



Full scale crash tests for cabin safety research

Several studies of rotorcraft accidents have been conducted to identify safety issues and research areas that might lead to a reduction in rotorcraft accidents and fatalities

Survivable accident

- Forces transmitted to the occupants cannot exceed the limits of human tolerance for abrupt accelerations
- Structure in the occupants' immediate environment must remain substantially intact to the extent that a liveable volume is provided through the crash

Fatal injury:

Results in death within 30 days of the accident

Serious injury:

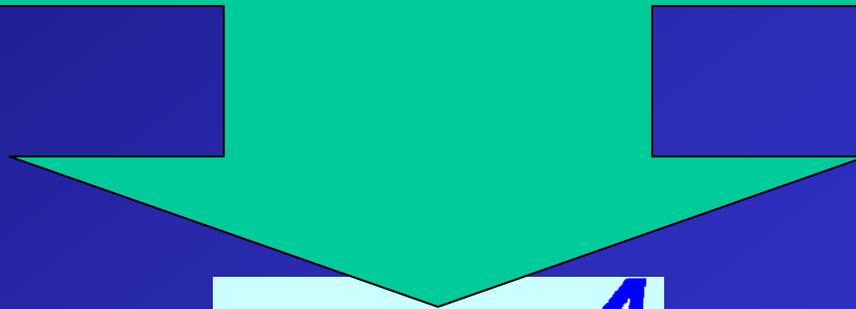
- Requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received
- Results in a fracture of any bone (except simple fractures of fingers, toes or nose)
- Involves lacerations that cause severe haemorrhages, nerve, muscle or tendon damage
- Involves injury to any internal organ
- Involves 2nd or 3rd degree burns, or any burns affecting more than 5% of body surface

Minor injury

Doesn't qualify as fatal or serious

- 1396 civil rotorcraft accidents in USA in which 491 people were killed (1990-1996)
- 22 civil rotorcraft accidents in UK in which 16 people were killed (1992-2001)
- 272 civil rotorcraft accidents in Germany in which 81 people were killed (1990-2003)

...hence the importance to investigate the most common crash scenarios and parameters in terms of impact directions, velocities, angles, surfaces and relevant injury patterns, to assess crash kinematics in order to facilitate the definition of safety equipment and crashworthy design





The **L**aboratory for **I**mpact test on **A**erospace Structures, located in South Italy (CAPUA), was inaugurated in April 2002

The laboratory main activities are deeply connected with experimental and numerical researches in crashworthiness of aerospace structures subjected to high energy impact



The full-scale crash test facility

Max. Test article weight: 10 ÷ 20 tons

Impact angle: 5°- 90°

Impact velocity: up to 20 m/s at each angle

Test article attitude: no limit

Velocity accuracy: ±5%

Trajectory angle: ±1°

Impact surface : water, concrete, soft soil



The full-scale crash test facility



Are both in the aeronautical field, as *passive safety*, included ditching and/or emergency landing, and in the space field, where the main objective is to protect payload during the recovery phase

**Ensure survivability of passengers in
case of impact with the ground**

Main aspects:

- Limiting acceleration forces on occupants in terms of dissipation of impact energy
- Maintaining occupants' living space ensuring structural integrity around them
- Limiting traumatic interactions between the structure and occupants (cabin safety)
- Facilitating cabin evacuation before fire or sinking (post crash)

Improve survivability of occupants in both cockpit and cabin in helicopter crashes and to minimise the risk of injuries



HELISAFE TA PROJECT

European Partners involved:



Automotive Safety



...to perform two full-scale crash tests (Bell UH-1D)

1st without advanced safety systems developed in previous Helisafe® (only standard), as basis for the research work within Helisafe TA

2nd integrating safety features, furtherly developed during the project, to assess and validate the achieved improvement of the safety equipment

Test article choice



Manufacturer	Bell Helicopters TEXTRON
Crewmembers	1 – 2 pilots plus 1 flight mechanics
Passengers	Crew chief and 14 troops
Engine	1 Avco-Lycoming, T53L-13 Turbo-Shaft
Engine Power	1 044 kW (1400 SHP)
Max velocity	220 km/h
Cruising speed	200 km/h
Cruising range	appr. 500 km
Absolute ceiling	4150 m
Overall length incl. main rotor	16,43 m
Fuselage length over tail boom	12,69 m
Overall height	4,41 m
Fuselage height incl. landing gear	2,37
Overall width	2,54 m
Basic weight	2315 kg
Take-off weight	4315 kg

Definition of crash scenario

Crash data and associated impact conditions have been collected, analysed and evaluated with respect to the most severe injury patterns

Impact path has been defined, combining horizontal and vertical velocity components

Impact parameters

Horizontal velocity (v_x)	+12,8 m/s (42 ft/s)	Forward
Lateral velocity (v_y)	0 m/s	
Vertical velocity (v_z)	- 7,9 m/s (- 26 ft/s)	Downward
Pitch angle (Phi)	+5°	Nose up
Roll angle (Theta)	0°	
Yaw angle (Psi)	0°	

Impact surface

Concrete has been preferred for the following reasons:

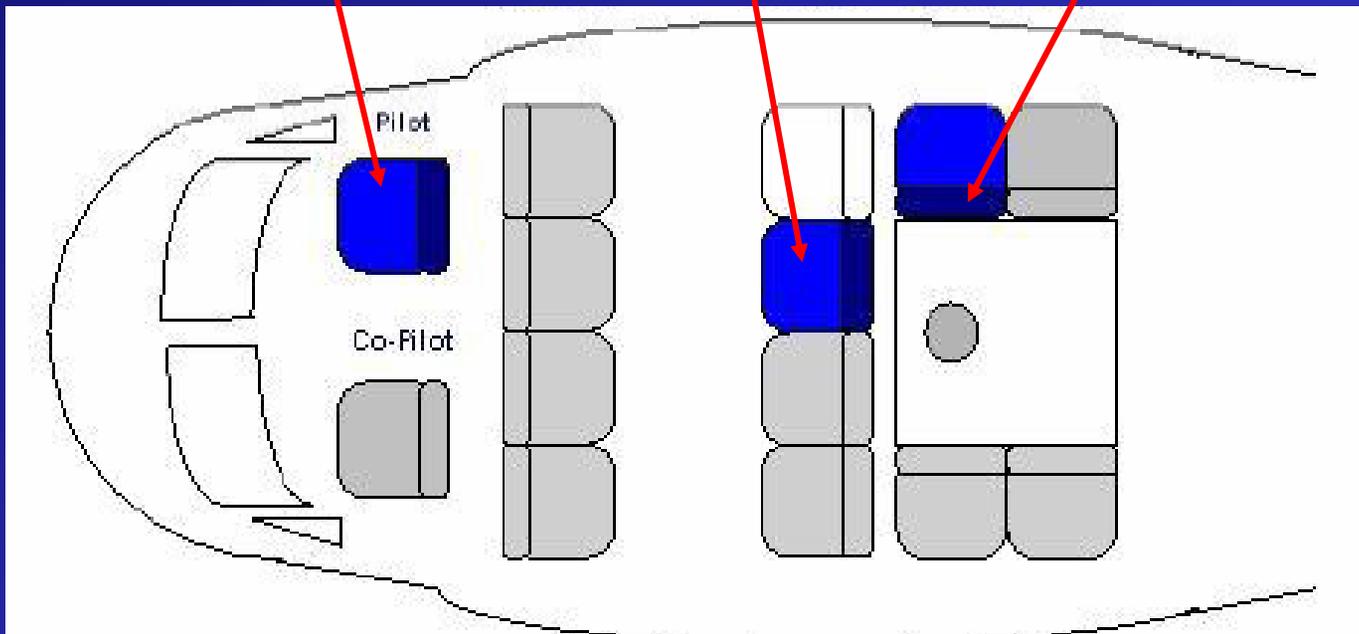
1. Vertical impacts are most severe on hard surfaces where is no energy absorption provided by ground deformation. Whereas longitudinal impacts tend to be most severe on soft soil when ploughing is likely to occur
2. The test is easily reproducible

Helicopter occupants

50%tile HeliSafe
FAA Hybrid III

50%tile FAA
Hybrid III

EuroSID
dummy



Channels for measurements

Instrumentation for	N° of channels
Pilot (FAA HIII-dummy)	27
Passenger (FAA HIII-dummy)	25
Passenger (EuroSID1-dummy)	28
Helicopter structure	48

Crash test objectives

- Establish injury levels with standard safety equipment to get realistic accident data and realistic crash pulses
- Improve understanding of the overall crash behaviour of the helicopter structure with regard to the occupant (cockpit and cabin)
- Improvement of protection devices for helicopter occupants that allow increasing the rate of survival and reduce severe injuries, independent of their weight, size and seat position

Crash test objectives

- Improve knowledge of helicopter accidents, by the motion analysis of occupants and resulting contacts with the cabin structure
- Define and prototype a crash sensor system including Electronic Control Unit
- Develop supplemental realistic aviation related injury criteria with focus more on the whole occupant
- Make airworthiness recommendations for certification requirements in the future

New Safety feature concept

Based on interacting safety features:

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Airbags

Active restraints

Crash sensor concept

Electronic control unit

New Safety feature concept

Future aviation safety systems have to fulfil a big number of requirements to **protect** occupants from multiple forms of injuries.

Improved restraint systems, lateral protection and corresponding design of cockpit and cabin have to be created.

Multiple impacts have to be taken in consideration and also the fast rescue of pilots and passengers before the start of post crash fire.

Only the combined application of a restraint systems with an energy absorbing seat guarantee optimal protection in case of crash.

New Safety feature concept

The new safety system developed by HeliSafe® is composed of :

- an advanced seat with inertia reel, pretensioner, load limiter and composite absorber
- a restraint system with a 4 point harness
- an airbag system

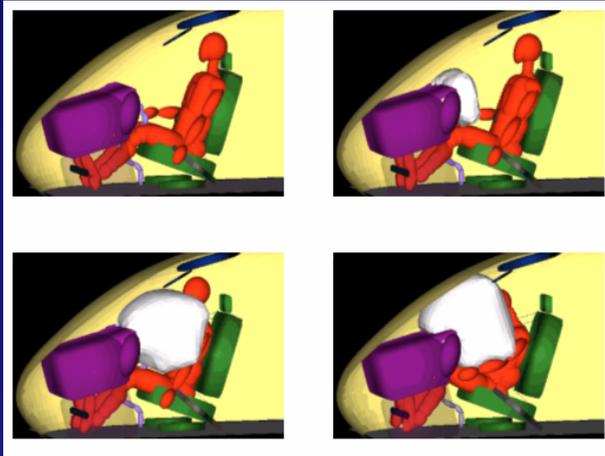
New Safety feature concept

Opportunely simulated and validated through parameter studies and sled tests....

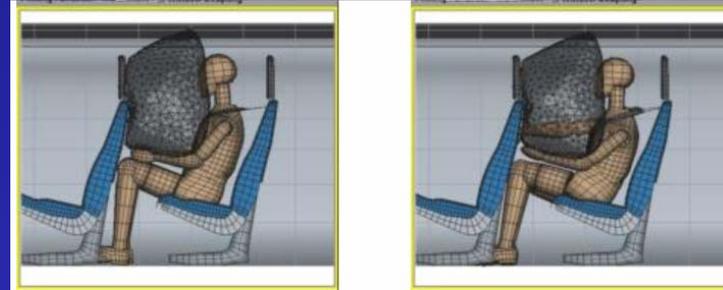
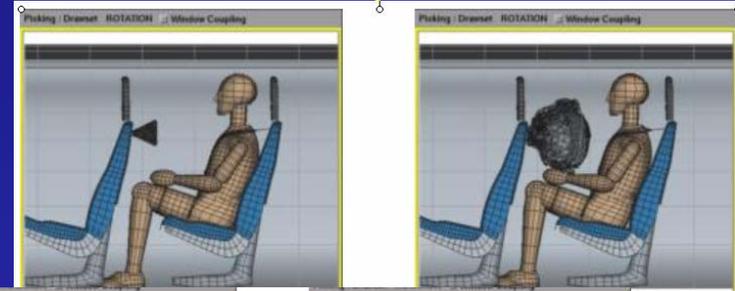
....Prototypes will be finally tested at LISA
through a full scale crash test

New Safety feature concept

AIRBAGS (cockpit / cabin area)



Cockpit simulation (MADYMO)



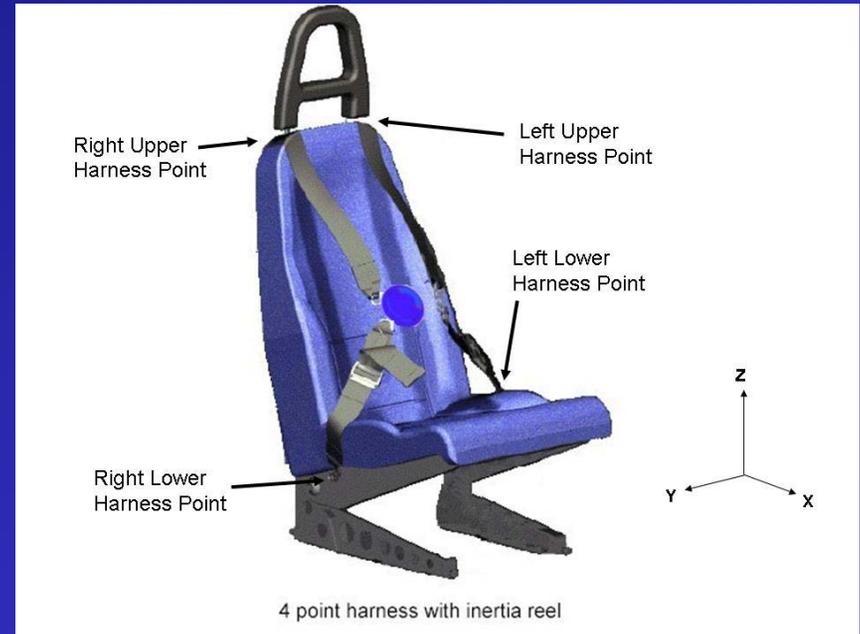
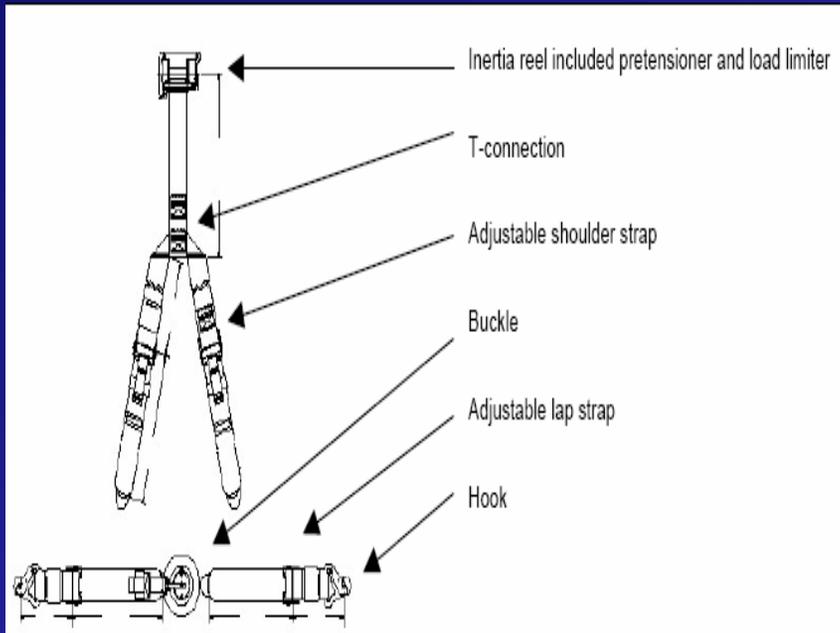
Cabin simulation (PamCrash) airbag in high position



Airbag and gas generator system

New Safety feature concept

Harness configuration and seat



4-point harness with adjustable shoulder and lap straps

SAD (Data Acquisition System)

- Up to 96 channels for acquisition from accelerometers, strain gauges, pressure transducers, etc.

Antropomorhpic dummies ATD

- Class Hybrid II and FAA Hybrid III

SRV (High Speed Videocameras)

- 2 digital cameras Phantom, up to 4000 fps frame speed, resolution up to 512x512 pxl
- 2 Kodak Ekta RO Imager cameras, up to 1000 fps frame speed, resolution up to 512x512 pxl

Crash Test Laboratory (LISA)

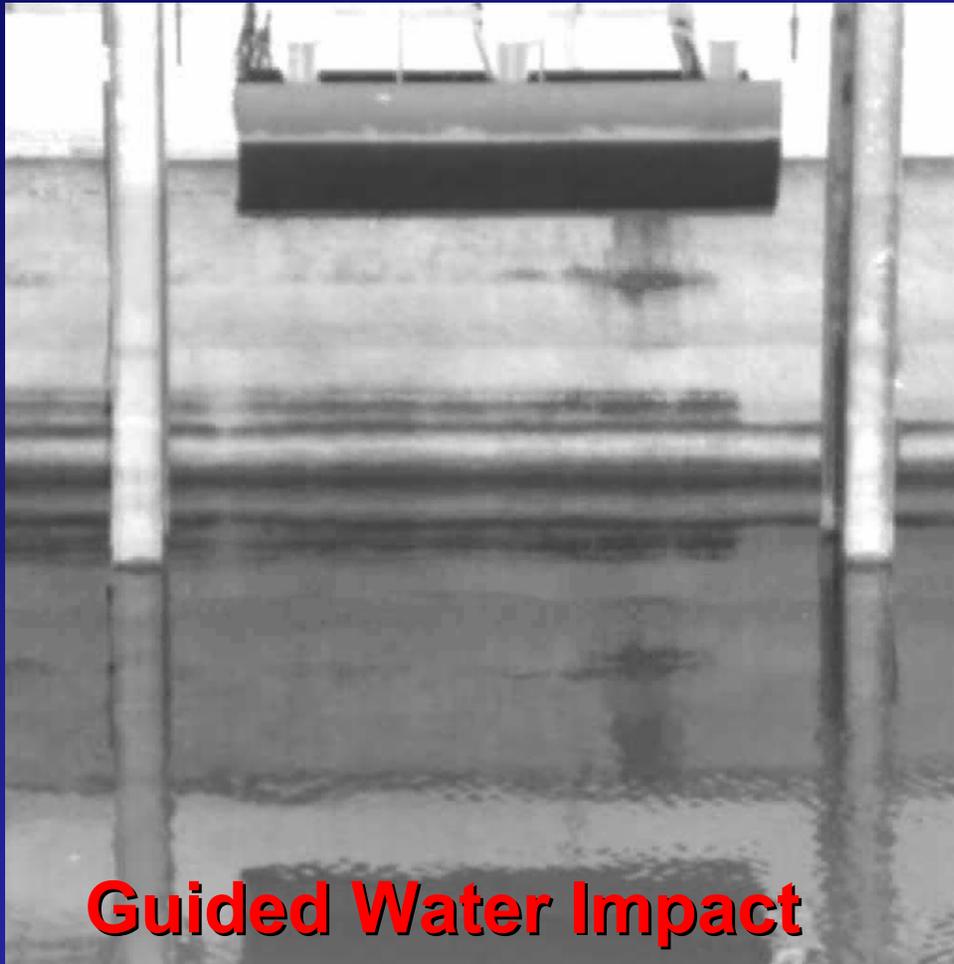


**Test Article:
AGUSTA AB204**

**Trajectory angle:
70°**

**Impact speed:
13 m/s**

Crash Test Laboratory (LISA)



Test article:

IAI composite subfloor

Client: CAST EU project

Impact speed: 8 m/s

Instrumentation:

37 strain gauges

9 pressure transducers

8 accelerometers

Crash Test Laboratory (LISA)



Water Impact Test

Test Article:
Westland WG30

Client:
CAST EU project

Impact speed:
7.95 m/s

Instrumentation:
21 accelerometers
12 pressure
transducers
1 ATD dummy

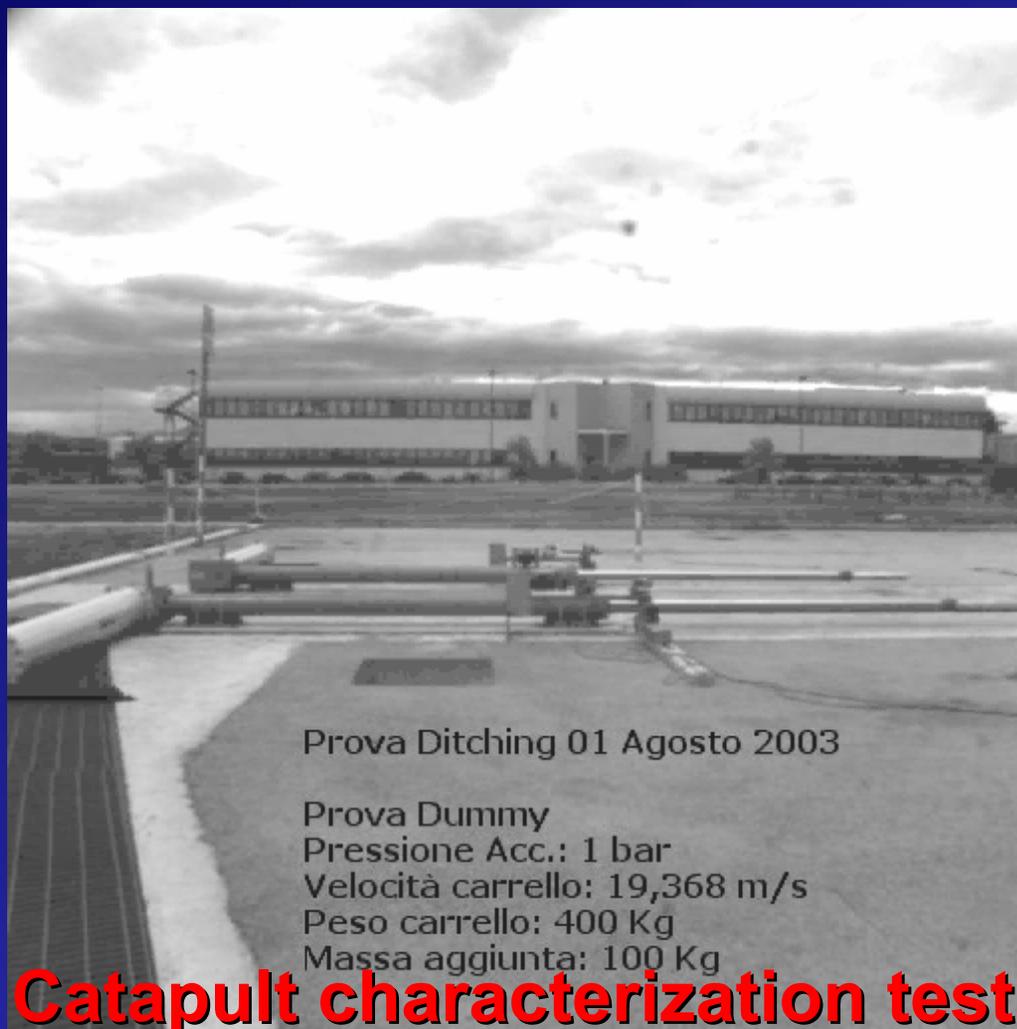
Crash Test Laboratory (LISA)

Test Article:
Dummy Tank

Article weight:
400 kg

Catapult speed:
19,4 m/s

Test for extension to ditching and emergency landing of current ENAC certification





Bird impact test

AB139 helicopter windshield

ENAC - Laboratory Certification



ENTE NAZIONALE per l'AVIAZIONE CIVILE

Certificato di Idoneità Tecnica
n. 1010/L

Ai sensi e per gli effetti del Regolamento Tecnico dell'ENAC
si certifica

che l'impresa **C I R A S.C.p.A. Centro Italiano Ricerche Aerospaziali**
con stabilimento in
Via Maforise- CAPUA (CE)
è tecnicamente idonea quale

LABORATORIO

con la specifica riportata nella
Specifica delle Abilitazioni SA/1010/L

IL DIRETTORE GENERALE
Avvocato dello Stato
Pierluigi Di Palma



BOLLO ASSOLTO IN MODO VIRTUALE
AUT. DIREZ. DIST. CENTRATE LAZIO
N. 13560/01 DEL 24/11/1998

Edizione 1

Il presente Certificato ha validità dal 20/01/2003 al 27/03/2004. I successivi rinnovi sono riportati al punto III della Specifica delle Abilitazioni.