European Helicopter Safety Analysis Team
EHSAT

Report

Preliminary Results of Helicopter Accident Analysis

Originally presented at the European Helicopter Safety Team (EHEST) Conference of 13 October 2008 in Cascais, Portugal

< v 1.0>

Report

Document ref.	Status	Date
EHSAT Preliminary results 2008	V1.0	20/04/2009
Contact details for enquiries:	European Helicopter Safety Team ehest@easa.europa.eu www.easa.europa.eu/essi	

Disclaimer:

The safety improvement analyses and recommendations produced by EHSAT are based on expert judgement and are supplementary to the official reports of the accident investigation boards (AIB). Such recommendations, and the safety improvement actions that may follow, are solely aimed at improving helicopter safety, are not binding and under no circumstances should be considered to take precedence over the official AIB reports. The adoption of such safety improvement recommendations is subject to voluntary commitment, and engages only the responsibility of those who endorse these actions. The EHSAT accepts no responsibility or liability whatsoever with regard to the content or for any actions resulting from the use of the information contained in these recommendations.

	Name	Date
Prepared	Marieke van Hijum, Martin Bernandersson, EASA	30/03/2009
Reviewed 1	Michel Masson, EASA, EHSAT co-chair	31/03/2009
Reviewed 2	Andy Evans, AviateQ, EHSAT co-chair	02/04/2009
Authorised	John Vincent, EASA, Jean-Pierre Dedieu, EUROCOPTER, and John Black, EHOC, EHEST co-chairs	08/04/2009

This page is intentionally left blank

Table of Contents

Acronyms

AIB	Accident Investigation Board
ASR	Annual Safety Review
CAST	Commercial Aviation Safety Team
EASA	European Aviation Safety Agency
ECAST	European Commercial Aviation Safety Team
ECCAIRS	European Coordination Centre for Accident and Incident Reporting Systems
EGAST	European General Aviation Safety Team
EHEST	European Helicopter Safety Team
EHSAT	European Helicopter Safety Analysis Team
EHSIT	European Helicopter Safety Implementation Team
ESSI	European Strategic Safety Initiative
FAA	Federal Aviation Administration
HF	Human Factors
HFACS	Human Factors Analysis and Classification System
ICAO	International Civil Aviation Organisation
IHSS	International Helicopter Safety Symposium
IHST	International Helicopter Safety Team
IR	Intervention Recommendation
LTE	Loss of Tail Rotor Effectiveness
SOP	Standard Operational Procedure
SPS	Standard Problem Statement
JHSAT	Joint Helicopter Safety Analysis Team
JHSIT	Joint Helicopter Safety Implementation Team

Executive Summary

The **European Strategic Safety Initiative (ESSI)**, a ten year program to enhance aviation safety for European citizens, is a partnership between the European Aviation Safety Agency (EASA), other European national aviation authorities, manufacturers, operators, professional unions, research organisations, military operators and the general aviation community. More than 150 organisations participate to date. The basic principle is to improve aviation safety by complementing regulatory action by voluntarily committing to cost-effective safety enhancements. Analysis of occurrence data, coordination with other safety initiatives and implementation of cost-effective action plans are carried out to achieve fixed safety goals.

The ESSI has three components: the European Commercial Aviation Safety Team (ECAST) - the European equivalent to CAST in the United States, the European General Aviation Safety Team (EGAST), and the **European Helicopter Safety Team (EHEST)**.

EHEST is also the European component of the **International Helicopter Safety Team (IHST)**. IHST was formed as a major initiative to improve helicopter safety worldwide. It is a combined government and industry effort to reduce the helicopter accident rate – both civil accidents and noncombat military mishaps - by 80 percent by 2016. EHEST is committed to this IHST objective, with emphasis on European safety.

In order to pursue the 80% accident rate reduction goal, the IHST adopted and adapted a process originally developed by the United States Commercial Aviation Safety Team (CAST). The CAST strategy is to significantly increase public safety by adopting an integrated, data-driven methodology to reduce the fatality risk in commercial air travel (fixed wing aircraft). The process involves a data-driven methodology, based on the review of occurrence data, and by developing safety enhancements and action plans are developed.

The IHST has so far created two working groups to deal with the different process steps: the Joint Helicopter Safety Analysis Team (JHSAT) and the Joint Helicopter Safety Implementation Team (JHSIT). The analysis team focuses on the review of occurrence data. The development and implementation of the safety enhancements are the tasks of the implementation team.

Under EHEST the analysis team is called the **European Helicopter Safety Analysis Team (EHSAT)**. This working group of EHEST performs the first step in the process: the review of occurrences. So far, nine regional teams have been created in Germany, France, United Kingdom, Italy, Spain, Switzerland, Ireland, Hungary and the Nordic Region (Norway, Sweden and Finland) to analyse helicopter accidents and derive recommendations for interventions. It is estimated that the current nine EHSAT regional analysis teams cover more than 90% of the civil European helicopter fleet. The analysis results of the different regional teams are consolidated on a European level. This initiative is unique in its efforts to prepare a European wide accident analysis of helicopter accidents. The EHSAT will in the end also be involved in the measuring of results and effectiveness.

The EHSIT was launched on 5 February 2009 and will develop action plans for safety enhancement based on the intervention recommendations produced by the EHSAT. These action plans will be submitted to EHEST for approval.

The EHSAT analysis consolidates analysis of European wide helicopter accident data. Section 6 presents the preliminary results based on the 186 helicopter accidents analysed up to 15

September 2008. The scope of the data set is accidents[1] within EASA Members States within the timeframe 2000-2005 and where a final investigation report from the Accident Investigation Board has been issued.

Of most accidents analysed so far, 72 accidents involve General Aviation operations. 66 accidents involve Aerial Work operations, 40 Commercial Air Transport operations and 8 State Flights. It is estimated that this number covers some 58% of the accident reports currently available and some 25% of the estimated total number of helicopter accidents within this timeframe.

Most accidents analysed by the EHSAT (34%) occurred during the en route phase of flight. Also, 68% of the *fatal* accidents in the dataset occurred during the en route phase. In 33% of the accidents, the pilot had less than 1000 hours total helicopter experience. In 26% of the accidents, the pilot had less than 100 hours flight experience on the helicopter type involved in the accident. It was also observed that pilot experience is not always a barrier to having an accident.

The accident analysis aims at identifying all factors, causal or contributory, that played a role in the accident. Factors are coded using two taxonomies: Standard Problem Statements (SPS) and Human Factors Analysis and Classification System (HFACS) codes.

The top 3 identified areas for the Standard Problem Statements are

- Pilot judgment & actions
- Safety Culture/Management
- Pilot situation awareness.

The high level results were compared with the US analysis results and showed a high correlation of 0.89.

The use of the HFACS taxonomy by the EHSAT provided a complementary perspective on human factors. In 76% of the accidents, at least one HFACS factor was identified. In most accidents unsafe acts or preconditions for unsafe acts were identified. In fewer accidents reports issues related to supervision or organisational influences were captured. The possibility of identifying those factors is very much dependent on the depth of the accident investigation performed.

For both the Standard Problem Statements and HFACS taxonomies, different patterns were observed for Commercial Air Transport, Aerial Work and General Aviation.

Most Intervention Recommendations (IR) were identified in the areas of Training/Instructional, Flight Operations & Safety Management/Culture, and Regulatory/Standards/Guidelines.

When more analysed accident data becomes available, the results may change. Nevertheless, it is estimated that the preliminary results already provide a good indication of the final results.

[1] as defined by ICAO Annex 13 Aircraft Accident and Incident Investigation.

1 European Helicopter Safety Team

The broader picture: ESSI and IHST

The **European Strategic Safety Initiative (ESSI)**[2], a ten year program to enhance aviation safety for European citizens, was launched in 2006. The ESSI is a partnership between the European Aviation Safety Agency (EASA), other European national aviation authorities, manufacturers, operators, professional unions, research organisations, military operators and the general aviation community. More than 150 organisations participate to date.

The basic principle is to improve aviation safety by complementing regulatory action by voluntarily committing to cost-effective safety enhancements. Analysis of occurrence data, coordination with other safety initiatives and implementation of cost-effective action plans are carried out to achieve fixed safety goals.

The ESSI has three components: the European Commercial Aviation Safety Team (ECAST) - the European equivalent to CAST in the United States, the European General Aviation Safety Team (EGAST), and the **European Helicopter Safety Team (EHEST)**.

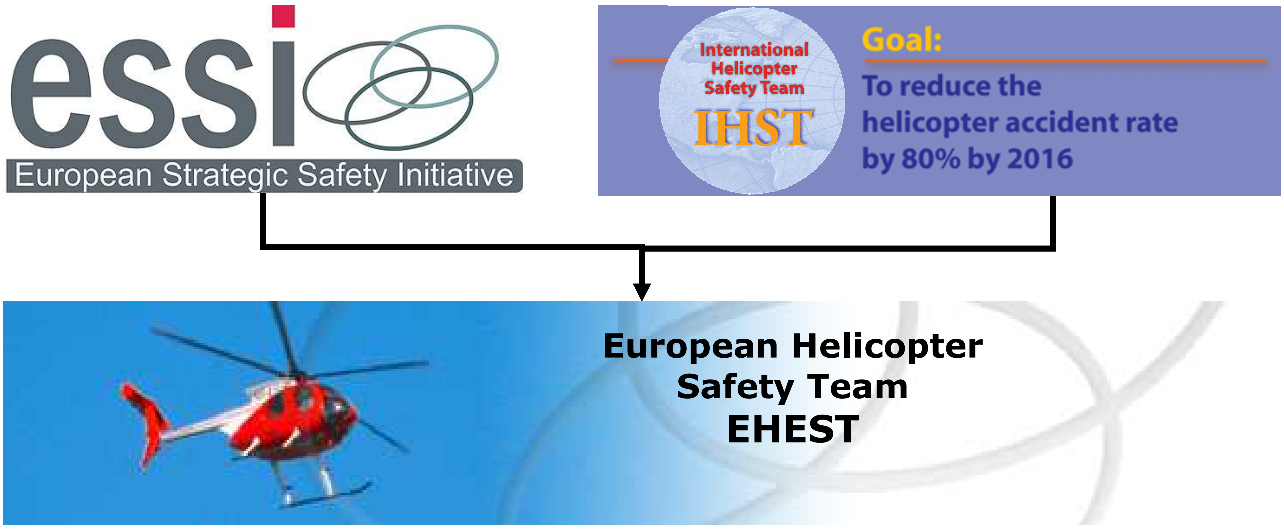
EHEST is also the European component of the **International Helicopter Safety Team (IHST)**[3]. The IHST was formed in 2005 after the International Helicopter Safety Symposium (IHSS) in Montreal, Canada. Central theme of this symposium was the persistence of unacceptably high helicopter accident rates and the need to improve this record. IHST was formed as a major initiative to improve helicopter safety worldwide. It is a combined government and industry effort to reduce the helicopter accident rate – both civil accidents and noncombat military mishaps - by 80 percent within 10 years.

The IHST is led by representatives of the Helicopter Association International, the United States Federal Aviation Administration (FAA), American Helicopter Society International, Transport Canada, the European Aviation Safety Agency (EASA), European Helicopter Association and several industry partners.

So far, regional teams have been established in the US, Europe, Canada, India, Brazil, and Australia. At the same time the IHST is seeking to further expand, for example by creating new groups in the Middle East, Far East, Commonwealth of Independent States and South Asia.

EHEST is committed to the IHST goal of reducing the helicopter accident rate by 80 percent by 2016 worldwide, with emphasis on European safety.

[2] http://easa.europa.eu/essi/
[3] www.ihst.org



The EHEST brings together helicopter manufacturers, operators, EASA, National Aviation Authorities, helicopter and pilots associations, research organisations, accident investigators, the general aviation community and a few military operators from across Europe [Ref.1-5]. EHEST comprises more than 75 participating organisations. A listing of participants is provided on the ESSI/EHEST website[4]. The safety team addresses the broad spectrum of helicopter operations across Europe, from commercial air transport to general aviation.

---

[4] http://www.easa.europa.eu/essi/ehestEN.html

2 Background data for Europe

In Europe[5], helicopters are used in a wide variety of operations and regions: from North Sea offshore operations to mountain flying, from fire fighting operations to pleasure flights.

For 2007, it was estimated that approximately 6860[6] helicopters were registered in Europe for civil use.

There is no reliable flight hour data available for all registered helicopters across Europe. However, an estimate can be determined for turbine powered helicopters[7]. For the year 2007 a total of 1.7 million flight hours and 5 million landings were estimated for civil use helicopters registered in Europe.

Data collected for the EASA Annual Safety Review [Ref.6] provides an indication of the total number of helicopter accidents within Europe, see Figure 1. For the year 2006 116 helicopter accidents were reported to EASA. In 2007 the number decreased to 96. It has to be noted however that four States did not provide data to EASA for the year 2007, with only one State in 2006. Since the year 2006, EASA started collecting accident information for light aircraft (maximum take-off mass below 2250 kg). Because of this, no trend can be observed based on the two year data.[8]

A total of 16 fatal accidents occurred in 2007, compared to 14 in 2006. In these accidents, 92 people were fatally injured (47 in 2007 and 45 in 2006).

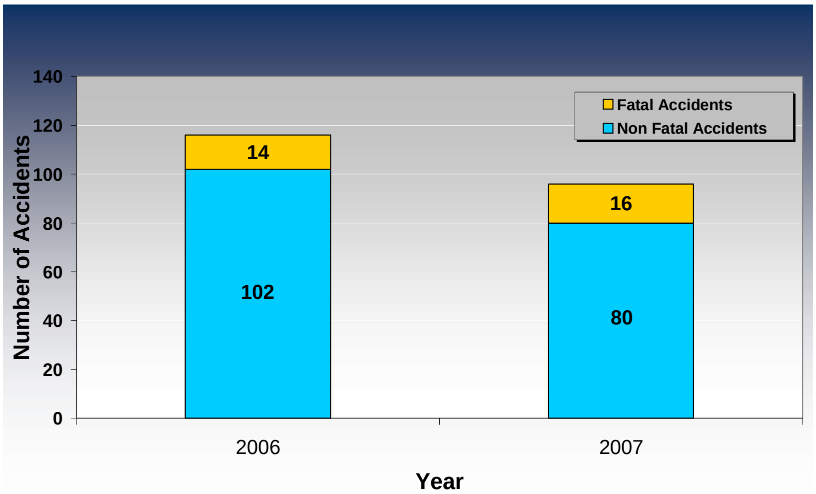


Figure 1 - Helicopter Accidents in EASA Member States (Civil Aviation, EASA Member States Registered Helicopters)

It can be concluded that helicopter operations are an important part of aviation for Europe. Accidents continue to occur. The following chapter describes what process the EHEST/IHST initiative had developed to work towards the goal of helicopter accident rate reduction.

---

[5] For this report, Europe is considered to be the 27 European Union Member States plus Iceland, Liechtenstein, Norway and Switzerland.
[6] Source Helicas and EASA Data Warehouse
[7] Source EASA Data Warehouse
[8] The Annual Safety Review for 2008 is yet to be published.

3 Process description

In order to pursue the 80% accident rate reduction goal, the IHST adopted and adapted a process originally developed by the United States Commercial Aviation Safety Team (CAST)[9]. The CAST strategy is to significantly increase public safety by adopting an integrated, data-driven methodology aimed to reduce the fatality risk in commercial air travel (fixed wing aircraft). CAST was formed in 1998.

The process involves a data-driven methodology, where based on the review of occurrence data, safety enhancements and action plans are developed. These enhancements may address both regulators and industry and should be implemented by the participating organisations. Both the level of the actual implementation and the effects have to be measured, in order to ensure that effective actions were put in place.

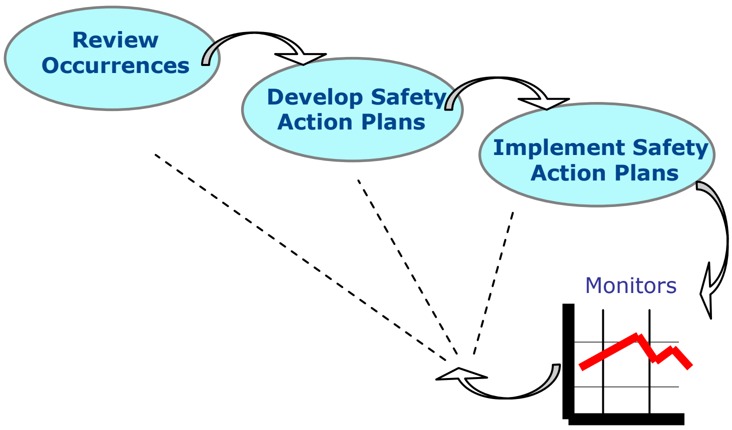


Figure 2 - Data-driven process adapted from CAST

The IHST has so far created two working groups to deal with the different process steps: the Joint Helicopter Safety Analysis Team (JHSAT) and the Joint Helicopter Safety Implementation Team (JHSIT). The analysis team focuses on the review of occurrence data. The development and implementation of the safety enhancements are the tasks of the implementation team.

Under EHEST the analysis team is called the European Helicopter Safety Analysis Team (EHSAT). This working group performs the first step in the process: the review of occurrences. So far, nine Regional Teams have been created in Germany, France, United Kingdom, Italy, Spain, Switzerland, Ireland, Hungary and the Nordic Region (Norway, Sweden and Finland) to analyse helicopter accidents and derive recommendations for interventions. It is estimated that the current nine EHSAT regional analysis teams cover more than 90% of the civil European helicopter fleet. The analysis results of the different regional teams are consolidated on a European level. This initiative is unique in its efforts to prepare a pan-European analysis of helicopter accidents. The EHSAT will in the end also be involved in the measuring the effectiveness of the implemented safety enhancements.

Launched on 5 February 2009 the EHSIT will develop action plans for safety enhancement based on the intervention recommendations produced by the EHSAT. These action plans will be submitted to EHEST for approval.

---

[9] http://www.cast-safety.org/

4 The EHSAT

EHSAT work is based on analysis of accident reports but must not be confused with an accident investigation performed by the Accident Investigation Boards. The EHSAT accident analysis is based on a standardised method featuring the use of taxonomies and expert judgement. Analysing an accident on all aspects requires a diverse and balanced set of competences. An analysis team should therefore present a balanced range of competences, bringing together representatives with different backgrounds from the national aviation authority, accident investigation board, civil operator, helicopter equipment manufacturer or type certificate holder, pilot association, the general aviation community, research organisations and, optionally, military organisation, etc.

To tackle the variety of languages used in accident reports and optimise the use of resources, EHSAT has established regional teams. The use of local language also facilitates work within national teams, whilst for aggregation purposes all teams are requested to deliver results in English. In a regional team based organisation, relations between team members are often already established and the teams are well aware of local contexts. Regional teams can also facilitate implementation of future safety enhancements at regional level.

EHSAT regional teams have been formed in France, Germany, United Kingdom, Italy, Spain, Switzerland, the Nordic region (Norway, Sweden and Finland), Ireland and Hungary. So far the countries covered by the regional teams account for more than 90% of the helicopters registered in Europe, see Figure 3.

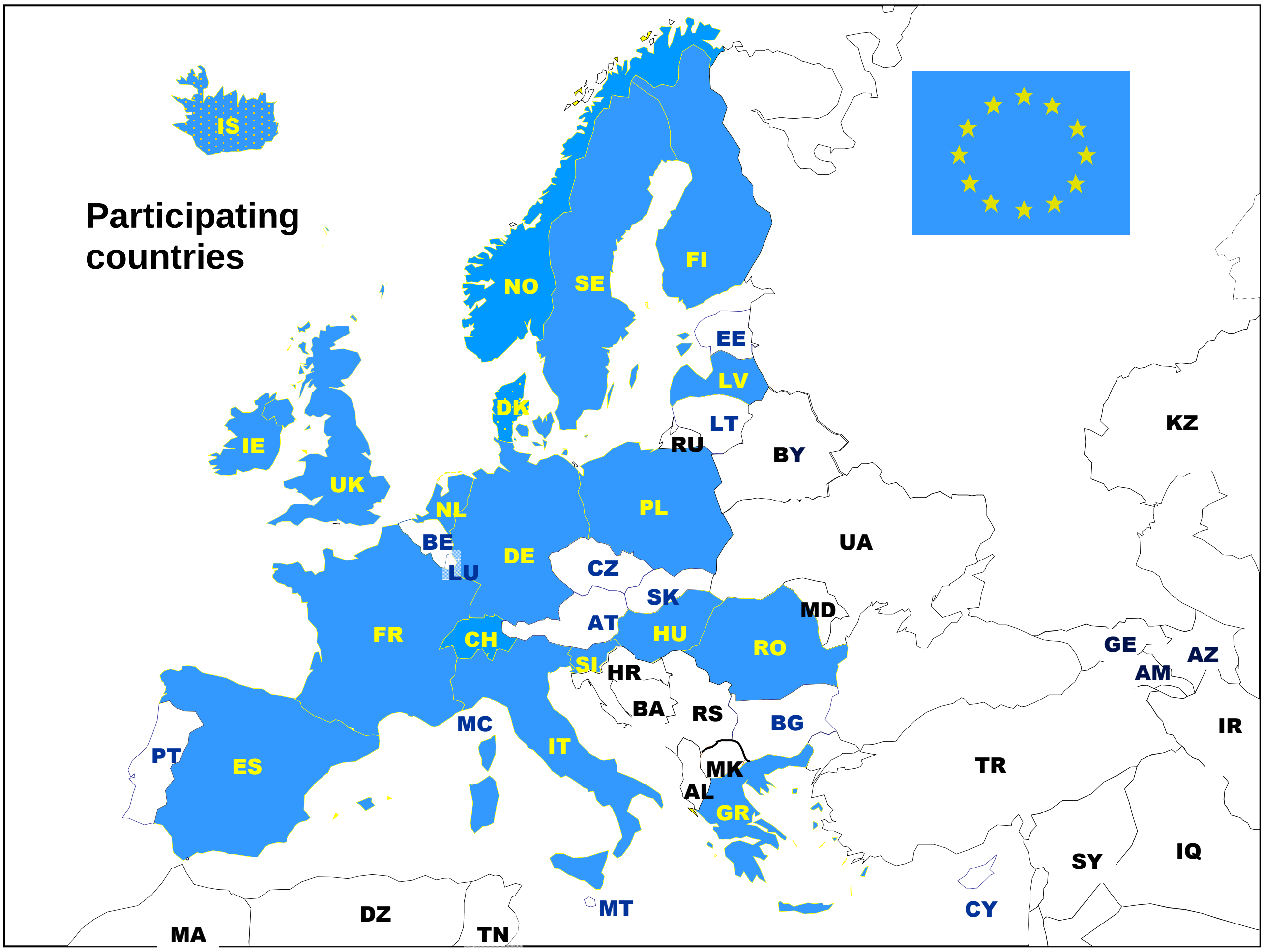


Figure 3 - Participating countries in the EHSAT (blue)

Analyses performed at regional level are aggregated by a central EHSAT team composed of representatives from all regional EHSATs and from EASA. The central EHSAT collects regional results and experiences, checks and aggregates results (including quality control), revises the taxonomies, tool and process manual for the purpose of standardisation, trains new regional teams, reports to the EHEST, and coordinates with the EHSIT, the JHSAT and the IHST.

5 Analysis Methodology

The EHSAT analysis scope has been initially limited to:

- Accidents (definition ICAO Annex 13) reported by the Accident Investigation Boards
- with date of occurrence being in the years 2000-2005
- State of occurrence located in Europe

In order not to interfere with ongoing accident investigation board investigations, only those accidents where a final investigation report has been issued are analysed.

EHSAT is committed to ensuring that the analysis carried out in Europe is compatible with the work performed by other analysis teams worldwide, so that the analyses can be discussed at worldwide level. The methodology therefore was basically inherited from the US JHSAT [Ref.7], which itself adapted to helicopters the methodology originally developed in the late nineties by CAST for the analysis of fixed wing commercial air transport accidents. The analysis is accomplished by a team analysing what happened and why (the chain of events), and what might have been done differently (interventions) to prevent similar events in the future.

The analysis methodology features five steps:

1. <u>Collect General Information</u>

Several accident identification elements are collected for classification and analysis purposes such as occurrence date, state of occurrence, aircraft registration, helicopter make and model, operation type, aircraft damage, injury level, phase of flight, meteorological conditions, and flight crew flight experience. EHSAT has introduced the ICAO ADREP 2000 taxonomy to collect this information, with the purpose of standardisation and of allowing exchange of information with the ECCAIRS[10] system.

2. <u>Describe and Analyse the Accident</u>

The analysis aims at identifying all factors that played a role in the accident. The underlying assumption is that accidents are the result of a chain of events that could have been prevented by altering or eliminating one or more of the “links” in the chain. Instead of focusing on an accident’s “primary cause”, the process focuses on identifying and removing one or more links in the accident causal chain, which could have initiated hours, days or even weeks before the accident.

An event is defined as a decision, action or failure that contributed to or led to an occurrence. Events and conditions are presented in chronological order, and analysed one by one. The method requires analysing what happened and why. The teams can first use ‘free text’ to describe the accident. ‘What happened’ provides factual description, using or summarising statements from the accident report, whilst identification of ‘why’ certain things happened is based on the analysis provided in the accident report and/or on aspects identified by the analysis team based on expert judgement.

---

[10] ECCAIRS stands for European Coordination Centre for Accident and Incident Reporting Systems. The mission of ECCAIRS is to assist National and European transport entities in collecting, sharing and analysing their safety information in order to improve public transport safety. The ECCAIRS Reporting System is composed of various applications forming together a suite of products allowing organisations to create, maintain and deploy a repository of accident and incident reports. ECCAIRS is used by many national aviation authorities and accident investigation boards in Europe, but also worldwide.

3. Assign standardised codes to the factors

The next step in the methodology is to translate the free text in step 2 into standardised codes. The use of standardised codes supports accident aggregation and statistical analysis. EHSAT uses two models to assign codes: Standard Problem Statements and HFACS codes.

The **Standard Problem Statements** (SPS) taxonomy inherited from IHST/US JHSAT has over 400 codes in 14 different areas. The structure consists of three levels: the first level identifies the main area of the SPS, and the second and third levels go into more detail. Level 1 categories are: Ground duties; Safety Management; Maintenance; Infrastructure; Pilot Judgement and actions; Communications; Pilot situation awareness; Part/system failure; Mission Risk; Post-crash survival; Data issues; Ground personnel; Regulatory; and Aircraft Design. A single factor identified in the accident can be coded using more than one SPS. Figure 4 presents an example of the translation of the analysis into a three-level SPS code.

Analysis /Why/Contributing factors	SPS nr.	level 1	level 2	level 3
The commander inadvertently entered IMC and probably became spatially disoriented	701005	Pilot situation awareness	Visibility/Weather	Inadvertent entry into IMC

Figure 4 - Example of Standard Problem Statement

Because of the ambitious goal setting of 80% accident rate reduction, where it can be foreseen that many of the identified factors will lie within the human factors domain, EHSAT decided to include a second model and taxonomy in the analysis phase to better address these human factors: **The Human Factors Analysis and Classification System (HFACS).** HFACS was developed from Reason's concept of latent and active failures [Ref.8-9]. The HFACS model describes human error at four levels: organisational influences, unsafe supervision, preconditions for unsafe acts and the unsafe acts of operators (e.g. flight crew, maintainers, air traffic controllers etc.). See Figure 5. The classification system contains over 170 codes in these four main areas. In addition to providing more detail on human factors, it also encouraged the EHSAT to not only identify the human error on an operator level, but to also search for underlying management and organisational factors. An example of HFACS coding in the EHSAT analysis is provided below in Figure 6.

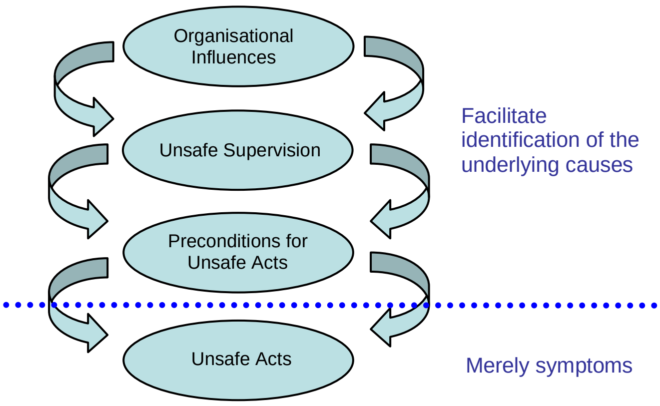


Figure 5 - HFACS model structure

Analysis /Why/Contributing factors	HFACS nr.	level 1	level 2	level 3
The commander inadvertently entered IMC and probably became spatially disoriented	5305100	Preconditions - Condition of Individuals	Perceptual Factors	Spactial Disorientation 3 Incapacitating
	5001040	Unsafe Acts - Errors	Skill-based Errors	Overcontrol/Under control
	5501030	Supervision	Inadequate Supervision	Local Training Issue / Programs
	5603020	Organizational Influences	Organizational Process	Program and Policy Risk Assessment

Figure 6 - Example of application of HFACS code

Additionally, a special HFACS Maintenance Extension (HFACS ME) was introduced to code maintenance related human factors. HFACS ME is the coding system for maintenance personnel and organisation developed by the US Naval Safety Center. The system features the following main categories (from local to remote): Maintainer Acts, Maintainer Conditions, Working Conditions, and Management Conditions.

4. <u>Produce Intervention Recommendations</u>
The next analysis step consists of identifying Intervention Recommendations (IRs) for all the factors identified in the previous steps. IRs are aimed at preventing factors, directly or more remotely involved, from reoccurring. One or several Intervention Recommendations (IRs) can be formulated for each SPS or HFACS. IRs are freely generated and formatted in free text, using the diverse expertises in the analysis team and supporting creativity. A special support table was created to invite the analysis teams to go through all flight phases and to target various aspects within the IRs such as regulations, design and other technical factors (e.g., weight and balance), certification, operations; procedures, staffing, qualification, licensing and training, weather, winds, turbulences and other environment factors, working environment factors, workload, fatigue, attitudes, national, regional, company and professional culture and other human factors, production, commercial and market factors, management, Safety Management Systems (SMS) and safety culture, and accident investigation aspects. Finally, the IRs are categorised to allow consolidation of results. Figure 7 presents an example of an Intervention Recommendation.

Intervention recommendation	Intervention recommendation
(free text)	(coded on Category level)
All periodic base check flying tests carried out by the Operator should include the pilot's capability to fly by sole reference to flight instruments.	Training/Instructional
Regulations should address the hazards of flight in a Degraded Visual Environment (DVE).	Regulatory

Figure 7 - Example of Intervention Recommendations

5. <u>Score Standard Problem Statements and Intervention Recommendations</u>
To assist the implementation team, and ultimately the industry and authorities, to determine best action course, all the coded factors in step 3 are scored on <u>Validity and Importance</u> and the IRs identified in step 4 on <u>Ability and Usage</u>. Validity is dependent on the level, quality and credibility of data and information available in the event report: factors associated with

hypothetical events not supported by documented evidence in the accident reports are scored low on validity. Importance is the measure of the identified factor importance in the event's chain of causal factors. Ability is the measure of how well an IR can mitigate an event's problem or contributing factor, assuming it performed exactly as intended. Usage is the measure of how confident we are that this intervention will be utilised and will perform as expected given this particular accident scenario.

Accident analyses provided by all regional teams are then analysed at aggregated level to present a European picture. The analysis results will finally be passed on to the implementation team, the EHSIT. Economic and other considerations are introduced in the EHSIT process to decide on best course of action and develop suitable safety enhancement action plans.

6 Preliminary Analysis Results

Analyses focus on:

- Accidents,
- Date of occurrence between 01/01/2000 – 31/12/2005,
- State of occurrence located in EASA Member States,
- Only those accidents are being analysed where a final report from an Accident Investigation Board is available.

The results presented in this report are preliminary results, based on the 186 accidents analysed by the nine EHSAT regional teams up to 15 September 2008.

It is estimated that this number covers some 58% of the accident reports currently available and some 25% of the estimated total number of helicopter accidents within this timeframe.

6.1 General data

Of most accidents analysed so far, a total of 72 accidents involve General Aviation operations, see Figure 8. A relative large proportion of Commercial Air Transport accidents have been analysed (40). This is most probably the result of good availability of accident reports for this type of operation. The same reasoning applies to the relative large share of fatal accidents analysed within the dataset, see Figure 9.

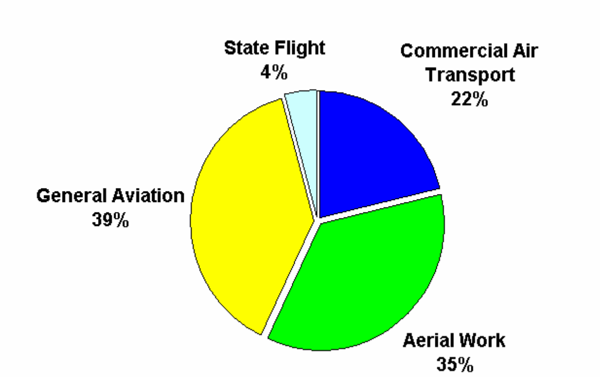


Figure 8 - Number of accidents per type of operation in the analysed dataset

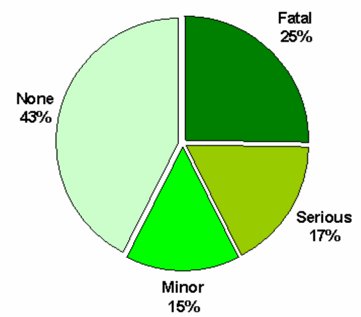


Figure 9 - Injury level in the analysed dataset

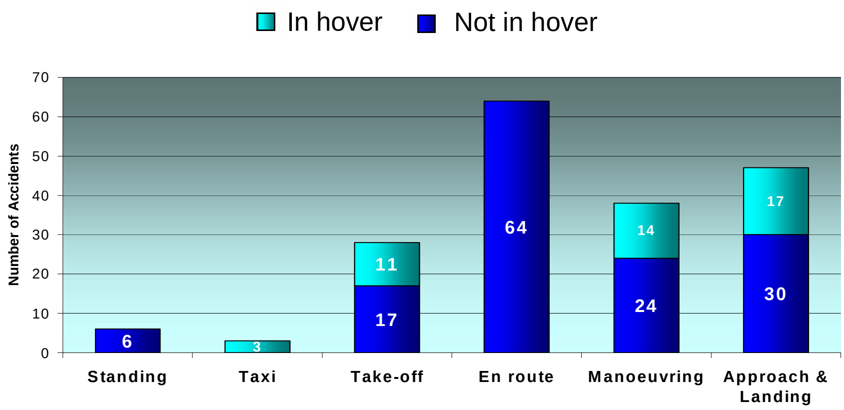


Figure 10 - Distribution of accidents over the phase of flight

Most accidents, 34%, occurred during the en route phase of flight, see Figure 10. In general, during the en route phase more time is spent at speed and therefore the energy available is higher. The preliminary results distribution over phase of flight is different from the distribution for fixed wing aircraft in commercial air transport operations as published in the EASA Annual Safety Review [Ref.6], where the share of Approach & Landing accidents is the highest.

In total, the helicopter was in the hover in 24% of the accidents. When looking only at fatal accidents, 68% of the fatal accidents occurred during the en route phase, see Figure 11.

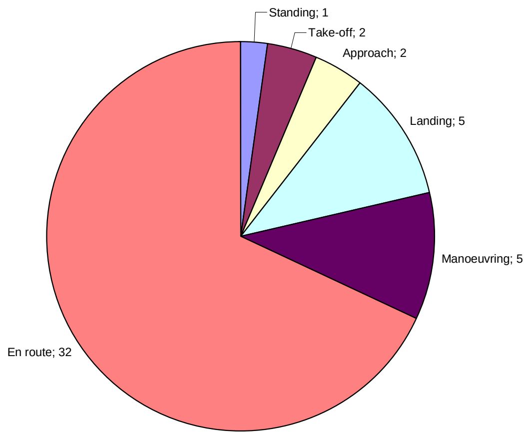


Figure 11 - Distribution of fatal accidents over the phase of flight

Data was gathered on the pilot-in-command flight experience for 83% of the accidents in the data set. In most accidents the pilot had limited flight experience; in 33% of the accidents the pilot had less than 1000 hours total helicopter experience, see Figure 12.

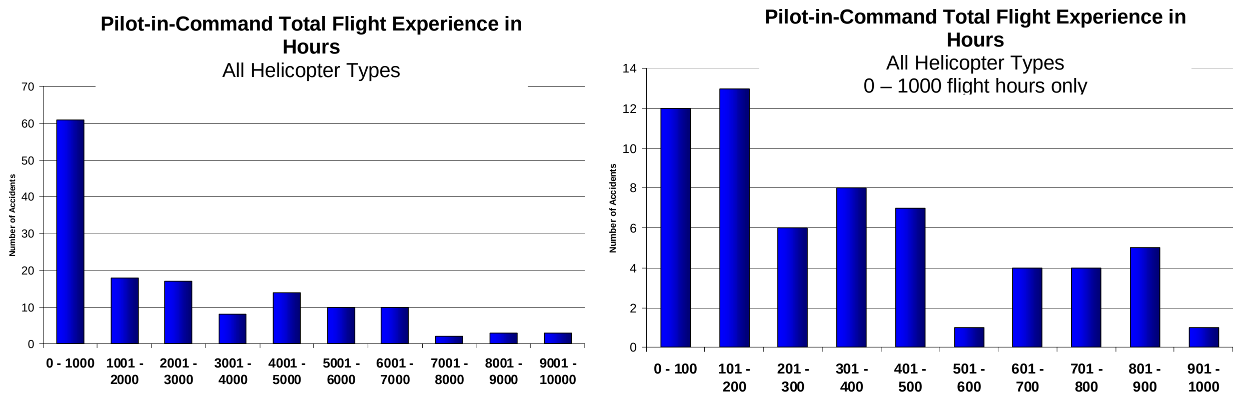


Figure 12 - Pilot-in-command Flight Experience on all Helicopter types (data from 155 accidents)

In 26% of the accidents, the pilot had less than 100 hours experience on the helicopter type involved in the accident see Figure 13.

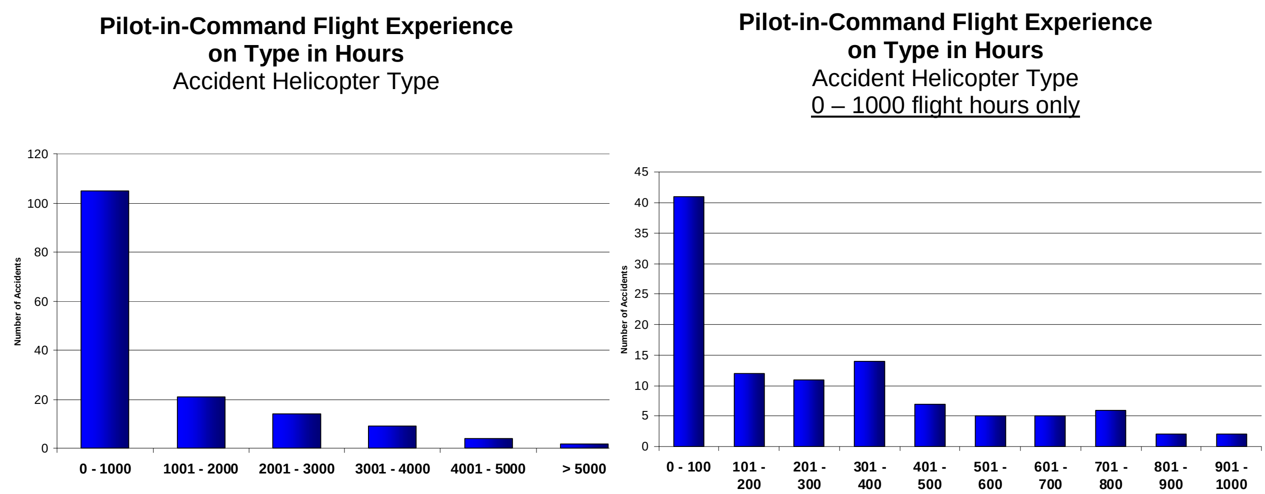


Figure 13 - Pilot-in-command Flight Experience on the Accident Helicopter Type in hours (data from 155 accidents)

It was also observed that pilot experience is not always a barrier to having an accident. In general, the proportion of less experienced pilots is higher for General Aviation accidents, see Figure 14. In 49% of the General Aviation accidents the pilot-in-command had between 0 and 100 flight hours experience on the *accident helicopter type*, compared to 14% and 9 % for Commercial Air Transport and Aerial Work operations. These statements on flight experience should however be interpreted with care, since no data is available on the overall distribution of flight experience in the helicopter community and for the different types of operation.

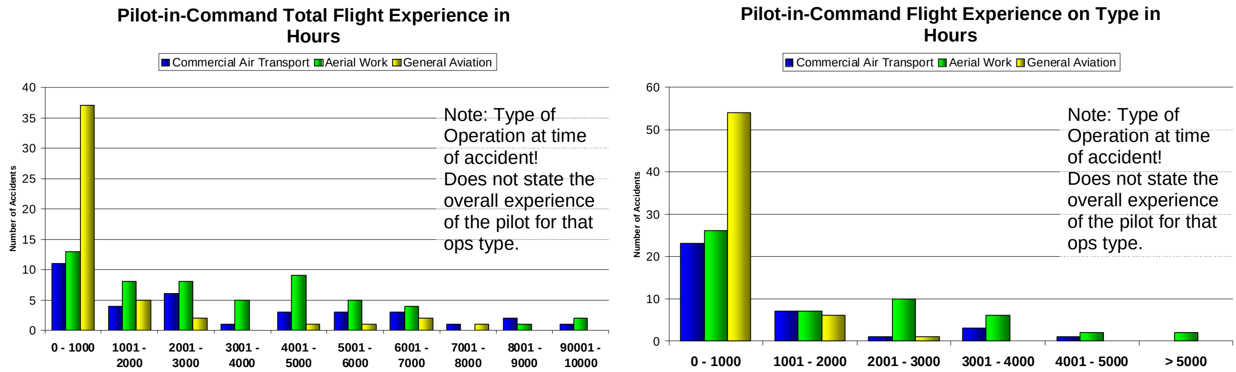


Figure 14 - Pilot experience per type of operation for all types and for the accident helicopter type

6.2 Factor identification

The accident analysis aims at identifying all factors, causal or contributory, that played a role in the accident. Factors are coded using two taxonomies: Standard Problem Statements (SPS) and Human Factors Analysis and Classification System (HFACS) codes. The Standard Problem Statements is a taxonomy developed by the IHST. The HFACS model specially focuses on human factors. The analysis teams were asked to identify, using both taxonomies in parallel, as many factors in an accident as felt needed by the team.

6.2.1 Standard Problem Statements

The Standard Problem Statements (SPS) is a three level taxonomy developed by the IHST. It consists of a list of over 400 codes in 14 different areas, see Appendix A. For the 186 accidents in the dataset, a total of 1067 Standard Problem Statement counts were identified, see Figure 15.

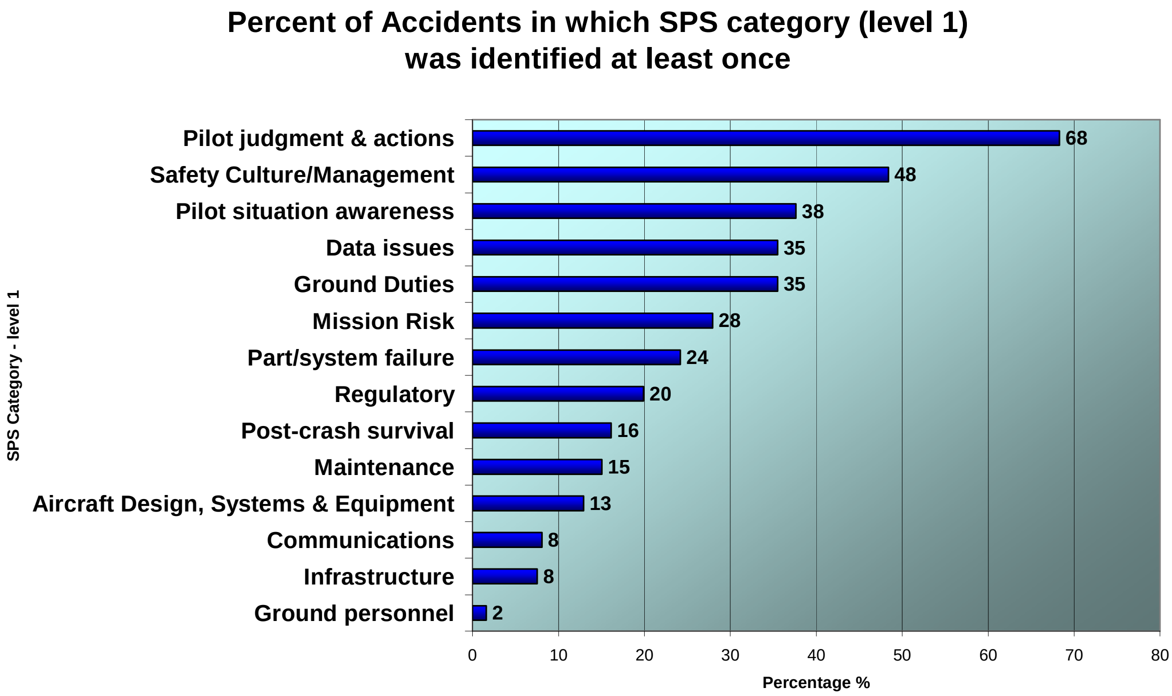


Figure 15 - Highest level Standard Problem Statement results in percentage of total number of accidents in dataset

The area that was identified in most accidents in the dataset is Pilot Judgment & Actions. This includes factors related to pilot decision making, unsafe flight profile, procedure implementation, Crew Resource Management and Human Factors such as diverted attention, perceptual judgment errors and aero medical factors. The second most identified area is Safety Culture & Management. This includes Safety Management Systems, training, pilot disregard of known safety risk, self-induced pressure and pilot experience. The third area is Pilot Situation Awareness. This covers in-flight factors such as reduced visibility and external obstacle or hazard awareness.

The area Data Issues is a specific area to code factors related to the lack of availability of information in the accident report. It was found by the teams that in 35% of the analysed accident reports there was insufficient information available to fully analyse and understand the accident. One of the reasons for insufficient information being available is the absence of a flight data recording capability in many helicopters[11]. In addition, some accidents were not investigated in detail. Since this is a special area not dealing with actual issues in the accident event sequence, this area will be left out from here on.

The area Ground Duties, identified in 35% of the accidents, includes factors such as mission planning and aircraft pre- and post-flight duties.

The United States Joint Helicopter Safety Analysis Team (US JHSAT) completed a first analysis report in September 2007. A total of 197 accidents from the year 2000 were analysed. When comparing the European data with the US results on a high level (SPS level 1), it was calculated that the correlation of the results was high (0.89), see Figure 16. The top five of the level 1 areas are similar for both the US [Ref.10] and the EHSAT analyses, but the order differs slightly.

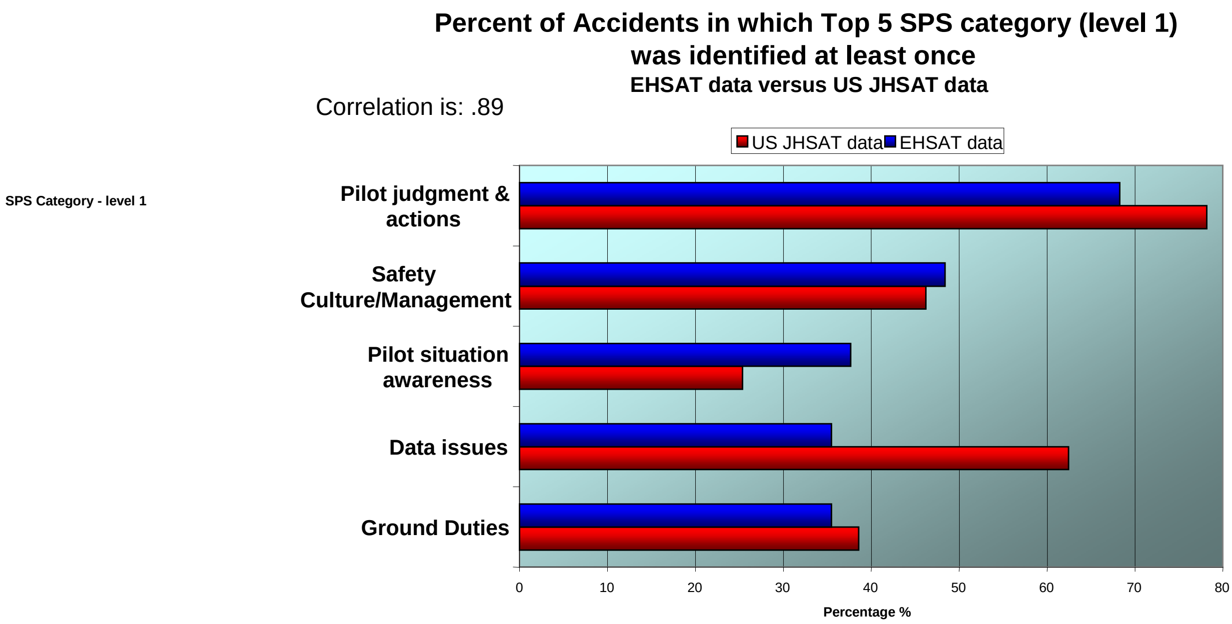


Figure 16 - EHSAT results on SPS Level 1 compared with US JHSAT results

---

11 EASA launched a research project on this subject in 2008.

The highest level of Standard Problem Statements, level 1, only provides information on a general level. To better understand what kind of factors played a role in the accident data set one must look at a deeper level in the taxonomy. Looking at the level 2 Standard Problem Statements, it becomes clearer that the main factors identified involve issues in the human factors domain. Pilot's decision making, mission planning and external environment awareness are the three most relevant factors, identified in respectively 31, 29 and 25 % of the accidents in the data set, see Figure 17.

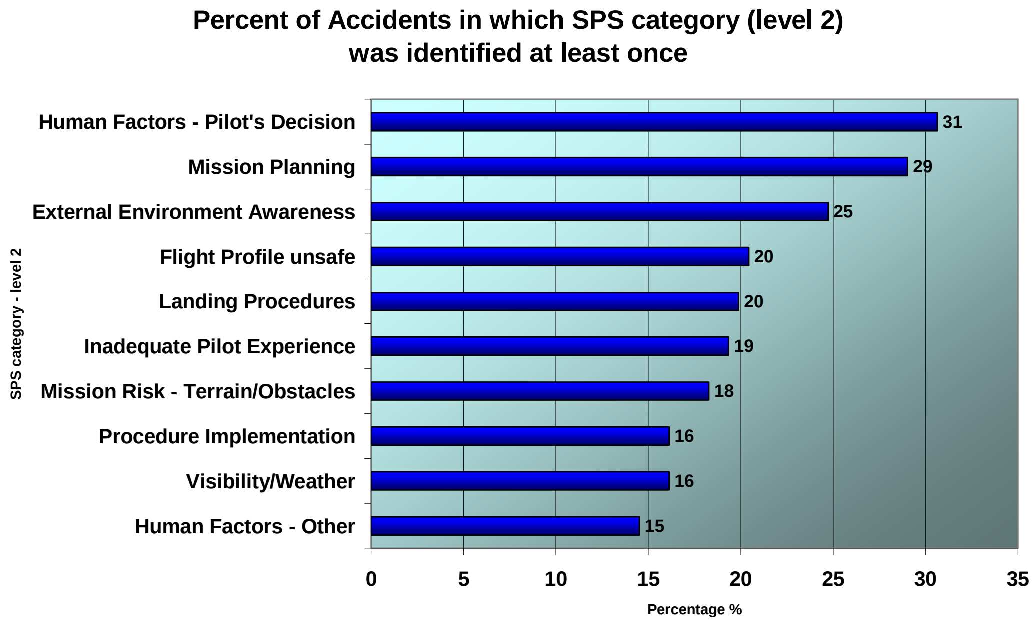


Figure 17 - Top 10 second level Standard Problem Statement results in percentage of total number of accidents in dataset (excluding factors related to Data Issues)

Because most of the identified factors lie within the human factors domain, EHSAT adopted a second model and taxonomy for factor identification to better address these human factors. Results will be presented in the next paragraph.

6.2.2 Human Factors Analysis and Classification System

Human Factors must be addressed in order to meet the IHST objective of achieving an 80% reduction in helicopter accident rates by 2016. HFACS address HF in a detailed and structured manner. The system is well documented and has been used with success in other studies. It is based on a well known theoretical framework [Ref.9, 11-13][12], and the analysis instructions are clear and easy to apply. HFACS was introduced in section 5.

For the 186 accidents in the data set a total of 445 HFACS factor counts were identified. In 76% of the accidents, at least one HFACS factor was identified. In most accidents unsafe acts or preconditions for unsafe acts were identified, see Figure 18. In fewer accidents issues related to supervision or organisational influences were captured. The possibility of identifying those factors is however very much depending on the depth of the accident investigation performed: if the accident investigator did not look into managerial or organisational aspects related to the accident, the EHSAT analysis team could not assign factors in those areas.

[12] See also http://www.hfacs.com/.

Unsafe Acts
For the lowest level in the model, the unsafe acts, 84% of the identified factors concerned errors: activities that failed to achieve their intended outcome. Most errors were identified as being judgment & decision making errors, such as poorly executed procedures, improper choices, or misinterpretation of information. These errors represent conscious and goal-intended behaviour. Skill-based errors on the other hand are errors that occur with little or no conscious thought, such as inadvertent operation of switches and forgotten items in a checklist. These errors were identified in 28% of the errors. Finally, perceptual errors are related to a degraded sensory input.

Violations, wilful disregard of rules and regulations, were identified in 16% of the unsafe acts.

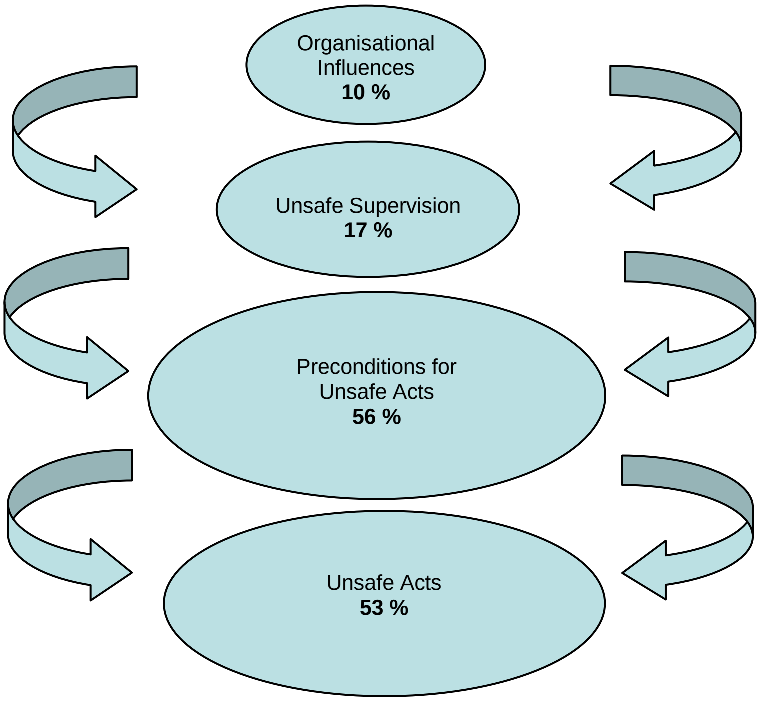
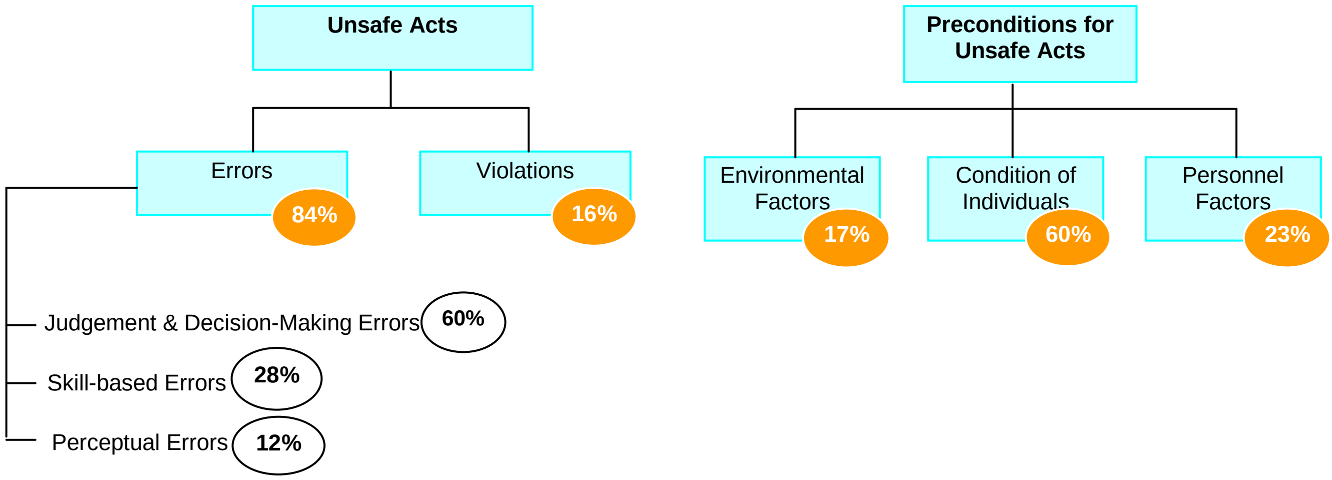


Figure 18 - Percentage of accidents where HFACS level was identified at least once

Preconditions for Unsafe Acts
Only focussing on unsafe acts, however, is "like focussing on a patient's symptoms without understanding the underlying disease state that caused it." [Ref.9]. Therefore, one must look deeper into preconditions to identify why the unsafe acts took place. 60% of the identified preconditions related to the condition of the individual. These conditions include overconfidence, channelised attention, 'press-on-itis', inattention, distraction, misperception of operational condition, and excessive motivation. Personnel factors mostly concerned mission planning. Also cross-monitoring performance and mission briefing were mentioned. For the Environmental factors, restricted vision by meteorological conditions, brownout/whiteout and windblast were identified.



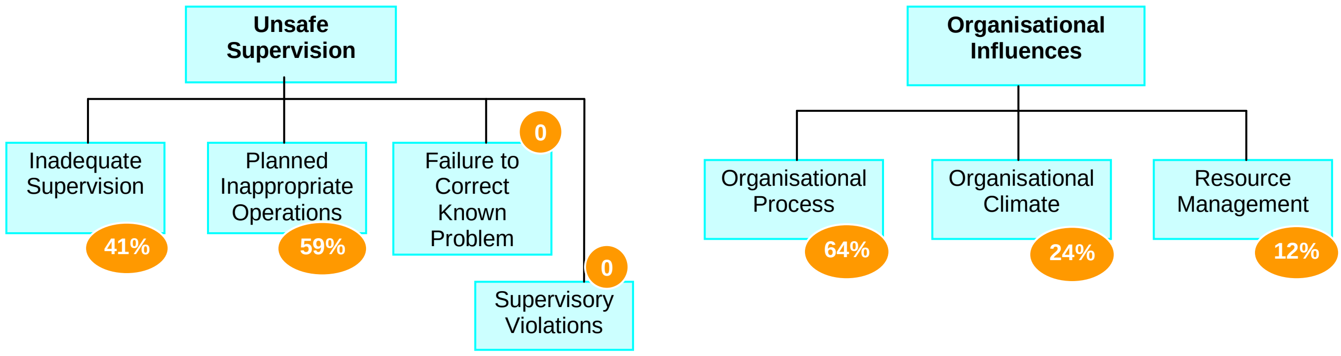


Figure 19 - HFACS results

Unsafe Supervision
In 17% of the accidents, latent failures on middle management level were identified. Under Planned Inappropriate Operations the factors limited total and recent experience and formal risk assessment, in case a supervisor does not adequately evaluate mission risks or risk assessment programs are inadequate, were identified. In addition, cases were identified under Inadequate Supervision relating to inadequate leadership/supervision or oversight and lack of policy or guidance.

Organisational Influences
In 10% of the accidents latent failures on the higher management level or organisational level were identified. Items identified under Organisational Process included issues related to procedural guidelines and publications, and doctrine. Under Organisational Climate organisational values/culture and organisational structure were identified.

6.2.3 Analysis per Type of Operation

The results presented so far were consolidated for all types of operations. Especially on a detailed level it is interesting to see if differences can be observed for the different types of operation. Table 1 to Table 3 present example results of the top issues identified for Commercial Air Transport, Aerial Work and General Aviation operations. The issues are presented on the lowest level of the used taxonomies.

The data in the tables provides the reader an understanding of a 'typical' accident scenario for the different types of operation. Differences and similarities between the three can be observed from the tables below.

Top issues – Commercial Air Transport	
Top issues Standard Problem Statements	**Top issues HFACS**
Pilot decision making	Brownout/whiteout
Pilot-in-Command self induced pressure	Decision-making during operation
Pilot's flight profile unsafe for conditions	Communication critical information
Reduced visibility – whiteout, brownout	Pressing
Pilot inexperienced with area and/or mission	Risk assessment – during operation
Pilot experience leads to inadequate planning regarding weather/wind	Procedural error
Selection of inappropriate landing site	Excessive motivation to succeed
Management disregard of known safety risk	Mission planning

Inadequate consideration of aircraft operational limits	Inattention
Failure to enforce company SOPs	Limited recent experience
	Procedural guidelines/publications

Table 1 - Top issues for Helicopter Commercial Air Transport operations (Excluding factors related to Data Issues)

Top issues – Aerial Work	
Top issues Standard Problem Statements	**Top issues HFACS**
Mission involves flying near hazards, obstacles, wires	Risk assessment - during operation
Pilot decision making	Channelised attention
Mission requires low/slow flight	Mission planning
Low flight near wires	Decision-making during operation
Inadequate consideration of obstacles	Error due to misperception
Diverted attention, distraction	Inattention
Risk management inadequate	Misperception of Operational Condition
Inadequate response to loss of tail rotor effectiveness	Excessive motivation to succeed
Inadequate training on avoidance, recognition and recovery of vortex ting state or LTE	Fatigue – Physiological/Mental
	Windblast
	Overconfidence
	Limited total experience

Table 2 - Top issues for Helicopter Aerial Work operations (Excluding factors related to Data Issues)

Top issues – General Aviation	
Top issues Standard Problem Statements	**Top issues HFACS**
Pilot decision making	Risk assessment - during operation
Mission planning –other	Overconfidence
Inadequate consideration of weather/wind	Vision restricted by meteorological conditions
Pilot inexperienced	Procedural error
Pilot control/handling deficiencies	Mission planning
Pilot misjudged own limitations/capabilities	Decision-making during operation
External environment awareness – Other	Overcontrol / Undercontrol
Disregard of known safety risk	Violation – Lack of discipline
Failed to recognise cues to terminate current course of action or manoeuvre	Inadvertent Operation
	Error due to misperception
	Channelised attention
	Get-Home-Itis/Get-There-Itis
	Misperception of operational condition

Table 3 - Top issues for Helicopter General Aviation operations (Excluding factors related to Data Issues)

HFACS and SPS complement each other well: SPS codes are technically more adapted to helicopter operations while HFACS adds a valuable, theory-driven HF analysis system. As shown in the tables above, the real benefit comes from *jointly* considering SPS and HFACS results in a single shell. When used in combination, HFACS and SPS provide a basis for richer analyses and recommendations.

The distribution of HFACS results per layer can be compared to other studies using the same taxonomy. When reviewing HFACS studies on Commercial Air Transport and General Aviation operations [Ref. 11-12] the preliminary EHSAT results show some differences with respect to a relatively lower frequency of skill based errors as part of the unsafe acts and relatively lower frequency of environmental conditions within the preconditions.

These differences can be partly due to a reporting bias. Human Factors can only be addressed as far as they were reported in the accident investigation report. This concerns especially the managerial and organisational issues. It is therefore suggested to the AIBs to report in the investigation reports these factors remote in time and space from the accident scene. Recommendations targeting the remote layers can help to prevent reoccurrence not only of the accident investigated but also of a whole set of potential accidents in which such factors can play a role.

6.3 Intervention Recommendations

The regional EHSAT teams were also asked to develop intervention recommendations that could possibly prevent similar accident factors from reoccurring. These intervention recommendations are free text and have been assigned to one of 11 categories. For the preliminary results, most recommendations fall into:

- Training/Instructional,
- Flight Ops & Safety Management/Culture, and
- Regulatory/Standards/Guidelines, see Figure 20.

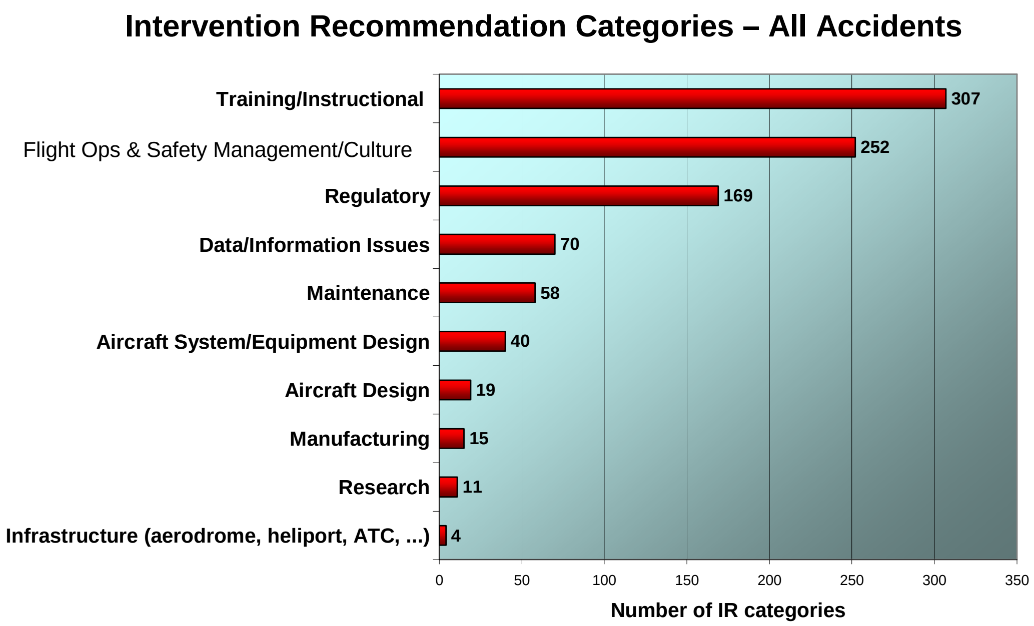


Figure 20 - Distribution of Intervention Recommendation categories for all analysed accidents

The actual recommendations have not been prioritised so far. Examples of intervention recommendations are: better training for specific missions, for example mountain operations, better training for specific operating environment, such as inadvertent entry into IMC conditions, risk assessment training, promoting safety culture and introduction of Safety Management Systems, increase of obstacles awareness, requirements for flight data recording, establishment of training requirements for aerial work operational crew other than flight crew, etc.

These intervention recommendations will be input for the second step of the European Helicopter Safety Team (EHEST) process: the development of safety action plans by the Implementation Team. This team will prioritise the intervention recommendations based on safety benefit and practicality and from there develop the safety action plans.

7 Concluding Remarks and Way Forward

The EHSAT analysis consolidates analyses of European wide helicopter accident data. This report presents the preliminary results of this analysis. The preliminary dataset consists of 186 helicopter accidents analysed by the nine regional EHSAT teams up to 15 September 2008.

Although these results are preliminary and might change when more data becomes available, it is estimated that they already provide a good indication of the type of accidents and the factors identified.

The top 3 identified areas are: Pilot judgment & actions, Safety Culture/Management and Pilot situation awareness. The high level results were compared with the US analysis results and showed a high correlation.

On the lowest level in the taxonomy different patterns were observed for Commercial Air Transport, Aerial Work and General Aviation.

The use of the HFACS taxonomy by the EHSAT provided a complementary perspective on human factors. Most intervention recommendations were identified in the areas of Training/Instructional, Flight Ops & Safety Management/Culture, and Regulatory/Standards/Guidelines.

The EHSAT will continue analysis in 2009 of accidents to complete the timeframe 2000-2005.

Launched on 5 February 2009, the European Helicopter Safety Implementation Team (EHSIT) will use the preliminary and final EHSAT results to develop safety action plans. These results will be shared with the International Helicopter Safety Team (IHST).

8 References

Ref.1 Van Hijum, M., Masson, M., Vincent J. (2007). European Helicopter Safety Team. 1st EASA Rotorcraft Symposium, Cologne, 5-6 Dec. http://www.easa.europa.eu/ws_prod/g/g_events.php

Ref.2 Van Hijum M. and Healey, A. (2008). European Helicopter Safety Team: Partnership for Rotorcraft Safety in Europe. ILA Berlin Air Show, Rotor and Rescue Conference, Schönefeld Airport, Germany, 29 May.

Ref.3 Masson M. and coll. (2008). The European Helicopter Safety Team (EHEST): European Partnership for Improving Helicopter Safety. 34th European Rotorcraft Forum organised by RAeS, BT Convention Centre, Liverpool, UK, 16 -19 Sep.

Ref.4 The European Helicopter Safety Team. EHEST Conference 2008, Hotel Miragem, Cascais, Portugal, 13 Oct. http://easa.europa.eu/essi/ehestconference.html

Ref.5 Mazzoletti M., Masson M., Eagles T., Steel J., Black J. (2008). Rotorcraft Safety in Europe: Analysis results by the European Helicopter Safety Team (EHEST) and paths for improvement. 2nd EASA Rotorcraft Symposium, Cologne, 4-5 Dec. http://www.easa.europa.eu/ws_prod/g/g_events.php

Ref.6 EASA Annual Safety Review 2007, European Aviation Safety Agency. http://easa.europa.eu/

Ref.7 US Joint Helicopter Safety Analysis Team (2007). Accident Analysis Process for a Joint Helicopter Safety Team. http://www.ihst.org/portals/54/JHSAT_Process_Guide.doc

Ref.8 Reason J. (1997). Managing the Risks of Organizational Accidents. Ashgate, Aldershot, UK.

Ref.9 Shappell, S.A. and D.A. Wiegmann (2000). The Human Factors Analysis and Classification System – HFACS. DOT/FAA/AM-00/7, U.S. Department of Transportation/Federal Aviation Administration.

Ref.10 US Joint Helicopter Safety Analysis Team (2007). Year 2000 Report to the International Helicopter Safety Team, Sept. 2007. http://www.ihst.org/portals/54/JHSAT_Report.doc

Ref.11 Shappell, S. et al. (2007). Human Error and Commercial Aviation Accidents: An Analysis Using the Human Factors Analysis and Classification System. Human Factors, Vol.49, No.2, April 2007, pp.227-242.

Ref.12 Wiegmann, D.A. et al. (2005). Human error and General Aviation Accidents: A Comprehensive, Fine-Grained Analysis Using HFACS. Final Technical Report AHFD-05-08/FAA-05-03, Aviation Human Factors Division, Institute of Aviation, University of Illinois.

Ref.13 Australian Transport Safety Bureau (2007). Human factor analysis of Australian aviation accidents and comparison with the United States. Aviation Research and Analysis Report B2004/0321.