

## HeliSafe®

### A new concept to reduce fatal and severe injuries in helicopter accidents

**André Herbst**

Product Manager for Occupant Safety Helicopter  
Autoflug GmbH  
Industriestraße 10  
25462 Rellingen  
Germany

HeliSafe® was a Research Project in the 5<sup>th</sup> Framework Programme of the European Commission. It started on 1<sup>st</sup> February 2000 and was finished 31<sup>st</sup> March 2003.

**ABSTRACT** *HeliSafe® is improving the survivability of occupants in helicopter crashes and minimising the risk of severe injuries in both cockpit and cabin. A reduction in fatal and severe injuries will be achieved by an Advanced Safety System based on interacting safety features like improved restraint systems consisting of airbags and advanced harness systems including inertia reel in automatic mode, pre-tensioners, load-limiters, etc.*

*Special attention is paid on current crash statistics with the aim to reduce major injuries, which subsequently lead into fatalities. This will be achieved by the advanced Cabin Safety System concept.*

*HeliSafe® has developed a concept and validated a numerical simulation tool to predict typical crash scenarios and simulate the response load on the human body with respect to the interaction of safety equipment.*

*HeliSafe® is providing a not yet in Europe existent simulation tool with an aviation related crash dummy. This simulation tool is validated and able to analyse and optimise any cockpit and cabin in respect of responds loads onto human bodies. Helicopter manufacturers can now optimise their new designs as well as*

*existing helicopter for survivability of occupants in typical crash scenarios.*

**INTRODUCTION** Fatalities in helicopter crashes are at ten times higher than in fixed wing aircraft.

*Is this fact purely related to the flight profile of helicopters close to the ground? Are the crashes survivable with the adequate safety equipment?*

The aim of the research project HeliSafe® within the 5<sup>th</sup> Framework Programme of the European Commission was to improve the survivability in case of helicopter crashes. It was divided into five work packages:

Work package 1	Scenarios and Specifications
Work package 2	Development and Validation
Work package 3	Safety Equipment Concepts
Work package 4	Simulation and Assessment
Work package 5	Management

The work packages were executed in three phases.

The first phase consisted of gathering data and information from the past to determine

a status quo. Then in the second phase a new simulation tool called HOSS was developed and evaluated within the standard regulations. In the third phase an example of a new safety system was developed and assessed.

The **first phase** of HeliSafe® was determined to lay down the cornerstones of the project. First of all a thorough review of helicopter crashes recorded at aviation authorities in Europe was conducted to find typical parameters for crash scenarios and their related injury patterns.

**Velocity Distribution of Civil and Military Crashes in HeliSafe**

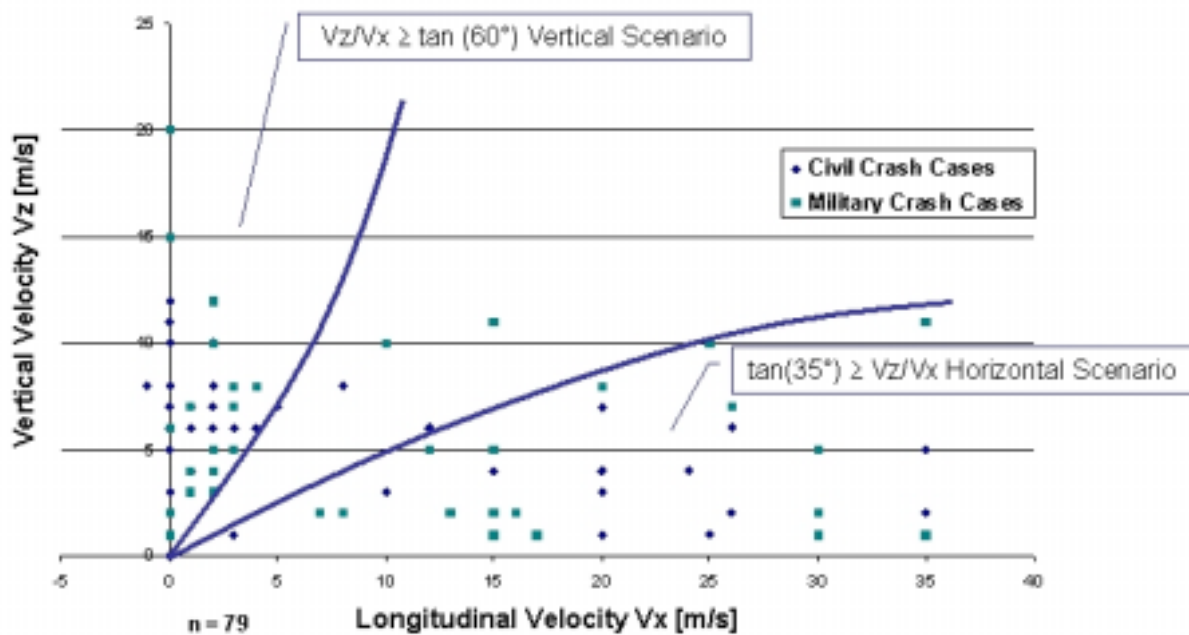


Figure 1

Requirements were reviewed for realistic crash scenarios suitable for the use in HeliSafe®. It was found that 95% of these crashes can be covered by defining two scenarios. The horizontal scenario in this project called **HeliSafe® 1**.

**HS1 scenario**

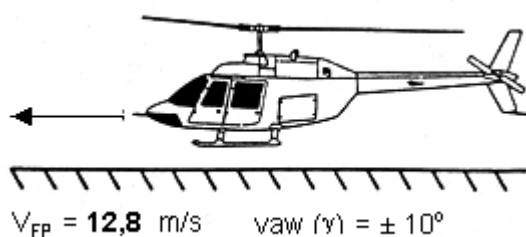


Figure 2

And the vertical scenario called HS2.

**HS2 scenario**

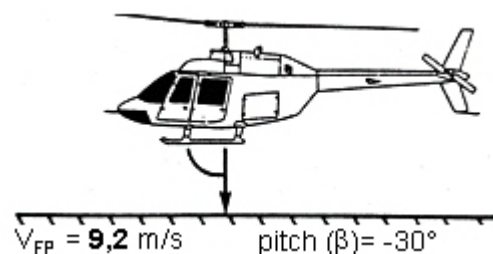


Figure 3

According to this scenarios in FAR and JAR regulations floor pulses with triangular shape can be found.

**FAR/JAR floor pulse for HS1**

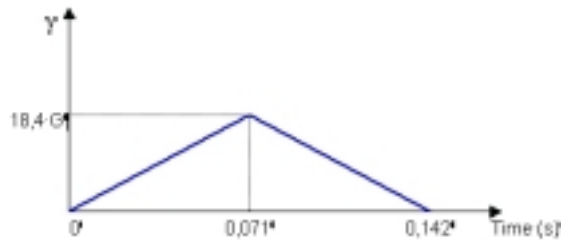


Figure 4

**FAR/JAR floor pulse for HS2**

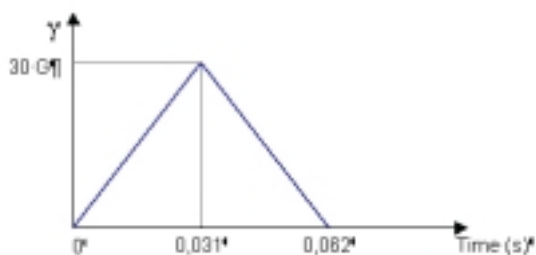


Figure 5

Looking at the results from real hardware crash tests e.g. the BK 117 the FAR/JAR floor pulses can only be considered as very much simplified.

The following floor pulse was computed with DRI-KRASH based on data from a BK 117 drop test.

**Floor pulse**

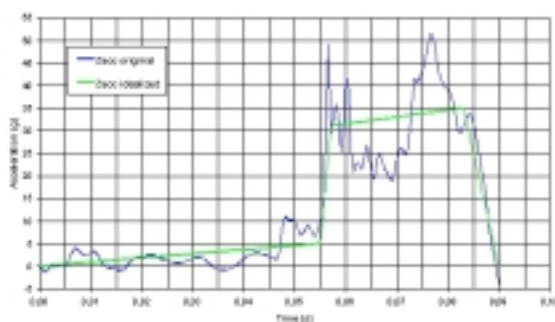


Figure 6

This could be idealised as a rectangular pulse with two flat steps (green line).

In order to keep the results independent from helicopter types the definition of a generic helicopter environment averaging the most common helicopter geometry for cockpit and cabin areas was performed. This geometry incorporates all safety

relevant features and was modelled in 3D-CAD for the use in the HOSS simulation concept.

The 3D-CAD model was then used to build the cockpit and cabin mock-ups, which were used for the hardware baseline sled tests including current passive “state-of-the-art” safety items.

**Standardised 3D-CAD Cockpit**

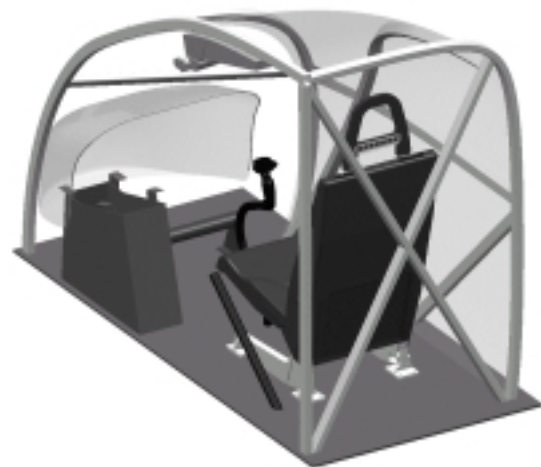


Figure 7

**According hardware / Cockpit mock-up**



Figure 9

Standardised 3D-CAD Cabin

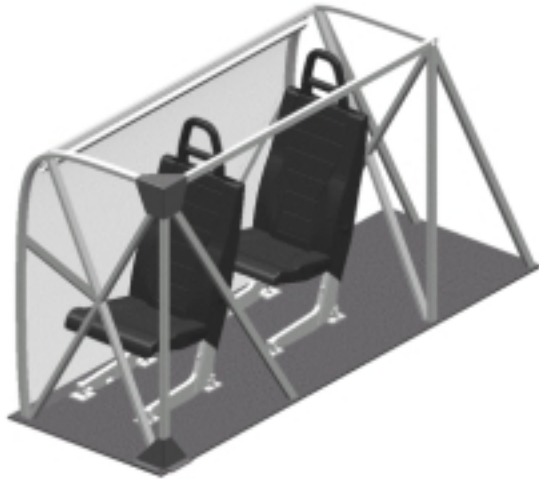


Figure 8

HeliSafe® already used energy absorbing safety seats according to FAR/JAR which have to be installed in new aircraft, but are unfortunately not yet mandatory for retrofit to existing aircraft. Forced by cost and weight nowadays manufacturers produce crashworthy seats to meet exactly the requirements specified in FAR/JAR. However, this could mean, that the seat can not protect the occupants in a real crash. For example an attenuating safety seat did not work as planned because the seat rails were aligned instead of bend in roll and pitch as demanded by FAR /JAR.

The **second phase** of HeliSafe® was determined to carry out the baseline hardware sled tests to validate the HOSS simulation tool for the following definition of a new safety concept.

**HOSS simulation tool**

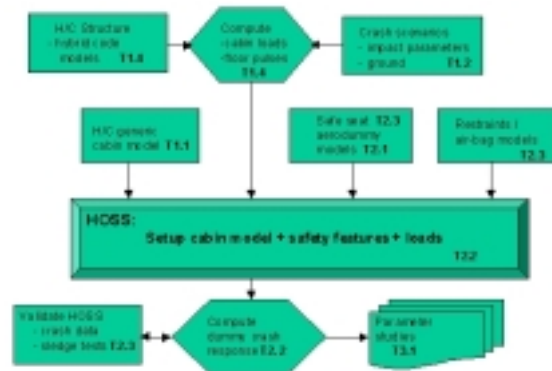
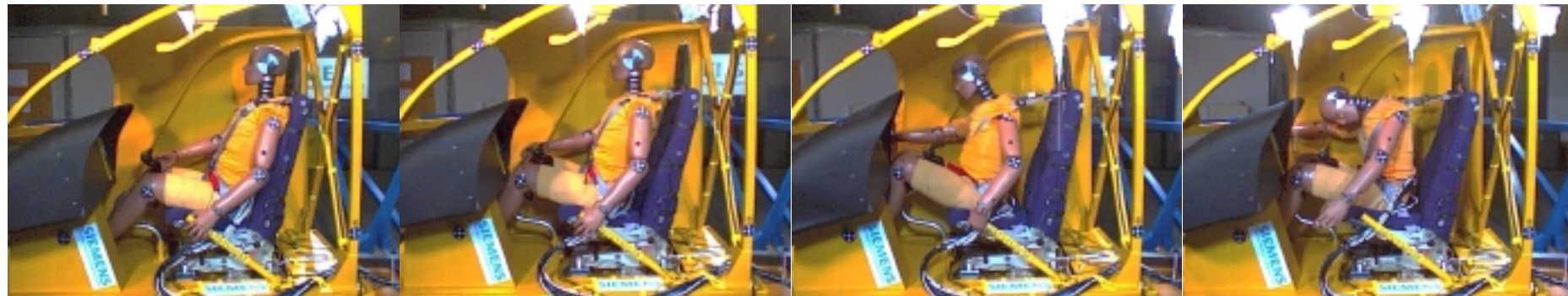


Figure 9

Both the cockpit and cabin baseline sled tests with the FAR/JAR standard pulses for rotorcraft seating as laid down in FAR/JAR 27 & 29 have been carried out and successfully validated the HOSS simulation tool. Now a tool was available to the engineers to conduct the parameter studies with the different parameters like airbag design and harness and seat characteristics. No hardware was necessary to find the ideal Safety system for the standardised cockpit and cabin. The following sequence gives an impression how simulation and reality correspond to each other.

*Comparison of simulated dummy position with high speed film results in SRS/DLR model (HS1-scenario)*



0 ms

66 ms

100 ms

134 ms

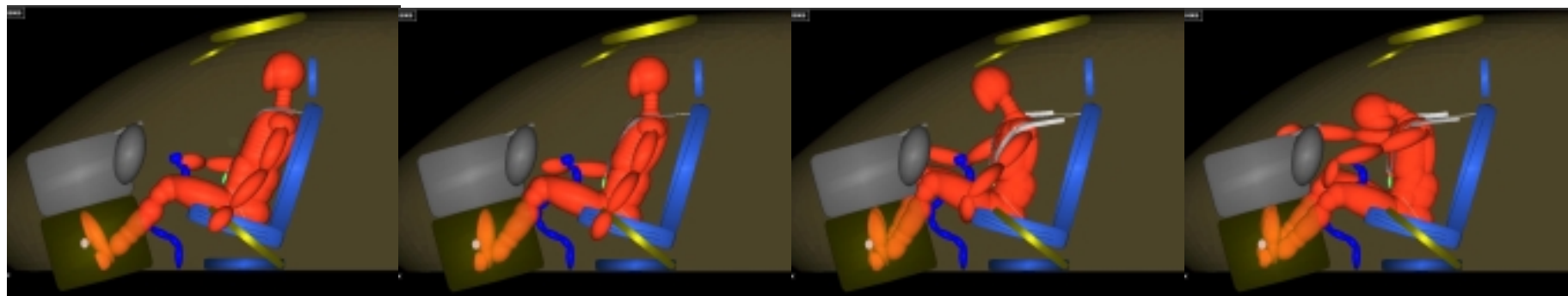


Figure 10

However, the results clearly showed a discrepancy of the data measured and the injuries of occupants determined in real crashes. The tests gave evidence that energy levels of current aviation authority requirements (FAR/JAR floor pulse) do not represent the level of energy that can be found in real crash cases. For the crash scenarios based on actual real helicopter crash kinematics, acceleration pulses were determined using different crash codes. These pulses were the input for continuous simulations and at the end further hardware sled tests.

To complete this task an Anthropomorphic Test Dummy (ATD) based on recommendations of the FAA Hybrid III ATD was defined with enhanced biofidelity being able to measure and assess the relevant injuries that were determined during the survey of helicopter crashes.

**New HeliSafe® test dummy**

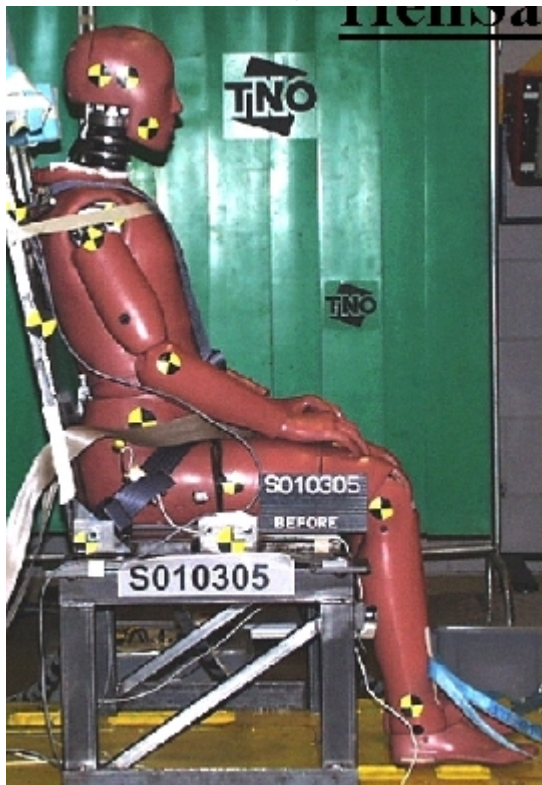


Figure 11

Exhaustive component testing had to be performed in order to be able to produce validated results with the new instrumentation.

Based on the injury patterns found in the survey of real helicopter crashes, a number of additional injury criteria were defined and measured at the HeliSafe® ATD. The current standard of measuring only for belt forces, lumbar loads and HIC values are considered as not sufficient to parameterise a safety system. Certain criteria with their thresholds already used in the automotive sector were considered for this purpose in order to adequately assess the level of safety also in a helicopter environment.

The **third phase** of HeliSafe® was determined to enhance the safety for occupants in helicopters. The general outline of the new safety system was defined and afterwards optimised by parameter studies using the HOSS overall simulation concept for the total cockpit and cabin environment.

**New Safety System Seat and Harness**



Figure 13

**Differences between FAR and HeliSafe® Dummy**

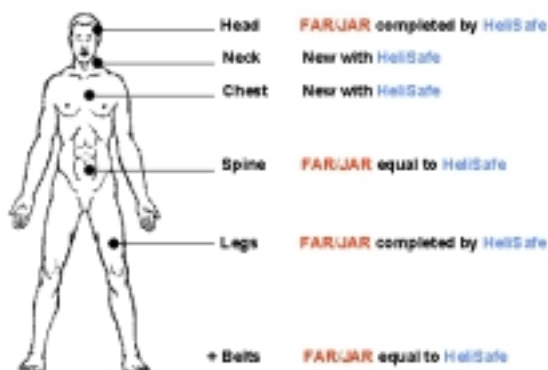


Figure 12

*Harness system concept  
with pre-tensioner and load-limiter*



Figure 14

The new advanced safety system was finally tested in hardware sled tests to verify the simulation results.

*Dummy behaviour at sled test with  
standard configuration after 150 msec*



Figure 15

*Dummy behaviour at sled test with  
advanced safety system after 150 msec*



Figure 16

The results were validated. It was demonstrated by simulation and with sled tests that fatal and severe injuries in real helicopter crashes can be reduced significantly even in comparison to “state-of-the-art helicopters”. In comparison to old helicopters it is obvious that the amount of improvement will be even better.

**CONCLUSION *Helicopter crashes are to a bigger degree survivable with adequate equipment*** The research work done in the HeliSafe® project clearly shows that FAR/JAR floor pulses are not reproducing the level of energy experienced in cases of real crashes. Because a real floor pulse in shape and strength is very much dependent on the helicopter structure and are very complex it is nearly impossible to create real floor pulses on existing sled facilities. A simplification was so far necessary. But now, based on HOSS parameter studies a safety concept will be directly and individually applicable to any future rotary wing aircraft as well as retrofit technology for existing aircraft. The research facilities in HeliSafe® are able with the knowledge gained to assess the level of safety as a centre of excellence for a broad variety of helicopters. They are able to predict the behaviour of a HeliSafe® Integrated Safety System in a given environment in order to stay below advanced HeliSafe®

injury criteria thresholds, which have to become the standard by aviation authorities.

HeliSafe® is approaching aviation authorities to change the regulations and give safety and survivability a better chance. HeliSafe® results will be disseminated to regulatory offices in order to provide aviation authorities with the direct results of the research work carried out and to allow for future considerations in creating new standards for integrated safety systems. The HeliSafe® ATD Hybrid III dummy is a validated tool to assess all relevant criteria.

### ***HeliSafe® Partnership***

*Co-ordinator:* Dipl.-Ing. Edgar Uhl  
Autoflug (D)

*Industrial partners:*  
Eurocopter (F)  
Martin-Baker Aircraft (GB)  
SIEMENS Restraint Systems (D)

*Research centres:*  
DLR (D)  
CIRA (I)  
TNO (NL)

*University:*  
PTM (I)

**Project web page: [www.helisafe.com](http://www.helisafe.com)**

