium
B13	Formal requirement to separate flight safety staff from the commercial operation	Medium
B14	Assessment of the consequences of grounding of one helicopter type	Medium
B15	Introduce wave height limitations	Low
B16	Implement Cat A breathing system	Low
B17	Implement restrictions on passenger size	Low
B18	Implement guideline requirements that pre-flight inspection shall include opening of cowlings for access to MRH, MGB, systems and engines, and that pre-flight inspection must be completed and signed by a certified technician	Low
B19	Implement guideline requirements for utilising ETOPS philosophy for planning and execution of maintenance	Low
B20	Not implement requirement for technicians to use bump caps	Low
B21	Implement a requirement for (heavy) maintenance to be performed in Norway	Low (Ref. M07)
B22	Prohibit outsourcing of CAMO tasks	Low (Ref. M07)
B23	Push manufacturers to focus on noise and vibrations, and comfort for pilots and passengers	Low
B24	Improve communication between pilots and passengers	Low
B25	Improve criteria to determine turbulence effects upon landing at helidecks	Low
B26	Implement helideck crew assessment	Low
B27	Tension testing of perimeter net on helideck on a yearly basis	Low
B28	Measures to prevent bird strike close to helideck	Low
B29	Implement measures and analyse operations to moving helidecks	Low
B30	AIP manual Norway	Low
B31	Introduce the Norwegian standard for rescue men as a requirement on the NCS	Low
B32	Stricter requirements for evacuation training of pilots, e.g. boarding liferaft at sea	Low

B33	Standardise and formalise requirements for passenger briefing for take offs and landings	Low
B34	Passenger briefings should hold information on securing loose items and tightening of the seat belt	Low
B35	Modify the zippers of the survival suits	Low
B36	Passengers headsets should transmit PA at a set volume also when volume is turned down	Low
B37	Standardising of push out windows, emergency exit markings and lights across all helicopter types	Low
B38	Further development of the common audit	Low
B39	Implement limitations to the number of hired pilots and technicians	Low
B40	Ban the use of matrix organisations in companies	Low
B41	Learning from fixed-wing experience on procedures	Low
B42	Coordinate all instructions (course, video, flyer) on how to do the "brace position"	Low
B43	Contingency procedures (in the event of one engine inoperative). Avinor will be offering this to the operators. Relevant for the Barents Sea	Low
B44	Measures to reduce the number of helideck incidents on vessels and oil rigs (ref. RNNP)	Low
B45	Make rig data available for everybody (not only rig owner) to make airport data sheet as required in BSL D 5-1	Low
B46	Measures to avoid collision with ship sails (dragon sails)	Low

B01 – Improved maintenance systems and -manuals

Priority: HIGH

The measure is about setting requirements to and improve the maintenance systems (i.e. data tools) and the electronic maintenance manuals. This includes the standardisation of descriptions of critical equipment and requirements related to the follow-up of the maintenance system.

Setting more specific requirements to the maintenance systems will improve the listing of maintenance due and maintenance executed, and also improve practises and procedures. The measure also implies specific approval of data programmes for the follow-up of maintenance and airworthiness status. There is almost no specific regulation of such systems today (only functional requirements), despite them being very central to the technical safety of helicopters. The choice of maintenance system is up to the individual company, but it must be demonstrated that the system is capable of meeting existing functional requirements.

The transition from paper to electronic maintenance manuals has been welcomed, but the quality is still varying. Some of the electronic manuals are perceived as difficult to navigate and not so user friendly.

<u>EFFECT:</u> The measure will reduce the risk of maintenance not being executed timely and that erroneous data can lead to sending a non-airworthy aircraft into operation.

<u>COST:</u> Some investment costs related to improvements are expected. Running costs are estimated to be low.

B02 – Agreement between operators and customers on a reasonable turn-around time

Priority: HIGH

The measure is about getting a unified agreement between operators and customers on reasonable turn-around times. An agreed customer requirement (for implementation in Norog 066) related to turn-around

time is suggested. The turn-around time must give room for safety critical tasks with some margin in a realistic way. There must be enough time to identify, assess and correct potential problems before the next flight, and also some time to catch up with the flight program in case of delays. It is still important that a technician has sufficient time to properly inspect the helicopter. The pilots must have sufficient rest between flights and time to plan the next flight. In case of an incident, there should be time for pilots to file an adequate report while the incident is still fresh.
EFFECT: The measure will reduce risk related to bad judgment and errors due to time constraints, and contribute to keeping a low stress environment for all tasks to be performed.

COST: The cost will depend on the need for having an additional helicopter to cover the planned flight programme within the same time frame. The cost related to reviewing the contracts is low.

The measure must be seen in relation to M40 concerning contract review and agreement on the use of penalties.

B03 – Online data transfer to helicopters

Priority: HIGH

The measure is about continuous updating of relevant information for the helicopter in flight. The most important will be weather information, but also helideck information, video from the destination, lightning/discharge forecast, logistics data etc. will be useful. The solution may build on an arrangement used in the British sector with a dedicated website containing all relevant information. Information given to the helicopter in flight might also reduce the need for radio communication.

Online data transfer to the helicopter should be evaluated as a requirement in Norog 066.

EFFECT: The measure will give increased situational awareness for the crew. The update of information will be particularly useful for flights of long duration.

COST: The investment costs are seen as relatively low since the technology is already available. Some running costs in relation to further development, adaption and training must be considered.

The measure is related to M05 concerning continuous data transfer from helicopters.

B04 – Stricter competency requirements for leaders in the helicopter companies

Priority: HIGH

The measure is about increasing the knowledge requirements for management personnel in the helicopter companies and maintenance organisations. This includes accountable manager and nominated persons (including Part M, Part 145, flight ops., ground ops.). As per today there are limited competence requirements for these positions. As a minimum, courses in current legislation and regulation should be required. A specified list of courses to be taken should be given for all the relevant management positions. Such requirements could be considered for inclusion in Norog 066 or in formal regulation through revision of AIC-N 10/15.

EFFECT: Increased management competence is likely to reduce the risk of erroneous decisions and subsequent implementation. This will benefit many managerial areas, including safety. The effect is estimated to be of the same order as for improved training for technical personnel (M07).

COST: Some investment costs related to setting the requirements and some costs related to courses and training. In total, the costs are assumed to be quite low.

8.3 Coarse prioritisation of measures

A summation of all the measures from HSS-3 (open measures only) and HSS-3b sorted by priority class is presented in Table 8.3. All measures in the priority class *High* were subjected to a coarse cost-benefit assessment in order to further prioritise between these measures.

Table 8.3: All measures from HSS-3 (open measures only) and HSS-3b sorted by priority class.

Ref.	Measure	Priority
M07	Improved training for technical personnel	High
B01	Improved maintenance systems and -manuals	High
B02	Agreement between operators and customers on a reasonable turn-around time	High
B03	Online data transfer to helicopters	High
M19	Handheld communication for pilots moving about the helideck	High
M24	AIS in helicopters, integrated in navigational displays	High
M25	ADS-B, ATC services and radio coverage in the Barents Sea	High
M37	Strengthening of capacity and competence in the Norwegian CAA	High
M38	Increased focus on communication to learn from incidents	High
M39	Norog's guidelines as the recognised norm	High
M40	Unified practise concerning contracts and the use of penalties	High
B04	Stricter competency requirements for leaders in the helicopter companies	High
M42	Monitoring safety through systematic use of indicators	High
M02	Requirement for TCAS II in all helicopters and flight simulators	Medium
M05	Continuous transfer of status data from helicopter	Medium
B05	Transfer of supervisory responsibility for helidecks to the CAA-N	Medium
B06	Strengthening of the dialogue between helicopter operators and manufacturers to drive changes and development of systems	Medium
B07	Design review by Type Certificate Holder following failures of components and systems on the production line, and implementation of relevant remedial actions	Medium
B08	Requirements to get a "satisfactory" share of B1/B2 support staff, and that responsible C technician shall be attending heavy maintenance	Medium
M16	Increased priority for helicopter operations at airports	Medium
B09	Depicting rig name on derrick	Medium
M21	Requirements for weather observation equipment	Medium
M27	Air traffic service on the land bases	Medium
M32	Night vision goggles for SAR-pilots	Medium
B10	Secure 100 % ATC radio communication coverage down to 1000 ft	Medium
B11	Coordination between oil companies to avoid company specific requirements	Medium
B12	Stricter competence requirements to aviation safety advisors	Medium
B13	Formal requirement to separate flight safety staff from the commercial operation	Medium

B14	Assessment of the consequences of grounding of one helicopter type	Medium
B15	Introduce wave height limitations	Low
B16	Implement Cat A breathing system	Low
B17	Implement restrictions on passenger size	Low
M06	Stricter regime for independent inspections offshore and on land bases	Low
B18	Implement guideline requirements that pre-flight inspection shall include opening of cowlings for access to MRH, MGB, systems and engines, and that pre-flight inspection must be completed and signed by a certified technician	Low
B19	Implement guideline requirements for utilising ETOPS philosophy for planning and execution of maintenance	Lav
B20	Not implement requirement for technicians to use bump caps	Low
B21	Implement a requirement for (heavy) maintenance to be performed in Norway	Low (Ref. M07)
B22	Prohibit outsourcing of CAMO tasks	Low (Ref. M07)
B23	Push manufacturers to focus on noise and vibrations, and comfort for pilots and passengers	Low
B24	Improve communication between pilots and passengers	Low
M10	Moving map in all helicopters	Low
M12	Proactive updating of manuals	Low
M18	Different lighting for prepared and unprepared helidecks	Low
M20	Training in English helideck phraseology	Low
M23	Improved routines for reporting safety-related faults	Low
B25	Improve criteria to determine turbulence effects upon landing at helidecks	Low
B26	Implement helideck crew assessment	Low
B27	Tension testing of perimeter net on helideck on a yearly basis	Low
B28	Measures to prevent bird strike close to helideck	Low
B29	Implement measures and analyse operations to moving helidecks	Low
B30	AIP manual Norway	Low
M30	Evacuation procedures for passengers	Low
M31	Requirement for full hangar offshore for SAR helicopters	Low
M33	Improved fire preparedness / automatic fire fighting system on unmanned facilities	Low
M36	Evaluating the "Committee for Helicopter Safety on the Norwegian Continental Shelf"	Low
B31	Introduce the Norwegian standard for rescue men as a requirement on the NCS	Low
B32	Stricter requirements for evacuation training of pilots, e.g. boarding liferaft at sea	Low
B33	Standardise and formalise requirements for passenger briefing for take offs and landings	Low
B34	Passenger briefings should hold information on securing loose items and tightening of the seat belt	Low
B35	Modify the zippers of the survival suits	Low
B36	Passengers headsets should transmit PA at a set volume also when volume is turned down	Low
B37	Standardising of push out windows, emergency exit markings and lights across all helicopter types	Low
B38	Further development of the common audit	Low
B39	Implement limitations to the number of hired pilots and technicians	Low
B40	Ban the use of matrix organisations in companies	Low
B41	Learning from fixed-wing experience on procedures	Low
B42	Coordinate all instructions (course, video, flyer) on how to do the "brace position"	Low
B43	Contingency procedures (in the event of one engine inoperative). Avinor will be offering this to the operators. Relevant for the Barents Sea	Low

B44	Measures to reduce the number of helideck incidents on vessels and oil rigs (ref. RNNP)	Low
B45	Make rig data available for everybody (not only rig owner) to make airport data sheet as required in BSL D 5-1	Low
B46	Measures to avoid collision with ship sails (dragon sails)	Low

8.4 Cost-benefit assessment of measures with high priority

A simplified cost-benefit assessment has been conducted for the measures given *High* priority in Table 8.3. The measure M39 – *Norog's guidelines as the recognised norm* is exempt from this analysis since the measure relates to conserving a practice that is already in place today. Therefore, the measure will give no risk reduction in a cost-benefit analysis. The measure is still seen as very important, and therefore treated separately.

Table 8.4: Categorisation of cost and benefit (estimated mid values in brackets).

Code	Class	Cost [mill. NOK]				Utility – reduction[a] in accidents			
		Investment (I)		Annual op. (O)		Frequency (F)		Consequence (C)	
1	Low	0–10	(5)	0–1	(1)	0–20 %	(10 %)	0–20 %	(10 %)
2	Medium	10–100	(30)	1–10	(3)	20–40 %	(10 %)	20–40 %	(10 %)
3	High	>100	(150)	>10	(13)	40–80 %	(10 %)	40–80 %	(10 %)

Note a: Reduction within relevant RIF(s) and accident type(s)

The total cost for a given measure is based on the investment plus five years of operating. Benefit is defined as risk reduction in the form of saved lives, where any change in risk is calculated based on changes in the frequency and/or consequences of accidents. The quantification of benefit rests on the link between the measures and the RIFs and the accident categories in the Helicopter model. See section 2.3.3 for a more detailed description of the method applied for the cost-benefit assessment.

Table 8.5 contains a summation of the cost-benefit assessment of the measures with highest priority (ref. Table 8.3). See the notes below the table for an explanation of the various table columns. The right column in the table presents the overall, qualitative result of the cost-benefit result for each measure.

The measures are as far as possible described in such a way that they are independent of other measures. However, some measures may rely on other measures being implemented in order to achieve the desired effect (risk reduction). This is considered in the final assessment of the measures. In general, the following factors are considered as a basis for the final selection of recommended measures:

- The measure holds a large risk reduction.
- The measure is cost effective.
- The measure is aimed at an area linked to several of the latest accidents and where actions are required.
- The measure is linked to factors that will ease the workload in general within the business, enabling a stronger focus on more important areas (like safety work).

The most important uncertainties related to the cost-benefit assessment are:

- A reduction of risk within a specific area may increase risk in other areas.
- The assessment is based on the model quantifications made in HSS-3 (from 2010). This quantitative basis is suspected to look somewhat different today (2016) given the changes in the business since 2010.

- Both the cost and effect assessments are coarse estimations.
- Given the time horizon for this assessment (0–5 years), the investment cost will be more dominant and the operating costs less important. This means that measures with low investment costs and/or high operating cost are more likely to be promoted in this study than would be the case in HSS-3.

Figure 8.2 presents a summary of the measures that have been assessed with respect to cost-benefit, sorted by the relative cost-benefit contributions for the measures. In addition, the figure presents the expected risk reduction given a complete implementation of the measure. The results show that the following measures are the most efficient based on cost-benefit:

- ADS-B, ATC services and communication coverage in the Barents Sea
- Improved training of technical personnel
- Strengthening of capacity and competence in the Norwegian CAA
- Unified practise concerning contracts and the use of penalties
- Stricter competency requirements for leaders in the helicopter companies
- Stronger focus on communication to improve learning from incidents

Disregarding costs, the measures giving the largest reduction in risk are:

- Improved training of technical personnel
- Strengthening of capacity and competence in the Norwegian CAA
- AIS in helicopters, integrated in navigational displays

Table 8.5: Summation of cost-benefit assessment results.

Measure	RIF[a]		A[d]	Cost[e]		Effect[f]		Reduction[g]			Relative cost/benefit wrt. risk[h]
	F[b]	C[c]		I	O	F	C	F	C	R	
Improved training for technical personnel	1.2	-	All	1	2	1	-	2 %	-	2 %	Medium
Improved maintenance systems and -manuals	1.2	-	All	2	1	1	-	2 %	-	2 %	Medium
Agreement between operators and customers on a reasonable turn-around time	12, 1.3	-	All	1/3[i]	1	1	-	2 %	-	2 %	Low/High
Online data transfer to the helicopters	1.4, 1.10	1.14	A5, A8	1	2	2	2	1 %	0 %	2 %	Medium
Handheld communication for pilots moving about the helideck	1.4, 1.8	1.8	A7	1	1	1	1	0 %	0 %	0 %	Low
AIS in helicopters, integrated in navigational displays	1.4, 1.8	1.10, 1.12	F: A2, A5 C: A3	3	1	2	2	5 %	1 %	5 %	Low
ADS-B, ATC services and radio coverage in the Barents Sea	1.4, 1.9	1.12	F: A4 C: All	1	1	2	2	0 %	2 %	3 %	High
Strengthening of capacity and competence in the Norwegian CAA	All	All	All	-	1					5 %	High
Increased focus on communication to learn from incidents	All	All	All	1	1					2 %	High
Unified practise concerning contracts and the use of penalties	1.1, 1.2, 1.3	-	All	1	1	1	-	2 %	-	2 %	High
Stricter competency requirements for leaders in the helicopter companies	All	All	All	1	1					2 %	High
Monitoring safety through systematic use of indicators	All	All	All	1	2					2 %	Medium

Note a: Risk influencing factor.
Note b: RIF number in the influence diagram for frequency, see Appendix A.
Note c: RIF number in the influence diagram for consequence, see Appendix A.
Note d: Accident category, see section 2.4.
Note e: Estimated investment costs (I) and operating costs (O), ref. Table 8.4.
Note f: Estimated effect for frequency (F) and consequence (C) for the relevant RIFs and accident categories, ref. Table 8.4.
Note g: Estimated risk reduction, i.e. the percentage reduction in the frequency contribution to risk (F), in the consequence contribution to risk (C) and in the total risk (R) (number of fatalities per million person flight hours).
Note h: Relative cost-benefit yield regarding risk compared to the other measures in the table. The cost-benefit result is calculated as risk reduction *per annual expense*. The investment costs are distributed over five years (2016–2020).
Note i: If the measure requires an additional helicopter, costs will be very high, otherwise costs will be low.

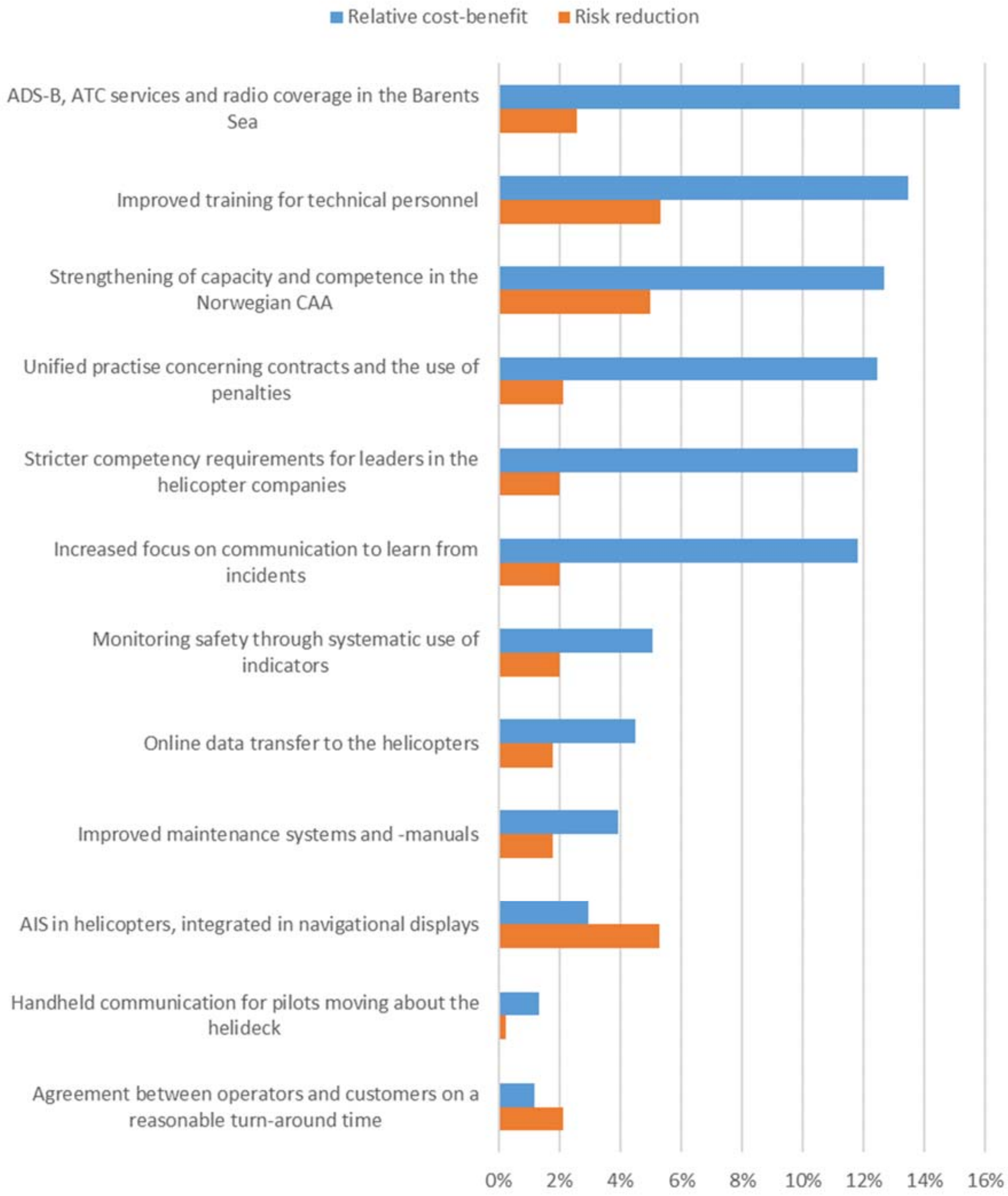


Figure 8.2: Overview of safety measures sorted by cost-effectiveness (relative cost-benefit yield for a measure compared to the other measures).

SINTEF

8.5 Conclusions from the cost-benefit assessment of measures

Å prerequisite for the assessments and recommendations made by SINTEF, is that the planned/expected development of already existing safety measures are not halted or reversed. This also includes the continuation of current requirements and norms. The most important prerequisites are:

- Maintaining the current requirements from the authorities, including the continuation of the special Norwegian requirements and the requirement for AOC approved by CAA-N
- Maintaining Norog 066 as the recognised norm (M39), including:
  - Requirement for using the latest proven helicopter technology for passenger transport (M04)
  - Traffic advisory (minimum TCAS I) in all helicopters (M01).
  - Continued development and increased utilisation of HUMS
  - Continued development and increased utilisation of FDM, adapted to helicopter operations
  - Increased level of automation for approaches (M11)

It is important to view the measures in context and assess the potential gains from implementing further measures within the different areas. If we examine each different measure and the combination of the cost-benefit relationship and the estimated risk reduction alone, the following measures stand out as the most beneficial (not in prioritised order):

- AIS in helicopters, integrated in navigational displays
- ADS-B, ATC services and communication coverage in the Barents Sea
- Stronger focus on communication to improve learning from incidents
- Unified practise concerning contracts and the use of penalties
- Improved training for technical personnel
- Stricter competency requirements for leaders in the helicopter companies
- Strengthening of capacity and competence in the Norwegian CAA

The final recommendations regarding which measures should be implemented to be able to control the potential threats and improve safety further, are summarised in section 9.6.

9 Main conclusions

The main conclusions of the study are presented in this chapter. The conclusions are structured as follows:

- Accident statistics
- Main development features
- Potential threats to helicopter safety
- The new EASA regulation (HOFO) and the Norwegian Oil and Gas guideline 066 (Norog 066)
- The British CAP 1145 safety study
- Recommendations
- Continued work

9.1 Accident statistics

- The statistics for accidents and fatalities in helicopter transport on the Norwegian Continental Shelf (NCS) have been very good for many years. Even when considering the Turøy accident, the NCS statistics are far better than the total North Sea average.
- For the period 2010–2015 there have been no helicopter accidents on the NCS. Looking at the extended period 1999–2015, there has been one accident and no fatalities. If one were to include the Turøy accident (13 fatalities) in this period, this would have given a rate of **1,0** fatalities per million person flight hours.
- For the British sector in the same period (1999–2015) the rate is **4,0** fatalities per million person flight hours. The rate is based on 15 accidents of which 4 were fatal with a total of 38 fatalities.

9.2 Main development features

- The petroleum business area is currently going through large changes and the future prospects are uncertain. A downturn in the business may result in an increased pressure on safety through downsizing and a strong focus on economy, both with the oil companies and the helicopter operators. There is not a one to one relation between economics and the level of safety, but the safety margins may erode over time due to decreased redundancy, loss of competence, longer maintenance intervals, etc.
- The helicopter fleet operating on the NCS has been the newest proven technology available. The Turøy accident created a new situation where a large part of the operating fleet (H225) is no longer available for passenger transport or SAR. It is uncertain how long this situation will last and whether the H225 will come back into service at all. Introduction of new helicopter types may be a result in order to keep a robust transport solution for the NCS.
- The opening of the Barents Sea for oil exploration is introducing new and potentially bigger challenges for offshore transport by helicopter due to long flying distances and a harsh environment.

9.3 Potential threats to helicopter safety

The most important potential threats to helicopter safety in the coming period are mainly the same as those identified in the HSS-3 study. Many of these threats now seem reinforced:

- Lack of the possibility to maintain established Norwegian additional requirements for offshore flights, or that it will not be possible to introduce new requirements adapted to the conditions on the NCS
- Exemption from offshore special requirements and deviation from recommended guidelines

- Unwanted consequences from changes implemented by the helicopter operators and other players in this area
- Reduced competence among technicians and pilots in the helicopter companies due to the retirement of existing personnel
- Lack of competence and resources regarding offshore helicopters in the Civil Aviation Authority – Norway (CAA-N)
- Too much focus on cost and revenue by the different players on the NCS

9.4 The new EASA regulation (HOFO) and the Norwegian Oil and Gas guideline 066 (Norog 066)

- The introduction of new European regulations for offshore helicopter operations (HOFO) from 2018 is creating general uncertainty as the full implications of the regulations are still unclear. As a rule, the European Economic Agreement (EEA) does not apply to the NCS outside Norwegian territorial waters (12 nautical miles). However, it is uncertain whether Norway will be able to – or even wish to – maintain this limitation.
- Threats to safety identified in HSS-3 are becoming more relevant by the introduction of HOFO. A new regulation that may decrease or all together remove the possibilities for special Norwegian regulations for offshore helicopter operations, will be a setback for the current Norwegian safety efforts.
- Norog 066 reflects the development and practical safety efforts established on the NCS trough several decades. This standard is viewed by many as world leading, and the main Norwegian stakeholders consider the guideline to be an important document that needs to be preserved and further developed.
- Overall, the Norog 066 guideline represents a higher safety standard than the HOFO regulation. The guidelines are used voluntarily in the current contracts between the oil companies and the helicopter operators, and this may also be the case for future contracts under HOFO. However, there is a concern that Norog 066 may become diluted and loose its position over time because of economic pressure in the industry and divergent priorities by new (or existing) actors under HOFO.

9.5 The British CAP 1145 safety study

- The British CAP 1145 safety study is viewed as a natural and very understandable reaction to the recent helicopter accidents in the British sector. The study contains a lot of relevant information and a set of actions and recommendations that seem to cover a particular British need following the accidents.
- The CAP 1145 study has received some critique from different Norwegian stakeholders; this is mainly related to: a) the recommendations are seen as reactive; b) the study is trivializing the differences between the British and the Norwegian sectors relating to accidents; c) the study seems to be somewhat rushed; d) the Norwegian contributions to the study were downgraded.
- The Norwegian approach is to maintain the established focus (e.g. from the previous HSS studies) on the *prevention* of accidents rather than reducing the consequences of accidents. The industry in Norway has a strong belief in this focus and wish to preserve and develop this as it has given robust safety results thus far. It is not a given that rational recommendations for the British sector will work equally well in the Norwegian sector, and vice versa.
- Many of the CAP 1145 recommendations are already more or less in place in Norway. The most relevant recommendations are mentioned in this report.
- Particularly, this study concludes that three controversial recommendations from CAP 1145 – relating to wave height limitations, breathing system and passenger marking – should not be introduced uncritically in the Norwegian sector (see section 9.6.2 below).

a) Wave height limitations may have a risk reducing effect in certain situations with the helicopter in the sea; however, the probability of such situations is seen as remote, and the total risk reduction associated with wave height limitations is considered to be marginal.
b) A Cat A breathing system (pressurised air) may have a risk reducing effect in certain situations with the helicopter in the sea; however, the probability of such situations is seen as remote, and the total risk reduction associated with a Cat A breathing system is considered to be marginal.
c) A regime with categorising and marking passengers by body size may have an effect in an actual evacuation; however; the total risk reduction associated with such a regime is considered to be marginal. Moreover, there are logistical, economical and ethical sides to such measures.

- Work is in progress on the development and certification of equipment that will prevent the helicopter from inverting after landing on the water. If this work proves successful, the need for reactive measures like the three measures mentioned above will in large part be eliminated.

9.6 Recommendations

This study confirms that the majority of the recommendations from HSS-3 are still relevant today. This shows that effort and focus over time is needed to be able to implement improvements.

Several of the recommendations in the HSS-3b study builds on important prerequisites about the continuation of the current regime and practice. For instance, it is presumed that implemented and planned measures from HSS-3 (and earlier) are not halted or reversed. Some of the HSS-3 recommendations have been implemented in the Norog 066 guideline, but full implementation will need to take some time.

9.6.1 Recommendations from the cost-benefit assessment

Based on a coarse cost-benefit assessment the most important safety recommendations are (not in prioritised order):

- AIS in helicopters, integrated in navigational displays
- ADS-B, ATC services and communication coverage in the Barents Sea
- Stronger focus on communication to improve learning from incidents
- Unified practise concerning contracts and the use of penalties
- Improved training of technical personnel
- Stricter competency requirements for leaders in the helicopter companies
- Strengthening of capacity and competence in the Norwegian CAA

Several of these measures have a high score in the cost-benefit assessment mainly due to relatively low costs of implementation, and not necessarily a high risk reduction. Those measures in the analysis that have the highest risk reduction (benefit) disregarding cost are:

- Improved training of technical personnel
- Strengthening of capacity and competence in the Norwegian CAA
- AIS in helicopters, integrated in navigational displays

It is emphasized that the selection of candidate measures for inclusion in the cost-benefit assessment is based on *both* the cost and benefit dimensions; hence, some measures that hold a relatively large risk reduction may not be included in the analysis for various reasons (excessive cost, low realism, wrong timing, etc.). Likewise, the analysis may include measures that hold a relatively *low* risk reduction if the associated cost is also low.

9.6.2 Recommendations related to CAP 1145

Recommendations for Norway related to the three specific CAP 1145 measures that are discussed the most in the Norwegian community and in HSS-3b, are as follows.

Wave height limitations

- Before possibly introducing flight limitations related to wave height, it is recommended to carry out a broad risk assessment also including possible indirect effects on other areas than the helicopter transport.
- It could be considered to introduce wave height limitations for night operations. This will be a step towards reducing night operations in bad conditions without giving any significant logistical implications. Any limitation pertaining to wave height should not be strictly formulated, but rather be seen as part of the evaluation of the complete meteorological situation. Exemptions should be made for passing areas of high waves en route. A thorough evaluation of this arrangement should be made before considering the introduction of any daytime limitations related to wave height.

Cat A breathing system

- As per today Norway should not introduce requirements for a Cat A breathing system on own initiative. It is recommended to await the coming HOFO introduction.
- Should the introduction of the HOFO regulation allow Norway to *choose* breathing system, a thorough assessment should be undertaken before any change is made. Risks associated with use both in training and in real evacuation situations – as well as cost and logistics – should all be considered.

Passenger marking

- As per today Norway should not introduce requirements for categorising and marking passengers by body size on own initiative. It is recommended to await the coming HOFO introduction.

"Air pocket" solutions

- Norway should support and follow up on the development of so called "air pocket" solutions as this is seen to largely eliminate the need for many of the reactive measures described above (i.e. wave height limitations, breathing system and passenger marking).

9.6.3 Recommendations related to HOFO and Norog 066

Recommendations related to the EASA HOFO regulation and the Norog 066 guideline are as follows:

- Norway should not implement the HOFO regulation on the NCS outside Norwegian territorial waters (12 nm). HOFO represents a possible realisation of key threats to offshore helicopter safety as identified in HSS-3. From a safety perspective, HOFO should not be considered implemented before it can be documented that there are no significant negative safety effects.
- Work should continue to seek legal formalisation of the Norog 066 guideline. As per today Norog 066 is just a *guideline* utilised by the oil companies through contracts with the different helicopter operators. A formalisation of Norog 066 into Norwegian law will strengthen the position of Norog 066 for the future.

9.7 Continued work

It is recommended to maintain the current practice of conducting regular safety studies of the helicopter activity on the NCS. Such safety studies have proven to be effective means to establish a common understanding and cooperation on the implementation of prioritised safety measures.

The HSS-3b study has a limited scope compared to previous HSS studies. In a future HSS-4, one should therefore address other issues and methods. For example, it will be necessary to further develop the RIF model that is used for risk quantification, including uncertainty considerations and an update of the data basis. Furthermore, the assessment of safety measures should be more thorough to obtain a better description of the cost-benefit relation.

Increasing petroleum activities in the Barents Sea represents new challenges related to helicopter transport under other conditions than further south on the NCS. Helicopter safety in the far north has not received much attention, and should be studied especially.

The downturn in the petroleum business has lasted for some time, and it is uncertain when and if the oil price and activity will rise again. Both oil companies and helicopter operators are struggling to make profit in today's market situation, and there is a considerable focus on cutting costs. Downsizing and cost-cutting may put safety under pressure, and it is recommended to study how helicopter safety is affected under such a regime. It would also be interesting to study safety in periods of strong growth.

There have been several serious gearbox incidents the last few years, drawing attention to the vulnerability of this critical part. Most of the incidents have occurred with Super Puma helicopters that are no longer in use on the NCS, but there have also been incidents with S-92. Manufacturers are continuously working on developing safe helicopters in general and gearboxes in particular. Still, Norwegian players should consider seeking influence on gearbox development, including design, modification, maintenance and condition monitoring. As a minimum, historical data could be examined to identified causes and implemented measures related to gearbox incidents, with the purpose of learning.

It should be examined to what extent recent accidents and incidents – especially the Turøy accident – affect the perception of risk in helicopter transport. The RNNP project features a simple indicator on perceived helicopter risk that is updated biannually, but this is not sufficient. Perceived risk will fluctuate more than "real" risk; HSS-3 discussed perceived risk in depth as per 2010, but having an updated picture of the situation today is considered important.

It would be very interesting to perform a broad comparative study of helicopter activities in the British and Norwegian sectors. At first glance there are many similarities between the sectors, like helicopter types, operators, environmental conditions, history, culture, etc. Under the surface, however, there seem to be differences and nuances that might encourage learning, and that might contribute to explain differences in e.g. accident statistics. Anecdotes and hearsays exist about alleged differences between the two sectors, but this has never been studied or documented. Such a study must have participants from both sectors with an emphasis on learning.

The recommendations given in this report should be followed up by the relevant stakeholders in the business. *Norwegian Oil and Gas* and the *Committee for Helicopter Safety on the NCS* seem to be the most natural arenas for this work.

9.8 Brief summary of recommendations and continued work

A brief summary of the main recommendations of the study is given below, including recommendations for further work.

Recommendations from the cost-benefit assessment (not in prioritised order):

- AIS in helicopters, integrated in navigational displays
- ADS-B, ATC services and communication coverage in the Barents Sea
- Stronger focus on communication to improve learning from incidents
- Unified practise concerning contracts and the use of penalties
- Improved training of technical personnel
- Stricter competency requirements for leaders in the helicopter companies
- Strengthening of capacity and competence in the Norwegian CAA

Recommendations related to CAP 1145:

- Not introduce strict wave height limitations
- Not introduce Cat A breathing system
- Not introduce marking of big passengers
- Support the development of "air pocket" solutions

Recommendations related to HOFO and Norog 066:

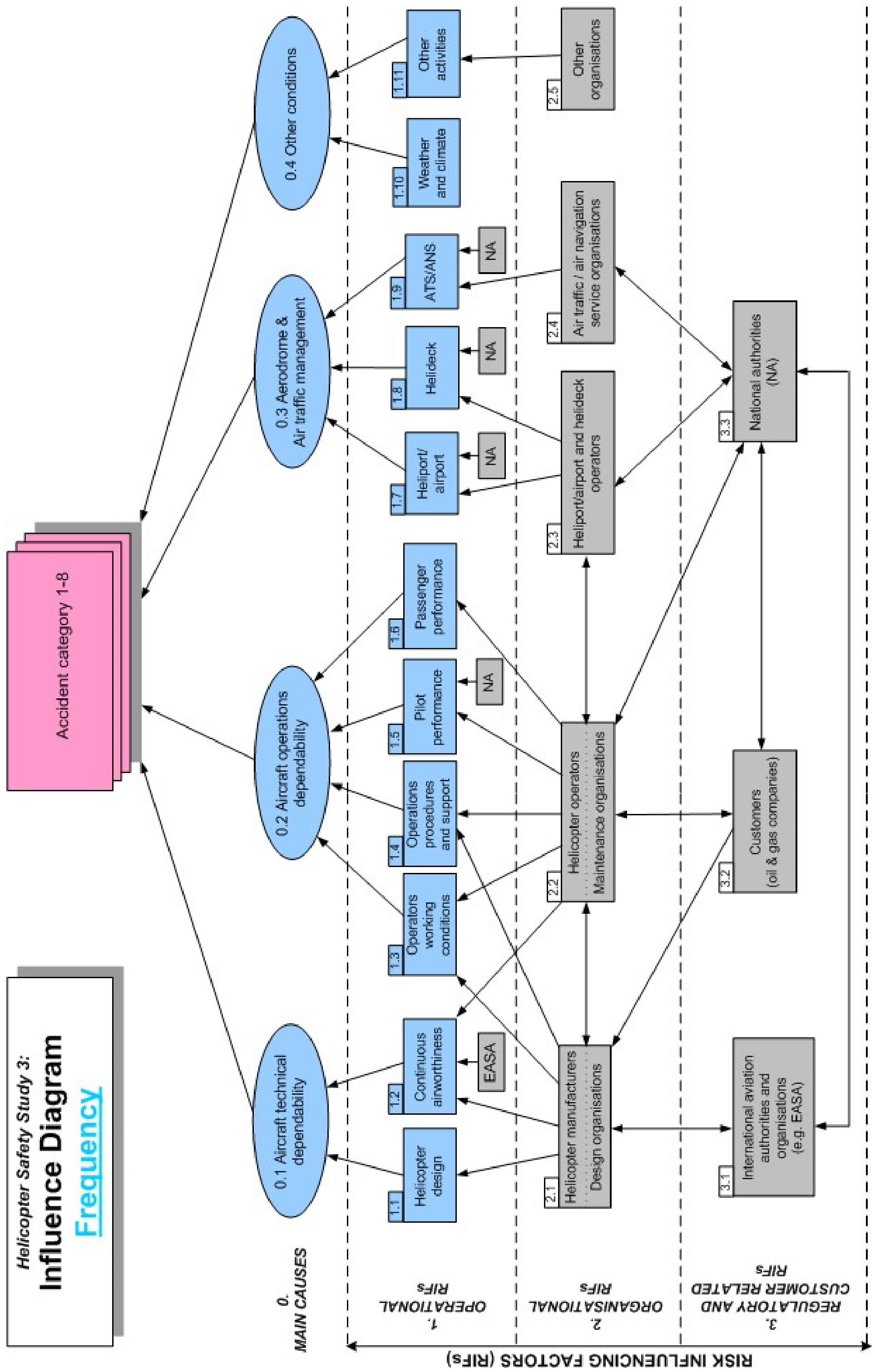
- Not introduce HOFO on the NCS
- Seek formalisation of Norog 066

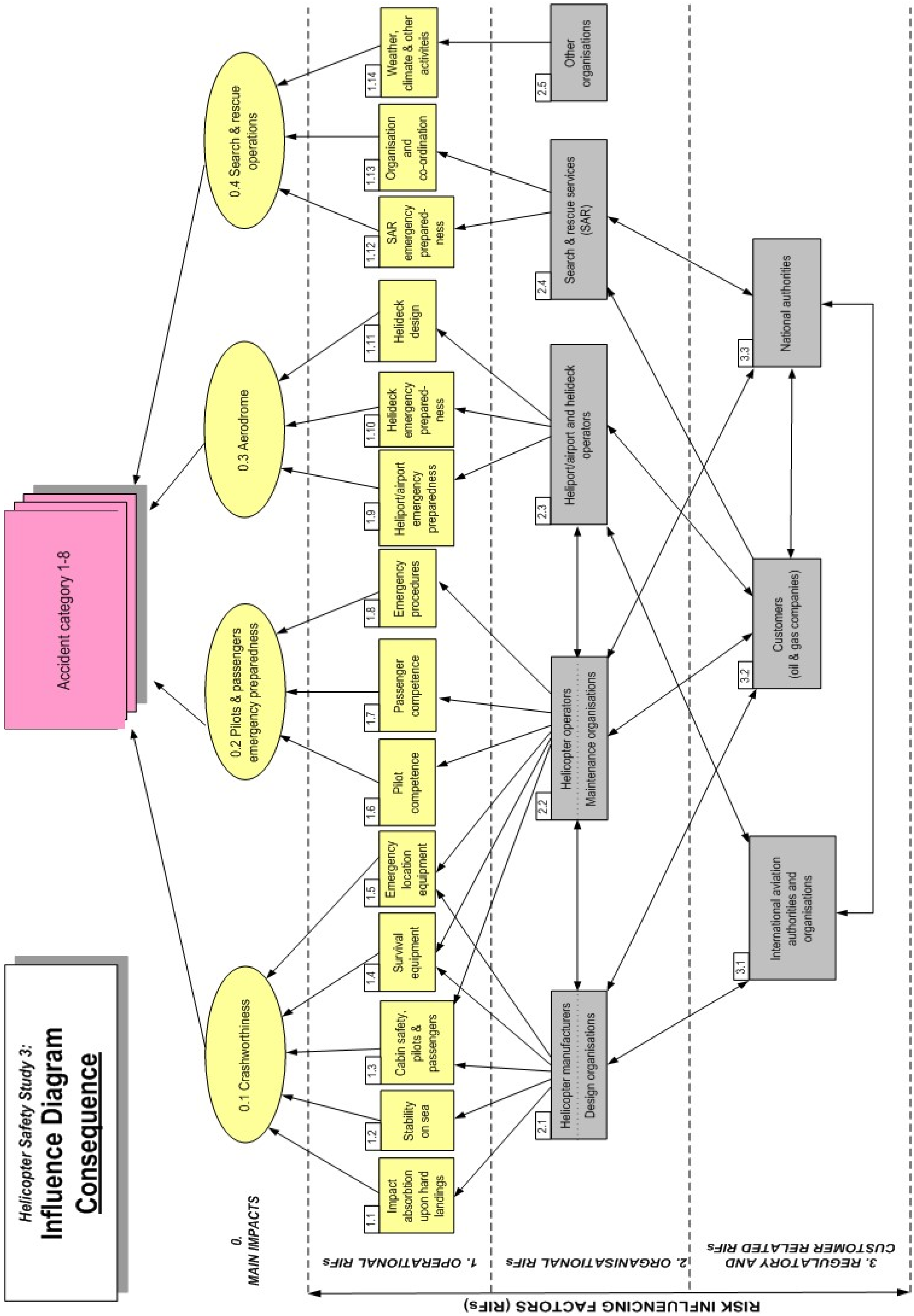
Recommendations for continued work:

- Conduct regular safety studies
- Study helicopter safety in the Barents Sea
- Study helicopter safety in times of recession and change
- Examine gearbox incidents and influence the development of gearboxes
- Examine perceived risk after the Turøy accident
- Conduct a comparative study of helicopter operations in the Norwegian and British sectors
- Follow up on the recommendations of this study

Appendices

Appendix A: Influence diagrams in the "Helicopter model"




Helicopter Safety Study 3:
Influence Diagram
Consequence
Accident category 1-8
0. MAIN IMPACTS
0.1 Crashworthiness
0.2 Pilots & passengers emergency preparedness
0.3 Aerodrome
0.4 Search & rescue operations
1. OPERATIONAL RIFs
1.1 Impact absorbtion upon hard landings
1.2 Stability on sea
1.3 Cabin safety, pilots & passengers
1.4 Survival equipment
1.5 Emergency location equipment
1.6 Pilot competence
1.7 Passenger competence
1.8 Emergency procedures
1.9 Heliport/airport emergency preparedness
1.10 Helideck emergency prepared-ness
1.11 Helideck design
1.12 SAR emergency prepared-ness
1.13 Organisation and co-ordination
1.14 Weather, climate & other activiteis
2. ORGANISATIONAL RIFs
2.1 Helicopter manufacturers
Design organisations
2.2 Helicopter operators
Maintenance organisations
2.3 Heliport/airport and helideck operators
2.4 Search & rescue services (SAR)
2.5 Other organisations
3. REGULATORY AND CUSTOMER RELATED RIFs
3.1 International aviation authorities and organisations
3.2 Customers (oil & gas companies)
3.3 National authorities
RISK INFLUENCING FACTORS (RIFs)

Appendix B: Recommendations in investigation reports after recent accidents in UK and CA

This appendix contains all safety recommendations from the reports after the last six investigated accidents (ref. Table 6.1).

Date	Place	Helicopter	Fatalities	Short description
2009-02-18	UK	H225	0	CFIT (sea) during offshore approach
2009-03-12	CA	S-92	17 of 18	Uncontrolled ditching after massive loss of oil from MGB
2009-04-01	UK	AS332L2	16 of 16	Loss of main rotor and crash due to technical failure in MGB
2012-05-10	UK	H225	0	Controlled ditching after loss of oil pressure due to technical failure in MGB
2012-10-22	UK	H225	0	Controlled ditching after loss of oil pressure due to technical failure in MGB
2013-08-23	UK	AS332L2	4 of 18	CFIT (sea) during approach to airport

Recommendations after the accident 2009-02-18

No.	Recommendation	Address
1	**Safety Recommendation 2009-064** It is recommended that the Civil Aviation Authority review the carriage and use in commercial air transport helicopters of any radio location devices which do not form part of the aircraft's certificated equipment.	CAA
2	**Safety Recommendation 2009-065** It is recommended that the Civil Aviation Authority advise the European Aviation Safety Agency of the outcome of the review on the carriage and use in commercial air transport helicopters of any radio location devices which do not form part of the aircraft's certificated equipment.	CAA
3	**Safety Recommendation 2009-066** It is recommended that European Aviation Safety Agency require manufacturers of Emergency Locator Transmitters (ELTs)/Personal Locator Beacons (PLBs) units to add details, where absent, of the correct use of the antenna to the instructions annotated on the body of such beacons.	EASA
4	**Safety Recommendation 2009-067** It is recommended that the Civil Aviation Authority ensure that all aspects of Emergency Locator Transmitter (ELT)/Personal Locator Beacon (PLB) operation, particularly correct deployment of the antenna, are included and given appropriate emphasis in initial and recurrent commercial air transport flight crew training, as applicable.	CAA
5	**Safety Recommendation 2011-049** It is recommended that the Civil Aviation Authority re-emphasises to Oil and Gas UK that they adopt the guidance in Civil Aviation Publication (CAP) 437, entitled Offshore Helicopter Landing Areas - Guidance on Standards, insofar as personnel who are required to conduct weather observations from vessels and platforms equipped for helicopter offshore operations are suitably trained, qualified and provided with equipment that can accurately measure the cloud base and visibility, in order to provide more accurate weather reports to helicopter operators.	CAA
6	**Safety Recommendation 2011-050** It is recommended that the Civil Aviation Authority encourages commercial air transport helicopter operators to make optimum use of Automatic Flight Control Systems.	CAA

No.	Recommendation	Address
7	**Safety Recommendation 2011-051** It is recommended that the Civil Aviation Authority ensures that commercial air transport offshore helicopter operators define specific offshore approach profiles, which include the parameters for a stabilised approach and the corrective action to be taken in the event of an unstable approach.	CAA
8	**Safety Recommendation 2011-052** It is recommended that the Civil Aviation Authority commissions a project to study the visual illusions that may be generated during offshore approaches to vessels or offshore installations, in poor visibility and at night, and publicises the findings.	CAA
9	**Safety Recommendation 2011-053** It is recommended that the Civil Aviation Authority (CAA) amends Civil Aviation Publication (CAP) 437, Offshore Helicopter Landing Areas - Guidance on Standards, to encourage operators of vessels and offshore installations, equipped with helidecks, to adopt the new lighting standard, for which a draft specification has been published in Appendix E of CAP 437, once the specification has been finalised.	CAA
10	**Safety Recommendation 2011-054** It is recommended that the Civil Aviation Authority reviews the procedures specified by commercial air transport helicopter operators as to when a crew may or should suspend a radio altimeter aural or visual height warning	CAA
11	**Safety Recommendation 2011-055** It is recommended that the Civil Aviation Authority reviews commercial air transport offshore helicopter operators’ procedures to ensure that an appropriate defined response is specified when a height warning is activated.	CAA
12	**Safety Recommendation 2011-056** It is recommended that the Civil Aviation Authority reviews the procedures set out by commercial air transport offshore helicopter operators to ensure that a member of the flight crew monitors the flight instruments during an approach in order to ensure a safe flight path.	CAA
13	**Safety Recommendation 2011-057** It is recommended that the International Civil Aviation Organisation introduces a Standard for crash-protected recordings of the operational status of Airborne Collision Avoidance System (ACAS) and Terrain Awareness and Warning System (TAWS) equipment, where fitted, on helicopters required to carry a flight data recorder.	Int. CAA
14	**Safety Recommendation 2011-058** It is recommended that the European Aviation Safety Agency requires that crews of helicopters, fitted with a Terrain Awareness and Warning System, be provided with an immediate indication when the system becomes inoperative, fails, is inhibited or selected OFF.	EASA
15	**Safety Recommendation 2011-059** It is recommended that the European Aviation Safety Agency reviews the acceptability of crew-operated ON/OFF controls which can disable mandatory helicopter audio voice warnings.	EASA
16	**Safety Recommendation 2011-060** It is recommended that the Civil Aviation Authority reviews the guidance in Civil Aviation Publication (CAP) 562, Civil Aircraft Airworthiness Information and Procedures, Part 11, Leaflet 11-35, Radio Altimeters and AVADs for Helicopters, regarding the pre-set audio height warning that is triggered by the radio altimeter and may not be altered in flight, to ensure that crews are provided with adequate warning to take corrective action.	CAA
17	**Safety Recommendation 2011-061** It is recommended that the European Aviation Safety Agency ensures that helicopter performance is taken into consideration when determining the timeliness of warnings generated by Helicopter Terrain Awareness and Warning Systems.	EASA
18	**Safety Recommendation 2011-062** It is recommended that the European Aviation Safety Agency reviews the frequency of nuisance warnings generated by Terrain Awareness and Warning System equipment in offshore helicopter operations and takes appropriate action to improve the integrity of the system.	EASA

No.	Recommendation	Address
19	**Safety Recommendation 2011-063** It is recommended that the European Aviation Safety Agency, in conjunction with the Federal Aviation Administration, defines standards governing the content, accuracy and presentation of obstacles in the Terrain Awareness and Warning System obstacle database for helicopters operating in the offshore environment.	EASA FAA
20	**Safety Recommendation 2011-064** It is recommended that the European Aviation Safety Agency establishes the feasibility of recording, in crash-protected memory, status indications from each avionic system on an aircraft.	EASA
21	**Safety Recommendation 2011-065** It is recommended that the European Aviation Safety Agency considers amending certification requirements for rotorcraft, that are certified in accordance with ditching provisions, to include a means of automatically inflating emergency flotation equipment following water entry.	EASA
22	**Safety Recommendation 2011-066** It is recommended that the European Aviation Safety Agency modifies European Technical Standard Order (ETSO) 2C70a and ETSO 2C505 to include a requirement for multi-seat liferafts, that do not automatically deploy their sea anchor, to include a label, visible from within the inflated liferaft, reminding the occupants when to deploy the sea anchor.	EASA
23	**Safety Recommendation 2011-067** It is recommended that the Federal Aviation Administration modifies Technical Standard Order (TSO) C70a to include a requirement for multi-seat liferafts, that do not automatically deploy their sea anchor, to include a label, visible from within the inflated raft, reminding the occupants when to deploy the sea anchor.	FAA
24	**Safety Recommendation 2011-068** It is recommended that the European Aviation Safety Agency requires Eurocopter to review the design of the fairings below the boarding steps on AS332 and EC225 series helicopters to reduce the possibility of fairings shattering during survivable water impact and presenting sharp projections capable of damaging liferafts.	EASA
25	**Safety Recommendation 2011-069** It is recommended that the European Aviation Safety Agency, in conjunction with the Federal Aviation Administration, review the design requirements and advisory material for helicopters for the ‘delethalisation’ of the structure to prevent damage to deploying and floating liferafts following a survivable water impact.	EASA FAA
26	**Safety Recommendation 2011-070** It is recommended that the European Aviation Safety Agency ensures that a requirement is developed for all emergency equipment, stowed in deployable survival bags, to be capable of being easily accessed and utilised by the gloved hands of a liferaft occupant whilst in challenging survival situations when a liferaft may be subject to considerable motion in cold, wet and dark conditions.	EASA
27	**Safety Recommendation 2011-071** It is recommended that the European Aviation Safety Agency reviews the location and design of the components and installation features of Automatically Deployable Emergency Locator Transmitters and Crash Position Indicator units, when required to be fitted to offshore helicopters, to ensure the reliability of operation of such units during and after water impacts.	EASA

Recommendations after the accident 2009-03-12

No.	Recommendation	Address
28	The Federal Aviation Administration, Transport Canada and the European Aviation Safety Agency remove the "extremely remote" provision from the rule requiring 30 minutes of safe operation following the loss of main gearbox lubricant for all newly constructed Category A transport helicopters and, after a phase-in period, for all existing ones.	FAA Transport CA EASA
29	The Federal Aviation Administration assess the adequacy of the 30 minute main gearbox run dry requirement for Category A transport helicopters.	FAA
30	Transport Canada prohibit commercial operation of Category A transport helicopters over water when the sea state will not permit safe ditching and successful evacuation.	Transport CA
31	Transport Canada require that supplemental underwater breathing apparatus be mandatory for all occupants of helicopters involved in overwater flights who are required to wear a Passenger Transportation Suit System.	Transport CA

Recommendations after the accident 2009-04-01

No.	Recommendation	Address
32	**Safety Recommendation 2009-048** It is Recommended that Eurocopter issue an Alert Service Bulletin to require all operators of AS332 L2 helicopters to implement a regime of additional inspections and enhanced monitoring to ensure the continued airworthiness of the main rotor gearbox epicyclic module.	Eurocopter
33	**Safety Recommendation 2009-049** It is Recommended that the European Aviation Safety Agency (EASA) evaluate the efficacy of the Eurocopter programme of additional inspections and enhanced monitoring and, when satisfied, make the Eurocopter Alert Service Bulletin mandatory by issuing an Airworthiness Directive with immediate effect.	EASA
34	**Safety Recommendation 2009-050** It is Recommended that Eurocopter improve the gearbox monitoring and warning systems on the AS332 L2 helicopter so as to identify degradation and provide adequate alerts.	Eurocopter
35	**Safety Recommendation 2009-051** It is recommended that Eurocopter, with the European Aviation Safety Agency (EASA), develop and implement an inspection of the internal components of the main rotor gearbox epicyclic module for all AS332 L2 and EC225LP helicopters as a matter of urgency to ensure the continued airworthiness of the main rotor gearbox. This inspection is in addition to that specified in EASA Emergency Airworthiness Directive 2009-0087-E, and should be made mandatory with immediate effect by an additional EASA Emergency Airworthiness Directive.	Eurocopter EASA
36	**Safety Recommendation 2009-074** It is recommended that the European Aviation Safety Agency, in conjunction with Eurocopter, review the instructions and procedures contained in the Standard Practices Procedure MTC 20.08.08.601 section of the EC225LP and AS332 L2 helicopters Aircraft Maintenance Manual, to ensure that correct identification of the type of magnetic particles found within the oil system of the power transmission system is maximised.	EASA Eurocopter
37	**Safety Recommendation 2009-075** It is recommended that the European Aviation Safety Agency, in conjunction with Eurocopter, urgently review the design, operational life and inspection processes of the planet gears used in the epicyclic module of the Main Rotor Gearbox installed in AS332 L2 and EC225LP helicopters, with the intention of minimising the potential of any cracks progressing to failure during the service life of the gears.	EASA Eurocopter

No.	Recommendation	Address
38	**Safety Recommendation 2011-032** It is recommended that, in addition to the current methods of gearbox condition monitoring on the AS332 L2 and EC225, Eurocopter should introduce further means of identifying in-service gearbox component degradation, such as debris analysis of the main gearbox oil.	Eurocopter
39	**Safety Recommendation 2011-033** It is recommended that Eurocopter review their Continued Airworthiness programme to ensure that components critical to the integrity of the AS332 L2 and EC225 helicopter transmission, which are found to be beyond serviceable limits are examined so that the full nature of any defect is understood.	Eurocopter
40	**Safety Recommendation 2011-034** It is recommended that the European Aviation Safety Agency (EASA) review helicopter Type Certificate Holder's procedures for evaluating defective parts to ensure that they satisfy the continued airworthiness requirements of EASA Part 21.A.3.	EASA
41	**Safety Recommendation 2011-035** It is recommended that the Federal Aviation Administration review helicopter Type Certificate Holder's procedures for evaluating defective parts to ensure that they satisfy the continued airworthiness requirements of Federal Aviation Regulation Part 21.3.0.	FAA
42	**Safety Recommendation 2011-036** It is recommended that the European Aviation Safety Agency (EASA) re-evaluate the continued airworthiness of the main rotor gearbox fitted to the AS332 L2 and EC225 helicopters to ensure that it satisfies the requirements of Certification Specification (CS) 29.571 and EASA Notice of Proposed Amendment 2010-06.	EASA
43	**Safety Recommendation 2011-041** It is recommended that the European Aviation Safety Agency research methods for improving the detection of component degradation in helicopter epicyclic planet gear bearings.	EASA
44	**Safety Recommendation 2011-042** It is recommended that the Civil Aviation Authority update CAP 753 to include a process where operators receive detailed component condition reports in a timely manner to allow effective feedback as to the operation of the Vibration Health Monitoring system.	CAA
45	**Safety Recommendation 2011-043** It is recommended that Eurocopter introduce a means of warning the flight crew, of the AS332 L2 helicopter, in the event of an epicyclic magnetic chip detector activation.	Eurocopter
46	**Safety Recommendation 2011-045** It is recommended that the European Aviation Safety Agency require the 'crash sensor' in helicopters, fitted to stop a Cockpit Voice Recorder in the event of an accident, to comply with EUROCAE ED62A.	EASA
47	**Safety Recommendation 2011-046** It is recommended that the Federal Aviation Administration require the 'crash sensor' in helicopters, fitted to stop a Cockpit Voice Recorder in the event of an accident, to comply with RTCA DO204A.	FAA
48	**Safety Recommendation 2011-047** It is recommended that the Civil Aviation Authority update CAP 739, and include in any future Helicopter Flight Data Monitoring advisory material, guidance to minimise the use of memory buffers in recording hardware, to reduce the possibility of data loss.	CAA

Recommendations after the accidents 2012-05-10 and 2012-10-22

No.	Recommendation	Address
49	**Safety Recommendation 2012-034** It is recommended that the European Aviation Safety Agency requires Eurocopter to review the design of the main gearbox emergency lubrication system on the EC225 LP Super Puma to ensure that the system will provide the crew with an accurate indication of its status when activated.	EASA
50	**Safety Recommendation 2013-006 issued on 18 March 2013** It is recommended that the European Aviation Safety Agency requires the manufacturers of aircraft equipped with a Type 15-503 Crash Position Indicator system, or similar Automatically Deployable Emergency Locator Transmitter, to review and amend, if necessary, the respective Flight Manuals to ensure they contain information about any features that could inhibit automatic deployment.	EASA
51	**Safety Recommendation 2013-007 issued on 18 March 2013** It is recommended that the Federal Aviation Administration requires the manufacturers of aircraft equipped with a Type 15-503 Crash Position Indicator system, or similar Automatically Deployable Emergency Locator Transmitter, to review and amend, if necessary, the respective Flight Manuals to ensure they contain information about any features that could inhibit automatic deployment.	FAA
52	**Safety Recommendation 2014-013** It is recommended that the European Aviation Safety Agency provide Acceptable Means of Compliance (AMC) material for Certification Specification (CS) 29.1585, in relation to Rotorcraft Flight Manuals, similar to that provided for Aeroplane Flight Manuals in AMC 25.1581 to include cockpit checklists and systems descriptions and associated procedures.	EASA
53	**Safety Recommendation 2014-014** It is recommended that the liferaft manufacturer, Survitec Group Limited, revises the Component Maintenance Manual for the Type 18R MK3 liferaft to include clear instructions and diagrams on how to route the rescue pack lines and mooring lines when packing the liferaft.	Lifraft manufacturer
54	**Safety Recommendation 2014-015** It is recommended that the aircraft manufacturer, Eurocopter Group, revise the Super Puma Aircraft Maintenance Manual Task 25-66-01-061 ‘Removal-Installation of the Liferaft Assembly’ to include clear instructions and diagrams on how to route the rescue pack lines and mooring lines when installing the liferaft.	Aircraft manfacturer.
55	**Safety Recommendation 2014-016** It is recommended that the European Aviation Safety Agency review the installation of the Type 18R MK3 liferaft in the EC225 sponson to ensure that there is a high degree of deployment reliability in foreseeable sea conditions.	EASA
56	**Safety Recommendation 2014-017** It is recommended that the European Aviation Safety Agency develop certification requirements for externally mounted liferafts fitted to offshore helicopters which ensure a high degree of deployment reliability in foreseeable sea conditions.	EASA
57	**Safety Recommendation 2014-018** It is recommended that the European Aviation Safety Agency amend the regulatory requirements to require that the long mooring line on liferafts fitted to offshore helicopters is long enough to enable the liferaft to float at a safe distance from the helicopter and its rotor blades.	EASA
58	**Safety Recommendation 2014-019** It is recommended that the European Aviation Safety Agency commission research into the fatigue performance of components manufactured from high-strength low-alloy steel. An aim of the research should be the prediction of the reduction in service-life and fatigue strength as a consequence of small defects such as scratches and corrosion pits.	EASA

Recommendations after the accident 2013-08-23

No.	Recommendation	Address
59	**Safety Recommendation 2013-021** It is recommended that the operator of Sumburgh Airport, Highlands & Islands Airports Limited, provides a water rescue capability, suitable for all tidal conditions, for the area of sea to the west of Sumburgh, appropriate to the hazard and risk, for times when the weather conditions and sea state are conducive to such rescue operations.	Airport operator
60	**Safety Recommendation 2013-022** It is recommended that the Civil Aviation Authority (CAA) review the risks associated with the current water rescue provision for the area of sea to the west of Sumburgh Airport and take appropriate action.	CAA
61	**Safety Recommendation 2016-001:** It is recommended that the European Aviation Safety Agency introduces a requirement for instrument rated pilots to receive initial and recurrent training in instrument scan techniques specific to the type of aircraft being operated.	EASA
62	**Safety Recommendation 2016-002:** It is recommended that the European Aviation Safety Agency reviews the existing research into pilot instrument scan techniques, particularly with respect to glass cockpit displays, with a view to addressing shortcomings identified in current instrument scan training methods.	EASA
63	**Safety Recommendation 2016-003:** It is recommended that the Civil Aviation Authority reviews the methods used by UK North Sea helicopter operators for confirming compliance with their Standard Operating Procedures (SOPs), to ensure they are effective.	CAA
64	**Safety Recommendation 2016-004:** It is recommended that the Civil Aviation Authority reviews the Standard Operating Procedures of helicopter operators supporting the UK offshore oil and gas industry, to ensure their procedures for conducting Non-Precision Approaches are sufficiently defined.	CAA
65	**Safety Recommendation 2016-005:** It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29) to align them with the Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes (CS 25), with regard to the provision of operational information in Flight Manuals.	EASA
66	**Safety Recommendation 2016-006:** It is recommended that the European Aviation Safety Agency requires manufacturers of Large Rotorcraft to develop Flight Crew Operating Manuals for public transport types already in service.	EASA
67	**Safety Recommendation 2016-007:** It is recommended that the Civil Aviation Authority expedites the requirement for companies operating helicopters in support of the UK offshore oil and gas industry to establish a Helicopter Flight Data Monitoring (HFDM) programme.	CAA
68	**Safety Recommendation 2016-008:** It is recommended that the European Aviation Safety Agency considers establishing a European Operators Flight Data Monitoring forum for helicopter operators to promote and support the development of Helicopter Flight Data Monitoring programmes.	EASA
69	**Safety Recommendation 2016-009:** It is recommended that the European Aviation Safety Agency collaborates with National Aviation Authorities and helicopter operators to develop and publish guidance material on detection logic for Helicopter Flight Data Monitoring programmes.	EASA Nat. CAA operators

No.	Recommendation	Address
70	**Safety Recommendation 2016-010:** It is recommended that the Civil Aviation Authority, in co-operation with UK offshore helicopter operators, initiates a review of existing Helicopter Flight Data Monitoring programmes to ensure that operating procedures applicable to approaches are compared with those actually achieved during everyday line flights.	CAA operators
71	**Safety Recommendation 2016-011:** It is recommended that the Civil Aviation Authority expedites the publication of the Helicopter Safety Research Management Committee report into improving warning envelopes and alerts.	CAA
72	**Safety Recommendation 2016-012:** It is recommended that the Civil Aviation Authority supports the ongoing development of Helicopter Terrain Awareness Warning Systems, following the publication of the Helicopter Safety Research Management Committee report into improving warning envelopes and alerts.	CAA
73	**Safety Recommendation 2016-013:** It is recommended that the European Aviation Safety Agency requires the installation of Helicopter Terrain Awareness Warning Systems to all helicopters, used in offshore Commercial Air Transport operations, with a Maximum Certificated Take-off Mass (MCTOM) of more than 3,175 kg, or a Maximum Operational Passenger Seating Configuration (MOPSC) of more than nine, manufactured before 31 December 2018.	EASA
74	**Safety Recommendation 2016-014:** It is recommended that the European Aviation Safety Agency introduces a requirement for the installation of cockpit image recorders, in aircraft required to be equipped with Flight Data and cockpit Voice Recorders, to capture flight crew actions within the cockpit environment.	EASA
75	**Safety Recommendation 2016-015:** It is recommended that the European Aviation Safety Agency introduces a requirement to install image recorders, capable of monitoring the cabin environment, in aircraft required to be equipped with Flight Data Recorder and Cockpit Voice Recorders.	EASA
76	**Safety Recommendation 2016-016:** It is recommended that the European Aviation Safety Agency instigates a research programme to provide realistic data to better support regulations relating to evacuation and survivability of occupants in commercial helicopters operating offshore. This programme should better quantify the characteristics of helicopter underwater evacuation and include conditions representative of actual offshore operations and passenger demographics.	EASA
77	**Safety Recommendation 2016-017:** It is recommended that, where technically feasible, the regulatory changes introduced by the European Aviation Safety Agency Rulemaking Task RMT.120 are applied retrospectively by the EASA to helicopters currently used in offshore operations.	EASA
78	**Safety Recommendation 2016-018:** It is recommended that the European Aviation Safety Agency amends the Certification Specifications for rotorcraft (CS 27 and 29) to require the installation of systems for the automatic arming and activation of flotation equipment. The amended requirements should also be applied retrospectively to helicopters currently used in offshore operations.	EASA
79	**Safety Recommendation 2016-019:** It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29), certified for offshore operation, to require the provision of a side-floating capability for a helicopter in the event of impact with water or capsize after ditching. This should also be applied retrospectively to helicopters currently used in offshore operations.	EASA
80	**Safety Recommendation 2016-020:** It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29), certified for offshore operation, to ensure that any approved cabin seating layouts are designed such that, in an emergency (assuming all the exits are available), each exit need only be used by a maximum of two passengers seated directly adjacent to it.	EASA

No.	Recommendation	Address
81	**Safety Recommendation 2016-021:** It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29), certified for commercial offshore operations, to include minimum size limitations for all removable exits, to allow for the successful egress of a 95th percentile-sized offshore worker wearing the maximum recommended level of survival clothing and equipment.	EASA
82	**Safety Recommendation 2016-022:** It is recommended that the European Aviation Safety Agency amends the Certification Specifications for Large Rotorcraft (CS 29), certified for use in commercial offshore operations, to require a common standard for emergency exit opening mechanisms, such that that the exit may be removed readily using one hand and in a continuous movement.	EASA
83	**Safety Recommendation 2016-023:** It is recommended that the European Aviation Safety Agency amends the operational requirements for commercial offshore helicopters to require the provision of compressed air emergency breathing systems for all passengers and crew.	EASA
84	**Safety Recommendation 2016-024:** It is recommended that the European Aviation Safety Agency (EASA) amends the operational requirements for commercial offshore helicopter operations, to require operators to demonstrate that all passengers and crew travelling offshore on their helicopters have undertaken helicopter underwater escape training at an approved training facility, to a minimum standard defined by the EASA.	EASA
85	**Safety Recommendation 2016-025:** It is recommended that the European Aviation Safety Agency amends the design requirements for helicopters to ensure that where liferafts are required to be fitted, they can be deployed readily from a fuselage floating in any attitude.	EASA
86	**Safety Recommendation 2016-026:** It is recommended that the European Aviation Safety Agency requires that, for existing helicopters used in offshore operations, a means of deploying each liferaft is available above the waterline, whether the helicopter is floating upright or inverted.	EASA

Appendix C: Actions and recommendations in CAP 1145

Actions for CAA

No.	Recommendation
A1	The CAA will establish and lead a new offshore operations safety forum to work for a substantial improvement in the safety of helicopter operations on the UK continental shelf.
A2	The CAA will accelerate its work with industry to develop and apply Safety Performance Indicators to improve the effectiveness of helicopter operators' Flight Data Monitoring programmes.
A3	The CAA will analyse lower risk occurrences (i.e. serious incidents and incidents) for the main areas of risk, technical and external cause occurrences in particular, in order to increase the 'resolution' of the analysis. This analysis will take the form of a rolling annual review of the last five years of occurrence reports.
A4	The CAA will work with the helicopter operators via the newly established Helicopter Flight Data Monitoring (FDM) User Group to obtain further objective information on operational issues from the FDM programme.
A5	With effect from 01 June 2014, the CAA will prohibit helicopter operators from conducting offshore flights, except in response to an offshore emergency, if the sea state at the offshore location that the helicopter is operating to/from exceeds sea state 6 in order to ensure a good prospect of recovery of survivors.
A6	With effect from 01 September 2014, the CAA will prohibit helicopter operators from conducting offshore flights, except in response to an offshore emergency, if the sea state at the offshore location that the helicopter is operating to/from exceeds the certificated ditching performance of the helicopter.
A7	With effect from 01 June 2014, the CAA will require helicopter operators to amend their operational procedures to ensure that Emergency Floatation Systems are armed for all over-water departures and arrivals
A8	With effect from 01 June 2014, the CAA will prohibit the occupation of passenger seats not adjacent to push-out window emergency exits during offshore helicopter operations, except in response to an offshore emergency, unless the consequences of capsize are mitigated by at least one of the following: a) all passengers on offshore flights wearing Emergency Breathing Systems that meet Category 'A' of the specification detailed in CAP 1034 in order to increase underwater survival time; b) fitment of the side-floating helicopter scheme in order to remove the time pressure to escape.
A9	With effect from 01 April 2015, the CAA will prohibit helicopter operators from carrying passengers on offshore flights, except in response to an offshore emergency, whose body size, including required safety and survival equipment, is incompatible with push-out window emergency exit size.
A10	With effect from 01 April 2016, the CAA will prohibit helicopter operators from conducting offshore helicopter operations, except in response to an offshore emergency, unless all occupants wear Emergency Breathing Systems that meet Category 'A' of the specification detailed in CAP 1034 in order to increase underwater survival time. This restriction will not apply when the helicopter is equipped with the side-floating helicopter scheme.
A11	The CAA will organise and chair an operator symposium on Safety Management to identify generic hazards, mitigations and Safety Performance Indicators for offshore operations.
A12	The CAA will review whether operations should continue at helidecks where the overall dimensions and/or loading values as notified for the helideck are insufficient to accommodate the helicopter types in use and take the necessary action.
A13	The CAA intends to assume responsibility for the certification of UK helidecks and will consult with industry to achieve this.
A14	The CAA will review the conditions applicable to the issue of offshore 'exposure' approvals with a view to making them appropriate to the intended types of operation.
A15	The CAA will commission a report to review offshore communication, handling and flight monitoring procedures from an air traffic control perspective and act on its outcomes.
A16	The CAA will, with industry, review the instrument flying training element for all EFIS-equipped offshore helicopter type rating courses to be satisfied that candidates have a firm understanding of the displays and techniques required for basic instrument flight. The CAA will propose to EASA any necessary improvements to the syllabus requirements.
A17	The CAA will review all helicopter AOC recurrent training programmes to ensure that basic instrument flight skills are maintained so that crews can readily deal with manual flight if required.

No.	Recommendation
A18	The CAA will review the requirement for instructor tutor training and, if appropriate, make proposals to EASA to incorporate within Part-Aircrew.
A19	The CAA will examine the output of its review into the safety of large UK commercial air transport aeroplane operations for relevance and applicability to ensure that any appropriate safety initiatives have been extended to the offshore helicopter environment.
A20	The CAA will amend its examiner assessment protocols (CAA Standards Document 24) to require specific 'de-identified' candidate performance indicators so that any trends in common failings are visible for proactive attention.
A21	The CAA will review the pilot recency requirements for helideck operations that have been incorporated into the draft requirements for the EASA Ops Specific Approval for Offshore Helicopter Operations and require operators to implement them to an agreed schedule.
A22	The CAA will review helicopter operators' safety cases for night operations to bow decks to assess operator procedures and mitigations and determine whether such operations should continue.
A23	The CAA will continue to develop its working relationship with EASA, in particular in the areas of sharing airworthiness information and the management of operator in-service issues. This will be achieved by periodic meetings and reviews with the appropriate EASA and CAA technical staff.
A24	The CAA will review CAA Paper 2003/1 (Helicopter Tail Rotor Failures) to determine how well the recommendations have been taken forward and to assess if further action is necessary. The conclusions of this review will be discussed with EASA.
A25	The CAA will review the human performance aspects of flight crew responses to engine bay fire warnings, specifically within the offshore operations environment.
A26	CAA Airworthiness will meet with offshore operators periodically to compare the trends of MORs with operator inservice difficulty / reliability data to ensure that the complete risk picture is captured, addressed and that the desired outcomes are being achieved.
A27	The CAA will focus on Vibration Health Monitoring (VHM) download procedures, system/component reliability, the handling of VHM management of alerts and defects during audits of UK offshore operators.
A28	The CAA will review CAP 753 to clarify alert generation and management, to ensure it is consistent and a system of amber/red warning thresholds is established to allow maintenance staff to identify the severity of the alert.
A29	The CAA will work with operators and their contracted engine and component maintainers to review processes that define when strip reports are required and determine necessary improvements to assure these are provided and thus ensure that potential safety information is not lost.
A30	The CAA will carry out a further review of Human Factors Maintenance Error data referred to in this report and publish the results to seek improvements in this important area.
A31	The CAA will form an Offshore Maintenance Standards Improvement Team with the offshore helicopter operators with the objective of reviewing the findings at Annex F to the CAA Strategic Review of the Safety of Offshore Helicopter Operations and making proposals to achieve a step change in maintenance standards.
A32	The CAA will: • promote and support the implementation of the results of the research on helideck lighting, operations to moving helidecks, Differential GPSguided offshore approaches and helicopter terrain awareness warning systems; • seek to ensure funding for the research on operations to moving helidecks, Differential GPS-guided offshore approaches and helicopter terrain awareness warning systems to allow timely progress to completion and once completed promote and support the implementation of the results.

SINTEF

Recommendations to EASA

No.	Recommendation
R1	It is recommended that EASA leads the development of a management systemthat provides a structured review of all accident and serious incident reports and recommendations of helicopters operating offshore or events which could have led to a ditching if the helicopter had been over water. This should be done in collaboration with other North Sea NAAs and the CAA to ensure a cohesive assessment of both accident causes (looking for trends) and remedies (looking for suitability and effectiveness) in order to prevent the segregated nature of accident reviews and ensure there is continuity to the safety reviews.
R2	It is recommended that EASA involve NAAs annually in a forum to agree and exchange information on the performance of safety actions taken in line with accident and serious incident investigation recommendations and potential other improvements that could be adopted, where appropriate.
R3	It is recommended that EASA introduces procedures to monitor and track the efficiency and reliability of maintenance interventions when these are used during the certification activity to assure the safety target of the rotorcraft.
R4	It is recommended that EASA ensures that the Type Certificate Holder completes a design review following a failure or malfunction of a component or system on any other similar feature on that aircraft type or any other type in their product line and defines appropriate corrective actions as deemed necessary.
R6	It is recommended that the EASA Helicopter Ditching and Survivability RMT.0120 consider making safety and survival training for offshore passengers a requirement.
R12	It is recommended that EASA require helicopter manufacturers, in conjunction with the major operators of the type and NAAs, to review their recommended training material so that pilots are better prepared for operating modern highly complex helicopters.
R20	It is recommended that EASA / Type Certificate Holder confirm the number of false engine fire warnings on offshore helicopters, investigate the reasons for them and determine what actions to take to address this important safety issue.
R22	It is recommended that EASA initiate a rulemaking task to adopt the critical parts life monitoring and assessment requirements of Certification Specifications for Engines (CS-E) for large transport rotorcraft, currently subject to CS-29, including retrospective application. This should cover at least for the following areas: i) Residual stress assessments ii) Vibratory stress measurements iii) Manufacturing plan iv) Laboratory examination of time expired part
R23	It is recommended that EASA revise CS-29.602 for large transport rotorcraft intended to operate over hostile sea conditions for extended periods of time, to ensure the failure mode effects and criticality analysis process used to identify critical parts recognises that a safe ditching may not always be possible.
R24	It is recommended that EASA provide additional guidance material to improve standardisation in approach to the classification of critical parts to minimise inconsistencies in the instructions for continuing airworthiness and where appropriate to require revisions to existing Instructions for Continued Airworthiness.
R25	It is recommended that EASA consider developing requirements that could be applied to helicopters which carry out Offshore Operations in hazardous environments in a similar fashion to those used for aeroplane Extended Operations and All Weather Operations.
R26	It is recommended that EASA establish a forum for discussion for best practice and developments on Vibration Health Monitoring (VHM). This forum should include NAAs, operators and VHM manufacturers. The CAA expects that this could be achieved by the end of 2014.
R27	It is recommended that EASA review AMC 29.1465 to clarify alert generation and management, to ensure it is consistent and a system of amber/red warning thresholds is established to allow maintenance staff to identify the severity of the alert.

SINTEF

Recommendations to the helicopter industry

No.	Recommendation
R5	CAA expects that offshore helicopter operators will address the following key items from the EASA RMT.0120 (27 & 29.008) draft NPA without delay: • Fitment of the side-floating helicopter scheme. • Implementation of automatic arming/disarming of Emergency Floatation • Equipment. • Installation of hand holds next to all push-out window emergency exits. • Standardisation of push-out window emergency exit operation/marking/lighting across all offshore helicopter types. • Ensure that external life rafts can be released by survivors in the sea in all foreseeable helicopter floating attitudes. • Ensure that all life jacket/immersion suit combinations are capable of self-righting
R9	The CAA expects the offshore helicopter operators to apply the riskreduction methodology detailed in CAP 437 (Standards for Offshore Helicopter Landing Areas) for operations to Normally Unattended Installations to ensure that the foreseeable event of a crash with fire is appropriately mitigated.
R10	It is recommended that offshore helicopter operators identify a set of 'best practice' standard procedures and engage with their customers to agree how these may be incorporated into contractual requirements.
R13	It is recommended that Approved Training Organisations and helicopter AOC holders adopt the aircraft manufacturers' operating philosophies and recommended practices, where available, within their type syllabi and current training and checking programmes with particular emphasis on automation. This information should also be reflected in instructor guidance so that specific learning points for the automated systems are addressed in a standard manner
R14	It is recommended that Approved Training Organisations and helicopter AOC holders review their type rating syllabi and recurrent training programmes to ensure that Standard Operating Procedures and monitoring pilot techniques are included at all appropriate stages of the type rating course, operator conversion courses and recurrent training/checking.
R15	It is recommended that Approved Training Organisations and helicopter AOC holders review their training syllabi to ensure that the correct use and emphasis upon Standard Operating Procedures is impressed upon crews throughout all stages of flight and simulator training.
R16	It is recommended that Approved Training Organisations and helicopter AOC holders address with aircraft manufacturers any shortfall in the Operational Suitability Data training syllabi for those destined to operate the type offshore.
R17	It is recommended that AOC holders, in conjunction with the CAA, develop an Alternative Means of Compliance to introduce the option of Alternative Training and Qualification Programme, as permitted for aeroplanes in accordance with ORO.FC.A.245.
R18	It is recommended that Approved Training Organisations work with AOC holders to ensure that their Synthetic Flying Instructors have current operational knowledge of the type(s) on which they instruct.
R19	It is recommended that Approved Training Organisations and helicopter AOC holders establish a requirement for training record narratives.
R21	It is recommended that the helicopter Type Certificate Holder identify all major components or systems that lead to a land immediately condition to ensure themselves that the actual reliability data available from the operators is validating the assumptions made at the time of certification. This review should be overseen by the regulator for the State of Design.
R28	It is recommended that the UK Met Office and the helicopter operators fully implement the triggered lightning forecasting system, subject to satisfactory performance during the present in-service trials

Recommendations to the oil and gas industry

No.	Recommendation
R7	The CAA expects that OPITO will review and enhance its safety and survival training standards with regard to the fidelity and frequency of training provided.
R8	The CAA expects the oil and gas industry to incorporate the fire-fighting provisions detailed in CAP 437 (Standards for Offshore Helicopter Landing Areas) for Normally Unattended Installations without further delay.
R11	The CAA expects that the oil and gas industry will review its audit and inspection practices to harmonise and pool audit schemes to reduce the impact on helicopter operators following the principles described in the Oil & Gas UK Guidelines for the Management of Aviation Operations.

Recommendations to all

No.	Recommendation
R29	It is recommended that the offshore oil and gas industry, helicopter operators, helicopter manufacturers and regulators: • continue to support the helicopter safety research programme • establish a less labour intensive, more regularised arrangement between participating organisations for the funding of research projects • establish, via Oil & Gas UK, a faster and more focused approach to implementation of successful research projects. This should be in addition to and in advance of the enhancement of the aviation rules and guidance material.

SINTEF

Technology for a better society

www.sintef.no