Developments in Norwegian Offshore Helicopter Safety

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Experience

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Introduction

On Friday 23rd of August 2013 an AS332L2 crashed during a non-precision instrument approach to Sumburgh Airport, Shetland. The crash initiated panic within UK Oil and Gas industry, demanding grounding of the Super Puma fleet of helicopters.

Four people died when the CHC Super Puma crashed on approach to Sumburgh Airport on 23 August 2013.

All Super Puma helicopter passenger flights to UK oil installations were suspended after a crash off Shetland claimed the lives of four people.
The Helicopter Safety Steering Group (HSSG) had advised grounding all variants of the helicopter.

The HSSG, which is made up of oil industry representatives, advised that all models of the Super Puma series including: AS332 L, L1, L2 and EC225 should be grounded for "all Super Puma commercial passenger flights to and from offshore oil and gas installations within the UK."

The Norwegian civil aviation authority had earlier rejected appeals from its unions to ground all its Super Pumas – which operate in the North Sea in very similar weather conditions to the UK fleet – insisting that Friday's crash was an isolated incident.

Geir Hamre, chairman of the Norwegian helicopter safety committee, told the Guardian: "We can't connect this to any similar accident previously, and that is the reason why we say it's an isolated case and have decided not to stop them flying." [1]

The Norwegian CAA consulted with Norwegian offshore operators and did not see any technical reason to demand a drastic grounding of the fleet of Super Pumas. However, the oil workers unions in Norway became very skeptical to the type based on 5 accidents in the UK sector since 2009.

The unions wanted the offshore operators to phase out the older Super Pumas of the type AS332L/L1/L2 and standardize on so called "New Technology" helicopters like S-92 and EC225.

This was based on subjective and emotional considerations which had no basis in reality. In fact Norway had not had any offshore accidents with Super Puma helicopters since the Norne accident in 1997 (AS332L1), and the newer version AS332L2 had not been involved in any fatal accident in Norwegian operations. In fact it could be looked at as the safest offshore helicopter introduced in Norwegian operations at the time. The author was Project Pilot and later Chief Technical Pilot during the introduction of all new helicopter types in Helikopter Service between 1981 and 2000, and the AS332L2 was the type with least teething technical problems during the introduction.

[1] Internet Thursday 29 August 2013. http://www.theguardian.com/world/2013/aug/29/super-puma-helicopters-cleared-fly-shetland

The UK Helicopter Safety Steering Group had cleared all Super Puma helicopters to return to service in the North Sea by 29 August 2013, nearly a week after a fatal crash off Shetland left four oil workers dead. .

<u>UK Aircraft Accident Investigation Branch (AAIB)</u>

The AAIB quickly analysed the helicopter Voice Recorder and Flight Data Recorder which indicated no technical malfunctions.

An AAIB preliminary report issued earlier on Thursday confirmed the Super Puma had entered the water "intact and upright", but then smashed into the rocks off Garths Ness, broke up and rolled onto its side.

"The evidence currently available suggests that the helicopter was intact and upright when it entered the water. It then rapidly inverted and drifted northwards towards Garths Ness. The helicopter was largely broken up by repeated contact with the rocky shoreline.[2]

All Super Puma helicopters have been cleared to return to the skies less than a week after the North Sea accident off Shetland that claimed the lives of four offshore workers.
The Helicopter Safety Steering Group will begin a "boots-on" campaign to restore the confidence of the workforce in the helicopter fleet following the latest ditching incident.

The HSSG said helicopter operators are satisfied there is no reason to believe there is an inherent mechanical problem with any of the Super Puma models.

<u>UK CAA response</u>

UK CAA responded by setting up a Helicopter Safety Review Panel:

[2] Internet 29 August 2013

The operations of helicopters in the North Sea are to be reviewed in the wake of recent accidents, the Civil Aviation Authority has announced.
The regulator said it would work with its Norwegian counterpart and the European Aviation Safety Agency to draw up a report, which it expects to publish early next year.
It will examine areas including helicopter airworthiness and training.

"The review we are announcing today will thoroughly examine the risks and hazards of operating in the North Sea and how these can be managed most effectively."
He added: "We are extremely grateful to Geir Hamre from the Norwegian CAA and the European Aviation Safety Agency for joining the review team.They bring additional expertise and experience which will be invaluable to the review."

UK North Sea Accidents

- *August 2013 - Four people died when a Super Puma AS332 L2 crashed into the sea as it approached Shetland. The investigation is ongoing.*
- *October 2012 - All 19 people on board a Super Puma EC225 were rescued safely after it put down in the sea off Shetland. The incident was caused by a cracked shaft in the main gearbox.*
- *May 2012 - All 14 people on board a Super Puma EC225 were rescued when it came down about 30 miles off the coast of Aberdeen during a flight to an oil rig.*
- *April 2009 - All 14 passengers and two crew on board a Super Puma AS332 L2 lost their lives after it came down in the North Sea. Eight of the victims came from the north east of Scotland, seven from the rest of the UK, and one from Latvia.*
- *February 2009 - A Super Puma EC225 ditched in fog a short distance from a BP oil platform in the ETAP field, 125 miles east of Aberdeen. All 18 people on board survived. Crew error and a faulty alert system were blamed.*[3]

CAP1145: Civil Aviation Authority – Safety review of offshore public transport helicopter operations in support of the exploitation of oil and gas[4]

Tha CAP1145 report was published 20 February 2014. From the report is extracted:

Chapter 6
Comparison with Norway
6.1 The UK occurrence data was compared to the equivalent data for Norwegian offshore helicopter operations. The comparison was constrained by the data that was readily available from Norway; however, the following conclusions were drawn:

In the period 1992 to 2012, the Norwegians suffered 1 fatal accident against 6 in the UK sector. In terms of the fatal accident rate this equates to:

UK	*6*	*1,754,512*	*0.34*
Norway	*1*	*926,926*	*0.11 (Norne accident)*

Although the accident rates may, at face value, appear to indicate a

[3] Internet 24 September 2013
[4] Internet 20 February 2014

difference in level of safety performance between Norwegian and UK operations, ***the application of a range of statistical tests indicates that the difference is not statistically significant.***
Overall, comparison of the Norwegian and UK occurrence data indicates similar patterns.

8.3.3 It is notable that, from 2008 onwards, despite having a much smaller fleet (in 2012, there were 56 offshore helicopters in operation in Norway compared to 95 in operation in the UK), there have been more occurrence reports for Norwegian operations than the UK sector. ***This could reflect a greater occurrence rate or it could be indicative of a better reporting culture.*** *In view of the smaller size of the Norwegian operation, it is the CAA's opinion that the latter explanation is more plausible.*

Norwegian CAA Response

Norwegian CAA was skeptical to several of the UK CAA Review Board's recommendations:

Authorities in Norway have criticised some of the changes to the UK's offshore helicopter industry which are being introduced this week.
The Norwegian Civil Aviation Authority (NCAA) said it has no plans to duplicate the 32 safety improvements planned for Scottish offshore helicopters.
The Scandinavian country has not seen a serious helicopter crash since (1997 Norne. ed). *Over the same period there have been five crashes in UK waters.*
Since a helicopter crash last year off Shetland, in which four people died, UK aviation authorities have been looking to improve safety.
The Civil Aviation Authority (CAA) published a report which contained 32 improvements.
But the NCAA is not planning to replicate any of them.
Roy Erling Furre, second deputy leader with the Safe Union which represents oil workers, said: "I think people would be more worried about working in the UK sector.
"It's the safety level, both in the helicopter and offshore."[5]

[5] Internet 2 June 2014

The Norwegian Civil Aviation Authority has dismissed the new safety changes for Scottish offshore helicopters.

Management Culture

UK Management Culture

UK CAA states that there is no difference between UK and Norwegian offshore operations or policy. However, could it be a difference in Safety Culture?
Technically there seem to be no difference between UK and Norwegian offshore operations. Both UK and Norwegian sectors have been working methodically to reduce the risk of accidents. However, there is one difference and that is company and management cultures. The Norwegian industrial culture is based on a flat management structure and more open and democratic with union involvement, whereas the British industrial management culture has a more vertical and closed structure with less union influence, similar to North American culture. When the author started with Helicopter Service in 1981 there were 22 British contract pilots flying for Helikopter Service. These pilots had been fired by Bristow due to an industrial dispute. We had industrial disputes with strikes and stand downs in Helikopter Service as well, but they were all solved over time.

Similarly, the Norwegian cockpit culture is reflected by the Management Culture, with quite an influence by the Pilot Unions. This has led to a quite flat cockpit command gradient, allowing the co-pilots more influence on the control of the aircraft. British cockpit command gradient has been steeper. An example of this may be a serious incident in Helikopter Service in the early 1980-ties. A Sikorsky S-61N was on an approach to a helideck in low visibility. The captain was PF and the co-pilot PM. The captain had started the visual descent from 200 ft Rad Alt but lost sight of the helideck. The airspeed dropped and they started to loose altitude. The captain increased collective to the stop but the speed dropped further and the helicopter developed Vortex Ring State and was descending with over torque. The co-pilot noticed in his corner of his eyes that the large white needle on his VSI was pointing downward and they had only been at 200 ft. Without saying a word he just grabbed the stich and pushed it forward. Immediately the helicopter accelerated forward and started a steep climb and they were saved. If the co-pilot had just warned the captain according to the standard procedure, they would have crashed in the sea. This incident may in some way be similar to the Shetland accident.

Management culture will to a large extent influence the company working environment. An example may be CHC Helicopter Service. Around 2000 Helicopter Service was taken over by CHC Helicopters of Canada. This company soon enforced North American management culture upon the Norwegian company. This may have had negative effects on the working environment of today's CHC Helikopter Service. The British management culture seems to be similar to the North American, which does not function well in Norway.

Norwegian Offshore Safety Culture

The Norwegian offshore safety culture is developed over time since Helikopter Service pioneered the offshore helicopter operations in 1966. The safety culture is very much influenced by the Norwegian open and inclusive management culture.
At the time large scale helicopter passenger transport was new and the helicopter types of that area, the Sikorsky S-61N and Bell 212, were not overall proven in large scale operations. Hence, as these types accumulated flight time, technical problems surfaced. This caused the sole Norwegian operator Helikopter Service to initiate the forming of the European Helicopter Operator Committee (EHOC). Helikopter Service President Morten Hanche became the first Chairman of the group and initiated a campaign against the manufacturers to get them to improve the safety of the helicopters. This engagement in international safety work became a tradition in Helikopter Service, leading to involvement in the European Helicopter Association (EHA) where several of Helikopter Service personnel were involved. Helikopter Service was the sole Norwegian helicopter operator that invested time and money in EHA and became the Norwegian Member of the EHA. These engagements led to a positive development of the safety culture within Helikopter Service.

Some Significant Norwegian Offshore Accidents and Incidents that influenced Safety Culture Developments

Norwegian offshore accidents and incidents.

The Norwegian offshore helicopter accidents during the 1970-ies sparked an intensive safety focus which led to many improvements. Below are listed the early passenger transport accidents in the Norwegian offshore sector:

1. 9 July 1973 North Sea, 80 NM SSW of Stavanger Airport. Sikorsky S-61N Offshore flight 15/2 (17) 4/1/12 Ditching due to Tail Rotor failure.

This accident was triggered by loss of a tail rotor blade. The crew initiated an autorotation but the helicopter capsised during the water landing. Sikorsky modified the tail rotor and it became mandatory for passengers to wear survival suits.

2. 23 November 1977 North Sea, 45 NM SSW of Stavanger Airport Sola. Sikorsky S-61N Offshore flight 10/2 (12) 12/0/0. Collided with the Sea at cruise speed and slight descent. Cause unknown.

The flight was an early morning flight from Forus heliport. The Aircraft Accident Board did not conclude on a cause, but it was a general belief among Helikopter Service pilots at the time that the crew had fallen asleep and not noticed that the helicopter was descending from the low cruise altitude of 500 feet. The S-61N did not have an autopilot with altitude hold and the PF had to control the altitude. The accident resulted in addition of warning on the radar altimeter and recommended cruise altitude to 1000 ft on radio altimeter. Helikopter Service was at the time in rapid expansion requiring intensive pilot training. Hence, the company had already ordered a flight simulator which was one of the first helicopter simulators in Europe.

3. 26 June 1978 North Sea, 85 NM WNW of Bergen Airport Flesland. Sikorsky S-61N Offshore flight16/2 (18) 18/0/0. Dropped into the sea from 1 000 feet altitude. Fatigue crack caused a MRB spindle to fail causing the MRB to fall off. [6]

This accident was caused by a cracked main rotor blade Spindle causing the blade to fall off. The accident investigations concluded that the crack was caused by metal fatigue. However, the Norwegian Accident Board did not conclude on the initiation of the fatigue crack. DNV concluded in a later test report that the crack was initiated by tiny “stress instability cracks” in the Spindle. These “instability cracks” were most probable caused by peak stress overload during practiced single engine landing (OEI) training at Forus heliport. Helikopter Service was in a period of heavy expansion and there were many new pilots going through transition training. During this time Helikopter Service installed an S-61N simulator at Forus heliport which resulted in much reduced wear and tear on the helicopters. This simulator was a huge boost in helicopter safety and resulted in a very professional and safety conscious pilot corps. It is important to notice that at the time there was no NCAA requirement for helicopter simulator training.

4. 19 April 1983 on M/V Buchentaur. Bell 212 Offshore flight. 4/2 (6) 0/0/6. Rolled over during lift off. Dynamic roll over caused by RH skid hooked up in the deck rope net.[7]

For many years Norwegian offshore regulations (BSL D 5-1) required offshore helidecks to have friction rope nets. These rope nets were looked at as safety risks. People could stumble and fall and helicopter skids and tail hooks could hook up. This is what caused the accident and Helikopter Service modified the B 212 skids so they could not hook up in the net. Helicopter Service tried without success, for many years to get NCAA to specify alternate means of deck friction. Helikopter Service wanted the regulations to mandate alternate friction means.

In 2006 AIBN issued report SL 24/2006 after a serious incident with an AS332L1 tail hook net hook up with a recommendation to specify alternate means of friction surface on helidecks[8]. The revised BSL D 5-1 regulation of 2007 still specified rope nets, even if it was allowed to deviate within certain conditions.[9]

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[6] http://www.aibn.no/Luftfart/Rapporter/1980-01
[7] http://www.aibn.no/Luftfart/Rapporter/1984-01
[8] http://www.aibn.no/Luftfart/Rapporter/2006-24?ref=1713

[9]

http://www.ptil.no/getfile.php/z%20Konvertert/Produkter%20Og%20Tjenester/Regelverket/Dokumenter/forslag_ny_forskrift.pdf

Serious incident with LN-ONI on Transocean Searcher in the North Sea 8 January 2004 operated by Norsk Helikopter. Extract form the AIBN report 2006-24[10]:

2.4 Bruk av taunett på helikopterdekk

2.4.1 Alternativ friksjonsløsning

Ref. 1.18.1.2. Krav om taunett på offshore helikopterdekk er et gammelt krav som har vært gjeldende siden 1960-årene. Til tross for tidligere ulykke og tidligere tilrådinger fra helikopteroperatørene om å finne alternative friksjonsløsninger, har dette kravet blitt stående. SHT mener det er flere eksempler på alternative friksjonsløsninger som kan brukes på både faste og bevegelige helikopterdekk. Dette kan gi bedre friksjon enn taunett, og det vil eliminere muligheten for å hekte seg fast i helikopteret. Samtidig vil det redusere faren for personskader under opphold på dekket. Det er flere eksempler på at personell har snublet i knuter på taunett. Videre vil det eliminere problemer man har i dag med å transportere last og bagasje til og fra et helikopter på dekk med taunett.

2.8 Myndighetenes ansvarsfordeling

2.8.1 NOU 2001:21

2.8.1.1 Havarikommisjonen vurderer at denne hendelsen og påfølgende undersøkelser (ref. 1.17.3 og 1.18.6, samt Ptils rapport) indikerer at det fortsatt hersker uklarheter med hensyn til myndighetenes ansvarsfordeling omkring helikopteroperasjoner på norsk sokkel.

2.8.2.3 Etter denne hendelsen valgte Ptil å iverksette gransking av hendelsen. Det vises til Ptils rapport *"Rapport etter gransking av helikopterhendelsen på Transocean Searcher 8.1.2004"*. Ref. 1.18.6.

2.8.2.4 Havarikommisjonen finner det naturlig at Petroleumstilsynet er opptatt av sikker helikoptertransport offshore. Imidlertid kan Ptils involvering i luftfartshendelser være med på å forsterke allerede eksisterende uklarheter med hensyn til myndighetenes ansvarsfordeling. Luftfartstilsynet er i all hovedsak myndighetenes forvalter av Luftfartsloven. Herunder ligger alle forhold som gjelder lufttrafikk, inkludert forhold tilknyttet landingsplasser og tilhørende personellopplæring. SHT mener at dette ansvaret også dekker offshoreoperasjoner med godkjennelse av opplæring av personell tilknyttet helikopteroperasjoner.

2.8.2.5 SHT er gitt mandat til å undersøke luftfartsulykker, alvorlige luftfartshendelser og luftfartshendelser innen sivil luftfart. SHT fremmer sikkerhetstilrådinger til Samferdselsdepartementet. Samferdselsdepartementet besørger at sikkerhetstilrådinger blir forelagt luftfartsmyndigheten (Luftfartstilsynet) og/eller andre berørte departementer til vurdering og oppfølging, jf. *"Forskrift om offentlige undersøkelser av luftfartsulykker og luftfartshendelser innen sivil luftfart, § 17"*.

2.8.2.6 Ptils granskingsrapport etter hendelsen på Transocean Searcher setter søkelyset på mange problemstillinger omkring offshore helikoptertransport og kan følgelig være nyttig som et referansedokument. Imidlertid kan det reises tvil om hvilket myndighetsorgan som skal være mottager av rapporten og dermed ansvarlig for oppfølging av rapportens mange "Eksempler på tiltak".

[10] http://www.aibn.no/Luftfart/Rapporter/2006-24

In 2007 NCAA revised the offshore regulations but maintained the requirement for rope net in spite of advice from offshore operators and AIBN. Extract from BSL D 5-1 (2007):[11]

§ 16. Friksjon

(1) Helikopterdekket skal ha en overflate som motvirker at helikopteret glir (non-skid), også når dekket er fuktig eller vått. Friksjonskoeffisienten skal være minst 0,40 eller høyere.

(2) Helikopterdekket skal, i tillegg til kravet i første ledd, være utstyrt med taunett.

(3) Taunettets størrelse bestemmes av det største helikopter som benyttes. Minste størrelse skal være:

a) Lite helikopter: 6 x 6 meter ev. 6 m diameter.

b) Middels helikopter: 12 x 12 meter ev. 12 m diameter.

c) Stort helikopter: 15 x 15 meter ev. 15 m diameter.

(4) Maskene i nettet må være slik dimensjonert at de ikke hekter seg fast i helikopteret.

(5) Taunett skal være festet for hver 1,5 meter. For å sikre at taunettet holdes tilstrekkelig stramt, skal minst 50 % av fastgjøringene være utstyrt med strammingsmekanismer.

(6) Taunett kreves ikke på innretninger og fartøy hvor helikopterdekkets overflate består av enkeltprofiler med særskilte friksjonsanordninger, forutsatt at dekket vedlikeholdes slik at tilfredsstillende friksjon er tilstede.

(7) Kravet om taunett på ikke-bevegelige helikopterdekk kan fravikes dersom dekket er slik utformet og det er etablert et system som sikrer at helikopteret ikke kan skli, og at friksjonskoeffisienten er minst 0,65. Kravet om taunett kan ikke fravikes dersom det er snø eller is på helikopterdekket.

5. 15 July 1988. North Sea, 70 NM SW of Sola. Eurocopter AS 332L Super Puma Offshore flight -/2 (-) 0/0/-. Controlled ditching after loss of a leading edge strip on a MRB. Deficient repair of the blade at Eurocopter and imprecise maintenance instruction.

The AS332L Standard Main Rotor Blades leading edges are protected by an erosion strip of stainless steel. The blade had been repaired by Eurocopter factory and after the accident the repair procedures were changed.

6. 18 January 1996. North Sea 40 NM SW of Stavanger Airport Sola. AS332 L1 Offshore flight16/2 (18) 0/0/18. Controlled ditching after onset of heavy vibrations caused by a split in one of the MRB leading edge strips. Flaws in manufacturing and maintenance of the strip which were not covered by the operator's maintenance program as specified by the manufacturer.[12]

The main rotor was equipped with de-iced rotor blades. These blades had leading edge erosion strips of titanium and hence softer material than the stainless steel strips of the standard blades. This caused more erosion wear on the leading edges which in this case cracked. The blade had been modified and inspected by Eurocopter and the accident resulted in Eurocopter to change the maintenance requirements.

7. 8 September 1997 at Norne in the Norwegian Sea, 100 NM WNW of Brønnøysund. Eurocopter AS332 L1 Super Puma. Offshore flight 10/2 (12) 12/0/0. Fell into the sea

[11] https://lovdata.no/dokument/SF/forskrift/2007-10-26-1181
[12] http://www.aibn.no/Luftfart/Rapporter/1998-02-eng?ref=1713

from 2000 feet altitude. Fatigue failure in the high speed shaft between the engine and the MGB. Failure of the overspeed protection system led to disintegration of the Power Turbine Wheel which cut the control rods to the MR.[13]

This was a tragic accident which may be related to the Eurocopter design. The AIBN official accident report does not conclude on a cause. It was found that the MGB had higher vibration levels than normal, but it could not be established why. What was alarming was that the same failure happened to a company helicopter back in 1985 with the author as pilot in command. In that incident the emergency overspeed system functioned as intended, but it identified a weakness of the design. The same failure happened to other operators before and after the LN-OPG accident. From the AIBN the following text is extracted:

3.1.2 The aircraft

k) LN-OMG, a helicopter belonging to HS, had experienced an incident in October 1985 that was very similar to what happened with LN-OPG. This time, however, the lock washer did not enter into the Bendix shaft and the helicopter landed safely on one engine. As far as the AAIB/N is aware, this incident did not lead to the safety risks of the system being detected.

1.6.7.2 *Reported practical experience with the main gearbox (MGB) and power transmission between the engine and the MGB*

10.00	10/85	x		MGB	M195, LH	Helikopter Service. LN-OMG. Engine overspeed and shut-down during approach to Tender Clipper. Cracks and loose pieces in splined sleeve. Crack pattern similar to LN-OPG. Speed probes (Nf) destroyed. No O-ring

This shows that the overspeed sensors in the LN-OMG were damaged and could have resulted in the same failure mode as in LN-OPG. This is an example of a badly designed safety system that was not properly analysed and corrected up to the LN-OPG accident 12 years later. It was assumed that a high speed shaft failure would be contained by the double speed sensors.

8. 5 November 2002. 17 NM SW of Stavanger Airport Sola. Eurocopter AS332 L2 Super Puma. Offshore flight 14/2 (16) 0/0/16. The helicopter developed heavy vibrations and the pilots made an emergency landing on a ship with a helideck close by. The vibrations were caused by the loss of a pendulum weight which made severe damaged to a MRB. The loss was caused by metal fatigue cracking of the bolt.[14]

This nonfatal accident (classified by AIBN as an accident due to severe damage to a lifting surface) proved insufficient Failure Mode Analysis by Eurocopter during the design of the Pendulum Vibration Absorber. Good luck prevented the Pendulum Weight from damaging the main rotor blade spar. The accident resulted in a redesigned vibration absorber with good reliability.

[13] http://www.aibn.no/Luftfart/Rapporter/2001-47-eng?ref=1713
[14] http://www.aibn.no/Luftfart/Rapporter/2005-27?ref=1713

Some developments in UK Offshore Sector

UK had its share of offshore helicopter accidents. An accident with an S-61N passenger helicopter an route from Penzance to the Isles of Scilly on 16 July 1983 sparked a review of UK helicopter safety.

A report investigating the incident was concluded twenty months later, in February 1985, finding the cause to be 'pilot error'. The official report concluded that the accident was caused by the pilot not observing and correcting an unintentional descent before the helicopter collided with the sea during an attempt to fly at 250 feet using visual clues in poor and deceptive visibility over a calm sea. The report also added that the following were contributory factors.

- Inadequate flight instrument monitoring due to flying in visibility conditions unsuited to visual flight.
- Lack of audio height warning equipment.

The Accident Investigation Branch made eight recommendations:

- The weather minima for helicopter flight in visual flight rules and the related crew instrument monitoring procedures should be removed.
- Radio Altimeters, with both audio and visual decision height warning, would be fitted to all helicopters operating offshore as a matter of urgency.
- Consideration should be given to the development of a ground proximity warning system for helicopters.
- The moving of the radio altimeter indicators to within the pilot's field of head-up vision should be examined.
- Helicopters used for public transport should be fitted with an automatically deployable survival radio beacon.
- Consideration should be given to pilots of helicopters used for public transport to wear lifejackets with dual frequency personal locator beacons.
- The use of QFE by the company on low level approaches to St Mary's aerodrome and the minimum RVR should be reviewed.
- The requirements concerning the strength of helicopter passenger and cabin attendant seats be reviewed.

It is interesting to note that the Norwegian equipment and procedures at the time covered all of the relevant recommendations.

<u>The HARP report</u>

This, and previous accidents in UK sector led the UK CAA to establish a Helicopter Airworthiness Review Panel (HARP) which led to the publication of the HARP Report in 1984[15].

[15] http://aerossurance.com/wp-content/uploads/2015/02/CAP491.pdf

Airworthiness Requirments Board formed a working panel known as Helicopter Airworthiness Review Panel (HARP) which completed its work in 1984.
The HARP report contained a list of recommendations related to the safety of helicopters. UK CAA has phased the implementations of these recommendations into three separate phases:

Phase 1 which was implemented in 1985 included, but not limited to:

- Improved ditching and survival capabilities.

Phase 2 to be implemented from 1990, included, but not limited to:

- Improved engine out capability (Category A/Group A/Phase 1).

Phase 3 to be implemented during 1990's, included, but not limited to:

- Rotor de-ice systems.

- Health and Usage Monitoring systems.

The report resulted in UK CAA initiating a review of the British offshore helicopter regulations. UK CAA focused on more stringent airworthiness requirements related to ditching and survivability, which was identified as Phase 1. This included among other items, floatation gear on the S-61N sponsons and ropes along the sides of the helicopter. The intention was to increase the floatation capability and the ropes were meant for survivors to hold on to in case of helicopter capsising. The Phase 2 was planned for Category A/OEI operations.

The Norwegian CAA (Luftfartsverket/LV/Aviation Inspection Dep[16]) consulted with Helikopter Service which operated the same type in Norway, and Helikopter Service objected to the proposed requirements. Helikopter Service' view was that these modifications would not make the helicopters safer, but only make them heavier. Further, Helikopter Service wanted to focus on the airworthiness and avoid having to ditch the helicopters in the first place. Firstly, Helikopter Service revised the operating procedures to include drop down calculations for offshore helideck landing and takeoff. Then Helikopter Service initiated an engineering program to develop and install Health and Usage Monitoring System (HUMS). These modifications made the S-61N the safest offshore helicopter in the Norwegian sector at the time. Due to the improved safety of the S-61N, the spacious cabin, low vibration and low noise level, some oil companies still preferred the S-61N. Hence it continued in operation in parallel with the types which were meant to replace the Sikorsky helicopter. The last S-61N was sold to Spain in 2004 following several of its predecessors, where the type was used as SAR helicopters. Some of the airframes had 40 000 + flight hours in Helikopter Service when they were phased out. Hence, the Sikorsky S-61N may be compared to the Douglas DC-3 in the fixed wing world.

The HUMS system was also installed in Boeing BV234LR helicopter types. In AS332L the Bristow developed system Integrated HUMS (IHUMS) was installed.
However, the Norwegian CAA was passive in this development and did not mandate such systems. Since HUMS system was not mandatory or certified in Norway, the company

[16] Luftfartsverket/Luftfartsinspeksjonen became an independent Civil Aviation Authority in 2000.

Minimum Equipment List (MEL) did not require the system to be fully operational during flights. Hence, the helicopters were permitted to fly with some of the sensors inoperative. Hence, this system did not register the increasing vibration level in the LN-OPG RH MGB input pinion (Norne accident). The AIBN accident report[17] suggested that if the sensor (accelerometer) in question had been operating, the accident might have been prevented. The similar HUMS system in the BV234LR identified increasing vibration in the aft Main Rotor shaft. When inspected it was registered previous lightning strike marks which could have initiated future fatigue cracks.

Another significant Norwegian development was the Modified Automatic Dependent Surveillance System (M-ADS). Helikopter Service was, together with NCAA (then Luftfartsverket/Directorate/Technical Department), a founding member of the Project Team. At the time of the Norne accident, Bodø ATC had got the system installed but the personnel had not yet been trained to operate it. Hence, on the day of the accident LN-OPG was only tracked on radar until outside radar cover. If the M-ADS had been observed, the system would have identified the GPS position of the crashed helicopter. Instead, when the SAR operation started, Bodø ATC directed the SAR helicopters to a position based on the last radar contact and not along the established helicopter route structure. This caused quite a delay before the crash location was found. In the actual case the delay did not cause any fatality, but in another accident with people floating in the water this surveillance system could have made a difference. This case highlighted the value of the M-ADS surveillance system which became mandated by NCAA in the Norwegian Sector.

Phase 2 of the UK CAA offshore requirements focused on helicopter offshore One Engine Operating (OEI) procedures. UK CAA wanted the helicopters to avoid ditching and be able to land or fly away with one engine inoperative. This was strongly opposed by the UK operators as this would be prohibitive regarding payload restrictions. The British Helicopter Advisory Board (BHAB) brought the topic on the EHA agenda. The argument was that there had been no accidents or incidents in this relation, and the payload reduction would be prohibitive. This resulted in the establishment of the EHA Performance Committee (PC). BHAB and EHA communicated with UK CAA and referred to the good safety statistics related to engine failure during offshore landing and takeoff. The EHA initiated a survey among members on the engine failure statistics. This proved that the probability of experiencing an engine failure during offshore landing or takeoff was extremely remote. The EHA PC initiated a simulator evaluation program to evaluate different offshore landing and takeoff procedures. The PC issued a report with recommended revised optimised offshore procedures. Eventually UK CAA transferred the Phase 2 regulation to JAA and EASA. EASA has continued to work on the issue, which initially led to the Exposure Time Procedure and eventually led to the Performance Category 2 Enhanced (PC 2e) procedures which still are not enforced. The operator's arguments are still the same, proven by statistics over 50 years; still no offshore accident or incident related to engine failure during rig operations.

Some safety developments in Norwegian Offshore Sector

<u>Helikopter Service</u>

International involvement.

[17] http://www.aibn.no/Luftfart/Rapporter/2001-47-eng

Helikopter Service started offshore flying in 1966 and was the first Norwegian offshore helicopter operator. LN-ORE arrived Sola from USA 11 July and LN-ORH arrived three weeks later. The first passenger flight from Norway to an offshore oil installation was flown on 18 July 1966 in LN-ORE with Mike Boxill as Pilot in Command and Sikorsky test pilot Ed Mullins as Co-Pilot. The flight was from Sola to the drilling rig Ocean Traveller at some 90 NM west of Sola.

There were several technical issues with the first Sikorsky and Bell helicopters. Hence, the company developed a close relationship with the manufacturers. Further, offshore flying was new and NCAA had no knowledge or experience with offshore operations. Hence, it was up to Helikopter Service to develop instrument flight and offshore procedures. To get support and advice Helikopter Service became heavily involved in international helicopter operator organisations like European Helicopter Operators Committee (EHOC) and European Helicopter Association (EHA). The first Helikopter Service' Managing Director Morten Hanche became the first Chairman of EHOC. Helicopter Service was a founding member of the EHA and was represented on the Board by Operations Director Jan Bengtson. Later Ops Director Bjørn Moe became Chairman of EHA, and Chief Technical Pilot Knut Lande became member of EHA Performance Committee and later it's Chairman. Later Operations Director Jacob Bae became Chairman and Svein Erik Lorentzen member of the EHA Offshore Committee. Hence, Helicopter Service was a world leading offshore helicopter operator which, in many respects, became an advisor to helicopter manufacturers.

Flight Simulators.

Even though there were technical issues with the helicopters, the offshore operations went reasonable well until 1973 when a tail rotor blade failed causing the first fatal accident. The aftermath of that accident sparked many safety improvements in Helikopter Service operations. The pilots and passengers were required to wear survival suits and Helikopter Service realised a requirement for a flight simulator in order to better train pilots in severe emergencies which were difficult to train in the helicopters. At the time flight simulators for helicopters were not readily available, and when Helikopter Service got the S-61N simulator operational in 1978, this was one of the first helicopter simulators in the world. The time frame between 1973 and 1978 saw a large expansion of offshore operations. This resulted in heavy wear and tear on the helicopters, which also had to be used for training many new pilots. This was highlighted by the crash of S-61N LN-OQS in 1978 where the AIBN report pointed to the extreme loadings on the Main Rotor Spindles during OEI landings at Forus heliport. The introduction of the flight simulator eliminated the training loads on the helicopters and raised the training standard for the pilots.


The old offshore work horse Sikorsky S-61N continued to operate successfully until 2004.


The initial primary offshore based shuttle and SAR helicopter, Bell 212.

In 1981 Helikopter Service ordered the helicopter types (then) Aerospatiale AS332L Super Puma Mk 1 and in 1982 the Boeing BV234LR Chinook. Both types were introduced offshore during 1983. Again Helikopter Service was in front and ordered the first AS332L simulator which became operational in 1984. This was very important as the new helicopters were more advanced and had more complicated systems then the older types. This simulator contributed to the high training standard of the Helikopter Service' Super Puma pilots.

For the BV234LR Helikopter Service rented simulator time with British International in Aberdeen/Farnborough, also operating the commercial Chinook. Hence, Helikopter Service was able to keep the same high pilot standard as with the other large offshore helicopter types.

Aerospatiale (later Eurocopter and now Airbus) AS332L was introduced in 1983.

In 1992 Helikopter Service ordered the new AS332L2 Super Puma Mk 2. However, this time the company did not invest in a new simulator, estimated to 10 million USD at the time. Hence, the pilots trained in the Mk 1 simulator at Forus and in the helicopter. This proved to be less than optimum. The danger of training in the helicopter was highlighted by a training accident at Sola (LN-OHC)[18] and a training incident at Haugesund (LN-OHE).[19]

From AIBN report 51/2001 is extracted:

> HSL ser alvorlig på denne form for trening i tyngre helikoptre i stedet for i en avansert simulator slik som for tyngre trafikkfly.
>
> HSL viser i denne forbindelse til en tidligere treningsulykke med AS 332L2 (LN-OHC) ved Stavanger lufthavn Sola, den 31. oktober 1997 (HSL 12/1999), der et treningshelikopter var nær ved å totalhavarere under lignende omstendigheter.
>
> I tillegg viser HSL til en luftfartshendelse med AS 332L2 (LN-OHA) vest for Bergen lufthavn Flesland, den 21. februar 2000, (HSL 01/2001) der besetningen fikk problemer med strømforsyningen. Grunnet tvil med hensyn til flysikkerheten valgte besetningen å stenge ned en motor. HSL vurderte at manglende simulatortrening var medvirkende til besetningens uheldige håndtering av situasjonen.

Here as well, the NCAA was absent regarding requirement for offshore helicopter simulators. In 2000 Helikopter Service experienced a serious incident with AS332L2 LN-OHA[20] where the AIBN in the report HSL 01/2001 made several recommendations to NCAA:

[18] http://www.aibn.no/Luftfart/Rapporter/1999-BUL12
[19] http://www.aibn.no/Luftfart/Rapporter/2001-51

TILRÅDINGER

HSL tilrår at Luftfartstilsynet:

-Vurderer om det nåværende utsjekks-og treningsprogram for AS 332L2 er tilfredsstillende (Tilråding 1/2001).

-Vurderer krav til påbud om simulatortrening for utsjekk og vedlikehold av sertifikatrettigheter på avanserte tyngre passasjerhelikoptre på samme måte som for tyngre passasjerfly (Tilråding nr 2/2001).

-Vurderer om den norske typesertifiseringen av AS 332L2 er akseptabel med hensyn til strømforsyning av viktige registrerings- og varslingssystemer som CVFDR og ICS/AVAD (Tilråding nr. 3/2001).

As an example on the NCAA response to two AIBN recommendations related to simulator and helicopter design:

2/2001: *"The recommendation should be withdrawn as there is no suitable helicopter simulator available"*. A statement that AIBN strongly opposed, based on the fact that without a requirement the incentive to spend large expenses for simulator development is rather vague.

3/2001: *"The helicopter is certified and satisfies the requirements"*. Again AIBN opposed the NCAA position and had follow-up meeting with NCAA to explain the importance of securing electrical power to these systems in emergencies which may lead to accidents.

Later Eurocopter built a simulator center in Marignane which solved the training problem for the AS332L2 helicopter type.

Flight Equipment.

Initially Helicopter Service was a Monopoly which at the time made it a solid company with good earnings and continued expansion. This led to a good financial basis and allowed the company to invest in new helicopter types and equipment. Much of the equipment was optional and not mandated by NCAA.

Helikopter Service implemented and developed procedures for safety equipment long before mandated by NCAA:

- Weather- and Navigation Radar
- Navigation Systems (Decca, Omega/VLF, Loran C, GPS)
- Radar - Navigation - Interphase
- Radio Altimeter with Audio Warning*
- Crash Position Indicator/Emergency Locator Transmitter (CPI/ELT)*
- Cockpit Voice Recorder (CVR)*

[20] http://www.aibn.no/Luftfart/Rapporter/2001-01

- HUMS*
- Nav/radar Interface
- Flight Data Recorder (FDR)*
- Rotor De-ice Equipment

* equipment which later became mandatory

The ideal Ekofisk Helibus Boeing Helicopters BV234LR Chinook.

Already in 1980 Helikopter Service' offshore helicopters were equipped with the latest avionic and navigation equipment. The aircraft were equipped with state-of-the-art flight instruments for IFR flying, Weather Radar with Mapping mode, Radio Altimeter, Omega/VLV navigation system in addition to ADF, VOR, DME, ILS and Radar Transponder.

In 1983 Helikopter Service introduced new helicopter types like Aerospatiale AS332L Super Puma Mk 1 and Boeing BV234LR Chinook with updated flight equipment. Training for these new helicopters was performed in modern flight simulators at Forus and in Aberdeen/Farnborough.

Helikopter Service kept updating its helicopter fleet by introducing Bell 214ST offshore based shuttle helicopter, and new transport helicopters like AS332L1 and L2. The Bell 212 shuttle helicopters were updated with SAR equipment and eventually replaced by AS365N2 shuttle helicopters with SAR equipment.

Eurocopter AS 332L2 Super Puma Mk 2 was introduced in 1993.

As soon as the Global Positioning System GPS became usable Helicopter Service initiated trial operations which eventually led to introducing GPS as an additional navigation sensor.

The BV234LR was a very successful offshore helicopter on the Ekofisk route structure. In 1995 Helikopter Service lost the contract to the newly formed Norsk Helikopter and AS332L1 Super Puma and the three helicopters were sold to Columbian Helicopters in USA. The loss of the Chinook contract was caused by NCAA issuing a dispensation from Norwegian offshore regulation which mandated use of onshore based alternate landing site without informing Helikopter Service of this possibility. That was clearly a favoring and rewarding of one operator and against the generally accepted safety norm in Norwegian offshore operations. This was the only time the concept of using offshore based alternate landing site was used in Norway, and in later contracts the oil companies required the bidders to specify onshore alternate. Today this is stated in Norwegian Oil and Gas' recommended Guidelines 066 for offshore helicopter transport. This is one example of how the NCAA contributed negatively to the Norwegian offshore helicopter safety instead of promoting safety. This was an indication of lack of knowledge of offshore helicopter operations among the NCAA personnel. The same can be said of the contract personnel in the oil company where the focus was on minimum cost.

By the turn of the century Helikopter Service fleet consisted of AS332L/L1/L2, AS365N2, B214ST and a few remaining S-61N. The last S-61N was sold to Spain in 2004. The high time S-61N had more than 40 000 flight hours and continued to fly SAR missions in Spain.

Eurocopter AS365N2 replaced the Bell 212 as shuttle/SAR helicopter at Ekofisk in 1995.

Personnel/functions/organisation

Being a financially solid company with focus on flight safety, Helikopter Service established a well-functioning engineering and operational organisation and quickly gained respect as a world leading offshore helicopter operator. Hence, the company became a consultant to the major helicopter manufacturers.

The company recruited well qualified technicians and pilots from the RNoAF and established a well-functioning Engineering and Maintenance Base at Forus Heliport. Special functions were established much in line with Air Force practice:

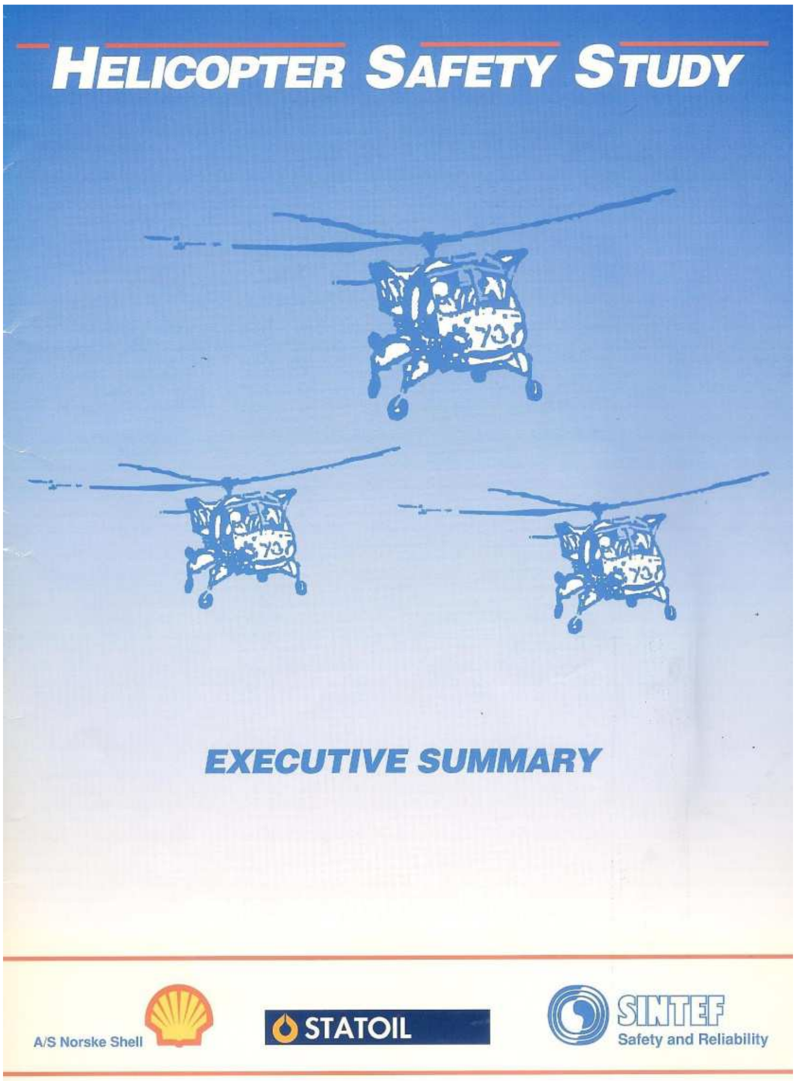
- Flight Safety Manager (developed incident reporting system and follow up)
- Navigation Manager (develop offshore route structures, offshore helideck plates, rig position charts, update Jeppesen North Sea Supplement, liaise with Stavanger ATC)
- Helideck Inspector (developed periodic helideck inspection procedures and follow up, developed Helikopter Service Helideck Manual))
- Offshore Fuel System Inspector (developed offshore fuel system specifications and developed periodic offshore fuel system inspection procedures and follow up)
- Project Pilot New Helicopters (evaluated new helicopter types, specified helicopter systems, cockpit layout, evaluations, accepting testing, maintenance testing)
- Chief Technical Pilot (replacement for Project Pilot position)
- Type Chief Pilots (developed operational procedures and follow up of daily flight operations)

These functions were all part of the company Safety System Management Team which led to increasing flight safety. This may be reflected by the good safety statistics between 1978 and 1997.

Helikopter Service' involvement in safety developments

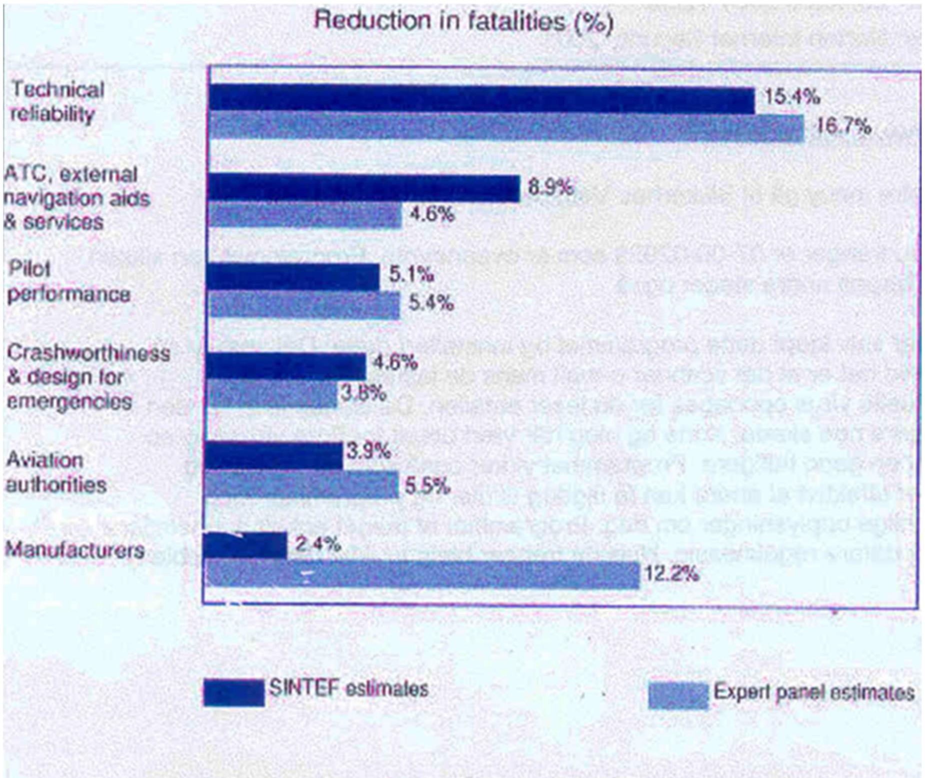
<u>Helicopter Safety Study 1 (HSS 1, 1990)</u>

During 1988 Shell Norway approached Helikopter Service and discussed potential safety cooperation. In a meeting between Shell Norway Safety Manager Erik Wiig and Helikopter Service Operations Director Bjørn Moe and Chief Technical Pilot Knut Lande, the potential safety project was discussed. Shell Oil Company had large scale offshore operations worldwide and they had high personnel loss rate in helicopter accidents worldwide. Shell Company made funding available for helicopter safety projects and Shell Norway was allocated a fair amount. This was the bases for Erik Wiig's meeting with Helicopter Service where he asked if Helikopter Service would be interesting in joining in. Bjørn Moe and I saw the potential and confirmed that Helikopter Service was interested. Bjørn Moe contacted Statoil's Aviation Advisor Jan Taarland who immediately responded positively. This led to the SINTEF Helicopter Safety Study I of 1990 where Helikopter Service was represented by Knut Lande from Operations and some engineers from the Engineering Department.



The HSS 1 report showed that offshore helicopter passenger transport accident statistics differed from airline passenger transport by a factor of 10. Another significant difference was that while in airline operations Human Factors were present in 80 % of the fatal accidents, while in offshore operations Human Factors were present in 20 % of the fatal accidents.

The SINTEF HSS 1 concluded that the significant risk factors in offshore helicopter operations were design and technical reliability in addition to lack of air traffic control of the offshore helicopter traffic.



Reduction in fatalities, following realistic improvement of risk factors (according to SINTEF and a group of helicopter experts)

<u>Health and Usage Monitoring Systems</u>

For Helikopter Service this led to a company development program developing and installing Health and Usage Monitoring Systems in S-61N and BV234LR. This was a significant safety improvement. Also the AS332L/L1/L2 helicopters were equipped with HUMS.

<u>Modified Automatic Dependent System (M-ADS)</u>

The second highest risk factor was the lack of offshore ATC and controlled airspace. This led to Helikopter Service joining the NCAA's (Luftfartsverket/Technical Dep) engagement in developing a Norwegian satellite surveillance system, Automatic Dependent Surveillance-Contract (ADS-C) System.

Helikopter Service made available an S-61N helicopter, installed test equipment and flew several test flights. The test results were promising and NCAA (LV Directorate/Technical

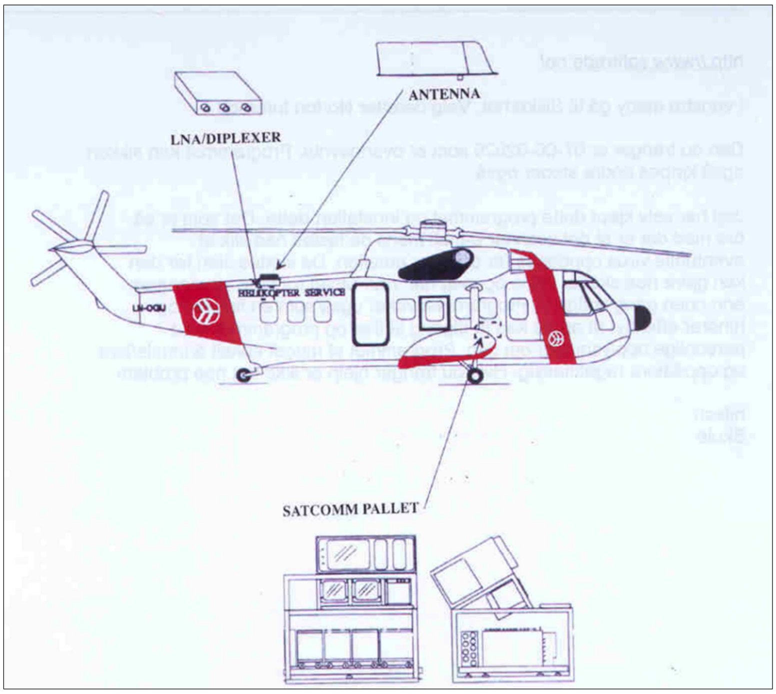
Dep) decided to initiate the development and fielding of a Norwegian ADS-C (contract) system, designated Modified ADS (M-ADS). The added name "Modified" was really superfluous but was added to the ADS(-C) because the ICAO specification for ADS-C systems included the capability for voice transmissions, which the Norwegian system did not include.

The crew on an Ekofisk Chinook flight; captain, cabin crew and copilot.

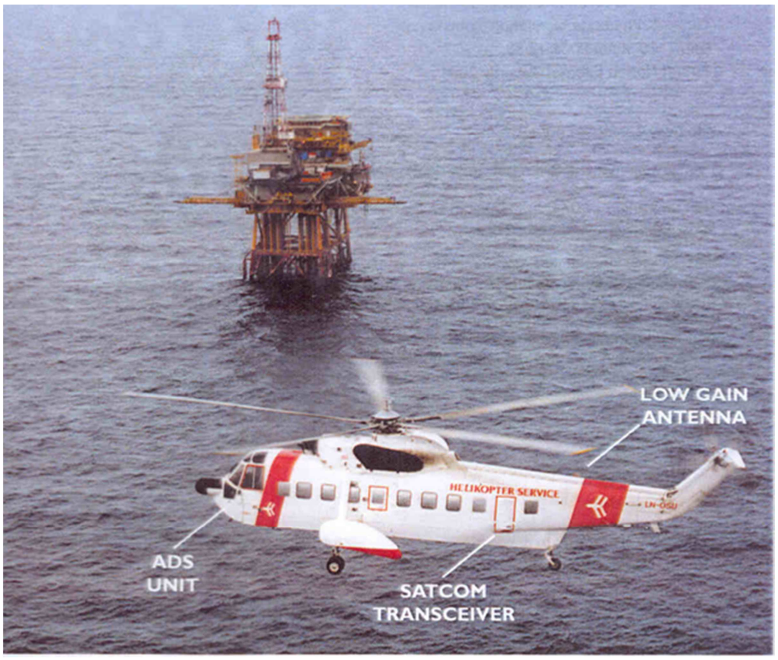
Kongsberg Defence and Aerospace (KDA) were given the development contract and Luftfartsverket/Stavanger ATC was tasked by developing the ADS route structure and procedures.

The Norwegian M-ADS project participating members.

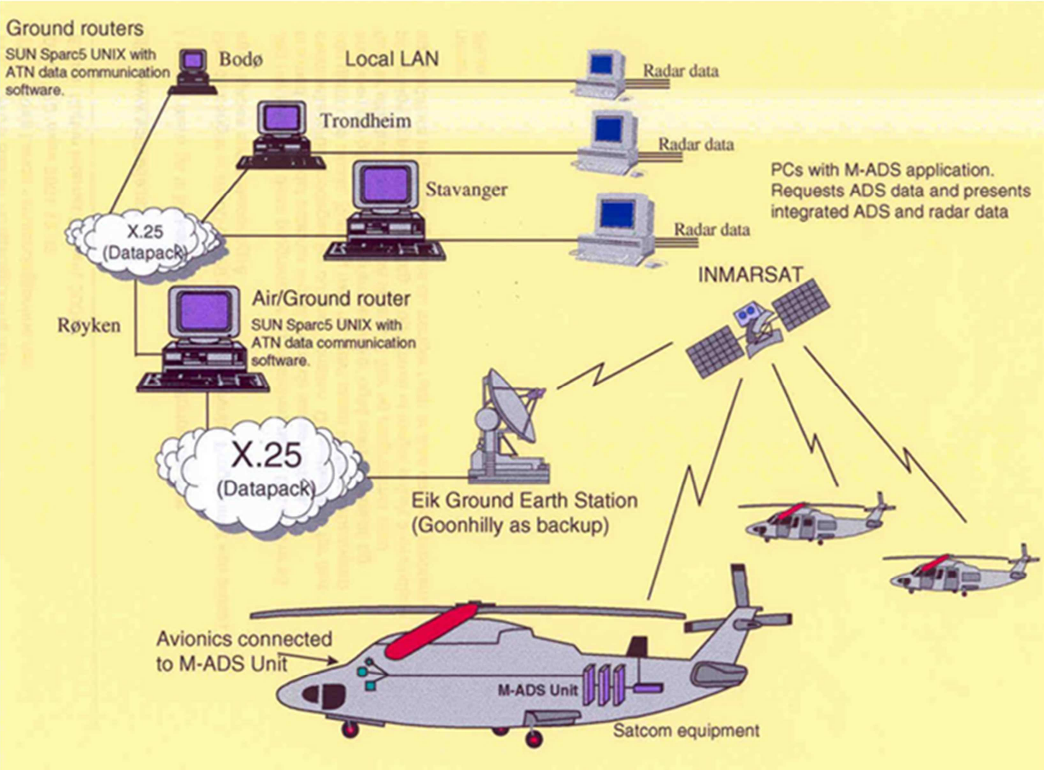
NCAA had established a Steering Group and a Project Group consisting of NCAA (Chair) Inmarsat Satellite Company, Shell, Statoil, Hydro, Televerket and Helikopter Service. Helikopter Service made available a test helicopter and performed the engineering and equipment installation.
The M-ADS system was tested during a trial period and became eventually mandated by NCAA. The system allowed direct routing outside radar coverage and allowed ATC radar operators to have the GPS position of the helicopters indicated on their combined radar/ADS screens all the way to landing offshore, or in case of accident, to the last indicated position on the sea surface. The system was a great advancement to overall helicopter passengers' safety. The safety potential was indicated during the search for LN-OPG at Norne.



The S-61N ADS-C test installation.

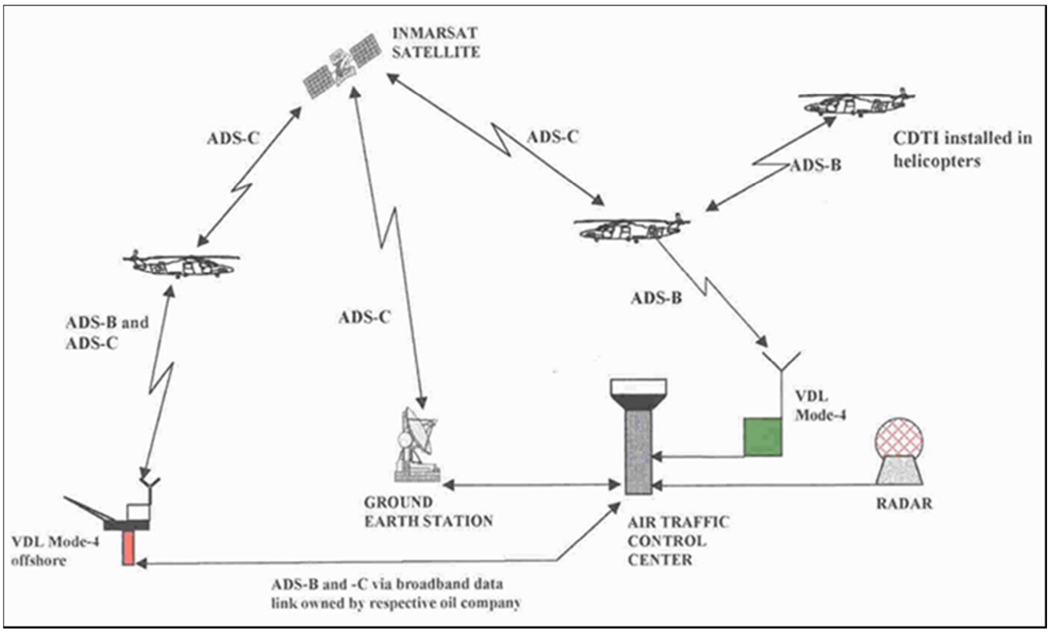


The S-61N test aircraft.

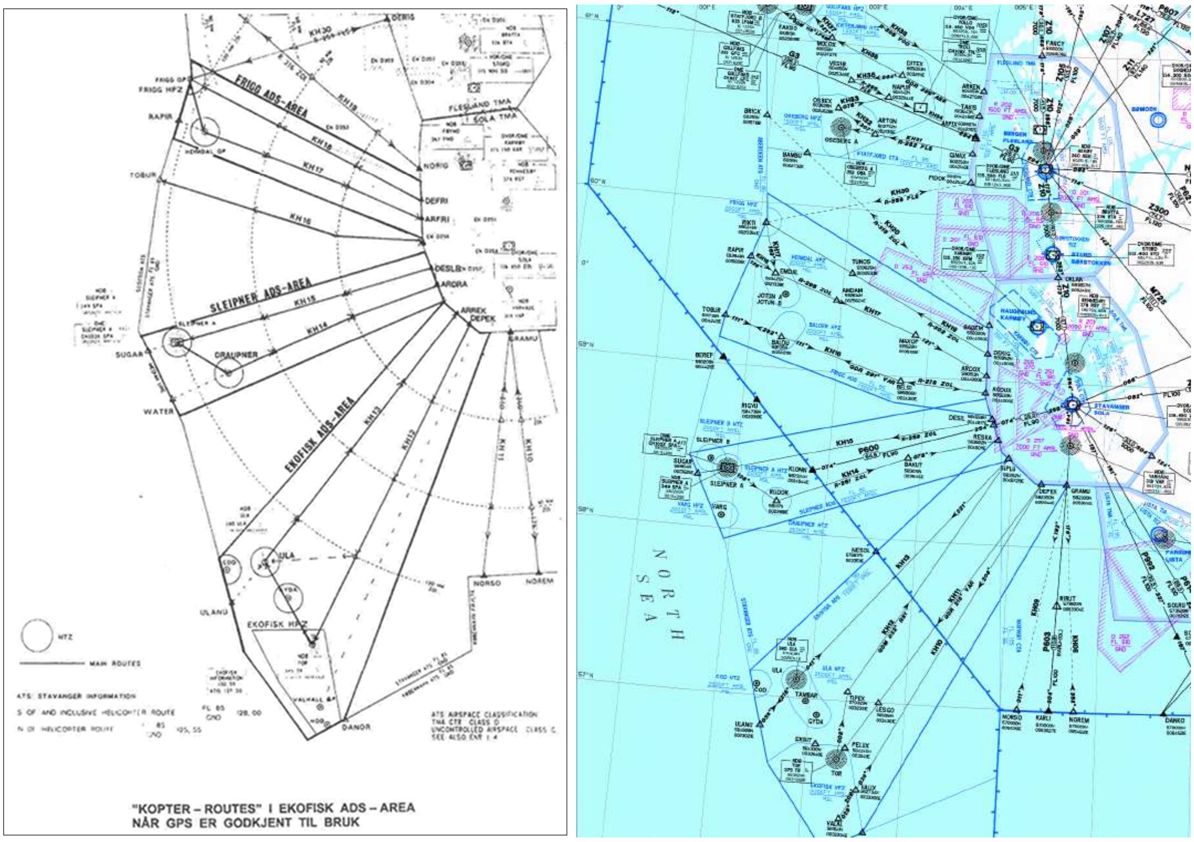


The Norwegian M-ADS-C Satellite Surveillance System.

The project plan had an option to extend the M-ADS (ADS-C, Contract) to include ADS-B (Broadcast), but this option was never activated due to lack of funding. If it had been developed at the time (during the late 1990-ies) Norway could have had an operational offshore ADS-B surveillance system (Dual Link ADS) from around 2000. This is an indication of short sighted future planning.

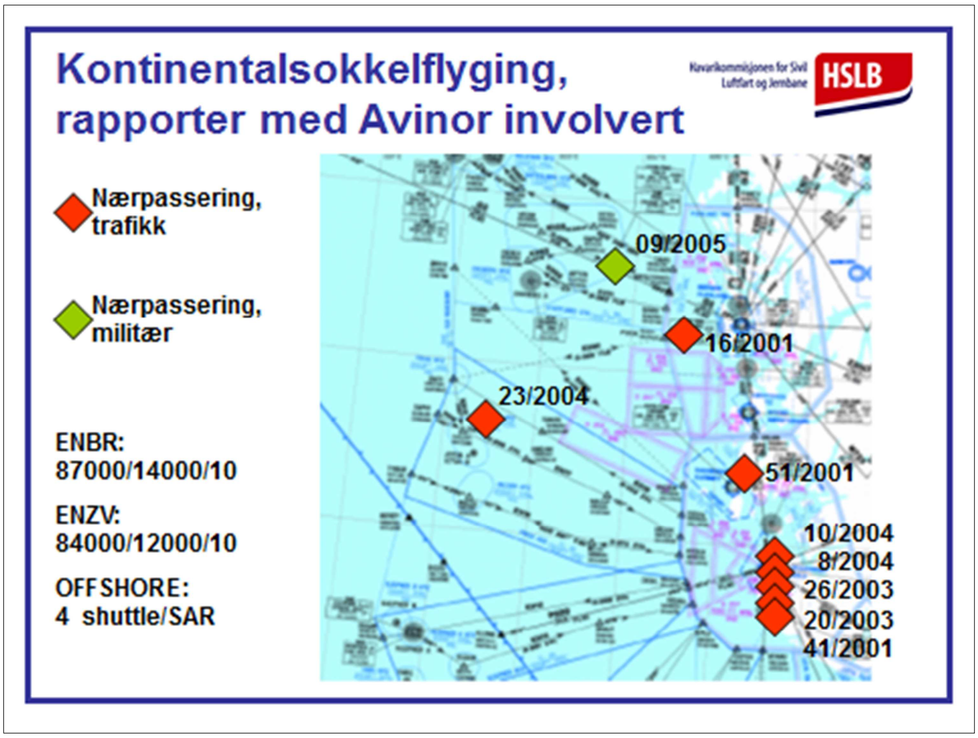


The proposed Norwegian Dual Link ADS-C and ADS-B System.



The designated ADS areas over Norwegian North Sea.

It is worth mentioning that other oil companies and helicopter operators declined the offer to bring funding or support to the project as they viewed the system to have no helicopter safety benefit. This is an indication of the strong flight safety culture in Helicopter Service compared to other operators' short sighted vision.



Offshore *ASR reports to AIBN involving Avinor ATC.*

A confirmation of the HSS 1 risk estimation regarding ATC is indicated by the figure from AIBN of 2005. It shows air traffic incident reports involving offshore helicopters.

The HSS 1 also recommended that the role of the Aviation Authorities should be examined. This had been a long standing deficiency, especially in Norway where NCAA for many years let the offshore industry control its self. This was for many years a challenge for Helikopter Service which was the pioneering and leading offshore helicopter operator and approved helidecks, offshore refueling systems, cooperated with Sola Air Traffic Control regarding offshore routing and maintained the Norwegian Jeppesen Offshore Supplement.

Helikopter Service' Helideck Manual

When Helicopter Service started offshore helicopter traffic with two Sikorsky S-61N helicopters during the summer of 1966, NCAA /Luftfartsverket/Directorate/Aviation Inspection Dep) had no regulations regarding such flight activity. NCAA/LV had to develop the BSL D 5-1 to regulate offshore helicopter operations.[21]
This regulation was very basic and limiting and NCAA/LV delegated much of its responsibility to Oljedirektoratet (Petroleum Direcotorate, later Petroleumtilsynet/Petroleum Authority). There was very limited regulation regarding offshore helicopter platforms/helidecks.
This forced Helikopter Service to develop its own Helideck Manual, employ a dedicated Helideck Inspector and develop a system for offshore helideck approval. This arrangement was intact up to 2000's when Helideck Inspection companies were formed, and authorised by UK CAA and NCAA to issue helideck approvals. Approvals issued by Helikopter Service were accepted by later competing helicopter companies like Offshore Helicopters, Lufttransport, Braathens Helicopters, Mørefly and Norsk Helikopter. During the late 1990 an initiative from Statoil led to transformation of the Helikopter Service' Helideck Manual into an OLF/NOG Helideck Manual.

Jeppesen Offshore Supplement

Due to lack of Norwegian offshore regulations and procedures, Helikopter Service supplied Jeppesen with procedures, offshore routing and cruising altitudes developed in cooperation with Sola ATC. Included was also helideck landing plates updated and approved by Helikopter Service. Updates were sent to Jeppesen Germany and Norwegian offshore helicopter operators had to buy the Offshore Supplement from Jeppesen.

Helicopter Offshore Refueling Systems

Just like the approval of offshore helidecks, approval of offshore helicopter refueling systems needed inspections and approval. Helicopter Service developed a Refueling System Specification and employed a Fuel System Inspector working full time travelling offshore inspecting fuel systems. The functions of the Helideck Inspector and Fuel System Inspector were combined during the 1990-ies and performed by a former offshore helicopter pilot. The fuel system specifications were continuously improved as late as before my retirement as Chief Technical Pilot when the Helideck Inspector reported to me. Later this fuel spec was transferred over to Helicopter Refueling Systems (Helifuel) AS and other manufacturers of

[21] https://lovdata.no/dokument/SF/forskrift/2007-10-26-1181

offshore helicopter refueling systems. Up to my retirement (end 1999) Helikopter Service had close cooperation with Helifuel and the company also gradually took over inspections and approvals of offshore fuel systems. In addition to the technical approval of the systems, each individual helicopter operator was required to approve the individual system before use.

Nordsjømøte

Due to lack of regulated offshore procedures in the Norwegian AIP, Stavanger ATC and Helikopter Service had periodic meetings discussing offshore routing, cruising altitudes, reporting points and reporting procedures. Stavanger ATC was the primary Offshore ATC center where the offshore specialists were working. In lack of NCAA initiatives, persons like Leon Nesbø, Ragnar Time and Stein Løken Clason were instrumental in developing offshore helicopter route structure and air traffic procedures, and worked closely with Helikopter Service. They were also enthusiastic contributors to the development of the M-ADS (ADS-C contract surveillance system) and the later ADS-B (broadcast surveillance system).

Involvements in new offshore helicopter developments

Based on Helikopter Service international recognised reputation as a leading offshore helicopter operator, the company was contacted by manufacturers requesting advice during developments of new helicopter types. Hence, Chief Technical Pilot Knnut Lande represented Helikopter Service at the launch presentation of the type in West Palm Beach in 1992. Then Helikopter Service became a consultant to Sikorsky during the development of S-92.
At one point Helikopter Service management decided to become the launch customer of the S-92, but this was later cancelled. However, Helikopter Service specialists like Chief Technical Pilot Knut Lande and Sikorsky Type Engineer Murry Timms identified several deficiencies in the initial S-92 design, and suggested several improvements, some of which later were adopted by Sikorsky. At the time Helikopter Service found that the type was not ready as a new Norwegian offshore helicopter and the decision to be a launch customer was cancelled.

Likewise, Helikopter Service was approached by Eurocopter during the development of the then “Super Puma Mk 3”. Eurocopter built a wooden mockup based on Helikopter Service specifications, including 185 cm cabin height and large baggage compartment. However, the project was cancelled after change of Eurocopter Managing Director. The project was then changed to EC225, with basically the same low cabin height as the AS332L2. The type did not come out as a new helicopter type, but an improved AS332L2 Super Puma.

Flight in icing conditions

In 1980 Helikopter Service ordered several new Aerospatiale AS332L helicopters, of which three were equipped with full rotor deice systems. AS332L was the first helicopter type produced in the West with rotor de-ice equipment. Hence, Helikopter Service was very cautious with its introduction and initiated a controlled trial program which showed several safety problems with the system resulting in several serious incidents. This led to dismounting of the system which had to be modified and recertified by Aerospatiale/Eurocopter. Helikopter Service data from the trial program was sent to Eurocopter for evaluation. Helicopter Service was advocating a requirement for rotor de-ice equipment north of 62° N, and requested de-ice equipment on the later model AS332L2. Unfortunately this was never developed. Today most new offshore helicopters are offered with rotor de-ice equipment.

Lightning Strikes on Offshore Helicopters

Helikopter Service experienced several lightning strikes on its offshore helicopters. Hence, the company started registering data from these types of incidents. It was noticed special meteorological conditions which led Helikopter Service to believe these lightning strikes were triggered by buildup of static electricity in the helicopter main rotor, and that it was temperature related. This observation was relayed to the Sikorsky and Eurocopter. However, the manufacturers did not accept this hypothesis and said that the helicopter was just hit by a natural lightning strike.

However, Helikopter Service published a paper on its experiences and presented this at an International Conference on Lightning & Static Electricity (ICOLSE) conference in Toulouse in 1999. The paper was well received and the findings correlated well with a UK Met Office study.

Today it is generally accepted that lightning strikes to aircraft are triggered lightning, caused by electrostatic potential between the aircraft and clouds or earth. This is also documented by later research by UK Met Office. At the time Helikopter Service developed operational procedures to limit the potential for lightning strikes.

Lightning Strikes on Helicopters – Effects, Detection and Avoidance

Knut Lande
Helikopter Service AS

Reprinted From: Proceedings of the 1999 International Conference on Lightning and Static Electricity (ICOLSE) (P–344)

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Helikopter Service paper on Lightning Strikes.

Limitations on moving helidecks

From the very start in 1966 Helikopter Service had to set limitations for landing and takeoff from moving helidecks. There was no guidance from NCAA (then Luftfartsverket). Helikopter Service soon established limitations on deck pitching, rolling and heaving for floating oil rigs. These worked fine for typical drilling rigs, but not so well for ships and boats which started to arrive during the 1990-ies.

Helikopter Service started an evaluation program which resulted in practical limitations on all floating and movable offshore helidecks. These limitations were accepted by the other operators end eventually were printed in the Jeppesen Offshore Supplement.

01.10.02 CATEGORISATION OF VESSELS

Vessel category	*Description of vessel*
A	Large ships (including production ships) and semi-submersible rigs
A+	Large ships (including production ships) and semi-submersible rigs, **with accurate monitoring equipment***
B	Small ships (diving vessels and similar)
B+	Small ships **with accurate monitoring equipment***

Table 4

***Accurate monitoring equipment** means equipment that provides information about the helideck motion characteristics with respect to roll, pitch and average heave rate. The system shall be able to record the history of the helideck movements over the last 10 minutes. The sensor(s) shall be located close to the helideck centre.

All information shall be numerically displayed for easy communication with helicopters in flight and the helicopter land base operations. The system shall facilitate transmittal of electronic data to the helicopter land base operations.

NOTE:
Restrictions for loading platforms (lastebøyer) are found on relevant rig chart.

Category	Landing and planning			
	Pitch & roll		Heave rate	
	Day	Night	Day	Night
A	±3°	±2°	1,0 m/s	0,5 m/s
A+	±3°	±2°	1,3 m/s	0,7 m/s
B	±2°	Not approved	0,5 m/s	Not approved
B+	±2°	±1,5°	1,0 m/s	0,5 m/s

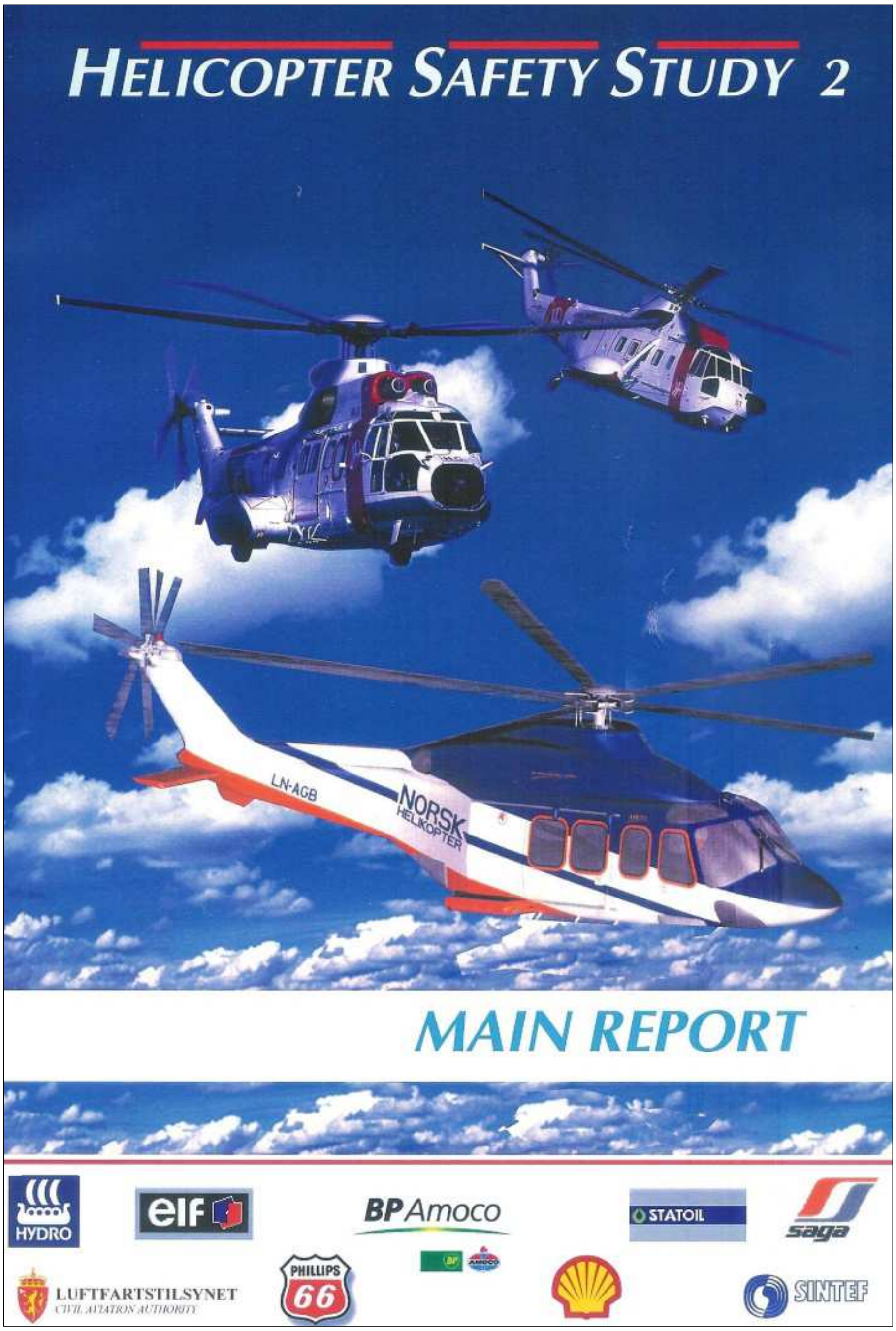
Helikopter Service developed offshore helideck movement limitations.

Helicopter Safety Study 2 (2000)

In 1997 the Norne fatal accident came as a shock after 19 years of safe flying without loss of offshore passenger lives. This sparked the initiation of a second HSS. This accident was mainly design related and reflected the conclusions of HSS 1 in 1990.

Academically this category of fatal helicopter accident should not have happened after all the safety improvements since 1978, and especially since the same failure happened to a company AS332L helicopter in 1985. During the incident in 1985 the nr. 1 high speed shaft failed and damaged the overspeed sensors, but fortunately they still worked and the safety system shut down the engine. Everybody thought that the design flaw was taken care of and it seemed to function well for 12 years. The AIBN report showed that the Super Puma design problem was still with us.

Again the study was initiated by Shell and Statoil, led by Erik Wiig and Jan Tårland. This time several other oil companies joined in the funding. Again the project was contracted to SINTEF, and again Helikopter Service participated with personnel including the Engineering Manager Jens Kørte and the Chief Technical Pilot Knut Lande.



HSS 2 concluded that the risk level was reduced by 50 % in the period from 1966 to 1990 (HSS 1) and was reduced by a further 12 % in the period from 1990 to 1998 (HSS 2). This correlates well with the fact that no fatal offshore passenger helicopter accident happened between 1978 and 1997.

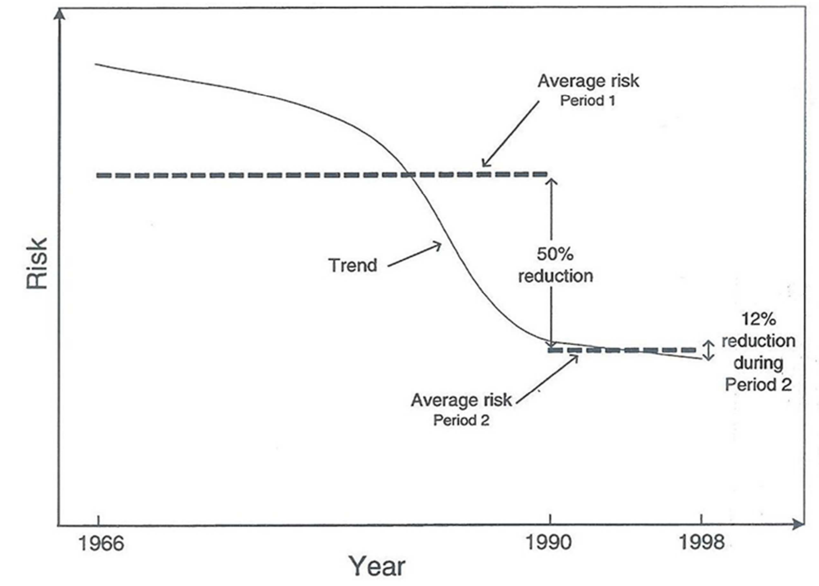


Figure 1. Illustration of estimated risk level for 1966-1998. Norwegian and British Sectors. The estimates of "Average risk" (Periods 1 and 2) are entirely based on the statistical data for these two periods. The given "Trend" for Period 1 (1966-1990) is included to give an indication of the assumed trend, whereas the given "Trend" for Period 2 (1990-1998) is derived from expert judgements.

In addition to several recommended improvements the HSS 2 confirmed that the findings of HSS 1 related to airworthiness and ATC were still not solved, ref. the Norne accident. The Experience in the Norwegian sector was that the highest risks were still related to airworthiness and ATC, and not to human factors as for fixed wing aircraft, or maybe in the British offshore sector.

- ***Future changes in helicopter Design (RIF F 1.1) should primarily be initiated for safety reasons and not, for example, to further increase the aircraft payload and range. In particular, the HUMS should be made more reliable as a decision tool. The NCAA should also take an active part in the future development and use of HUMS. Furthermore, the rotor systems and the flight control systems should be further developed (made more redundant), and the performance with one engine inoperative should be improved.***

K.L.

- ***A decision should be made regarding the controlled airspace issue, including the introduction of Automatic Dependent Surveillance (ADS) areas and routes.***

KL

Helicopter Safety Study 3 (2010)

The author was not involved in the HSS 3 but it is included here for completeness. Bristow Norway and CHC Helikopter Service contributed to HSS 3 as they did to HSS 2.

Figure 0.1 shows the risk reduction in the three 10-year periods that have been analysed. In HSS-2 the risk reduction between the two first periods was estimated to be 45 %. In HSS-3 a risk reduction of 16 % is estimated for the period 1999–2009 compared to the previous period (1990–1998), and an additional 23 % risk reduction is predicted for the coming 10 year period: 2010–2019. The reduction of 23 % in this period is given under the assumption that already planned improvements will be implemented, ref. above list. In addition, a further reduction of risk is expected if additional safety measures are implemented, see below.

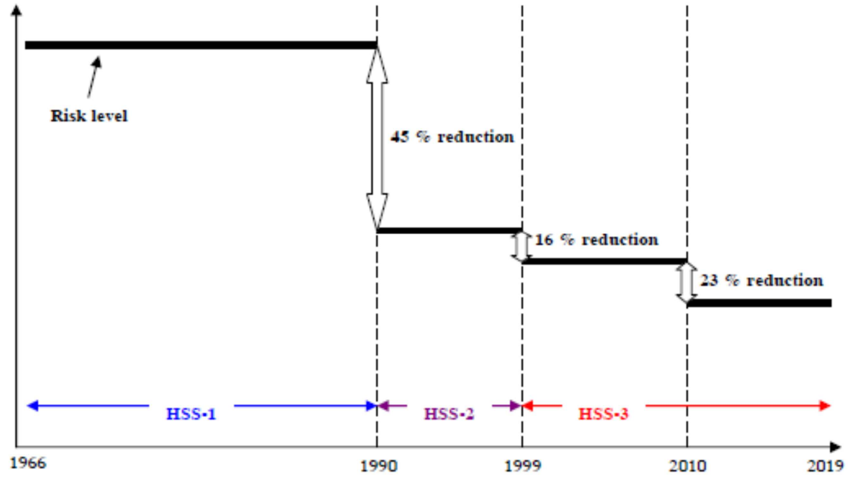


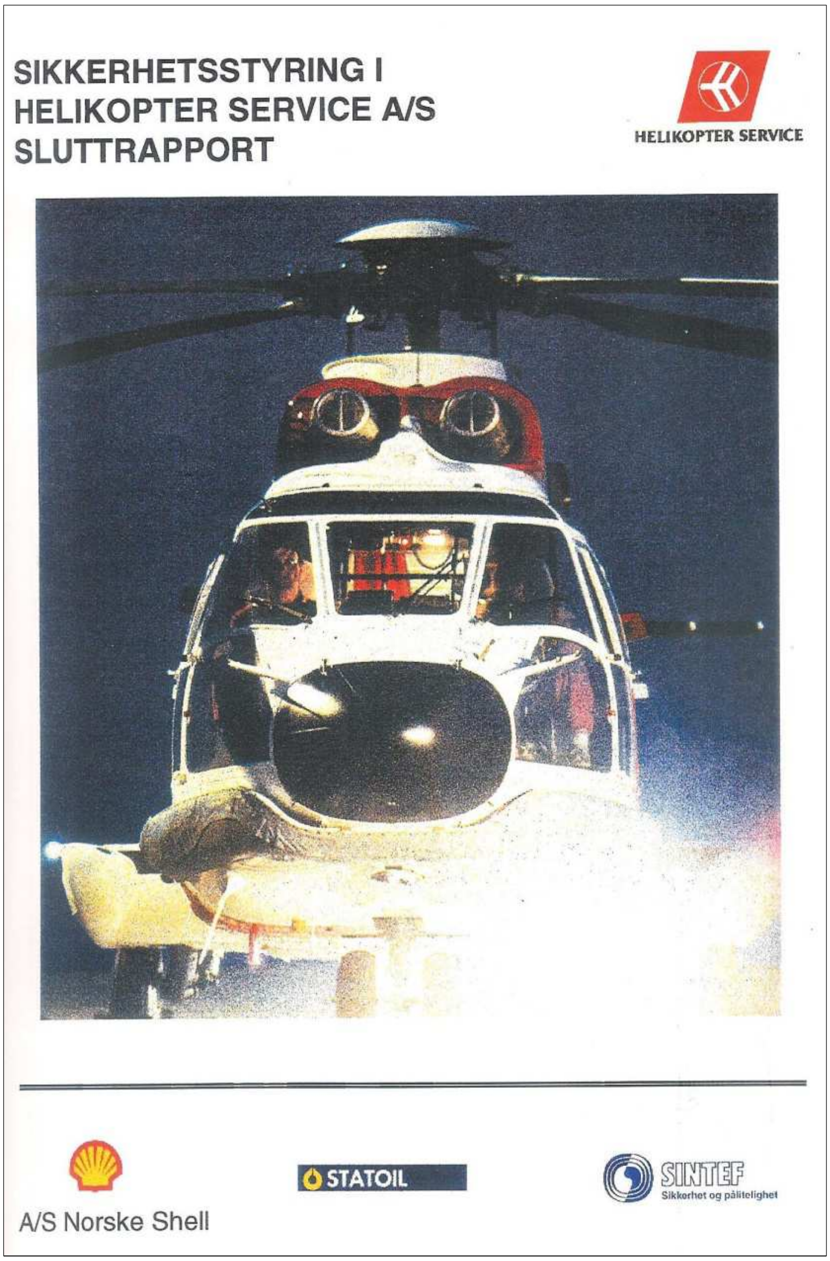
Figure 0.1. Estimated change in risk levels 1966–2019.

HSS 3 corrected somewhat the risk reduction figures from HSS 2. The estimated risk reduction from 1966 to 1990 was 45 % (from 50 %), the risk reduction in the period 1990 to 1999 was estimated to be 16 % (from 12 %) and the risk reduction between 1999 and 2010 was estimated to be 23 %.

This is a remarkable overall safety improvement since Helikopter Service pioneered Norwegian IFR offshore helicopter operations, almost without assistance from NCAA. This safety level is also indicated by the accident statistics with one fatal accident (Norne) since 1978. The improvement in risk level up to 1990 is primarily a result of Helikopter Service Safety Culture, Safety Management System, and close cooperation with Sola ATC, Shell and Statoil.

<u>Safety Management in Helikopter Service (1996)</u>

In 1992 Helikopter Service contracted SINTEF to perform a study project regarding optimising the safety management system within the company. The project was funded by Helikopter Service with financial support from Shell Norway and with professional support from Statoil. The final report was issued in January 1996.



The project developed new methods for managing of safe helicopter transport including:

- A revision of the company's Safety Philosophy and Safety Objectives
- A Safety Program which is a tool for systematic and continuous improvement of safety
- A Safety Auditing tool which is an aid to managers in controlling that the new safety policy and the safety requirements are being met within their area of responsibility
- A new specification for the Safety Reporting System which includes aviation safety and in addition all other aspects of Safety, Health and Environment, and recommendations for improvements and choice of new system
- A plan for systematic improvement of Safety Competence with recommended course types and curricula

The safety study identified the company safety management status and development potential. During the period from 1966 tom 1980 the company safety management gradually developed from “Mål og Aviksstyrt” (managed by objectives and incidents/reactive). This was heavily influenced by the accidents during the 1970-ies. During the 1980-ies the safety management developed into “Forbedringsstyrt” (managed by improvements/proactive). As a result of the SINTEF safety study the safety management in Helikopter Servive developed into “Verdistyrt” (managed by values/predictive), which again led to “proactive” and “predictive” safety management systems.

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Sikkerhetsstyringens status og utviklingspotensiale i HS

	I REGELSTYRT	II MÅL- OG AVVIKSSTYRT	III FORBEDRINGSSTYRT	IV VERDISTYRT
A. MÅL, KRAV AMBISJONER	Tilfredsstiller regelverket, ingen ambisjoner utover dette	Mål og ambisjoner ligger over regelverkets krav Sikkerheten skal høyne renoméet	Sikkerheten skal utgjøre et konkurranse-fortrinn "Sikkerhet lønner seg" Underleverandører velges etter de samme kriterier	Mål og ambisjoner styres av etiske motiver Selskapet leder utviklingen innen sikkerhet Selskapet arbeider aktivt for forbedre regelverket
B. POLICY, LEDELSE	Bygger i hovedsak på regelverkets krav Målkonflikter fortrenges, eller håndteres på ad-hoc basis	Er orientert mot mål, planer og resultater Målkonflikter håndteres etter vedtatte prosedyrer, når de oppstår	Er orientert mot prosessene, kontinuerlige forbedringer og samordning Målkonflikter forebygges systematisk, men kan oppstå	Er orientert mot verdier, bedriftskultur og ideelle mål/visjoner Målkonflikter oppstår sjelden eller aldri
C. FORMALISERING	Instrukser, prosedyrer og håndbøker er rettet mot tilfreds-stillelse av regelverkets krav	Instrukser, prosedyrer og håndbøker er rettet mot tilfreds-stillelse av egne krav, som er strengere enn regelverkets	Instrukser, prosedyrer og håndbøker er under kontinuerlig forbedring Eget forbedringsprogram for sikkerhet finnes	Toppledelsen stiller funksjonelle krav Eget forbedringsprogram for sikkerhet har toppledelsens fulle oppmerksomhet
D. AVVIKSBEHANDLING	Avvik behandles på ad hoc-basis, oftest etter eksternt påtrykk	Avvik identifiseres aktivt og behandles systematisk Avviksbehandlingen omfatter også nesten-ulykker	Identifisering og behandling av avvik omfatter også: bakenforliggende årsaker potensielle avvik/farlige forhold	Potensielle kritiske og større avvik identifiseres og fore-bygges vha. scenarier/sårbarhetsanalyser
E. ERFARINGS-OVERFØRING	Foregår tilfeldig	Foregår planmessig, hovedsakelig basert på egne erfaringer	Foregår planmessig, basert på egne og andres erfaringer	Foregår planmessig, i stor grad basert på andres erfaringer
F. FORHOLD MELLOM SIKKERHET, HMS OG KVALITET	Lite bevisst på HMS, kvalitet og systematisk kvalitetssikring	Praktiserer kvalitetssikring etter NS-EN ISO 9001, 9002 e.l. Ser kvalitetssikring og sikker-hetsstyring i sammenheng	Praktiserer kvalitetsledelse etter NS-EN ISO 9004-1 e.l. Kvalitetsledelse, sikkerhets-styring og HMS-ledelse er samordnet	Legger en avansert TQM-modell til grunn for kvalitets-ledelse Sikkerhetsstyring og HMS-ledelse er integrert i TQM-modellen

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Figur 15 Modell for fastleggelse av sikkerhetsstyringens status og utviklingspotensiale

No other Norwegian offshore helicopter company spent so much resources on internal “soul searching” and analysis towards the goal of zero accidents. Seen in light of this study the Norne accident was a severe blow to the company safety management. For us involved in the safety work and development it felt “unfair” that we had to experience a fatal accident with loss of passengers and good colleagues. Still, it was somewhat comforting that the AIBN accident report did not conclude that the accident was caused by company wrongdoing, but identified a Super Puma design flaw which should have been corrected after the 1985 incident with another company helicopter flown by this author.

Norwegian Industry and Government initiated safety studies

<u>HSS 2, Helideck Safety and HSS 3</u>

While the Helicopter Safety Studies 1 (1990) and 2 (2000) were initiated by the oil companies with Shell and Statoil in the lead, NCAA became more involved in the HSS 2 and 3. This is an indication of the time it took before NCAA became more involved in offshore helicopter safety work.

In addition to the HSS 2 in 2000, SINTEF was also contracted to perform a Helideck Safety Project. The helideck study was ongoing in parallel with the HSS 2 and as Chief Technical

Pilot I was involved in both studies, before I retired by year end 1999 and started as an inspector of accidents (air safety investigator) with AIBN (then Norwegian Aircraft Accident Board).
The Helideck Safety Project Report – Design Guidelines, made many recommendations to improved helideck design, from helideck size to improved helideck systems, indicating and information systems. However, several of the recommendations were not adapted by NCAA in the revised BSL D 5-1 of 2006.

<u>NOU 2001: 21 Helicopter Safety on the Norwegian Continental Shelf</u>

"The Committee for the Review of Helicopter Safety on the Norwegian Continental Shelf was appointed by the Ministry of Transport and Communications 24 July 2000. The Committee was appointed to conduct the first of two reviews regarding helicopter traffic connected to petroleum activities on the Norwegian Continental Shelf. The mandate was to review the organising of the public authorities' involvement in this field. Based on an overview of all the laws and regulations as well as the public authorities and service providers, the Committee's scope has been to map and evaluate roles, tasks and responsibilities, how the supervision is carried out, indistinctness in laws and regulations etc."

SINTEF was contracted to contribute with data and information to the Committee and I was subcontracted to SINTEF as an advisor. Members of the Committee were persons from operators, oil companies and industry. The review highlighted the absence of NCAA in offshore helicopter operations matters and made several recommendations related to the organisation of the authorities governing the offshore helicopter transport.

"Historically, the Civil Aviation Authority has been too passive when it comes to regulating and supervising helicopter traffic on the continental shelf neither has the Petroleum Directorate given this area sufficient priority*. For these reasons the level of services, and thus safety, has to a great extent been handed over to the helicopter operators themselves in cooperation with the oil companies."*

"It is the Committee's opinion that neither the Norwegian Civil Aviation Authority, the Norwegian Petroleum Directorate nor the Norwegian Maritime Directorate act as a driving force for promoting safety in relation to helicopter safety on the continental shelf. *As time has passed, these circumstances have led to inadequate and unclear minimum requirements and lack of common standards in some areas. For example, inadequacies in requirements for equipment, training and weather observations offshore have led to considerable differences in the quality of weather observations. One of the consequences is that the helicopter pilots often get inaccurate information and unreliable weather reports. This is, in the Committee's opinion, not satisfactory. The relationship between the Norwegian Air Traffic and Airport Management, the Norwegian Civil Aviation Authority, the Norwegian Petroleum Directorate and the Norwegian Meteorological Institute is unclear and the different authorities have no common understanding of their own responsibilities.*
Generally, there is a need for better cooperation and coordination between the different parties within the helicopter activities on the Norwegian Continental Shelf. Simultaneously, there is a need for a more proactive risk based method of supervision."

The NOU 2001:21 confirmed that the NCAA previously had left the safety development to the oil companies and operators. In this respect I will postulate that we may thank Helikopter Service, Shell and Statoil for the remarkable safety level reached in Norwegian offshore helicopter operations. The fact that the safety level is based on the safety work performed by the helicopter operators and oil companies seem to be forgotten today.[22]

NOU 2002:17 The Committee for the Review of Helicopter Safety on the Norwegian Continental Shelf – (Delutredning nr. 2: Utviklingstrekk, målsettinger, risikopåvirkende faktorer og prioriterte tiltak).

"The Committee for the Review of Helicopter Safety on the Norwegian Continental Shelf was appointed by the Ministry of Transport and Communications 20 July 2001. The Committee was appointed to conduct the second of two reviews regarding helicopter safety on the Norwegian Continental Shelf. The first review was handed over to the Ministry of Transport and Communications 21 June 2001 and deals with the organizing of the public authorities' involvement on the shelf (cf. NOU 2001:21, "Helicopter Safety on the Norwegian Continental Shelf. Part 1: Organizing of the public authorities' involvement"). The mandate for this review is mainly to examine reports and conclusions from review no. 1 and based on these, among other things, suggest specific and realistic helicopter safety objectives, consider whether today's helicopter safety level is acceptable compared to the mentioned objectives, and also consider the need for specific measures to promote helicopter safety."

SINTEF was leading the Committee and again I was contracted as an advisor to SINTEF. Members of the Committee were persons from operators, oil companies and industry.

"Helicopter safety on the Norwegian Continental Shelf has been considerably improved during the last years. In spite of this, safety is still below the level of other air transport of passengers. *On this background, and because of the Norne-accident in 1997 in which 12 people were killed, there has been an increased pressure from the parties in this field to put into effect measures for further improvement of safety. The Committee regards the safety level as inadequate and has defined a large number of possible risk influencing factors and measures during its review. This includes measures concerning aircraft technical and operational dependability, preparedness measures and regulatory and customer related factors."*

NOU 2002:17 made several recommendations to NCAA, but again not all were implemented. The implemented recommendations have undoubtable made significant impact on improved Norwegian offshore helicopter safety.

Oil Companies' Influence On Flight Safety

Initially Shell was very influential regarding offshore helicopter safety. Shell had an active Aviation Department and large global offshore activity, and experienced several fatal helicopter accidents. Hence, Shell Norway through the safety manager Erik Wiig had a close relationship with Helikopter Service. Later Statoil's aviation advisor Jan Taarland built a close relationship with Helikopter Service as well. These two companies had a positive influence on Helikopter Service procedures developments, and together with Helikopter Service initiated the first HSS in 1988. However, before 2000 the oil companies were somewhat passive regarding funding of flight safety enhancement, like new equipment or flight research projects. The view was that the most of the oil companies tokk it for granted that the helicopter companies adhered to the Norwegian regulations and that NCAA (LV/LI)

[22] http://annualghac.com/assets/pdf/Day%201/11%20Einar%20Schjolberg%20.pdf

set the safety standard. This was changed after NOU 2001:21 and NOU 2002:17 were published in 2001 and 2002.

Up to 1982 Helikopter Service was a Monopoly. From the oil companies viewpoint this was costly. However, from the flight safety point of view this proved to be beneficial. The company had economy to invest in the latest helicopter types and the latest equipment. Combined with a well-organized Engineering and Operational organization and competent personnel the company had a large influence on the overall improvements in flight safety.

This was also recognized by the Labour Government with transport Minister Reiulf Steen. He wanted a strong sole offshore helicopter company like the Scandinavian Airline. However, the Monopoly was broken when Statoil gave "birth help" and an offshore contract to Lufttransport operating in the Barent Sea. This led to reduction in contract fees and Helikopter Service got less funding for new projects. Helikopter Service tried to get extra funding from the oil companies for investments in new equipment, but the general response was that this was the responsibility of the helicopter operators and NCAA.

From 1999 onwards Statoil took a leading role in OLF (later NOG) and was heavily involved in all the offshore safety studies and NOU's, and hence had a large influence on the Norwegian offshore safety level. This led to development of OLF Helideck Manual and OLF/NOG 066 Guidelines for offshore helicopter operations[23]. These documents were basically developed from Helikopter Service manuals.

Offshore helicopter companies

Helicopter Service (HS) started offshore flying in 1966. In 1975 Offshore Helicopters started offshore helicopter operations from Bergen with Aerospatiale (Eurocopter) AS 330 Puma. This was not the ideal offshore helicopter and the company was taken over by Helikopter Service in 1978. In 1982 came Lufttransport (LTR). LTR was a small company which had little influence on Helikopter Service' market share, and towards the end of the Statoil contract it was clear that Statoil did not want to pay extra to keep Lufttransport in operations. In the end LTR was fused into HS by the new majority owner of HS, the Andenes Group which was more interested in the HS capital assets than offshore helicopter operations. This led to a shift in safety focus within HS. Up to that time focus had been on safe offshore passenger transport and offshore Search and Rescue operations. With the new management from the Andenes Group, additional activities were introduced, called Special Operations like offshore aerial work (external load) and onshore SAR operations. Unfortunately the organisation was not fully prepared and trained before the new operations started. This led to two fatal accidents, one involved in offshore flare tip replacement (B 212 Ekofisk, 3 fatal) and the other CFIT during an onshore SAR mission (B214ST Alden, 5 fatal). It is worth pointing out that these accidents were not related to the primary mission of transporting offshore passengers. These accidents led to a complete revision of the Helikopter Service safety management system, from now also including risk assessments for all new type of operations.

When we look at the accidents between 1966 and 1978, the accident in 1973 was caused by a design flaw (Sikorsky tail rotor), the accident cause in 1977 was unknown, but possible human factor (wet leased S-61N from Wiking Helicoptes, Germany).

[23] https://www.norskoljeoggass.no/Global/Retningslinjer/Drift/LuftfartHelikopter/066%20-%20Anbefalte%20retningslinjer%20for%20flyging%20på%20petroleumsinnretninger.pdf

The accident in 1978 was another design flaw (Sikorsky main rotor).
The non-fatal Bell accident in 1983 was related to the NCAA requirement for rope nets on offshore helideck. Helikopter Service had frequently warned against rope nets. Many years later a Super Puma's tail skid hooked up in the net and caused a serious incident.
The next fatal accident was the Norne accident. This was again a design flaw by Eurocopter which had been discovered in 1985.

We may conclude that Helikopter Service Safety Management System functioned well for regular offshore passenger flying, at the same time as the company continuously was working on safety improvements.

As other Norwegian helicopter operators were established similar safety developments have been introduced. All of the new Norwegian offshore helicopter companies recruited experienced engineers, technicians and pilots from Helikopter Service. Hence the positive safety culture was spread to other Norwegian helicopter companies. Fortunately, since 1997 we have not had fatal accidents in Norwegian offshore passenger transport operations. However, in the time period between 1966 and 2000 it was mainly Helikopter Service which contributed to the offshore helicopter safety in Norway. The credit for this positive safety development should go to the Operations Directors of Helikopter Service, namely Mike Boxill, Jan Bengtson, Bjørn Moe and Jakob Bae. Without their leadership, commitment to safety and development of a sound company safety culture the statistics may have been different.

The NCAA was very passive in relation to Norwegian offshore helicopter regulation until NOU 2001-21 were issued. The new independent CAA was formed in 2000, and after 2002 the new NCAA has taken the lead, and together with NOG and the helicopter operators in the Safety Forum, are continuously overlooking the offshore helicopter operations and cooperating on safety improvements.

Looking to the future there are some worrying clouds over the development of Norwegian offshore helicopter safety. The major Norwegian offshore helicopter companies are owned by North American (NA) companies and to a large extent managed through their UK sub-companies. These companies have no knowledge of the Norwegian industrial culture and are enforcing NA/UK management policies on the Norwegian sub-companies. This may cause conflicts which may influence safety.

Further, Norway has developed offshore regulations and many offshore helicopter safety systems since 1966. These regulation and safety systems have supported the positive development of the Norwegian offshore helicopter safety level to be the highest in the world. EASA has now proposed new EU regulations (EASA Opinion 4/2015) which in practice prohibits Norway to manage its own offshore helicopter safety level. This is like neglecting the safety work performed in Norway over 50 years.

Conclusions

- The Super Puma accident at Shetland prompted UK CAA to set up a Helicopter Safety Review Panel to investigate why there was a significant difference between UK and Norwegian offshore safety level.

- The Panel Report concluded that the application of a range of statistical tests indicates that the difference is not statistically significant, and overall, comparison of the Norwegian and UK occurrence data indicates similar patterns (in other words; Norway's good statistics is just luck, something this author does not believe).

- This author believes that the technology and knowledge are similar among UK offshore helicopter operators and Norwegian operators. However, it is believed there is a difference in Management Culture of which the Norwegian Culture may have had positive influence on the Norwegian Safety Culture and Cockpit Pilot Command Gradient.

- The UK and NA Management Culture seems different to the Norwegian Culture. This may have influenced the positive development of the Norwegian Safety Management Culture. It is all well with good technology and procedures, but the Management must have the respect and trust by the hands-on engineers, technicians and pilots. They are the safety performers on a daily basis and are vital contributors to the Safety Culture.

- The pioneering Norwegian offshore helicopter operator was Helikopter Service. As a result of three fatal accidents during the 1970-ies the company invested heavily in flight safety management. Hence, the Norwegian Safety Culture has developed gradually over many years, initially based on, and developed in parallel with, Helikopter Service Safety Management System. Over the years new Norwegian Offshore helicopter companies have been established. All of these companies recruited experienced personnel from the pioneering Helikopter Service. Hence, these persons brought with them the safety culture from Helicopter Service and continued to build on that in their new company.

- EASA has now proposed new EU regulations for offshore helicopter operations (EASA Opinion 4/2015). The proposed EU regulations may be damaging to the achieved high level of the Norwegian offshore safety level.

- In the opinion of this author, the most significant organisations influencing the Norwegian offshore safety developments over time are Helikopter Service (Mike Boxill, Jan Bengtson, Bjørn Moe, Jakob Bae), Shell Norway (Erik Wiig), Statoil (Jan Taarland, Erik Hamremoen) and Luftfartsverket/Avinor/Stavanger ATC (Leon Nesbø, Ragnar Time and Stein Løken Clason).