Aero Sekur

Rotorcraft Airbags
How to improve the crashworthy

Cologne, 6-7th of December 2016


B-MHJ
AEROSEKUR
SAFETYFIRST
HONG KONG
July 5, 2010

Scope of presentation

The aim of the presentation is to show the potential rotorcraft improvement, in terms of **crashworthy performances**, that can be achieved with the use of a **vented airbag** system.

As a consequence of the improved crashworthy capabilities a lighter rotorcraft structure can be conceived, **saving weight and fuel**.

Test at CIRA (LISA Facility)

Vented Airbag for ExoMars Mission

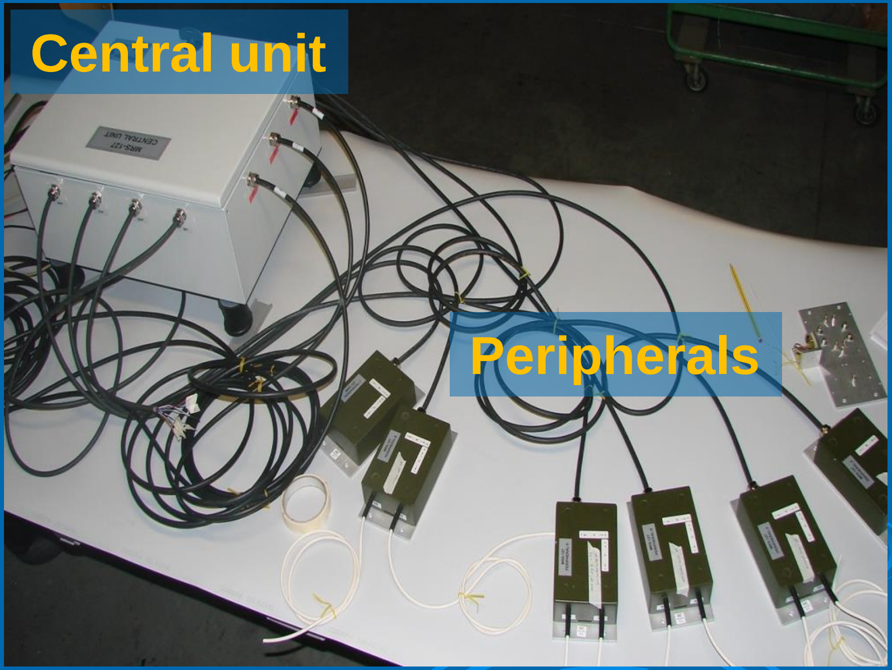
Test at Aero Sekur

Vented Airbag for ExoMars Mission

Vent control logic

The vent control system is composed by:

- No. 6 peripherals including accelerometers and pressure probes located near each airbag chamber
- No. 1 peripheral including accelerometers and rate-gyros located near the payload CoG
- No. 1 central unit for sensors acquisition and processing



Vent control algorithm

The vent control algorithm takes into account the vertical component of the acceleration, measured in the local coordinate system; the calculated acceleration is then integrated in order to obtain the velocity. No real time filtration is required.

The algorithm is based on accelerometer sensors. the airbag is equipped with seven peripheral units, six of which are used for the vent control (one per each airbag chamber) managed by the central unit.

Vent Control Algorithm ®

System Arming Section

The system is armed when all the following conditions are met:

1) An emergency condition is met
2) Vertical velocity exceeds a predefined value
3) The rotorcraft distance from ground is below a predefined value

Max impact velocity detection

The system is now able to detect, in real time, the maximum impact velocity on the base of which the trigger velocity will be calculated.

The trigger velocity is calculated independently for each airbag chamber.

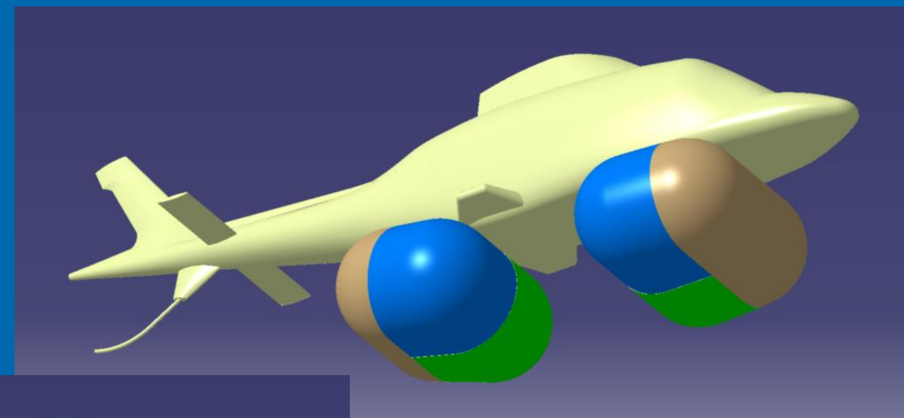
Trigger velocity detection and valve opening

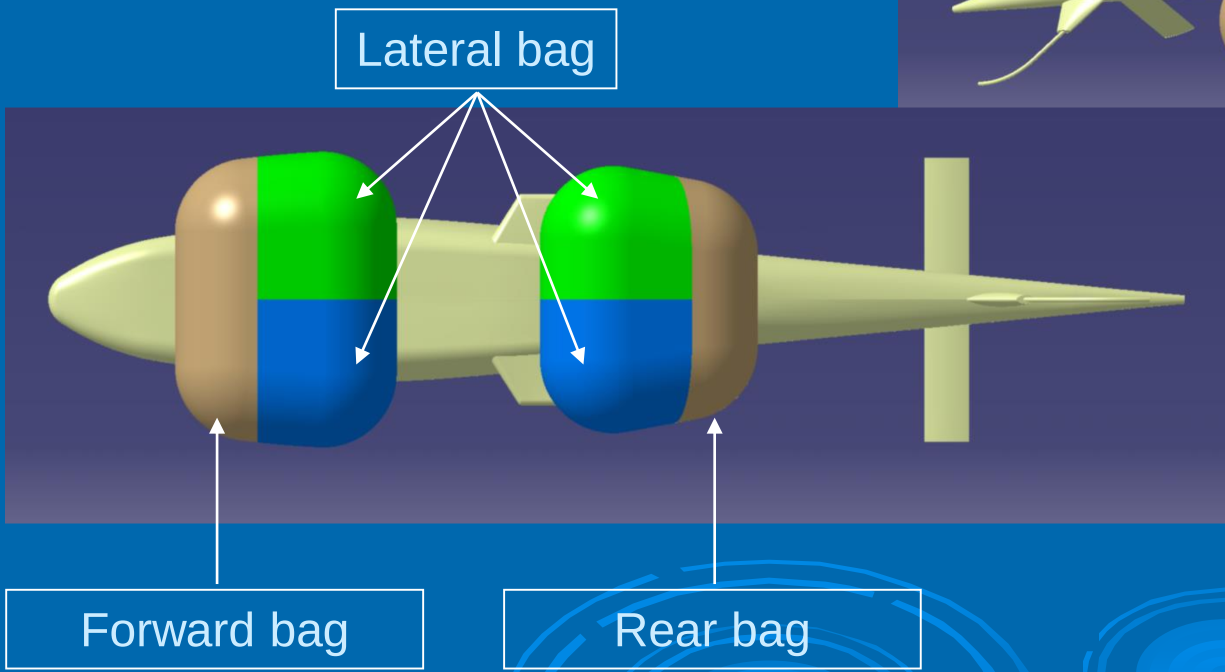
The system is now able to detect, in real time, the trigger velocity on the base of which the airbag valves are opened.

Each chamber valve will be independently opened.

Vented Airbag technology Transfer to Rotorcrafts

Technology experimentally verified in Space has been verified by analysis to be suitable to cope with rotorcraft applications





The terrain and the helicopter fuselage have been modelled as a rigid body

Airbag dimensions and assumptions

The analysis has been carried out using LS-Dyna software.
Airbag dimensions and analysis assumptions can be summarized as follows:

- Airbag volume:
  - 2.2 m^3 for the lateral bags
  - 2.3 m^3 for the forward and rear bags
- Inflation pressure:
  - 1.1 bar (absolute) for the backward airbag segment
  - 1.2 bar (absolute) for the forward airbag segment
- Impact surface:
  - The impact surface has been considered rigid and smooth
- Friction between the rotorcraft / airbag and the ground:
  - 0.2

Impact conditions of case 1

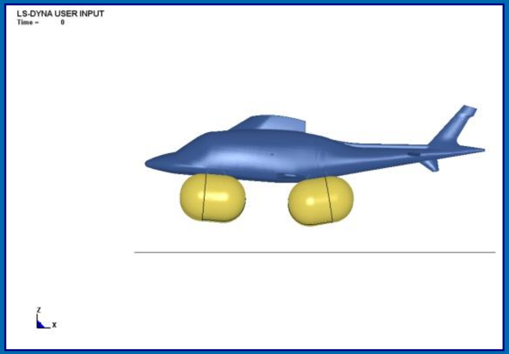
The impact conditions have been extracted from the MIL-STD-1290 and are below summarized:

- **Vertical velocity:**
  - 12.8 m/sec
- **Horizontal velocity:**
  - 8.5 m/sec
- **Attitude:**
  - Pitch +5°
  - Roll +5°

The inertia characteristics considered for the simulation of the rotorcraft are the following:

- I_{xx} = 1967 kg*m^2
- I_{yy} = 9336 kg*m^2
- I_{zz} = 9250 kg*m^2
- Total Mass = 3200 kg

Case 1: impact sequence



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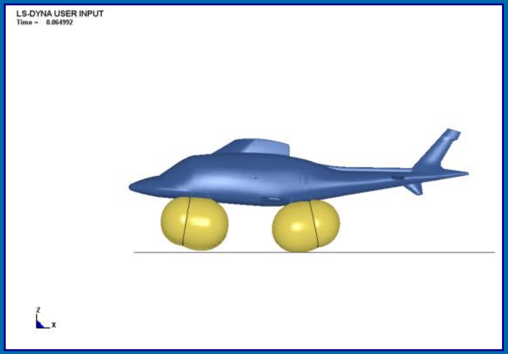

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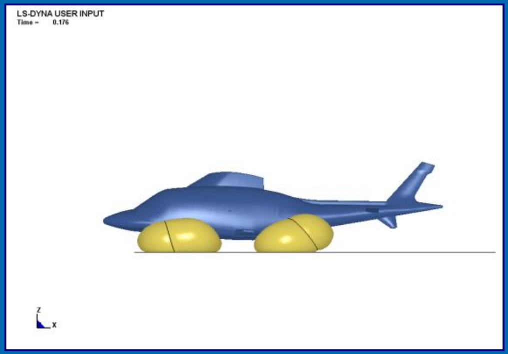

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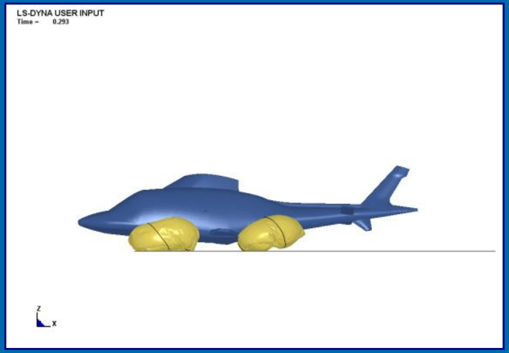

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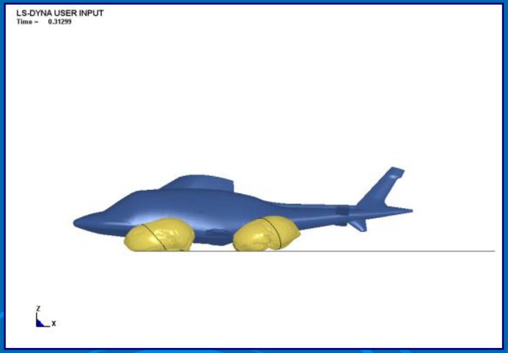

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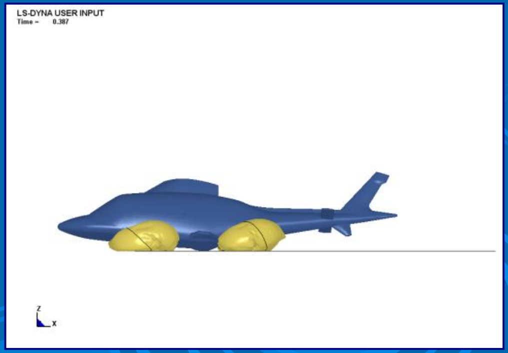

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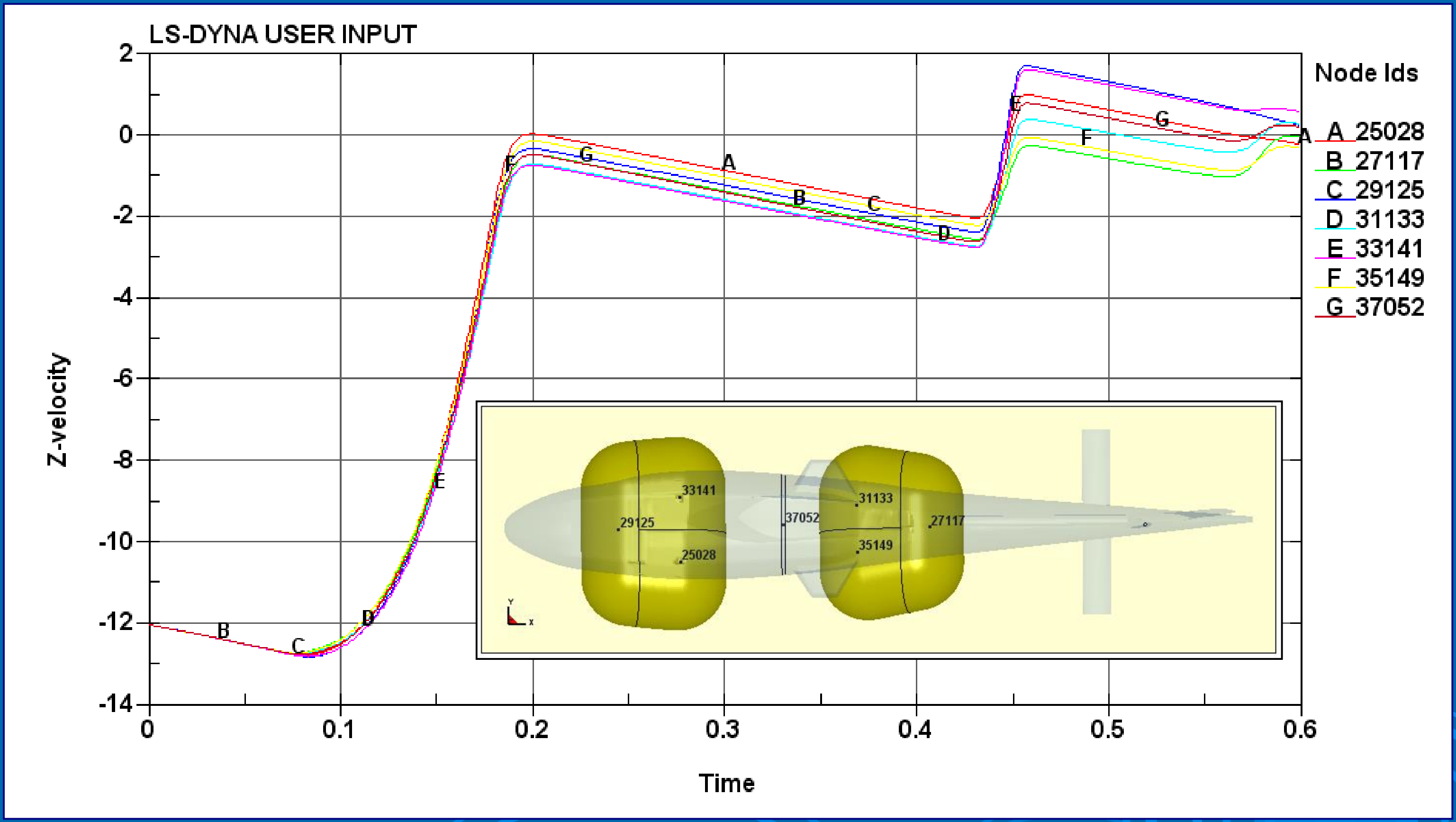
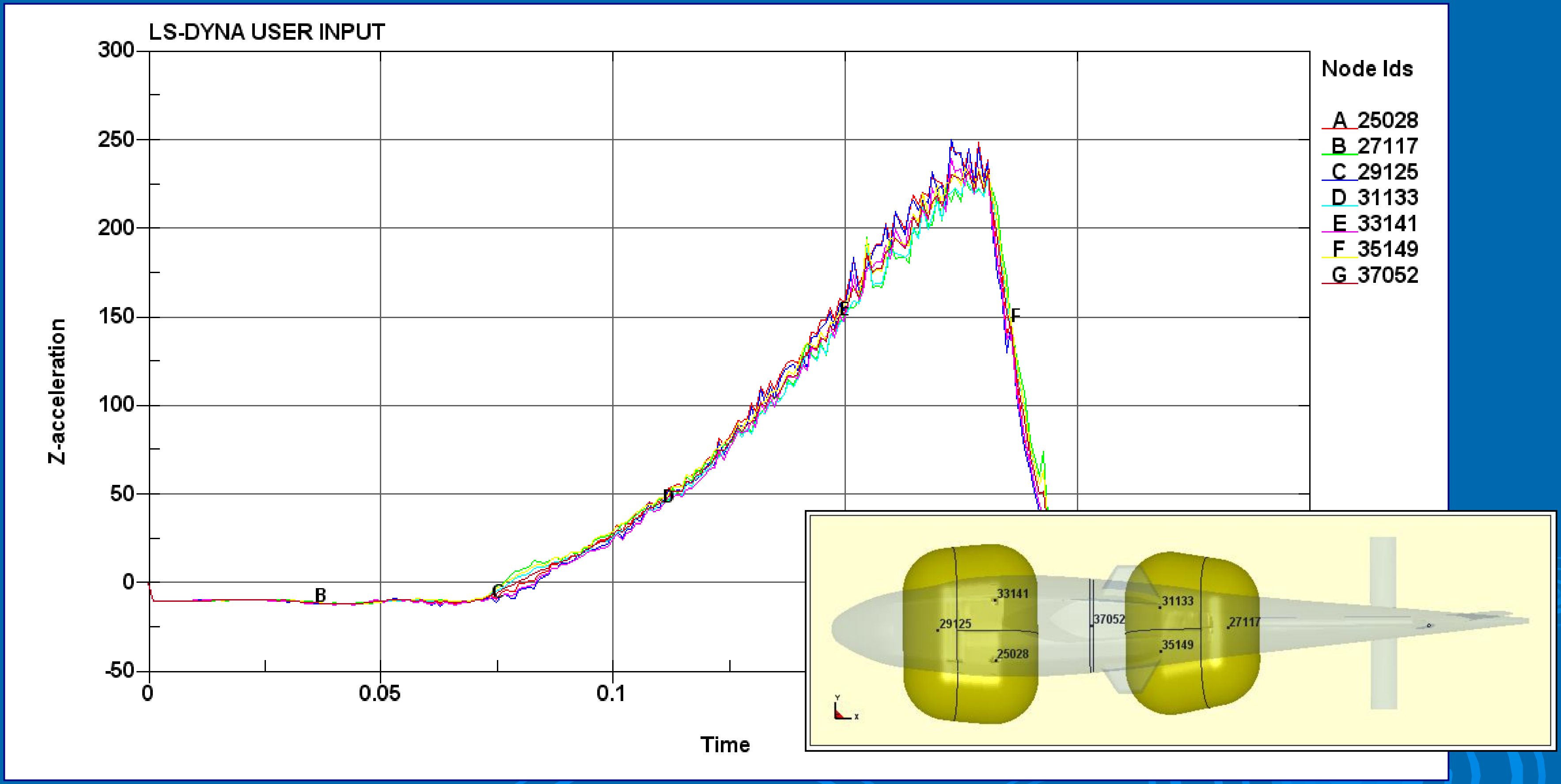
Case 1: vertical velocity behaviour



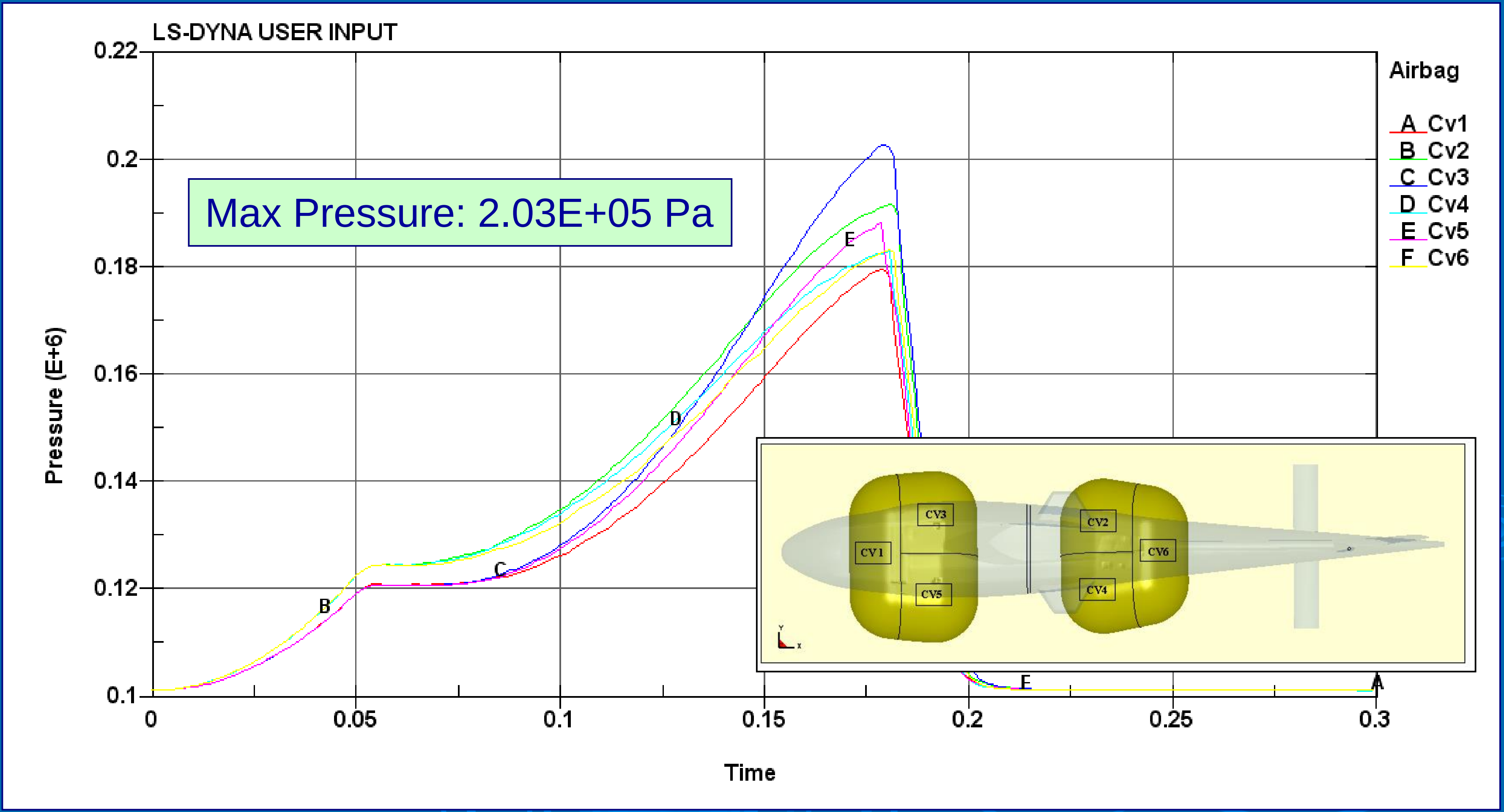
The FEM nodes used to implement the vent control logic algorithm are located in the accelerometer positions.

Case 1: vertical accelerations behaviour

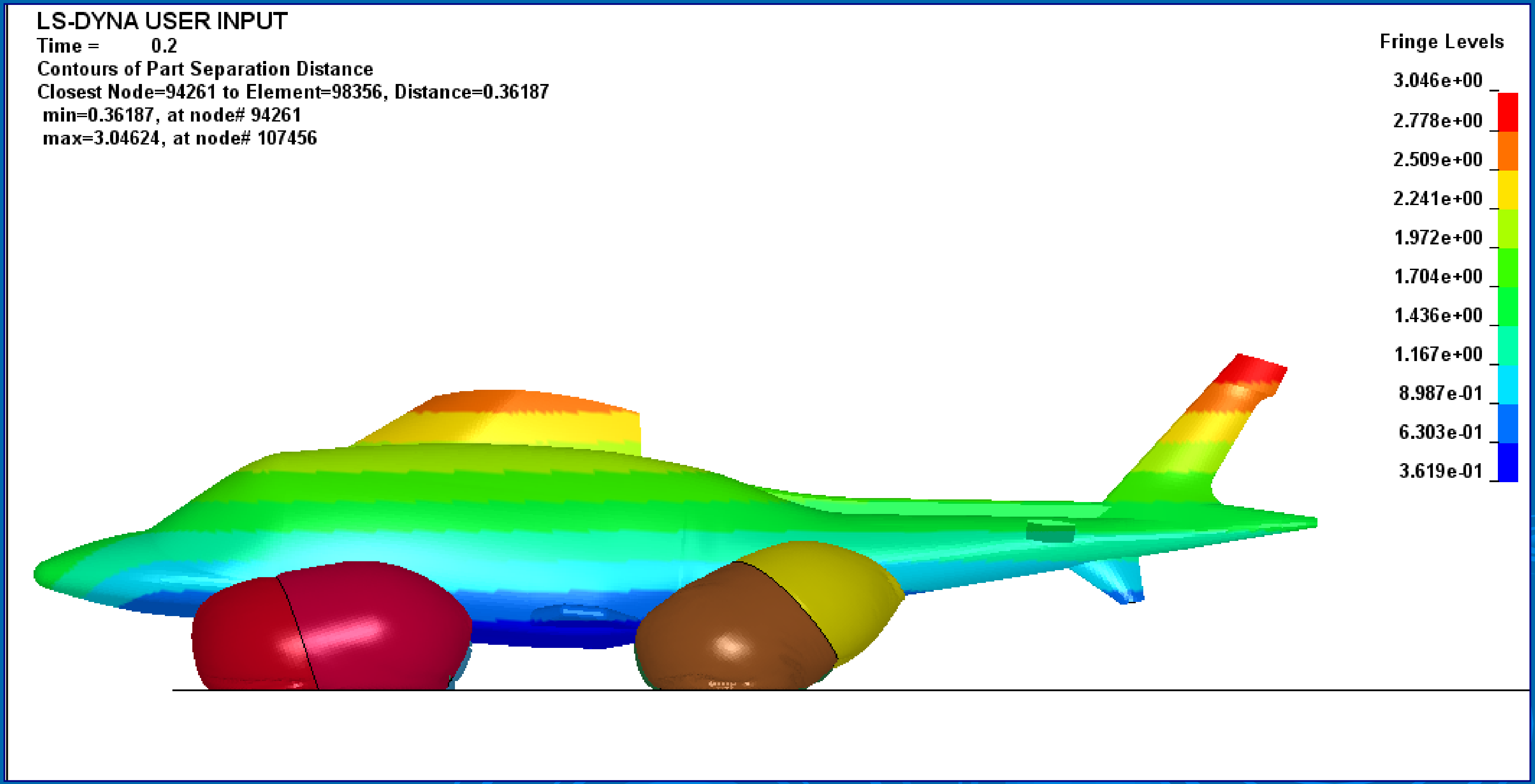


The peak fuselage rigid body accelerations are below 25g

Case 1: airbag pressures (absolute)



Case 1: clearance with ground

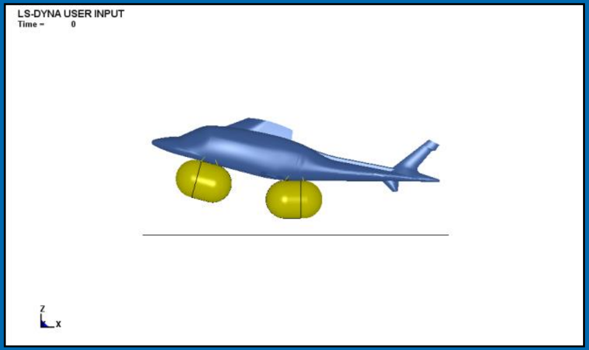


Impact conditions of case 2

The second analysis has been performed considering an increase of pitch angle (according to MIL-STD-1290).

- Impact velocity
  - Vertical velocity: 12.8 m/s
  - Horizontal velocity: 8.5 m/s
- Friction between rotorcraft / airbag with ground
  - 0.2
  - The impact surface has been considered rigid and smooth.
- Attitude
  - Pitch 15°
  - Roll 0°

Case 2: impact sequence (1/2)



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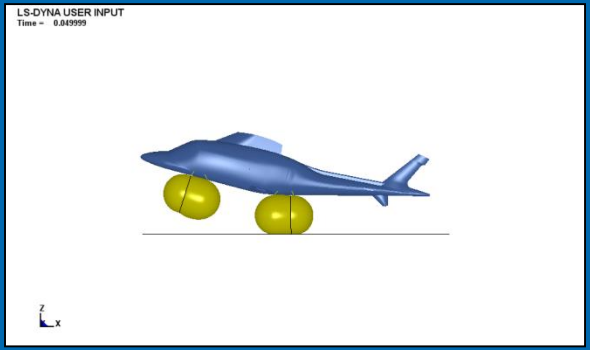

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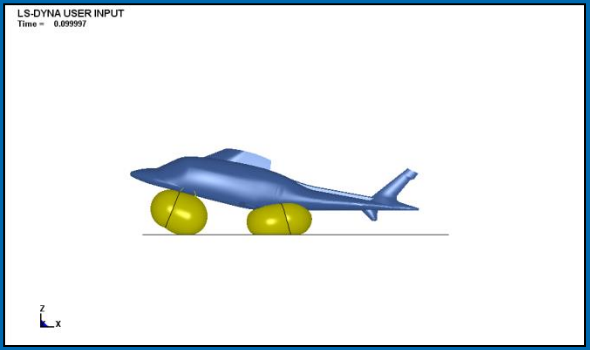

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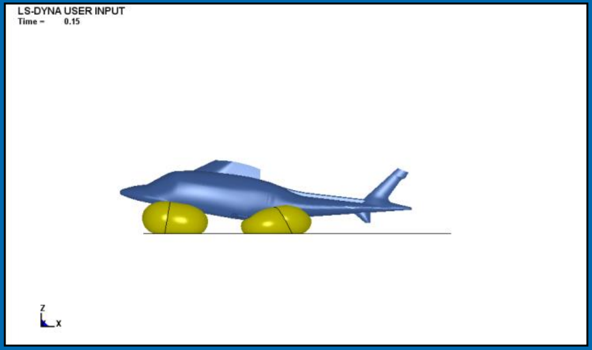

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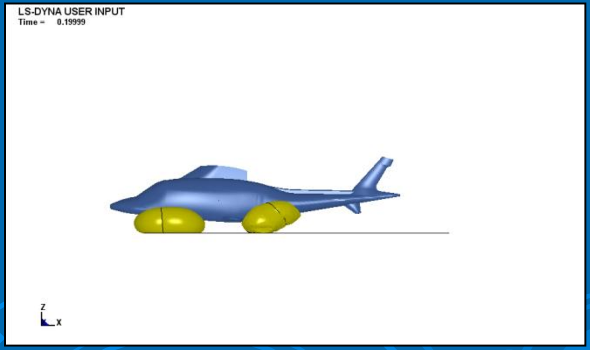

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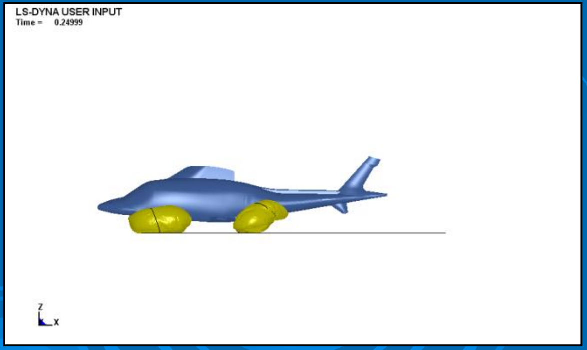
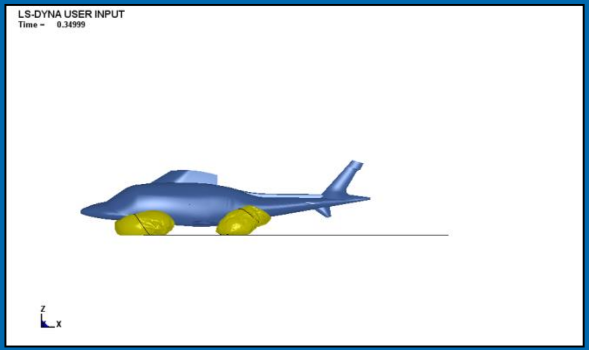


Time step = 0.25 sec

Case 2: impact sequence (2/2)



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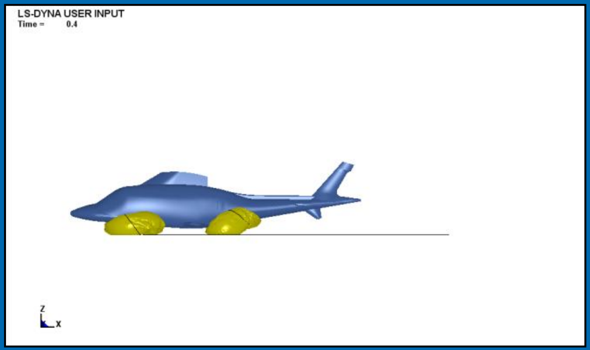
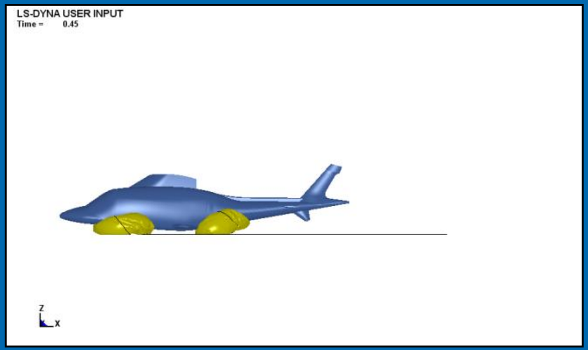


Time step = 0.40 sec



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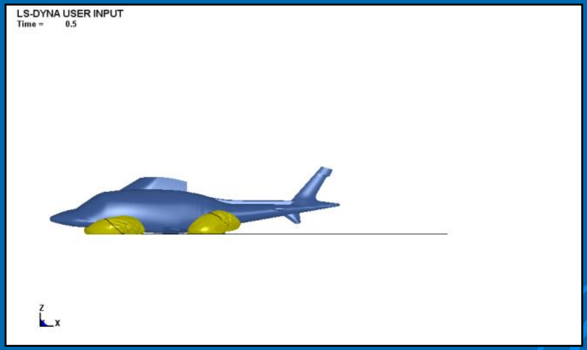

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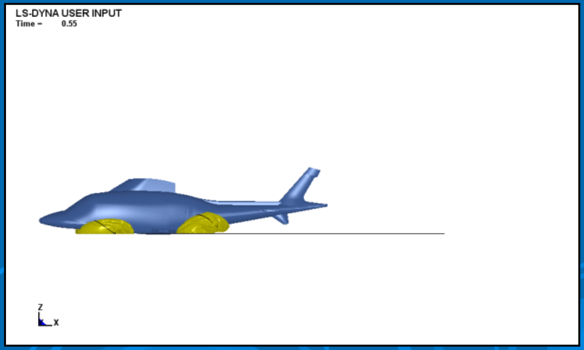
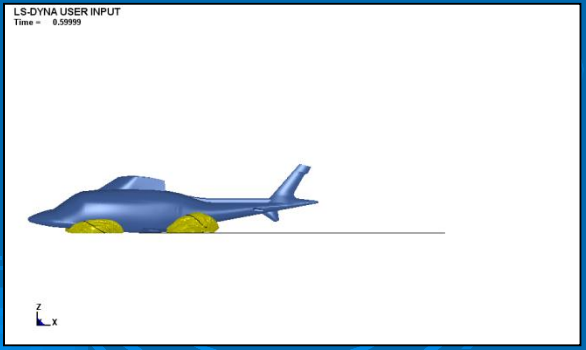
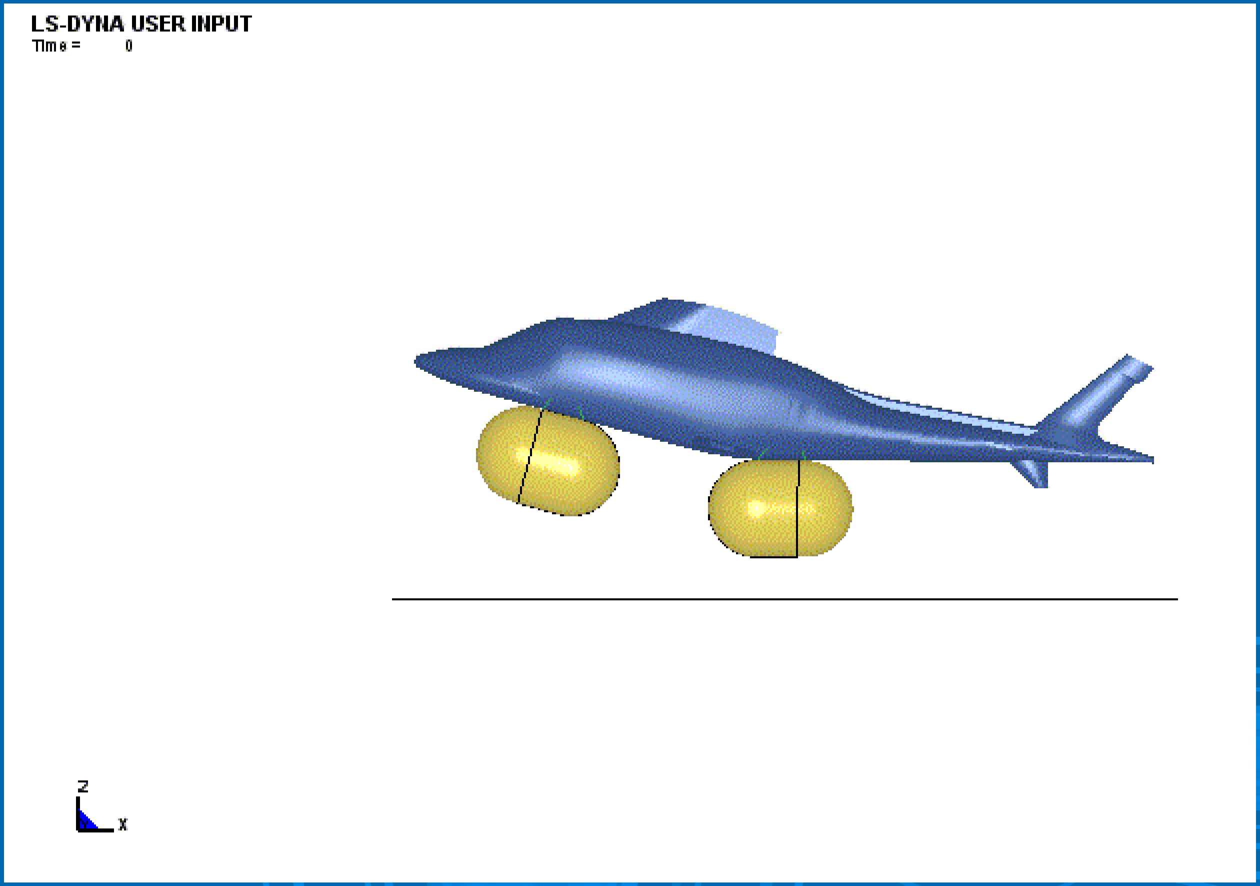


Time step = 0.55 sec

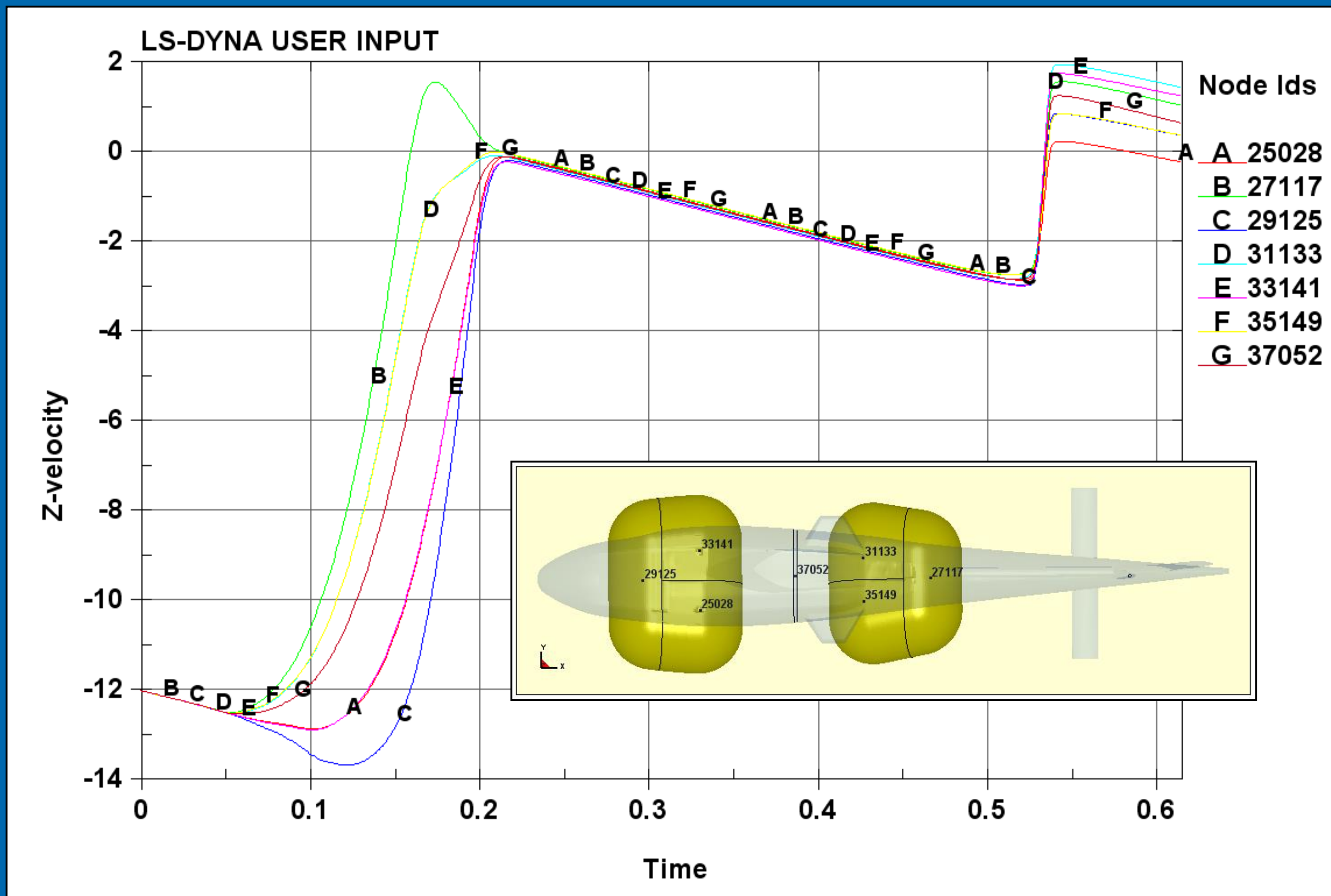


Time step = 0.60 sec

Case 2: impact movie

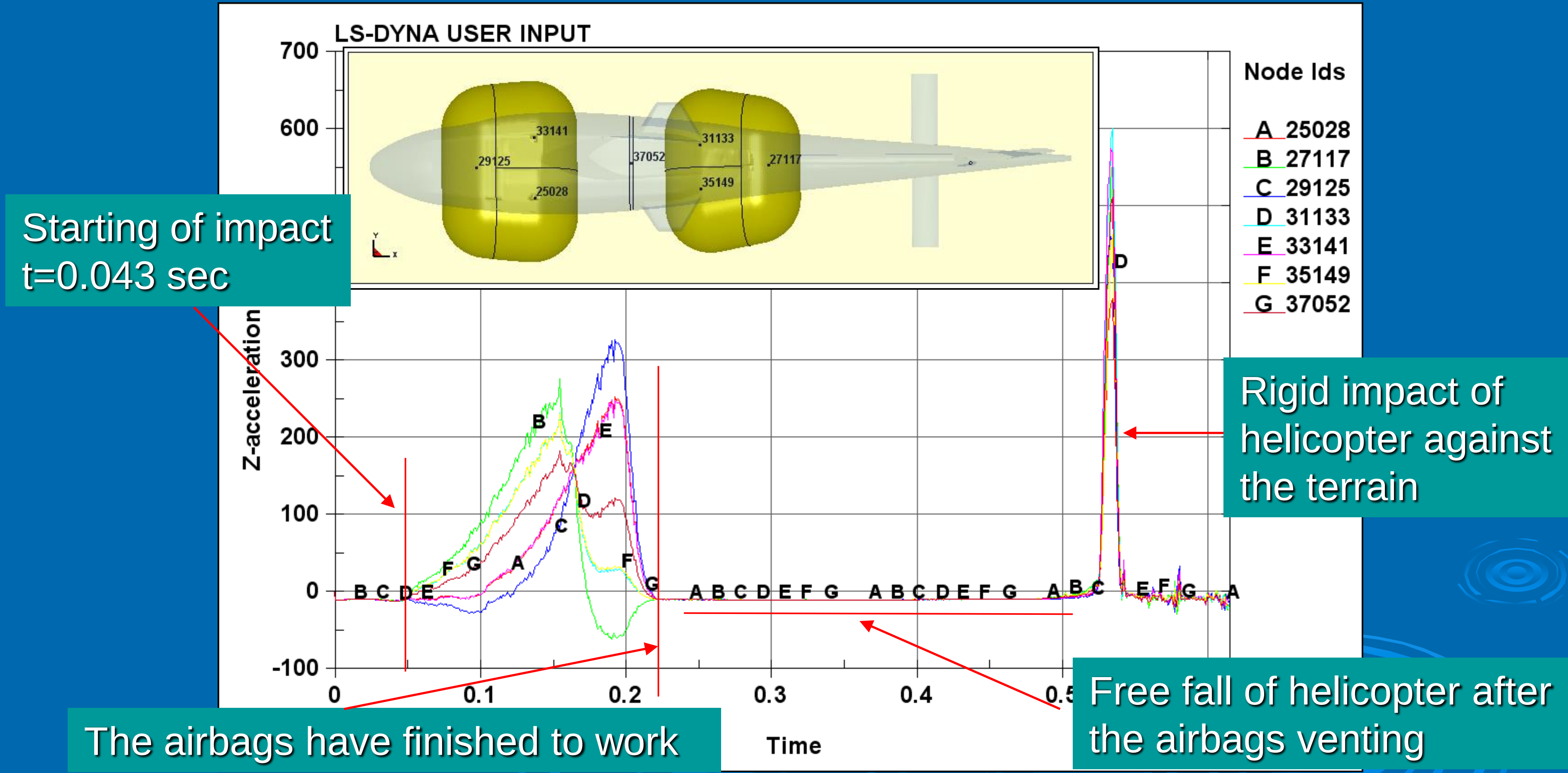


Case 2: vertical velocity behaviour



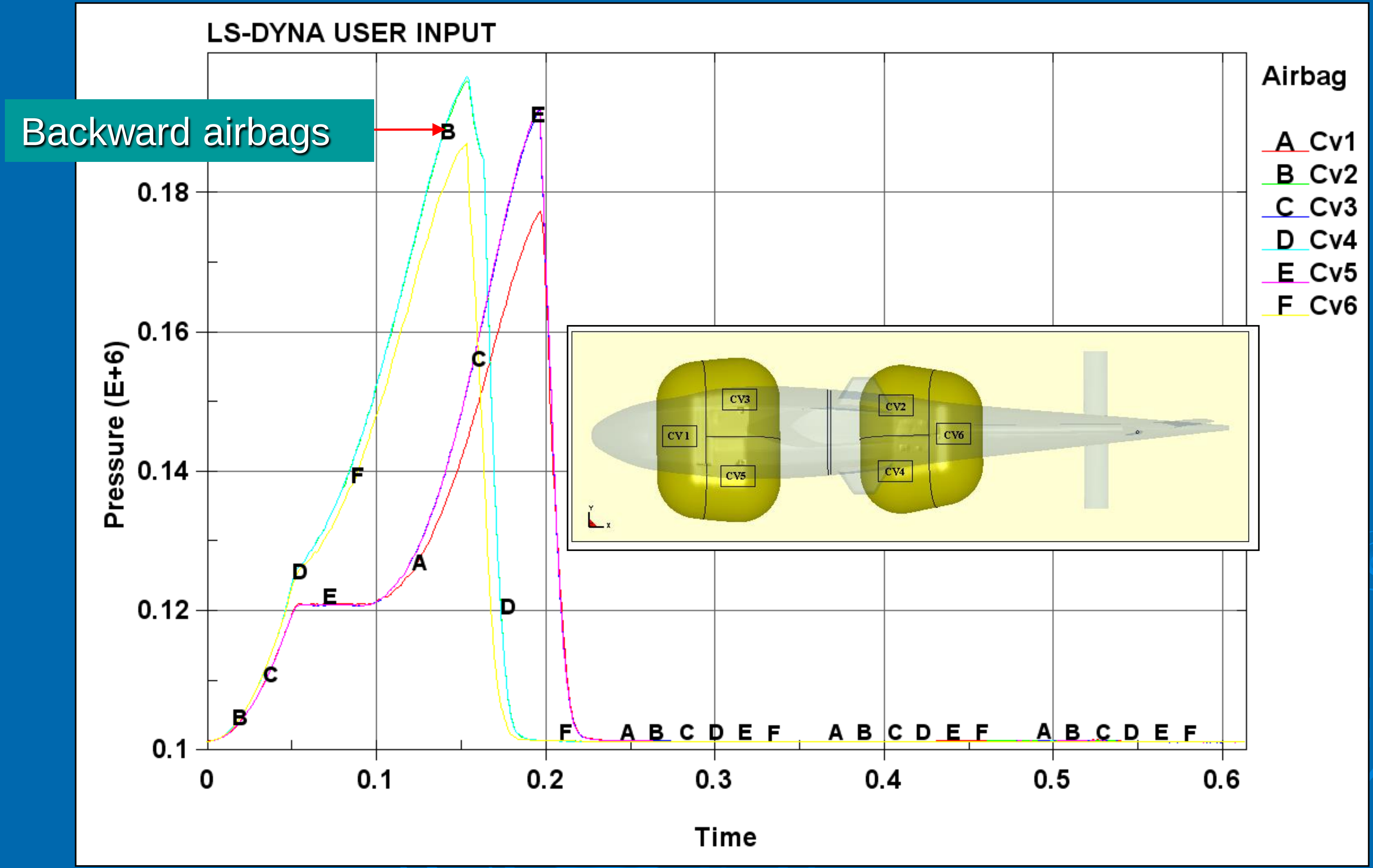
The nodes where are located the accelerometers are attached to the helicopter structure.

Case 2: vertical accelerations behaviour

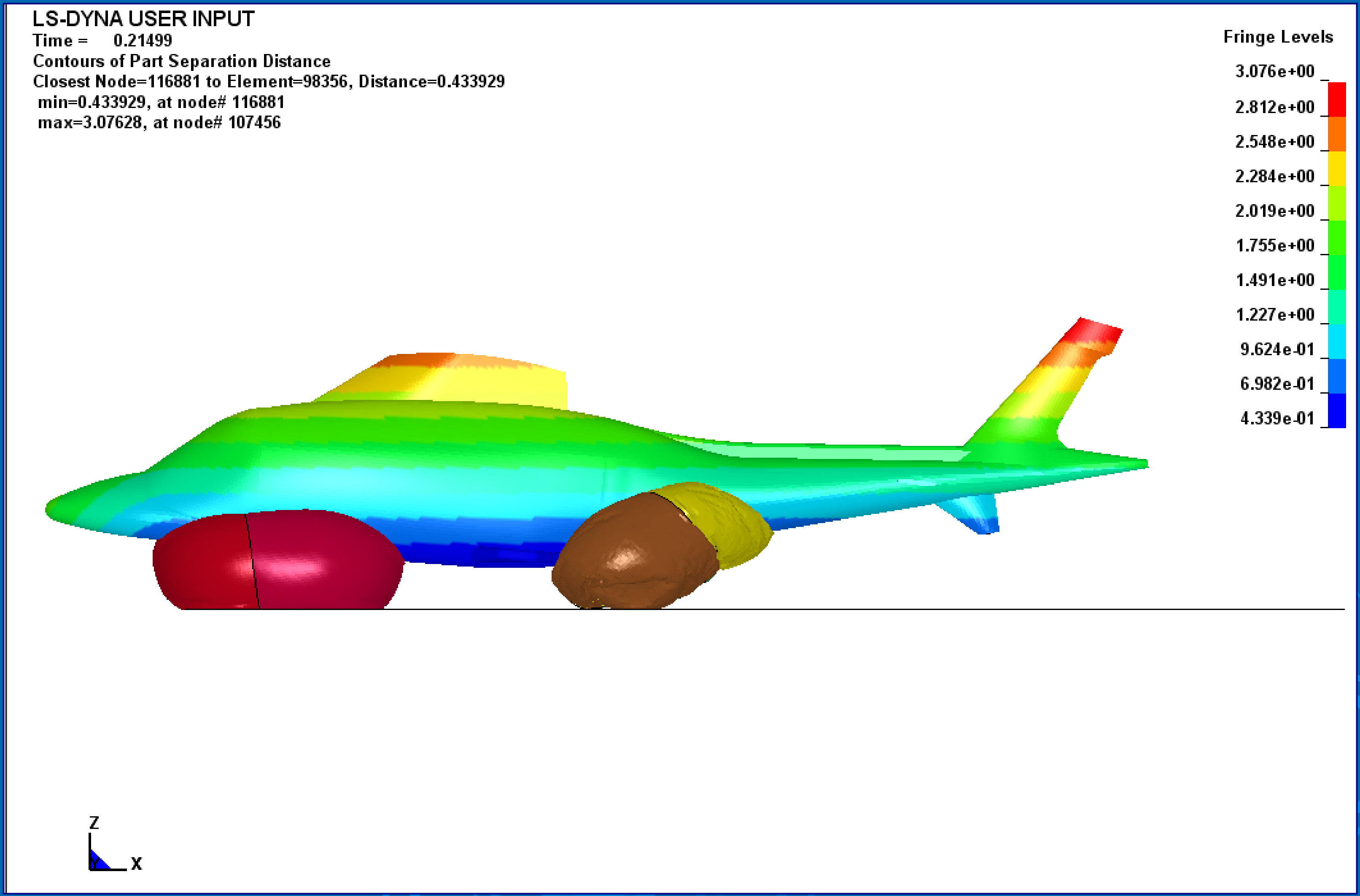


The maximum acceleration is 31g and is localized on the forward accelerometer.

Case 2: airbag pressures (absolute)



Case 2: clearance with ground



Conclusions on landing analyses

From the preliminary analyses performed, the vented airbag is a promising system to be used to control velocity and attitude of the helicopter during crash.

Concerning the vertical component of velocity, it has been drastically reduced allowing the helicopter to start the free fall from 0.4 m with null vertical velocity.

Vent valve concept

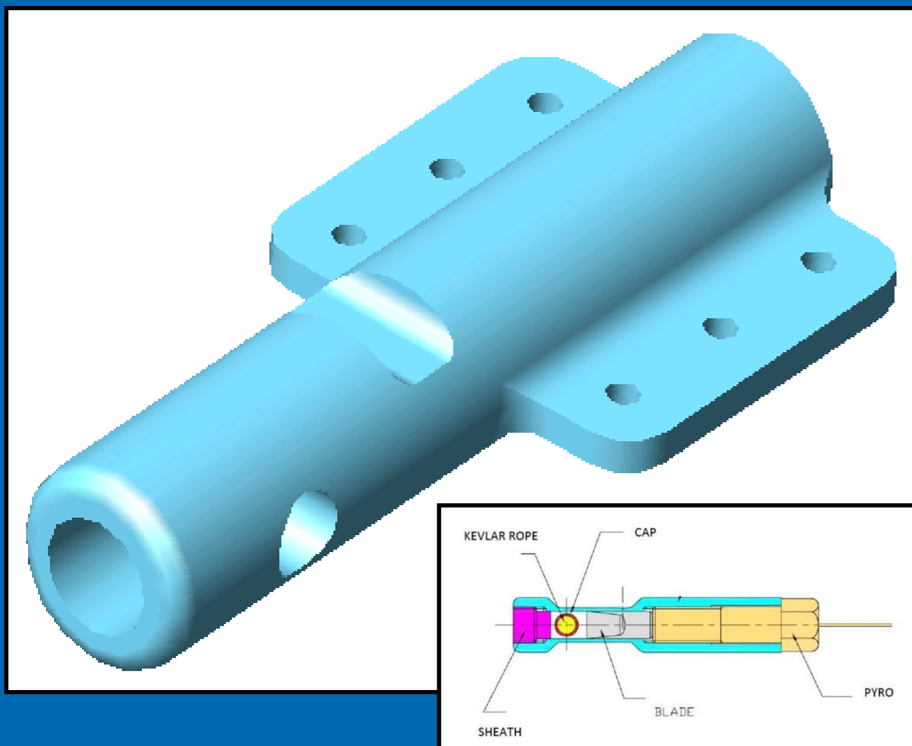
The petals provide the structural strength to the closed valve and are held closed by a single cord running through loops at the apex of each petal.

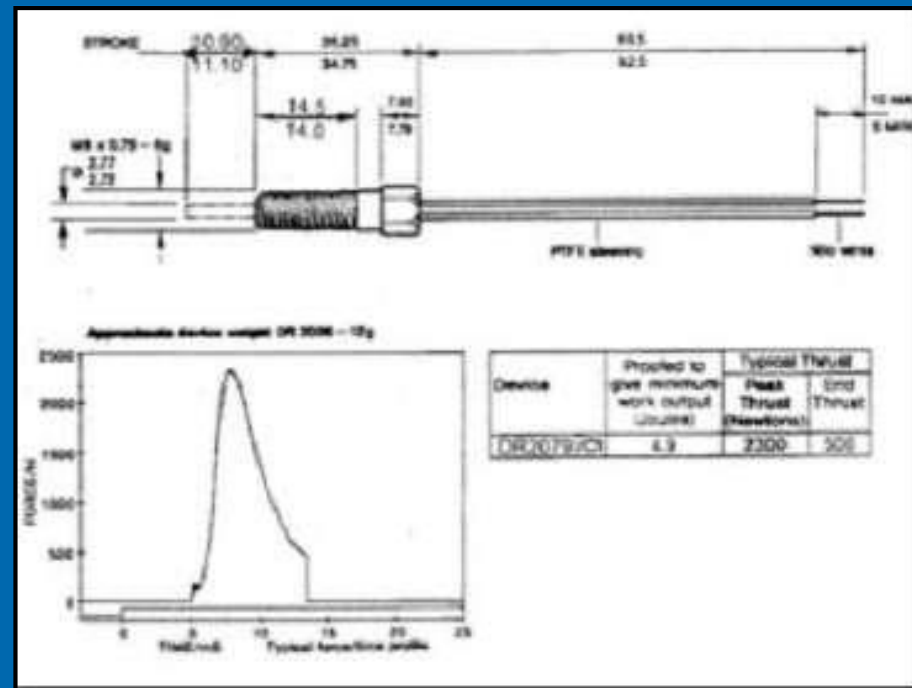
Vent valve concept

A cylindrical tube is stowed behind the petals and forms the gas barrier part of the assembly.

One end of the tube is attached to the rim of the valve, the other is sealed with a self fusing type material or by joining the two sides together.

Pyrotechnic device





The valve is opened by cutting the cord which allows the airbag pressure to push the tube through the petals. Once the tube is fully "inflated" the seal closing the end of the tube is broken allowing the gas to escape.

Mass budget

The total mass of the airbag installation is 103 kg. This value can be reduced, up to 80 kg, by:

- ✓ Reducing the mass of the IS using for example hot gas generators
- ✓ Reducing the airbag mass optimizing its volume and shape

Thanks for your attention