

Adaptive Impact Absorption and Structural Health Monitoring for General Aviation

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Presentation outline:



- Adaptive Landing Gears for Improved Impact Absorption
- Adaptive pneumatic landing gear for UAV
- Adaptive flow control based airbags
- SHM systems for aeronautical applications



Adaptive Landing Gears for Improved Impact Absorption



ADLAND

FP6-2002-Aero-1, 2003-2006

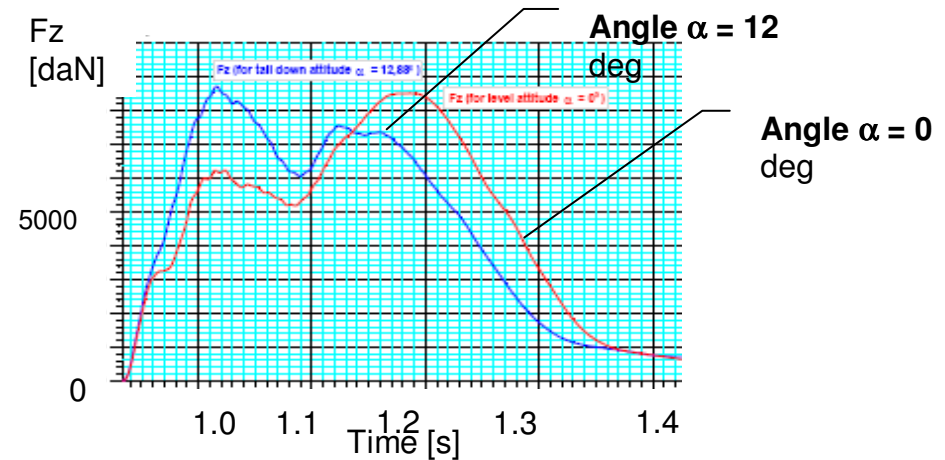
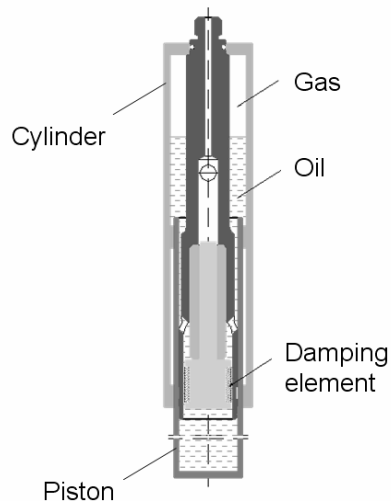


Adaptive Landing Gears
for Improved Impact Absorption



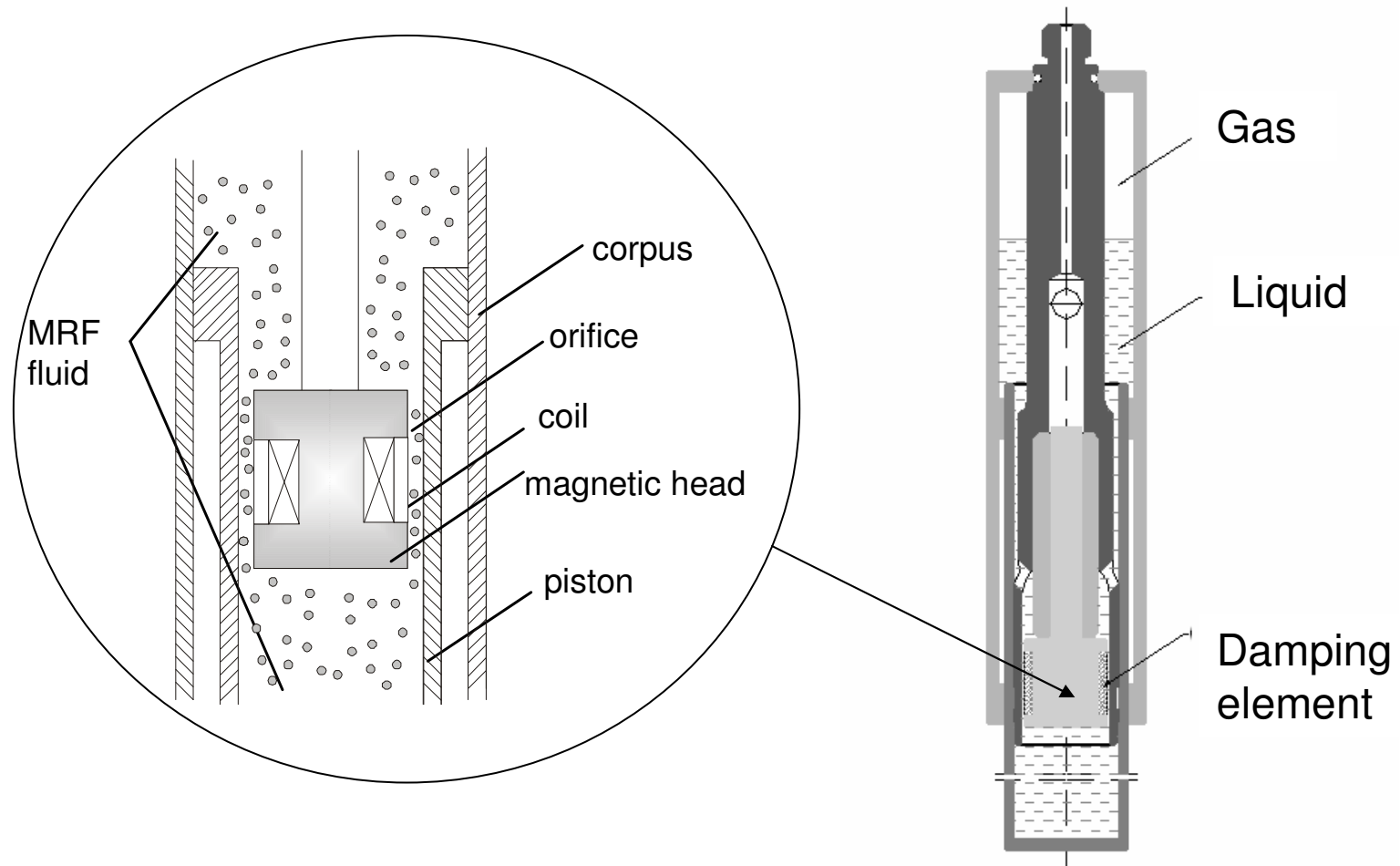
- According to the regulations (e.g. FAR23) the landing gear is designed for the appropriately chosen limit load case (e.g. vertical velocity equal to 3,05m/s)
- Statistically, the touch-down velocity during most of the typical landings is below this limit

Passive shock absorber:



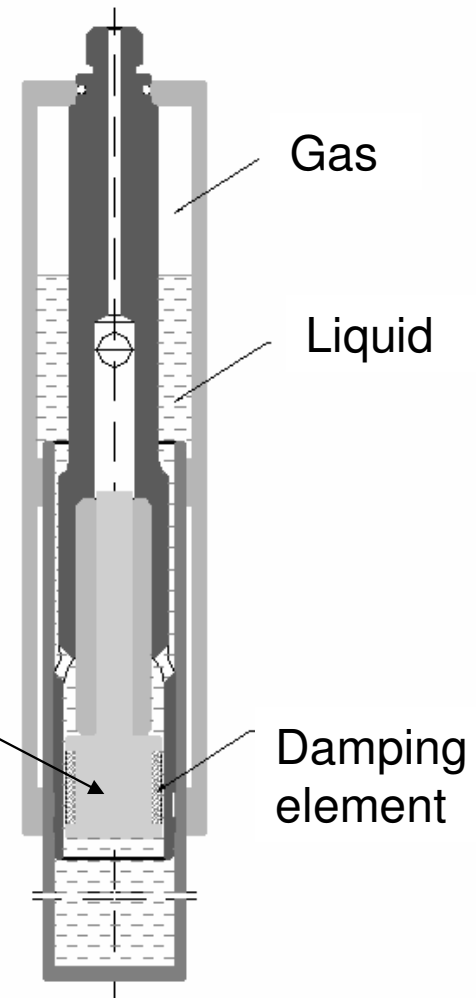
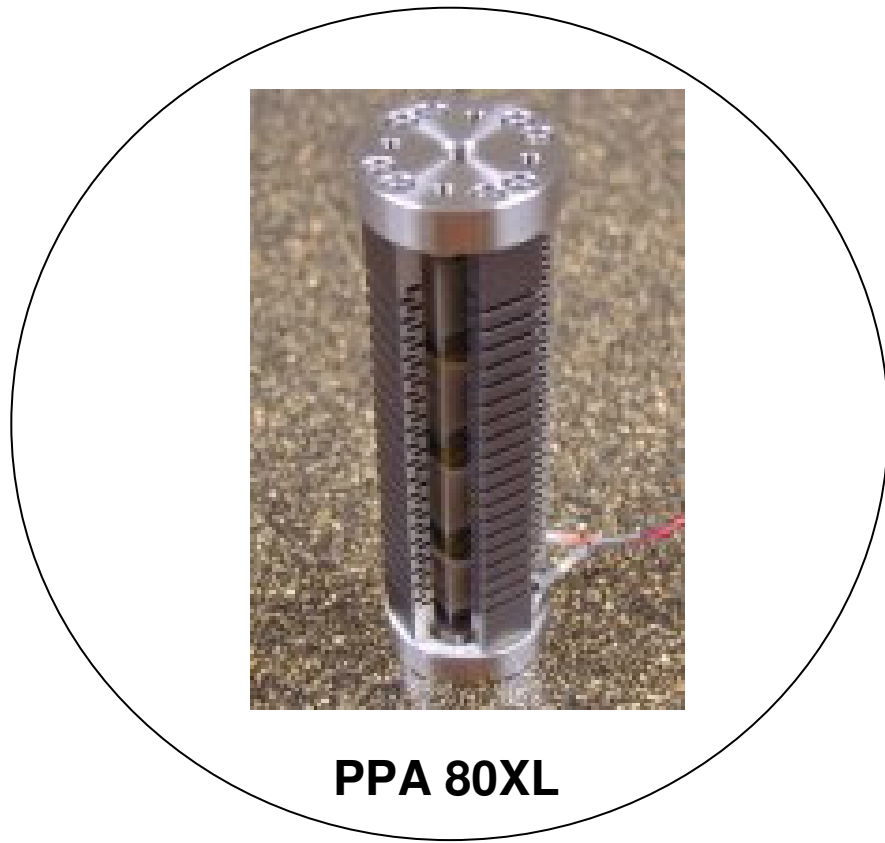
Adaptive shock absorber

MRF (magnetorheological fluid) - based ALG



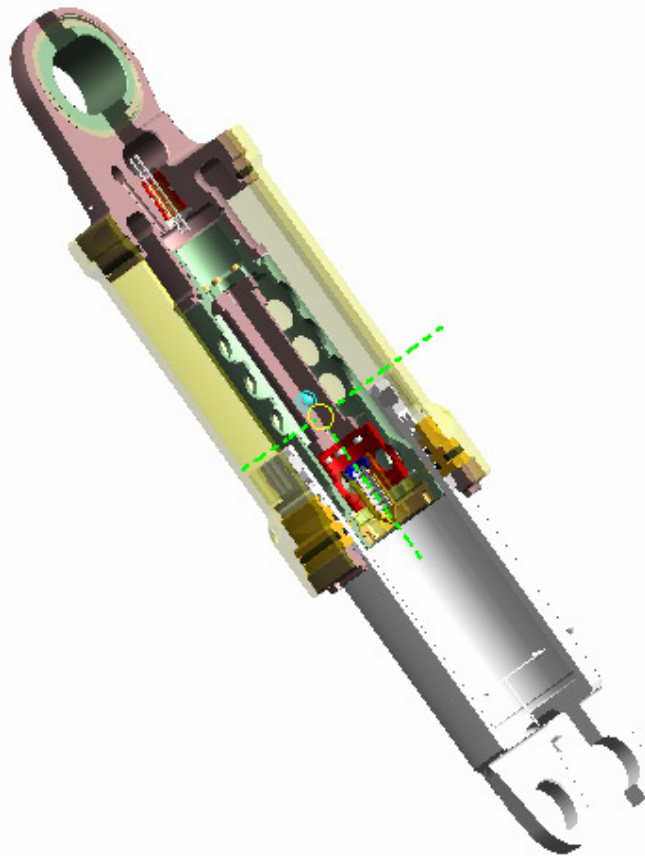
Adaptive shock absorber

Piezo-actuator based ALG



Adaptive shock absorber

Piezo-actuator based ALG

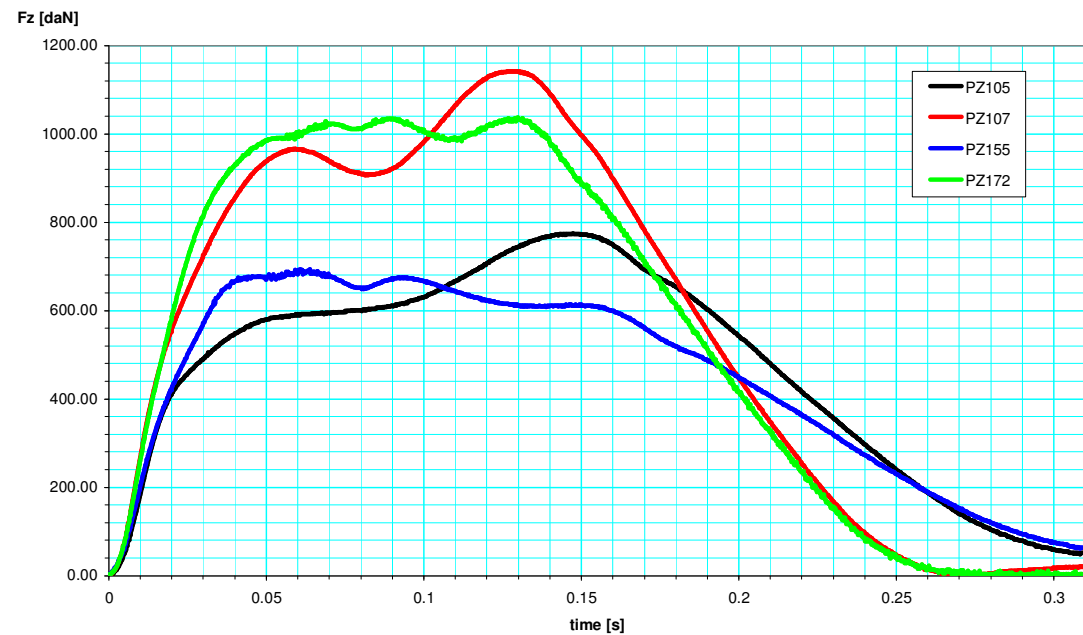


Full scale laboratory tests

Experimental stand for dynamic testing at the Institute of Aviation



Evolution of total vertical ground load

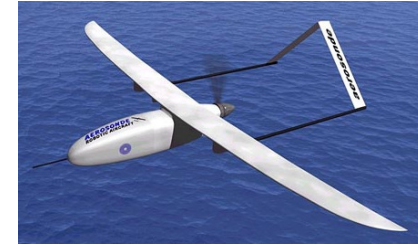


- Pz105 – low touch-down kinetic energy, no control
- Pz155 – low touch-down kinetic energy, optimal control
- Pz107 – high touch-down kinetic energy, no control
- Pz172 – high touch-down kinetic energy, optimal control

Field tests in PZL Mielec – M28 „Skytruck”

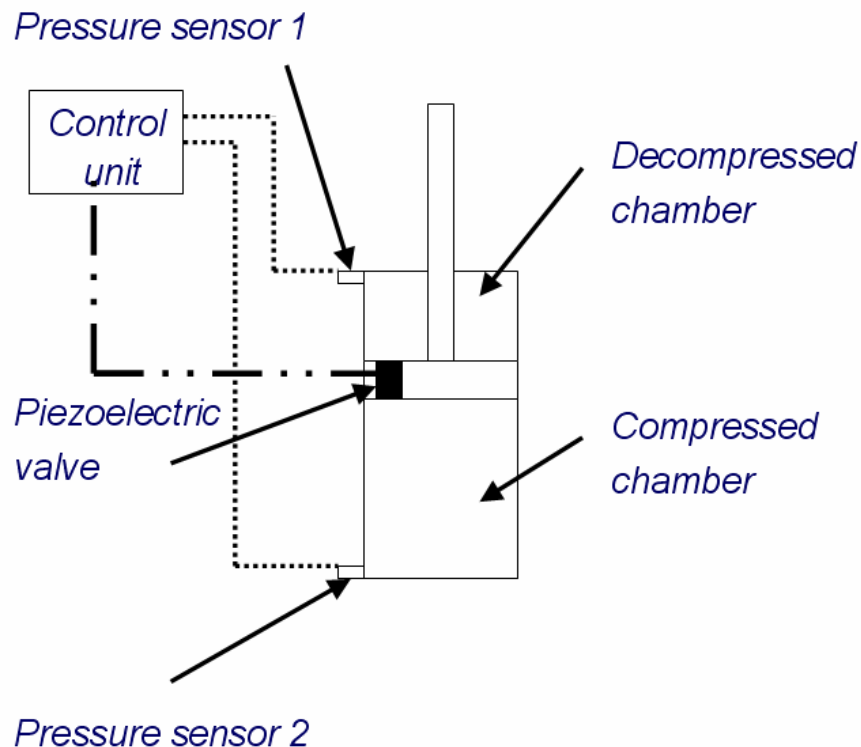


Adaptive pneumatic landing gear for UAV



- Light weight unmanned aerial vehicle
- Mass: 15 kg, landing velocity up to 6m/s
- Tasks: to absorb landing kinetic energy, to provide suspension during taxiing

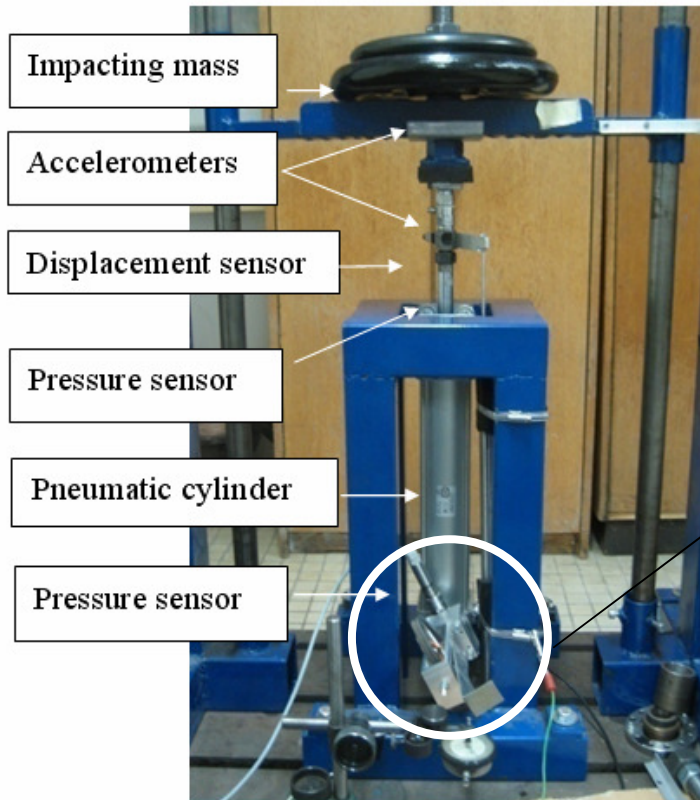
Scheme of the proposed system:



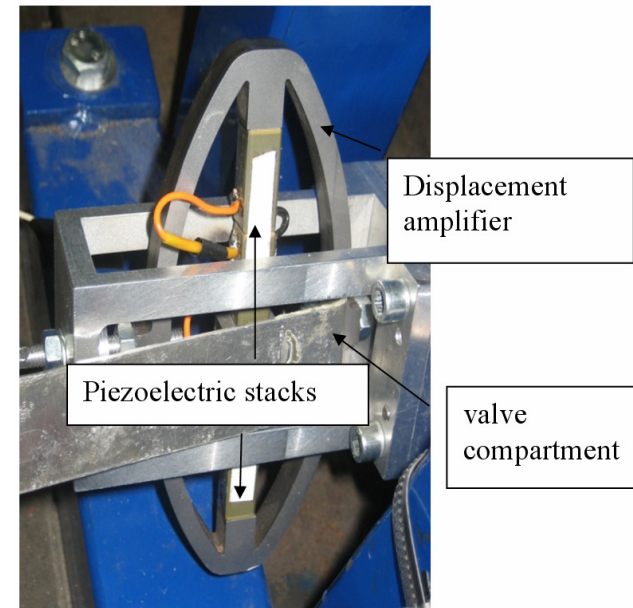
Main working principles:

- piezoelectric valve (response time: 2 ms) controls flow of the gas between lower and upper chamber of the cylinder
- the measurements from both pressure sensors are utilized to keep constant level of pressure gradient between upper and lower chamber

Experimental testing of adaptive pneumatic absorber

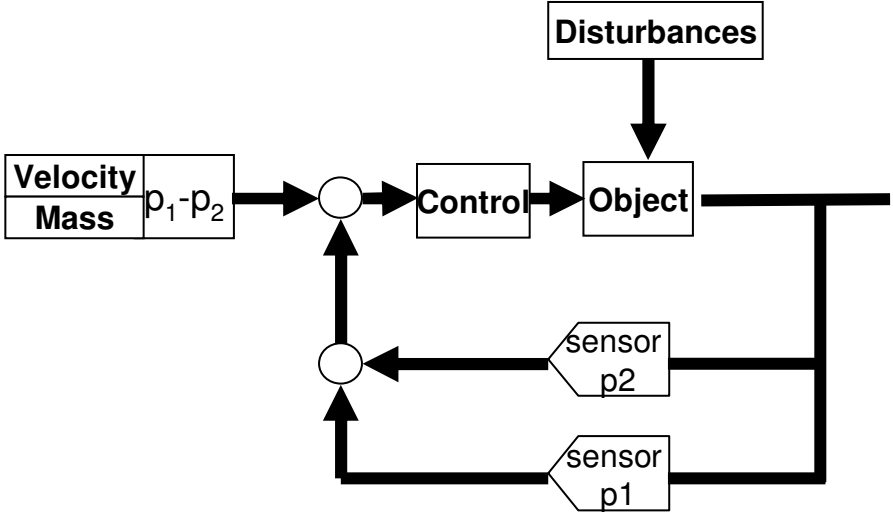


Experimental drop testing stand

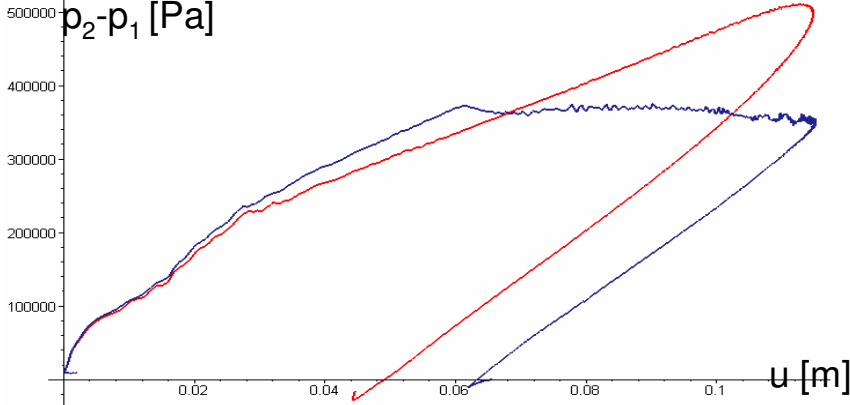
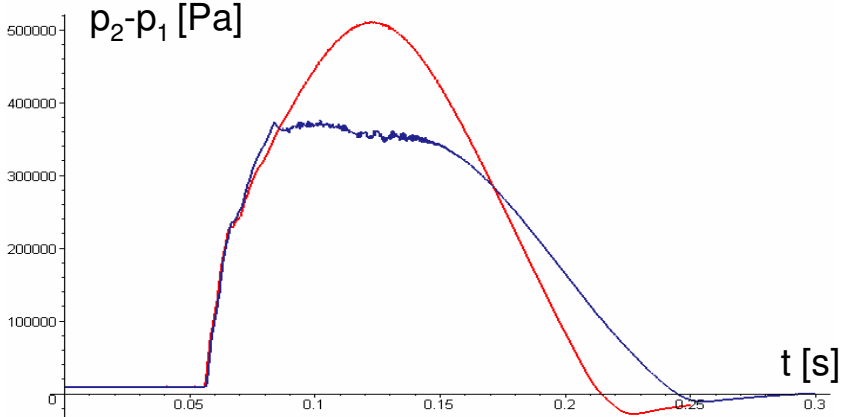


FPGA control unit cooperating with Labview system

Adaptive pneumatic absorber: experimental results



Applied control system



Forces generated by absorber in **semi-active** and **active** case

Adaptive Airbags for helicopter emergency landing

- Existing passive solutions



Israeli Bell 216 equipped with airbag for emergency landing



NASA Mars Pathfinder



Polish helicopter Anakonda equipped with airbags for landing on water

- Intrinsic drawbacks of passive airbags:

- initial inflation and release of pressure from the airbag are not precisely controlled
- airbags are not adapted to actual velocity and direction of landing
- as a result passive airbag does not protect landing object and its passengers in optimal way

Adaptive Airbags for helicopter emergency landing

- Working principles of adaptive multi-chamber airbag system:

1. **System of sensors** recognizes actual conditions of emergency landing
2. During initial stage of collision **controllable pyrotechnic inflators** blow up each adaptive airbag to optimal initial pressure
3. **Active high performance valves** execute predefined strategy of gas release providing optimal landing scenario

- Required equipment:

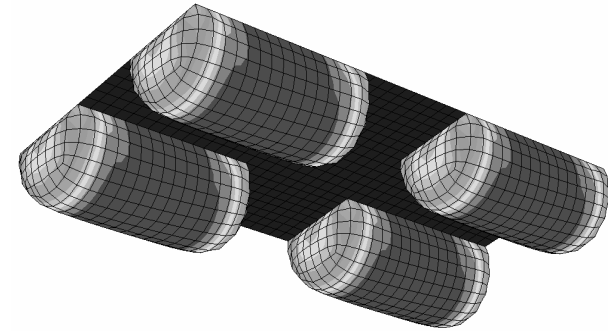
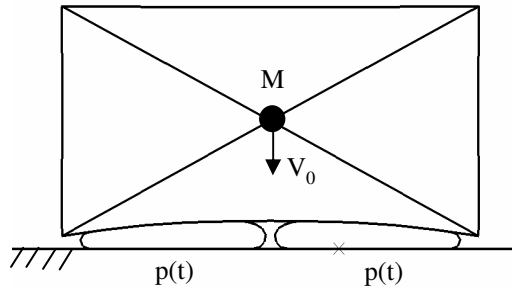
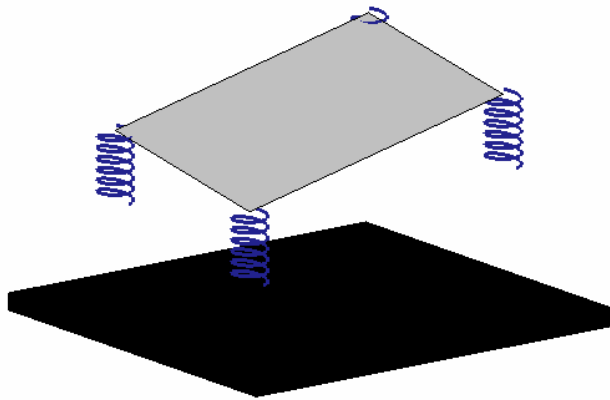
- system of sensors: ultrasonic velocity measurement, impacting mass sensors, etc
- fast reacting controllable pyrotechnic inflators
- High Performance Valves
(Patent pending: membrane valve)

Target object of the project: helicopter PZL Sokół



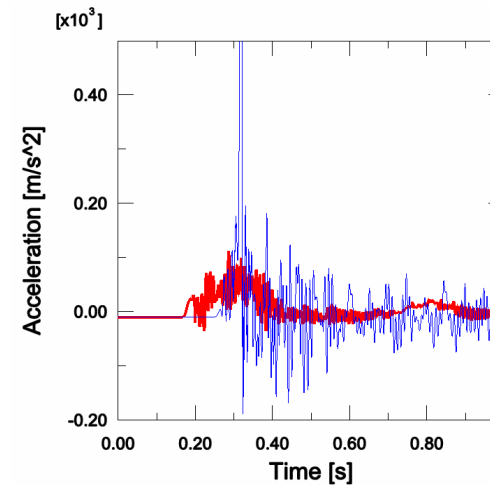
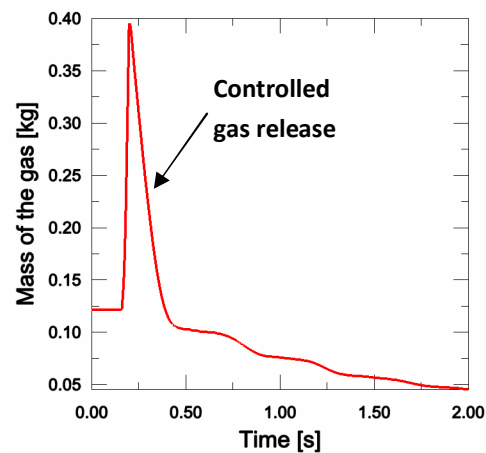
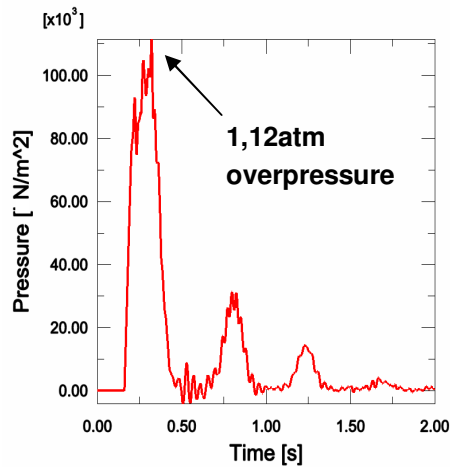
Adaptive Airbags: modelling and simulation

- Numerical models of falling object with adaptive airbags:



- Preliminary simulation of emergency landing with adaptive airbag

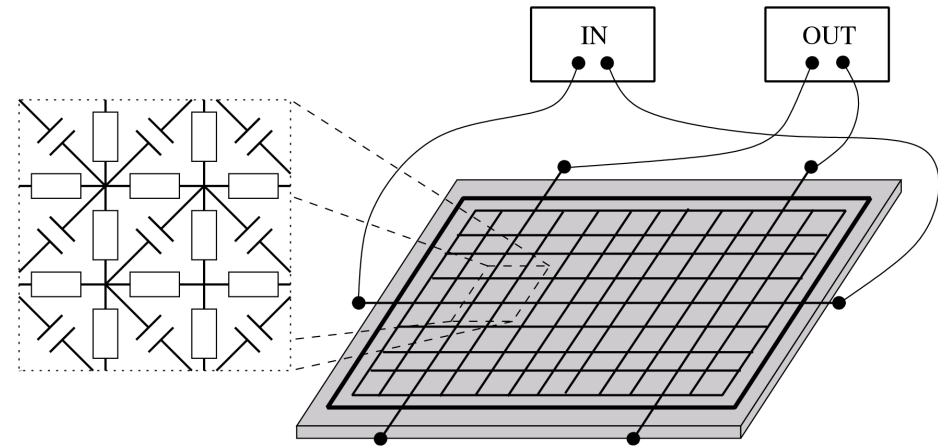
mass: 5000 kg; impact velocity: up to 10m/s, airbags dimensions: 4 x 1m² x 0.5m



ELGRID: innovative SHM system for composite structures

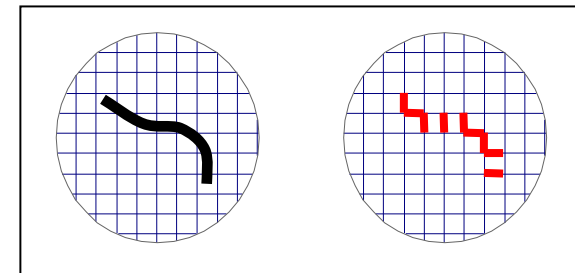
Concept:

built-in electrical system (network of distributed sensors) which sustain damages along with the occurrence of mechanical defects



Applications:

- Detection of cracks and delamination in composites (laminated, honeycomb)
- Monitoring of wings, rotor blades, fuselage

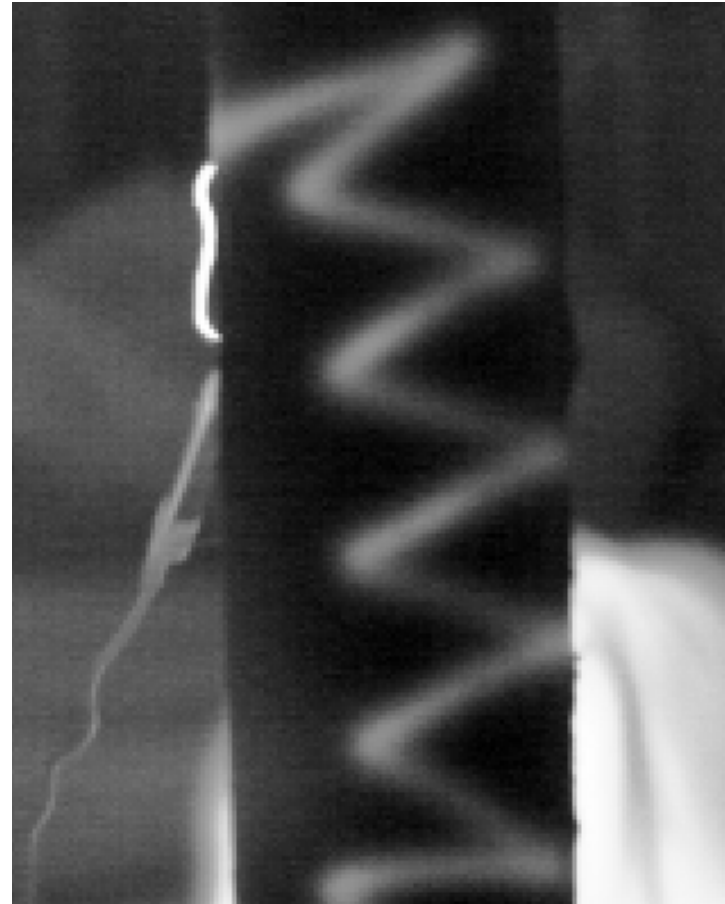


Economical alternative to SHM systems based on optical fibres or piezoelectric sensors

ELGRID: innovative SHM system for composite structures

Steady-state approach:

- DC/AC supply of the network
- identification of defects based on:
 - resistance / impedance measurement
 - steady-state response
 - observation / measurement of thermal field



Thermal image of a laminated beam
with the built-in resistive wire

ELGRID: innovative SHM system for composite structures

Dynamic approach:

- supply by the dynamic test signal
- identification of defects (changes of conductance or capacitance within the network) based on differences in responses between healthy and damaged structure (gradient-based model updating)

