Accidents in offshore and onshore helicopter operations – improvements in safety through exploring the socio-technical systems

R. J. Bye
NTNU

S. O. Johnsen
SINTEF and NTNU

G. Lillehammer
Safetec

ABSTRACT: The accident levels of Helicopter transport international is varying. By comparing helicopter safety with the Norwegian experiences, it seems that a significant improvement in safety and reduction of accidents is possible. However, a challenge is access to accident data internationally. Accidents in offshore helicopter transportation on the Norwegian continental shelf have decreased since the 1990s. The number of fatal accidents per million flight hours were 11.2 in the period 1980-1990; 2.8 for the time period 1990-1999 and zero for the time period 2000 to 2015. Looking at the Norwegian onshore (inland) helicopter transportation, the accident rate in the period 2000-2012 were 13.9. Looking at helicopter transport internationally (i.e. emergency services) – fatal accidents per million flight hours varied between 9,1 and 47 (different countries and varying time periods: 1982-2004). An obvious question to ask is; why is there such a big difference in accident rates? The Norwegian analysis shows that there are major differences between offshore and inland helicopter transportation, both in the "sharp" and the "blunt" end of the operations. This includes differences in the operation/tasks, composition and qualifications of the crews, technology in use, work organization, extent of training, employment conditions, market conditions and regulators. There are great variances in public attention and focus on helicopter accidents internationally – with different reporting schemes (poor normalization of accidents per million flight hours) – however the level of accidents seems very high and could be improved. This article presents a systematic comparison of sociotechnical issues, followed by a discussion regarding possible safety implication. A central finding is that differences in market conditions, and the actual requirements set by the users of the helicopter services, may explain some of differences in accident levels. We suggest that merely using the identified best practices could reduce the level of accident to less than 3 fatal accidents per million flight hours. In the oil and gas industry (internationally), that would reduce the annual average of 24 accidents per year to 8 per year. The FAR rate for fixed wing is 0,23 thus there should be possibility of improvement of helicopter safety.

1 INTRODUCTION

The accident rate of Norwegian onshore (inland) helicopter transportation has been significantly higher than accidents in offshore helicopter transportation. When we look at the onshore (inland) helicopter transportation in Norway, the number of fatal accidents per million flight hours in the period 2000-2012 were as high as 13.9. In the offshore helicopter transport, the corresponding frequency were 2.8 for the time period 1990-1999, and zero for the period 2000 to 2015. There has been a fatal offshore helicopter accident in 1997, and a fatal accident recently in 2016.

Analysis of Norwegian inland helicopter transportation in 2013 concluded that the fatal accident risk had increased during the previous 5 years (Bye et al. 2013). Although the analyzes overall showed a relatively high risk for inland helicopters, there were a wide variation between different types of inland helicopter operations. Ambulance and police operations were distinguished by a considerably lower risk level. Whereas the expected number of fatal accidents associated with passenger transportation were estimated to 0.36 per year, the corresponding value for ambulance and police operations were 0.06[1], i.e. one sixth of inland personnel transport.

When observing the variation in risk estimates, it is reasonable to ask the question: *Why is it much safer to use helicopter transport offshore than onshore?*

In this paper we want to address whether there could be some organizational factors that may contribute to an explanation. In order to do this, we have conducted a systematic comparison of how Norwegian offshore helicopter, ambulance/police and inland helicopter are organized. The aim is to presents

[1] There was a fatal helicopter accident with ambulance helicopter in 2014.

some hypothesis regarding organizational differences that may explain the variation in risk levels.

We have also performed a limited review of papers describing helicopter safety internationally. There were few papers that had normalized their finding related to (fatal) accidents per flight hours, thus there were difficult to get a comprehensive overview. Within helicopter medical emergency services, there was some specific results documenting that fatal accidents per million flight hours varied between 9,1 and 47 (this were from many different countries and varying time periods: 1982-2004).

2 METHOD AND THEORY

The method is based on an inductive analysis, of 3 areas: (1) offshore helicopter transportation, (2) inland ambulance and police operations, and (3) inland aerial work and passenger transportation[2]. This analysis is performed to identify differences in how the activities are organized and managed.

We have used the taxonomy of organizational and management from the socio-technical model of safety management, Rasmussen (1997).

Figure 1. Organizational issues from Rasmussen (1997).

The model represents the relationship between the hazardous work conducted in the "sharp" end of an organization vs. the "blunt end". The stakeholders are the workforce, management, regulators and government. The model addresses the impact of "environmental stressors", such as market conditions, financial pressure, public awareness etc. As seen in the figure 1, we have defined a set of organizational features related to helicopter operations, compared across the three areas of helicopter transportation.

The data used in describing these organizational aspects are based on previous and ongoing helicopter studies in Norway. This includes reports from the *Helicopter Safety Study 1,2, 3* from 1990 to 2010 (see Herrera et al. 2011), the annual report *Trends in risk level in the petroleum activity* (PSA 2014), the *Safety study inland helicopters* (Bye et al. 2013), and the ongoing research project *Work related accidents in road, sea and air transportation* (Nævestad et al. 2015).

The comparisons of these aspects between the 3 areas of operations relies partly on different data. Inland ambulance and police operations, and inland aerial work and passenger transportation relies partly on results from analysis of survey data. Equivalent survey data has not been accessible from the offshore helicopter studies. This lack of synchronicity in data sources is due to that we are conducting a meta-analysis of several research projects with different design. This has been handled by only comparing organizational aspects that are based on accessible, but partly different, data.

To perform a limited survey of Helicopter accidents, we have performed a literature review using keywords such as "Helicopter", "Helicopter transport, operations", "Safety", "Accidents", "Accident rates". Based on the identified papers we have followed relevant references to uncover additional relevant papers discussing helicopter safety of personnel transport. The key focus has been to identify papers discussing level of accidents that has been normalized (such as fatal accidents per million flight hours).

3 OPERATIONS AND ACCIDENTS

In the following we have described the operations in Norway followed by a short overview of international data.

3.1 *Type of operations*

Offshore helicopter transportations may be divided into two main operations[3]; 1) transport service between onshore bases and offshore installations, and 2) Shuttle traffic between installations.

Onshore helicopter operations in Norway are more diverse, and may be divided into three main

[2] The distinction between inland ambulance and police operations, and inland aerial work and passenger transportation is introduced because they represent two different market sectors.

[3] Offshore helicopter operation does also include Helicopter Emergency Medical Service (HEMS), and Search and Rescue (SAR). Emergency Medical Service (HEMS) are considered as a part of transport service between onshore bases and offshore installations. Search and Rescue operations (SAR) is not included in our analysis.

segments[4]: 1) Ambulance and police operations, 2) Aerial work and passenger transportation (AW/PAX operations), 3) Non-commercial activity. Further, the AW/PAX operations may divided into a variety of different operations. The Safety study inland helicopters (Bye et al. 2013) differentiate between the following 15 main operations:

1. Transportation of passengers from A to B[5]
2. Transportation of passengers from A to A
3. Parachuting
4. Ambulance/SAR[6]
5. Educational and training flights
6. Police missions[7]
7. Line Inspection/top control/… etc.
8. Reindeer herding/counting/tagging etc.
9. Tower installation/power-line construction
10. Firefighting/lime treatments of water/measurements… (flying external equipment at low altitude)
11. Logging
12. Film photo
13. Advertising banner
14. Other flights with external load
15. Other flights (technical, transfer etc.)

3.2 *Flight hours*

The total number of flight hours in Norwegian offshore and onshore helicopter transport are presented in Figure 2, showing that flight hours onshore and offshore are about the same order of magnitude.

The annual number of flight hours within offshore helicopter transportation has been increasing since 1999, from 42753 hours in 1999 to 56747 hours in 2012. The shuttle traffic between the installations counts for 12 % of the total flight hours, entailing that the flight hours related to transport service between onshore bases and offshore installations dominates.

Flight hours associated with Aerial work and passenger transportation (AW/PAX) have increased since 2000. There has also been an increase in flight hours associated with ambulance and police (Am/Pol) operations, although more modest.

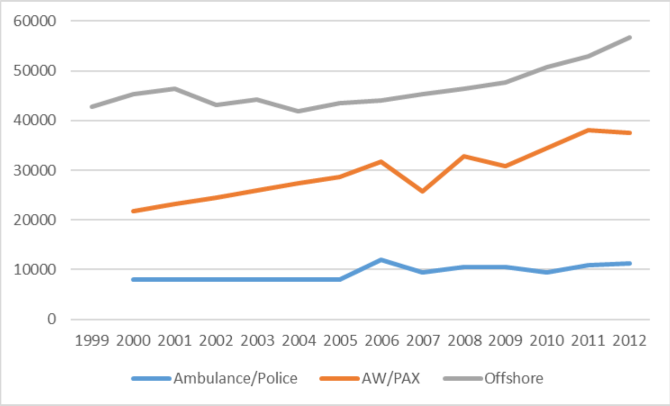


Figure 2. Yearly flight hours - offshore and onshore.

3.3 *Accident frequencies*

Number of accident[8] per million flight hours within offshore helicopter transportation have dropped from 11.2 (measured in the period 1980-1990) to 2.8 (in the period 1990-1998). There has been one fatal accident with offshore helicopter in 1997 (Table 1). This implies 2.8 fatal accidents per million flight hours for offshore helicopters from 1990 through 1998, and 0 from 1998 until 2008[9].

In onshore operations, there were 39 accidents within AW/PAX operations from 2000 through 2012, giving an accident rate of 102 accidents per million flight hours. 7 of these accidents were fatal, resulting in 18.3 fatal accident per million flight hours. When we look closer into the 7 fatal accident related to AW/PAX operations, 3 of them occurred during PAX operations (transportation of passengers) and 3 occurred in relation to other flights (technical, transfer etc.). The last fatal accident occurred during a AW operation.

Table 1. Accident records and flight hours.

	Offshore 1990-1998	Offshore 1999-2008	Amb./Police 2000-2012	AW/PAX 2000-2012
Number of accidents	4	1	2	39
Helicopter crash	1	0	0	23
Accidents with personal injuries	1	0	1	20
Fatal accidents	1	0	0	7

[4] Transportation of pilots between onshore bases and ships along the Norwegian coast are also regarded by the as a segment of inland helicopter, but not included in our analysis.

[5] Not including regular scheduled flights with helicopters.

[6] Mainly carried out by two operators commissioned by state enterprise, but may also include some mission carried out by other helicopter operators on single assignments.

[7] Mainly carried out by the police own helicopter service, but may also include some mission carried out by other helicopter operators, on assignment from the police.

[8] A condensed version if the definition of an accident by the International Civil Aviation Organization (ICAO) is an occurrence associated with a flight operation that results in fatal or serious injured people, or damage/structural failure that normally would require major repair/replacement of the affected component.

[9] In offshore helicopter operations: fatal accident in 1997 (Norne:12 fatalities) and in 2016 (Turøy: 13 fatalities).

Fatalities	12	0	0	16
Flight hours	355760	442764	122052	382452

When calculating accident frequencies per million flight hours divided by type of operations, it is apparent that the PAX operations and other flights (technical transfers etc.) are rather accident prone activities (Figure 3). During the same period there were 2 accidents within ambulance and police operations (Table 1). None of them were fatal.

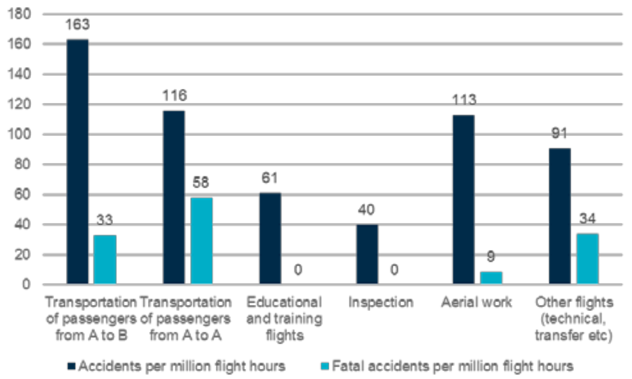


Figure 3. Accidents per million flight hour inland helicopter 2000-2012, divided by type of operation.

3.4 *Characteristics of inland helicopter crashes*

If we look closer into the historical accident with inland helicopters, we see that all fatal accidents have occurred as a result of crashes[10]. In order to identify causes of helicopter crashes, a binary logistic regression analysis and correspondence analysis of incident data has been performed (Asprang & Bye 2013). The results show that a helicopter crash, compared to other accident types, were associated with;

- PAX operations
- Bad weather conditions
- Loss of control in the air ("loss of control in flight" LOC-I)
- Inadequate planning
- Pilot's age (younger pilots were more involved in crashes)
- Pilot's total number of flight hours (i.e. fewer than 1000 flight hours)
- Types of operators (small aerial work/PAX operators, foreign operators, and private pilots)

3.5 *Offshore helicopter incidents and analyses*

Offshore helicopter safety has been in focus since the establishment of offshore production and need for transport of personnel. The oil and gas industry in Norway (Shell and Statoil) initiated a helicopter safety study in 1980´s (Ingstad et al. 1990). Main conclusions from the study were that offshore helicopter transport (Norwegian and UK sector) had a fatal accident rate of approximately 38 fatal accidents per million flight hours, that is 10 times higher than of scheduled airline services (fixed wing). It was estimated that the number of fatalities could be reduced by 40% over the next 10 years. The main area to be improved was technical reliability followed by: ATC- external navigation aids and services; Pilot performance; Crashworthiness; Aviation authorities and Manufacturers. The Helicopter Safety Study 2, (Hokstad et al. 1999) pointed out that the risks were significantly reduced since the first study, with a 50 % reduction from period I (1966-1990) to period 2 (1990-1998). The risk estimate for Norway and UK were 1.9 fatalities per million passenger flight hours. The main contributing factors were suggested to be the following: Implementation of systems to improve technical reliability (implementation of HUMS (Health and Usage Monitoring System i.e. Condition Based Maintenance System); improved radar and radio coverage and the separation of flight routes; Implementation of quality management standards; implementation of new helicopter types; improved aircraft crashworthiness.

The Helicopter Safety Study 3 (Herrera et al. 2010) documented that there had been only one helicopter accident with no fatalities on the Norwegian sector in the period 1999 to 2009. The risk reduction was estimated to be approx. 16% in period 3 (1999-2009) compared to period 2. The main contributing factors were: New helicopter types; use of HUMS; Increased pilot skills; improved flight operating procedures; improved helideck design and operations; improved emergency preparedness; introduction of safety management system; and establishment of Committee for Helicopter safety.

The list of contributing factors contain a broad set of many issues, however the issue of technical reliability and the use of tools such as HUMS have been identified as one key factor to improve safety. This focus on conditioned based maintenance of critical components was pointed out in the first helicopter study in 1990, and looking at the most recent accident in Norway (at Turøy in 2016), mechanical failure in the gearbox has been identified as the probable cause at present, AIB (2016), more than 26 years later.

The safety record of Norwegian Offshore Helicopter traffic has been impressive, in the UK sector the statistical risk was estimated to be 5,6 in the period 1999 to 2009, however due to the low probability of an accident and length of the observation period it is difficult to conclude that the Norwegian sector has a significant lower accident rate (i.e. the observation period must be longer.)

Internationally there has been several reviews that has been performed. From OGP (2010) the estimated

[10] "Crash" implies that the helicopter collides with terrain/structure, or overturns in connection with an attempted landing, resulting in damage and/or injuries.

Fatal Accident Rate (FAR) identified a good safety level in the North Sea.:

Table 2: FAR Rate Helicopter and Fixed Wing

Offshore Transport	**FAR rate**
- Helicopter North Sea	1,44
- Helicopter Gulf of Mexico	4,54
- Helicopter Rest of the World	8,15
Fixed wing transport	0,23

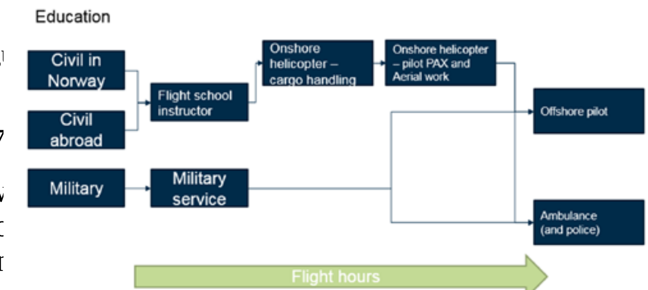
In …

3.6 *Pilots*

The educational background of the helicopter pilots in Norway vary between those who have their education from 1) the military, 2) civilian flight school in Norway, and 3) civilian flight school abroad (predominately USA). The military background is considered as more comprehensive than the others. 28 % of the pilots working within ambulance/police operation have their education from the military (Asprang & Bye 2013b). Only one pilot among the AW/PAX pilots has a military background.

Working as a pilot in offshore transportation requires a set of certificates; EASA CPL H (*Commercial Pilot License* which permits the holder to act as a pilot of a commercial aircraft), EASA IR (*Instrument Rating* which permit the pilot to perform instrument based flight, without visual references), EASA ATPL H (*Air Transport Pilot License* permit the pilot to act as pilot in command within a two pilot system). The companies require also a minimum of accumulated flight hours. The companies operating in Norway require between 800 - 1 000 flight hours. However, the customers (oil companies) requires that the pilot in command should have up to 2 500 flight hours. The recruitment process involves use of standardized tests of the candidates.

Working as an AW/PAX pilots requires only CPL H. Survey results (N=47) shows that 80 % pilots conducting with ambulance or police operations holds a IR certificate, and 55 % have a ATPL H certificate (Asprang & Bye 2013b). The requirement for these pilots are CPL H and IR, and all will hold an ATPL H theory. Minimum flight hours for ambulance pilots are; 2000 hrs relevant experience as helicopter commander, 200 hrs night flying, 100 hrs instrument flying and 50 hrs flying supported by night vision goggles (NVG). For police pilots the numbers are as follows; 1500 hrs helicopter, 1200 hrs as commander, 200 hrs night, 25 hrs NVG (with approval). No limits are set for IR. In 2012 the average number of total flight hours among Am/Po pilots were 5 647, and the average years of experience were 19. The survey results (N=97) shows that 27 % of the AW/PAX pilots have IR certificate, and 13 % got a ATPL. The average number of flight hours were 3 230 timer, i.e. 2 417 hours less than the average among pilots working with Amb/Pol operations. Average years of experience among AW/PAX pilots were 10 years. 57 % of the AW/PAX pilots pilots had less than 8 years of experience. The corresponding percentage among Amb/Pol were 8 %.These results regarding variation in experience are not suprising among people working in this branch of the aviation industry. It is a common view that employment within different sectors of the helicopter industry is closely linked to the career path of the individual pilot. Working for AW/PAX companies is by many seen just as a phase in the career towards working as ambulance or a offshore pilot. Figure 4 illustrate different common carrier paths among helicopter pilots in Norway. For many is inland AW/PAX operationis an intermediary period in order to accumulate enough flight hours in order to get a job within the offshore transportation or ambulance operations.



Fig

3.7

Tw

sho

co

rocopter EC225). The helicopters are equipped for instrument flights. The helicopters are also equipped with extra safety equipment such as e.g. flight monitoring systems HUMS, VHM etc.

Twin engine turbine is also the required helicopters within the police and ambulance segment of the inland helicopter activity. These crafts are also equipped for instrument flights.

Within the AW/PAX segment the use of twin engine helicopters are relatively rare. The total helicopter fleet of the 15 AW/PAX companies were 110 crafts in 2012. 51 % of the AW/PAX fleet consist of different versions of Airbus/Eurocopter 350 single engine. 27 % of the fleet is piston engine helicopters, consisting mainly of Robinson 44 and Robinson 22.

The AW/PAX helicopters are not equipped for instrument flight, relying only on meteorological conditions that permits visual based flights. Further, the helicopters have less protective equipment (such as e.g. floats and impact absorption/protection). The average age of the fleet (9 years) is higher than within the A/P segment (7 years).

Number of accidents with piston engine helicopters, resulting in personal injuries among crew members, per 100 000 flight hours have been more than 2 times as high compared to the frequency related to single engine turbine helicopters (Figure 5).

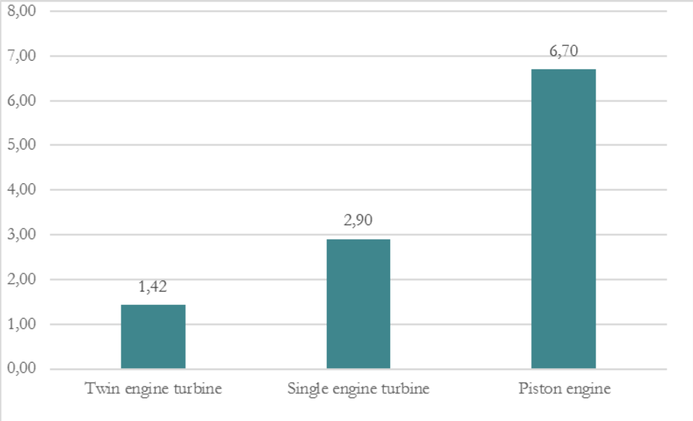


Figure 5. Inland helicopter accidents resulting in personal injuries among crew members per 100 000 flight hour by motor type (excluding private flights), 2005-2012 (N=10).

3.8 *Companies (the suppliers)*

The offshore helicopter transportation on the Norwegian continental shelf is mainly conducted by two major companies; CHC Helicopter Service and Bristow Norway. These two operators are the largest helicopter companies in Scandinavia. In 2015 CHC helicopter Service has about 200 pilots, while Bristow Norway has about 150. Two other helicopter operators have entered the operations on the Norwegian shelf recent years, Blueway and "Norsk Helikopterservice", but their activities have been marginal. Blueway is non-Norwegian, but "Norsk Helikopterservice" is a Norwegian company.

The ambulance services are supplied by two companies. One of them are organized as a nonprofit foundation. The commercial ambulance supplier is also a provider of AW/PAX, scheduled flight with helicopters, and offshore transportation of pilots. The police operators are an integrated part of the police agency.

The suppliers that are only into inland AW/PAX operations, consisted of 15 different companies in 2013. In additions these companies have to compete with foreign competitors (Swedish companies), and private noncommercial-certified pilots that conduct AW/PAX operation illegal without permission. These private pilots compete in some market segments, especially within film/photo and reindeer herding. Analysis of company data shows that the majority of the aerial work/PAX companies have had negative operating profit over the past 5 years (Aasprang & Bye 2013b).

The accident frequencies are higher among the small AW/PAX companies (less than 6 helicopters), compared to the medium (6-14 helicopters) and large companies (more than 15 helicopters). Between 2005 and 2012, the number of accidents with personal injuries among crew members per 100 000 flight hours were e.g. twice as high for small companies, compared to medium and large companies (Figure 6).

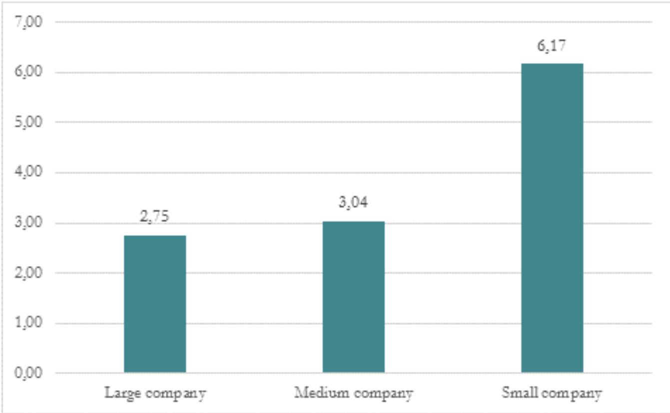


Figure 6. Number of accidents with personal injuries among crew members per 100 000 flight hours among aerial work/PAX operators of different company size, 2005-2012. (N= 9).

3.9 *Training*

Pilots within offshore transportation receive 12 hours of simulator training per year (Herrera et al. 2010). Requirement regarding training is introduced by customers and included in the contracts.

The extent of training among ambulance pilots are also described and included in the contract as a customer requirement. The training focus especially on the interactions among the crew members (CRM).

Survey results (Bye 2013) shows that 91% of the ambulance/police pilots agree that they receive retraining if they have not conducted a specific operation in a while (N=48). With the exception of one respondent, all ambulance/police pilots agreed that they have received sufficient training in handling critical situations (N=45). In comparison, 48 % of the aerial work/PAX pilots agree that they receive retraining if they have not conducted a specific operation in a while (N=97), and 62 % of the AW/PAX pilots claimed that they have received sufficient training in handling critical situations (N=95).

Very few of the AW/PAX pilots receive systematic training initiated by the company, or the customer. Pilot training is by some operators included as a part of transfer operations. However, the majority of the operators have training facilities that make it possible to conduct training on e.g. external load operations that implies interactions with personnel outside the helicopter. The quality of this facility varies. The extent of the training, measured in hours, are in general limited, and in some companies the pilots have to pay for the use of the helicopters when conducting e.g. recertification (Bye et al. 2013).

3.10 *Employment conditions*

Pilots within offshore operations, and police/ambulance operations are in general full time employed. The conditions are quite different within inland AW/PAX operations. Survey results (Bye 2013) shows that 22 % of the pilots employed by the AW/PAX operators only work part time. The proportion of pilots working only part time varies between large, medium and small operators. 2 % of the pilots employed by the large companies work part time, whereas the equivalent portion in small companies are 46 %.

In addition, there is an extensive use of freelance pilots in some companies, partly based on so-called "Fly for food" agreements. This implies that helicopter pilots conduct work on behalf of a company in exchange of accumulating flight hours in order to keep their certificates and to document experience towards potential employing companies. Further, 27 % of the pilots employed by AW/PAX have been temporary laid off once or several times by their present employer, and as many as 40 % of the pilots employed by AW/PAX have additional employment outside the helicopter company (freelance pilots not included). There is a general view among pilots that the employment conditions are best among the larger operators (Bye et al. 2013).

3.11 *Customers, regulators and regulations*

The main regulating body in Norway is the Civil Aviation Authority Norway (NCAA), which has a dedicated section for helicopter with the responsibility for case management, regulations and supervision.

Within offshore helicopter transportation the Petroleum Safety Authority, Norway (PSA) represents an additional governmental regulatory body. The customers, Oil and gas companies, are considered as responsible party by the PSA in terms of helicopter safety, and may impose stricter safety requirements in their contracts. The normal contracts imply long term agreements (several years), including fixed day rate plus hourly compensation. Other regulatory stakeholders include labour unions, both among the pilots and the users of the helicopter services, and Norwegian medias. Offshore helicopter transport has traditionally received a high media attention in Norway.

Ambulance helicopter has only 1 customer, a public company responsible for contracting air transportation on behalf of the national public health enterprises. The normal contracts imply long term agreements (several years) and fixed day rates. Additional requirements are set by the customer, and includes requirements regarding e.g. the level of training among the crew members. Due to the interdisciplinary composition of the crew, other professional associations and unions (physicians) have interests and attention directed towards the activity.

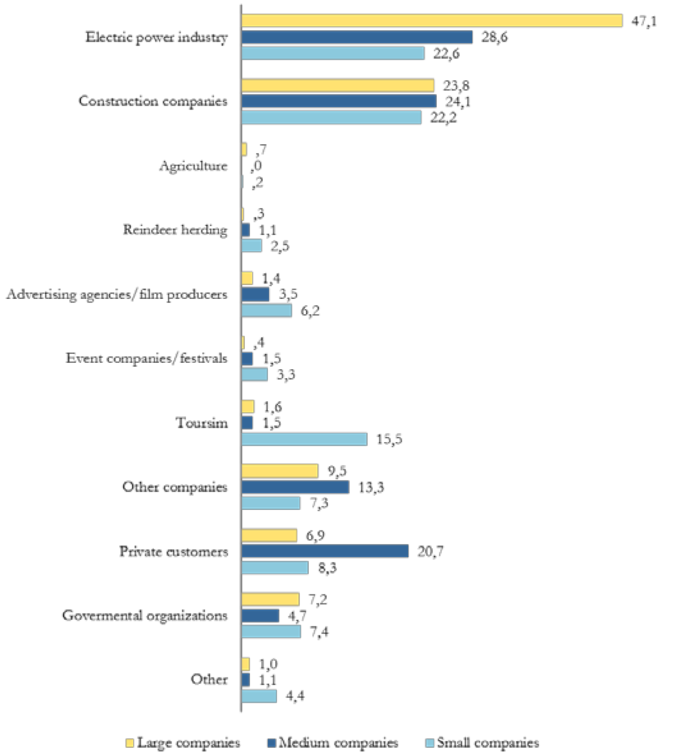


Figure 7. Types of customers and their estimated contribution to the production volume of the inland AW/PAX helicopter suppliers (Aasprang & Bye 2013b)

The inland AW/PAX companies have a wide range of different customers, ranging from enterprises to private individuals (Figure 7). The services are predominately based on single assignments, were price often is the only criteria for an assignment (Bye et al. 2013). Compared to the rest of the aviation industry, the trade unions are relatively weak, and the activity receive less attention from national medias.

The helicopter operations are regulated by national requirements based on an adaptation of common European standards. The EU has decided to impose new common European rules on aviation operations. Some regulations are published as EU regulations with associated implementing rules and "acceptable means of compliance". In the Treaty of the EEA Norway is obliged to implement all EU-regulation for the aviation sector and have its regulation in complience with EU-standards as if the country was an EU-member itself.

No common international regulation existed on this area before EASA OPS. AW was regulated in Norway by national regulations until 1. January 2016. The regulation requires the operator to send the national authority a declaration before starting operations. The national authority will then oversee the operations. Commercial helicopter operators performing "high risk specialized operations" will need an approval from the national authorities before starting operations.

3.12 *International experiences of inland helicopter transport (especially emergency transport)*

In the following we have documented some of the experiences from international helicopter transport. In Hinkelbein et al. (2011) a reiew of German helicopter emergency operations were presented, based on data from 1970 to 2009 (i.e. 40 years). The fatal accident rate in the period was 47 pr million missions, showing a reduction in the last period. There was no compulsory reporting of flight hours, thus it was difficult to normalize the results. The Human Factors Analysis and Classification System (HFACS) from Shappell and Wiegmann (2001) was used, and accidents most often happened during landing. Hinkelbein et al. (2010) compared fatal crash rates of helicopter emergency medical services (EMS) based on eleven relevant studies, where the fatal crash rates (FAR) ranged between 9,1 and 47 per million flight hours. It was difficult to gather and compare relevant data due to differences in reporting, the data documents a significant variations thus there is a need for more standardized reporting to be able to compare and learn across different countries. However there has been a reduction of fatal accidents from the period 1980-1990 to the 1990-2004 period.

Table 3: FAR Rate Helicopter EMS

Country	**Period**	**FAR**	**Ref**
Australia	1992-2002	14,6	Holland
Germany	1982-1987	41	Rhee
Germany	1999-2004	9,1	Hinkelbein
US	1982-1987	47	Rhee
US	1987-1993	16,1	Harris
US	1992-2001	16,9	Blumen
US	2000-2004	18	Wright

In Baker et al. (2006) a review of US helicopter EMS accidents in the period 1983 to 2005 was performed, documenting a fatal accident rate of 17 per million flight hours. 68% of all fatal crashes occurred during darkness, and bad weather increased the probability of fatalities. Some mitigating suggestions were presented such as improvement of crashworthiness of the helicopters (such as crash resistant fuel systems) and improved standards for certification of helicopters.

4 DISCUSSION

There is a striking difference between the accidents rates of offshore helicopter traffic and onshore (inland) helicopter traffic – especially when we compare transportation of passengers. Exploring the framework of Rasmussen (1997) we observe that there seems to be several conditions that are quite different when we compare the different segments of the industries. Some of these might help us in our attempt to interpret and formulate hypotheses regarding the differences in accident rates.

When we look at the most accident prone operations (PAX inland and inland transfer flights), these are the same ones that the pilots themselves consider as the easiest and least hazardous operations (Bye et al. 2013b). These operations are associated with relatively inexperienced pilots. It is reasonable to assume that the task performances of the pilots are further influenced by the composition of the crew, the technology in use, the extent of organizational support, the extent of training, and employment conditions.

Our exploration of the variation in employment conditions may especially raise question regarding the actual fatigue management within this segment of the industry, and the implication of a thigh coupling between pilot revenues (e.g. salary and flight hours) and mission accomplishment.

Further, the differences in accident frequencies between different PAX/AW inland helicopter suppliers of different size, may reflect the observed covariations between company size and employment conditions and extent of training.

The differences in customers and the risk based approach from the customers and the regulators, especially when it comes to the extent of special additional requirements, may explain the great differences in the technology in use, extent of training and the experience level of the pilots. It seems to be the case that the customers of offshore helicopter transportations are more concerned, are willing to identify and explore key safety issues, are willing to follow up on mitigating actions and have more willingness to pay (ore use resources) for conditions assumed to influence the safety level.

EASA is now working on a common European regulation on offshore transportation. These new regulations could imply that foreign helicopter operators may be contracted, and that some of the requirements introduced by the Norwegian Oil and Gas (NOG - the collaborative body for companies within the oil and gas industry in Norway), will be discontinued.

NOG strive to keep the existing requirement that offshore helicopter operators on the Norwegian continental shelf to carry a Norwegian Air Operator Certificate (AOC). NOG consider the existing requirements, based on the existing three-part cooperation (authority, union and operators), as a major contributor to the high safety level on the Norwegian continental shelf by the petroleum industry.

5 CONCLUSION

In this paper we have conducted a systematical comparative analysis between Norwegian offshore and onshore/inland helicopter operation, using an analytical framework based on the socio-technical model of safety management, suggested by Rasmussen (1997). We have also included data from international helicopter traffic.

The analysis shows that there are several key differences between onshore and offshore helicopter transportations that may contribute to explain the difference between the accidents rates. Our analysis indicates that especially that the additional safety concerned requirements set by the customer have a significant impact on the safety level within in the different segments of helicopter operations.

The systematic work on helicopter safety that has been conducted in Norway since 1990 driven by the industry seems to have had a significantly impacted the organization, technology and awareness of offshore helicopter transport. Similar collaboration and improvement processes have not been undertaken within the onshore helicopter industry.

On an international level, there are significant differences in helicopter safety. The safety record of offshore helicopter transport form the North Sea has been identified as best practice regime (i.e. industry collaboration) – that can be explored internationally. As suggested from Clark et al. (2006) the average of 24 fatalities pr. year involving offshore helicopter traffic can be reduced to 8 fatalities pr. year if the regime from the North Sea is implemented internationally within oil and gas industry. However, this same regime should be implemented for all Helicopter transport activities not only offshore helicopter transport. The goal should be to reach the safety level of fixed wing airplane – i.e. 0,23 FAR. To reach this goal, some of the first steps should be to identify the actual accident levels of helicopter transport between different sectors (i.e. offshore, ambulance…) and the safety between different countries – to identify the best regimes of helicopter safety.

REFERENCES

Aasprang, B. & Bye, R.J. (2013) *Analyse av risikopåvirkende faktorer* [Analysis of risk influencing factors]. Attachment D-1. Doc.Nr. ST-04215-2. Safetec.

Aasprang, B. & Bye, R.J. (2013b) *Sikkerhetsstudie* [Safety study]. Attachment C. Doc.Nr. ST-04215-2. Safetec.

AIBN (2016) Investigation of helicopter accident at Turøy near Bergen in Hordaland county, Norway retrieved at www.aibn.no/Aviation/Investigations/16-286.

Baker, S. P., Grabowski, J. G., Dodd, R. S., Shanahan, D. F., Lamb, M. W., & Li, G. H. (2006). EMS helicopter crashes: what influences fatal outcome?. Annals of emergency medicine, 47(4), 351-356.

Bye, R.J. (2013) *Sikkerhetsstudie* [Safety study]. Attachment F. Doc.Nr. ST-04215-2. Safetec.

Bye, R.J., Seljelid, J., Heide; B., Lillehammer, G. Aasprang, B., Antonsen, S. Vinnem, J.E., Bø, B. (2013) *Sikkerhetststudie innlandshelikopter - Hovedrapport*. [Safety study inland helicopters – main report]. Doc.Nr. ST-04215-2. Safetec.

Bye, R. J., Ekle, R., Heide, B., Aasprang, B., & Antonsen, S. (2013b). When to worry? The relationship between modeled risk and perceived risk among helicopter pilots. *Safety, Reliability and Risk Analysis: Beyond the Horizon*, 259.

E. Clark, C. Edwards, P. Perry, G. Campbell and M. Stevens, (2006) Helicopter Safety in the Oil and Gas Business, SPE98672-MS.

Herrera, I. A., Håbrekke, S., Kråkenes, T., Hokstad, P., Forseth, U. (2010). Helicopter Safety Study 3. Main report. SINTEF report no. A14973, Trondheim, Norway.

Hinkelbein, J., Schwalbe, M., Neuhaus, C., Wetsch, W. A., & Genzwürker, H. V. (2011). Incidents, accidents and fatalities in 40 years of German helicopter emergency medical system op-erations. European Journal of Anaesthesiology (EJA), 28(11), 766-773.

Hokstad, P., Jersin, E., Hansen, G. K., Sneltvedt, J., Sten, T. (1999). Helicopter Safety Study 2. Volume 1: Main Report. SINTEF report no. STF38 A99423, Trondheim, Norway.

Ingstad, O., Rosness, R., Sten, T., Ulleberg, T., Rausand, M., Lydersen, S(1990). "Helicopter Safety Study. Main Report. SINTEF Report STF75A90008.

Nævestad,T.O., Ross, O.P.; Elvebakk,B., Bye, R.J., Antonsen,S. (2015) Work related accidents in road sea and air transport: prevalence and risk factors. Report. Nr. 1428/2015, ISBN 978-82-480-1653-3. TØI: Norwegian Centre for Transport Research.

OGP (2010) Risk Assessment Data Directory *Report No. 434 – 11.1 March 2010.*

PSA (2014) Risikonivå i petroleumsvirksomheten Hovedrapport, utviklingstrekk 2014, norsk sokkel [Trends in risk level in the pertroleum activity]. Petroleum Safety Authority Norway.

Rasmussen, J. (1997). Risk management in a dynamic society: a modelling problem. *Safety science*, *27*(2), 183-213.

Shappell, S.A. & Wiegmann, D.A. (2001). Applying Reason: The Human Factors Analysis and Classification System (HFACS). Human Factors and Aerospace Safety, 1(1): 59-86.