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HeliSafe TA

Helicopter Occupant Safety Technology Application

Specific Targeted Research Project

Aeronautics and Space

Publishable Final Activity Report

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1 Publishable Executive Summary

HeliSafeTA started on March 2004. The present summary covers the full duration of the project (1st March 2004 to 30th November 2007).

Background

Helicopters are unique in the variety of tasks they can perform and in the types of sites at which they can be carried out. Accidents may occur mainly when lifting off, landing and due to critical manoeuvres at low altitude, often in bad weather conditions. On the other hand the occupant has a great chance of surviving when flying close to the ground at low velocity. To date most of the work on helicopter safety has been concentrated on preventing technical failures and crashworthy design for airframe structures (absorbing elements in the sub floor, landing gear and seats). Nevertheless today's safety equipment in helicopter still consists of passive harnesses and vertical energy-absorbing seats in new helicopters, which can not reduce the risk of fatal or severe injuries, especially if the impact loads are higher. Since crashworthy structural concepts are now well established, attention has been turned to increased occupant survivability in helicopter crashes based on cockpit and cabin safety through interacting advanced safety equipment. The approach to occupant safety was studied in the European Research Project HeliSafe®TA based on these aspects of helicopter safety.

HeliSafe®TA - The **Helicopter Occupant Safety Technology Application** is to improve the survivability of occupants in case of helicopter crashes and to minimise the risk of severe injuries in both cockpit and cabin.

Special attention was paid to current crash statistics with the aim to reduce major injuries which subsequently may lead to fatalities. A full-scale baseline drop test was carried out in May 2005 with a full-scale helicopter fuselage. The impact scenario applied was determined in order to cover the most typical helicopter accidents. The intention was to get reliable crash data of a real world crash and the accompanying kinematics in order to develop enhanced safety features to protect the occupants in crash cases that have a high probability of occurrence and significance. Based on the measurements during impact the acceleration floor pulses were determined with the aim to decouple the helicopter structure for the forthcoming investigations by using real crash loads.

Two full-scale test rigs were designed and assembled representing the most common helicopter geometry's of the cockpit and cabin area. The geometry incorporates all injury related details of the interior to be as close as possible to the reality. These mock-ups were used for the hardware sled tests where as basic condition current standard safety items were used to validate the HOSS simulation concept and to establish a starting point to compare later improvements.

Based on the substantial injuries found in the documentation of helicopter accident investigations certain additional injury criteria were considered to be relevant for the enhancement of the HeliSafe FAA Hybrid III dummy. These criteria with their thresholds defined in the automotive sector were considered for this purpose in order to adequately assess the level of safety in a helicopter environment. Furthermore to cover the majority of the population an additional FAA Hybrid III dummy was developed. Both dummies enabled the consortium to measure and assess all relevant areas of injuries by covering 95% of the adult population. Exhaustive component testing was performed in order to produce validated results with the new dummy.

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Parameter studies are then carried out to investigate the effectiveness and to optimise the layout of the new developed and proposed safety concept. These were simulated with the cabin/occupant software to evaluate the effectiveness of the enhanced safety features and to verify the safety system concept for crash load scenarios.

The final safety concept was finally tested in a second full-scale test at the end of the project to confirm the improvement under real crash loads.

HeliSafe®TA provides a safety concept which does not yet exist in Europe and a validated numerical simulation tool to predict typical crash scenarios and to simulate the response load on the human body with respect to the interaction of safety equipment. This simulation tool is able to analyse and optimise any cockpit and cabin in respect to response loads to human bodies. Helicopter manufactures can now design safe cabin systems as well as getting recommendations for retro-fitting to existing helicopter for improving survivability of occupants in typical crash scenarios. This is achieved by an advanced Cabin Safety System concept based on Interacting Safety Features such as enhanced safety seats, airbags and improved harness systems including inertia reel in automatic mode, pre-tensioner and active load-limiter.

The HeliSafe approach was to improve the knowledge of helicopter crash dynamics and human body limits to enhance the safety for occupants in helicopters in the event of a crash. HeliSafe results will be disseminated to regulatory offices in order to provide aviation authorities directly with the results of the research work carried out and to allow for future considerations in creating new standards for integrated safety systems.

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2 Contractors involved

An overview of the HeliSafe TA consortium is given in the table below.

The consortium is representing members of seven member states. Autoflug, the project co-ordinator, is a small and medium sized family owned independent enterprise (SME) with less than 250 employees. The most of the HeliSafe TA (2004 – 2007) participants have worked together in the previous HeliSafe project (1999 – 2003). This has ensured a smooth operation of the project.

The consortium was well balanced to perform the envisaged scientific work as well as for providing the technical hardware to validate the findings in hardware tests. Five research oriented organisations (four research establishments and three universities) have covered the research activities in HeliSafe TA while the five industrial companies have tackled application oriented aspects of the RTD work including exploitation of results. The two participating helicopter manufacturers will assure that HeliSafe TA RTD work will be product and exploitation oriented.

The HELISAFE TA consortium consists of the following partners:

No	Organisation Name	Nation	Business Activity	RTD Role
1	Autoflug	D	Safety Equipment Supplier	Co-ordinator Equipment technology
2	CIDAUT	E	Research & Development Institute in Automotive	Principal contractor; Airbag specialist
3	CIRA	I	Research Establishment	Crash technology
4	DLR	D	Research Establishment	Crash/structure technology
5	Eurocopter-S.A.S	F	Helicopter manufacturer	Helicopter technology
6	Eurocopter D	D	Helicopter manufacturer	Helicopter technology
7	PTM	I	Automotiv & aero-nautical research	Human Injury specialist
8	PZL	PL	Helicopter manufacturer	Helicopter technology
9	SRS	D	Automotive safety technology	Airbag specialist
10	TNO Automotive	NL	Research Establishment	Crash software specialist
11	University Coventry	GB	Automotive & aero-nautical research	Crash software specialist
12	University Delft	NL	Automotiv & aero-nautical research	Bio-mechanical specialist

The HELISAFE TA partners are the most professional European players in their field, assuring an added value not attainable on a national level.

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- AUTOFLUG (D), the co-ordinator, is an experienced aeronautic safety equipment manufacturer and will develop, together with the partners, a helicopter crash survival concept. AUTOFLUG will later design and produce part of the safety-related aeronautics products.
 - CIDAUT (ES) is a specialist in crashworthiness and occupant safety. They have a sophisticated Crash Research Laboratory able to carry out high demanding experimental tests on their sled facility. They will provide knowledge from the automotive sector regarding restraints transferable for aviation use.
 - CIRA (I) will conduct and perform full-scale crash tests on their large Aerospace Structures Impact Testing Facility (LISA). They will analyse the crash phenomenology and provide crash data for restraint optimisation and finally for assessment of effectiveness.
 - DLR (D) is a leading European specialist in aircraft crash simulation and analysis. They will provide their knowledge of composite structure elements for modelling and simulation of structural impacts. The DLR will refine and specify the HOSS concept to extend the capabilities. They will support the industrial research performed in HeliSafe TA.
 - EUROCOPTER-SAS (F) has engaged R&D activities in the helicopter crash domain, performing and analysing different structure crash tests. EUROCOPTER will provide necessary helicopter (crash) data to the project and will provide helicopter data to adapt the fuselage mock-ups. They will guarantee that HeliSafe TA research is product relevant.
 - EUROCOPTER (D, a subsidiary of EUROCOPTER-SAS) is a helicopter manufacturer who will provide knowledge from flight safety. The long and various experiences in handling, maintaining and accident investigation will be productively involved in the improvement of airworthiness and crashworthiness.
 - POLITECNICO DI MILANO (I) is a specialist in both car and aircraft crash simulation and analysis. They will support transfer of safety technology to Fixed Wing Aircraft.
 - PZL Swidnik S.A. (PL) has over 20 years experience in application of composite structures and is manufacturing helicopter, glider and small fixed wing aircraft. They will guarantee that HeliSafe TA research results is product relevant and transferable to fixed wing aircraft.
 - TNO Automotive, Safety R&D (NL) is a crash dummy specialist, crash software provider and crash test house. In this project TNO Automotive, Safety R&D will provide state-of-the-art predictive simulation software tools. TNO Automotive, Safety R&D will participate in the definition and realise the prototyping of the crash dummy adopted for aeronautical applications.
 - SRS (D, a subsidiary of SIEMENS) is a specialist in integrated occupant safety systems and crash dynamics. They will provide its automotive experience and their know-how in designing airbags, sensors and device modules. They will perform crash analysis simulation, numerically and experimentally (sled), and will develop, together with the partners, a helicopter crash survival concept.
 - COVENTRY UNIVERSITY (UK) is a leading European specialists in automotive crash simulation and multi-body system analysis. CU will provide their knowledge to define adaptive structure elements transferable for aviation use.
 - UNIVERSITY DELFT (NL) is a leading specialist in mechanics of impact, bio-mechanics of impacts, injury criteria. One of the main contributions will be the optimisation of a seat energy absorber for vertical crash scenarios.
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3 Project objectives

3.1 Overview of general project objectives

3.1.1 Scientific Objectives

The global aim of HELISAFE TA is to save lives and to mitigate the consequences of survivable aircraft accidents under real world crash conditions. The *scientific issues* are a better understanding through full-scale tests and computer modelling of helicopters crash dynamics to improve the knowledge of human body limits and injury criteria. In detail these are:

- Improve understanding of the overall crash behaviour of the helicopter structure with regard to the occupant, not only the cockpit/cabin in a rigid environment.
- Development of appropriate prediction tools, which need to cover the total airframe behaviour, the cabin and occupant in a crash.
- Develop supplemental realistic aviation related injury criteria with focus more on the whole occupant.
- Application of previous research technology of HeliSafe to further improve the survivability and mitigate severe injuries like offset, second and third impact, side impact effects.
- Improve knowledge of the detailed course of helicopter accidents, by the motion analysis of occupants and resulting contacts with the cabin structure.
- Consider intelligent crash management concepts able to predict an accident, choose the necessary safety devices before and during a crash and identify post crash scenarios.
- Transfer the high level of passive/active safety standard of automobiles into occupant safety in helicopters and tilt rotors and later into fixed wing aircraft.
- Make Airworthiness recommendations for certification requirements in the future.

3.1.2 Technical Objectives

Developing and improving protection devices for helicopter occupants that allow increasing the rate of survival and reduce severe injuries in a crash.

- Adaptation of advanced automotive technology where possible and validation of the concepts.
 - Develop supplemental passive/active restraint systems to protect occupants independent of their weight, size and seat position.
 - Develop a modified FAA Hybrid III dummy (including hardware and instrumentation) appropriate for helicopter crashes.
 - Integration of safety features (active/passive) into the seat – harness system to get a modular occupant safety system easy for retrofit in new and/or current helicopter types.
 - Evaluate intelligent adaptive structure elements which either do not exist or need significant improvements regarding the fuselage.
 - Assess the effectiveness of proposed safety concepts and equipment by using the HeliSafe HOSS concept to simulate occupant response.
 - Introduce new/advanced safety features in the cockpit and cabin because these topical issues are not addressed by the current airworthiness rules.
 - Put the HeliSafe sensor concept in concrete terms and show feasibility.
 - Integration of automotive active safety technologies like adaptive structures, roll bars in the direct occupant environment (seats, panel, sticks, side wall etc.).
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- Evaluation of unconventionally inflatable features especially intended for aviation use (active seat cushion, harness airbags, inflatable carpets, knee-padding etc.) in order to find alternative solution for occupant protection and compute/demonstrate their advantage.
- Application of previous research technology of HeliSafe to further improve the survivability and mitigate severe injuries like offset, second and third impact, side effects.

4 Main Achievements

Within the duration of HeliSafeTA the main achievements have been:

- Ü Definition of a crash scenario suitable to carry out a drop test with a full scale helicopter structure
- Ü execution of a baseline full-scale drop test to establish injury levels with standard safety equipment and to get realistic accident data
- Ü definition of an advanced Helicopter Occupant Simulation Software (HOSS) concept, in particular to extend the modelling capability to include the more complex cabin and cockpit systems, extended safety system concepts and more severe crash scenarios.
- Ü definition of an enhanced HeliSafe FAA Hybrid III hardware dummy with enhanced instrumentation for injury assessment under severe crash loads. Determination of a non-standard dummies (95%ile) representing the critical occupant size appropriate for helicopter crashes.
- Ü execution of baseline sled tests to determine the state-of-the-art technology in order to compare later the improvement of HeliSafe TA designed safety equipment.
- Ü Development of an enhanced restraint system consisting of harnesses, airbags and seats.
- Ü Perform parameter studies in order to get an enhanced occupant safety system with high crash survival capabilities.
- Ü Conducting final sled tests to confirm the effectiveness of the enhanced HeliSafe TA safety equipment.
- Ü Definition and prototyping of a crash sensor system including Electronic Control Unit (ECU).
- Ü Execution of a final full-scale drop test to assess and validate the achieved improvement of the safety equipment developed in HeliSafe TA.
- Ü Assessment of helicopter safety improvements based on simulation and hardware tests.
- Ü Assessment of the HeliSafe TA results with respect to transferability to fixed wing aircraft.
- Ü Airworthiness recommendations for future helicopters. If required, authorities will be supported in their rule making process.
- Ü Implementation strategy plan for HeliSafe TA advanced technology.

After finalisation of the project, the results may set new standards for aviation safety systems resulting in new specifications. Since US competitors started some times ago to intensify their research on pilot/passenger survivability, European helicopter manufacturer have to address this subject in order to maintain competitive.

Crushable fuselages of the aircraft lead to non sufficient energy absorption demonstrating that passenger safety is not limited to the aircraft design but depends to a large extend on

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the safety equipment. Furthermore, accident analysis has shown that restraint systems alone are not sufficient to guaranty survivability. Studies and investigations of crash cases show that in spite of using energy absorbing devices fatalities occurs also within the specified crashworthy range due to main head and upper body injuries.

Crashworthy seats capable to sustain a crash case without a loss of their structural integrity may result in an unacceptable dynamic response which a human body is not able to withstand. Energy absorbing devices fitted to crashworthy seats become state-of-the-art in the meantime to modern helicopter and for retro-fit. As shown in the automotive industry, aircraft structure, the seat and the harness system have to be considered as one closed system. All together provide sufficient energy absorption for survival and, hence, for the fulfilment of existing requirement specifications.

The suppliers of the safety systems in HeliSafe TA are all SME's which will strengthen the European aerospace market with supplying new technologies, the airframe manufacturers Eurocopter and PZL will use the knowledge gained in the course of the project already to enhance occupant safety with regard to structural components as well as adapt new developments to be ready to accept HeliSafe TA safety systems, if aviation authorities issue new requirements and every aircraft has to be equipped with adequate safety features.

The research facilities in HeliSafe TA are now able with the knowledge gained to assess the level of safety as a centre of excellence for a broad variety of helicopter users. They will be able to predict the behaviour of a HeliSafe TA Integrated Safety System in a given environment in order to stay below advanced HeliSafe TA injury criteria thresholds which have to become the standard by aviation authorities.

The FAA Hybrid III dummy (50th and 95th percentile) is a validated tool to assess all relevant criteria. It will be further marketed by TNO being already the supplier for the multi-body simulation code MADYMO and anthropomorphic test dummies (ATD).

Strengthening the European aeronautical industry this way will create new jobs having a positive influence on social and economic conditions. Spin offs of the new technologies may be the use in other applications such as but not limited to inflatable passenger restraint systems in helicopter or general aviation aircraft with a broad application.

5 Publishable Results

Further to the above description additional information can be seen on the HeliSafe website <http://www.helisafe.com>
