POLITECNICO DI MILANO

A Preliminary Study on Helicopter Crashworthy Stages Adapted to Different Impact Conditions

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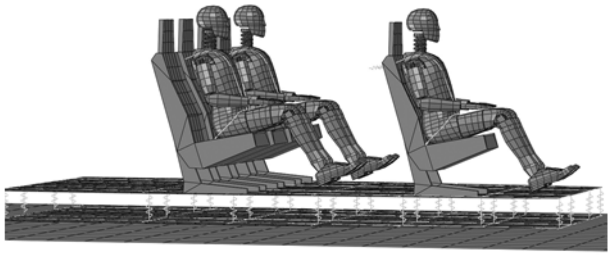
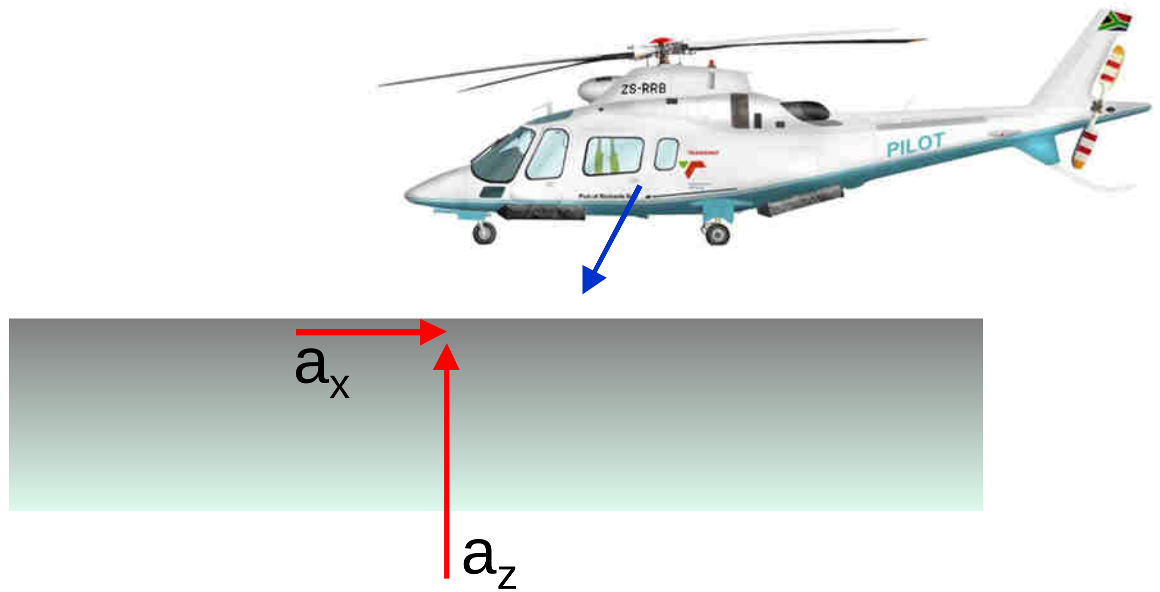
Crash and dynamic test facilities and numerical tools



Crash conditions

High vertical component of acceleration



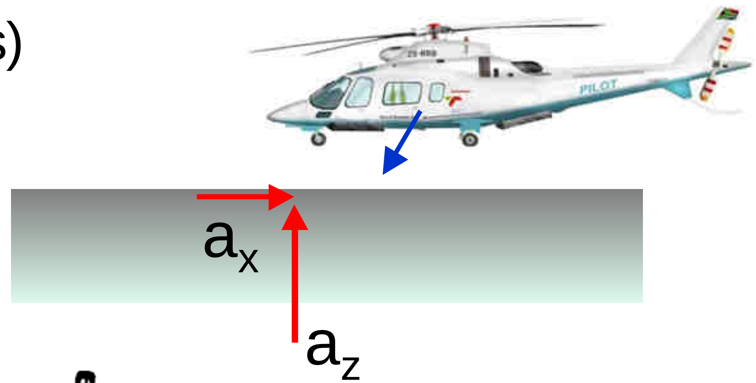
Main injury risk:

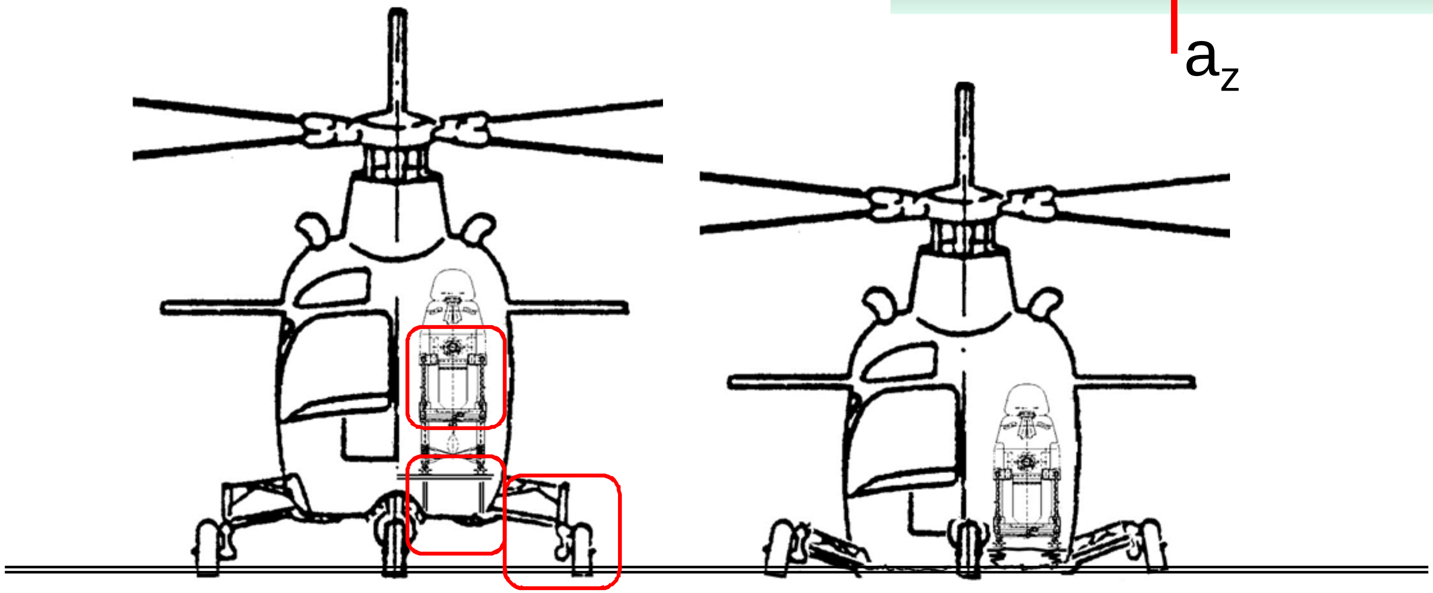
- High lumbar spine load

Crash loads mitigation

Energy absorption by:

- Landing gear shock absorber (certification at v = 2 m/s)
- Subfloor (general recommendations)
- Seat (certification at 9.15 m/s, 30 g’s)

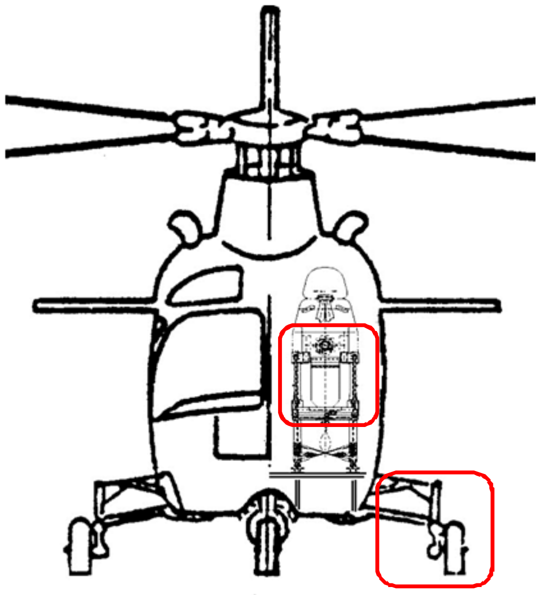




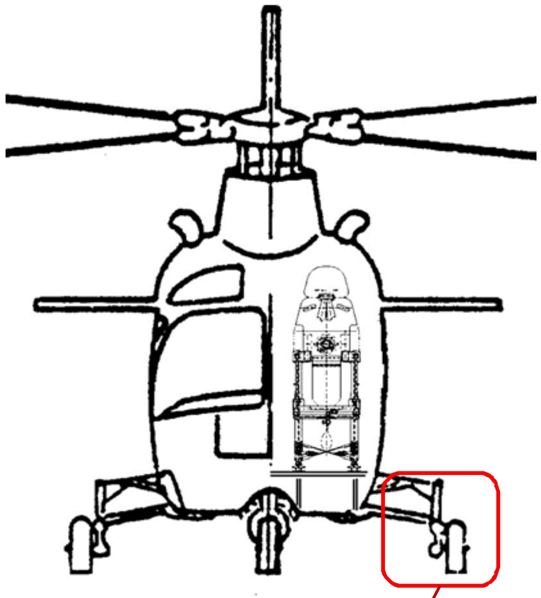
Object

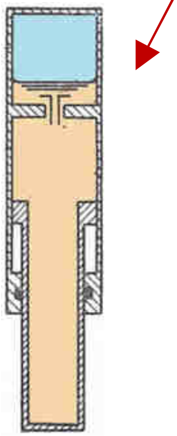
Preliminary study:

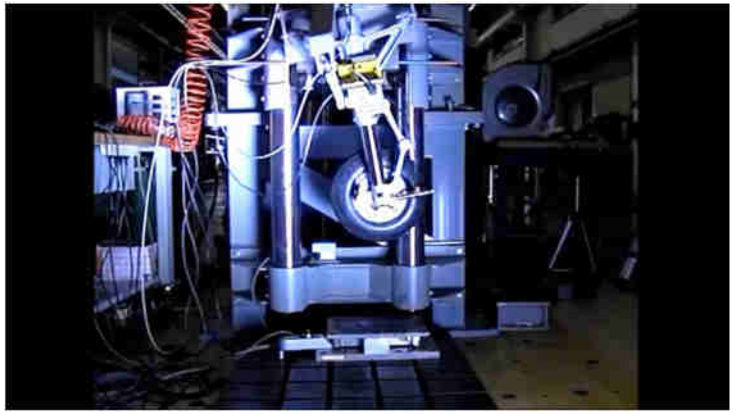
1. Set-up a numerical model of the relevant structural area and systems
2. Define the mechanical parameters that could be controllable and adaptive
3. Carry out parametrical analyses at increasing impact speeds

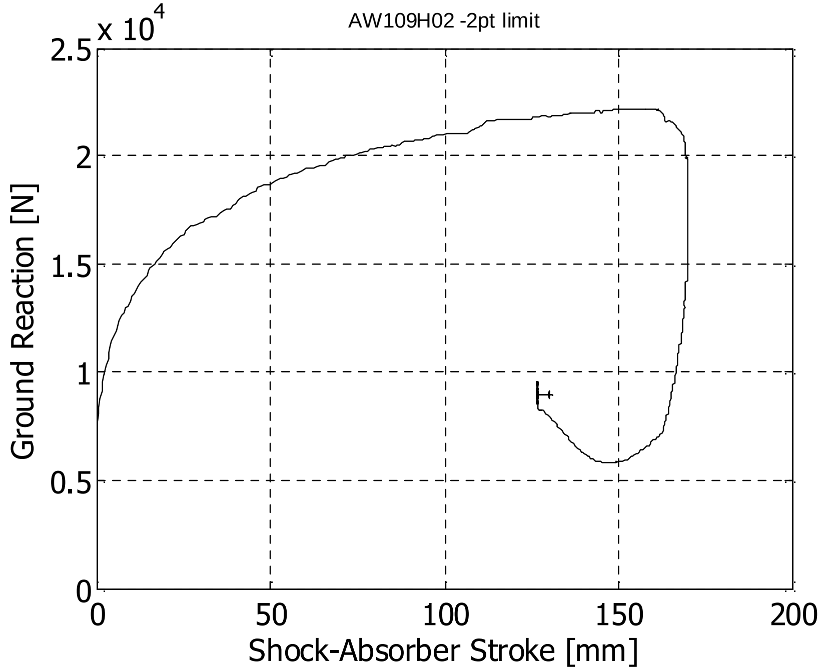


Landing gear

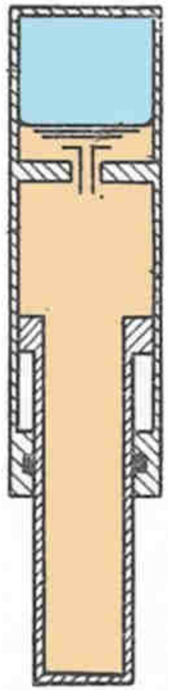


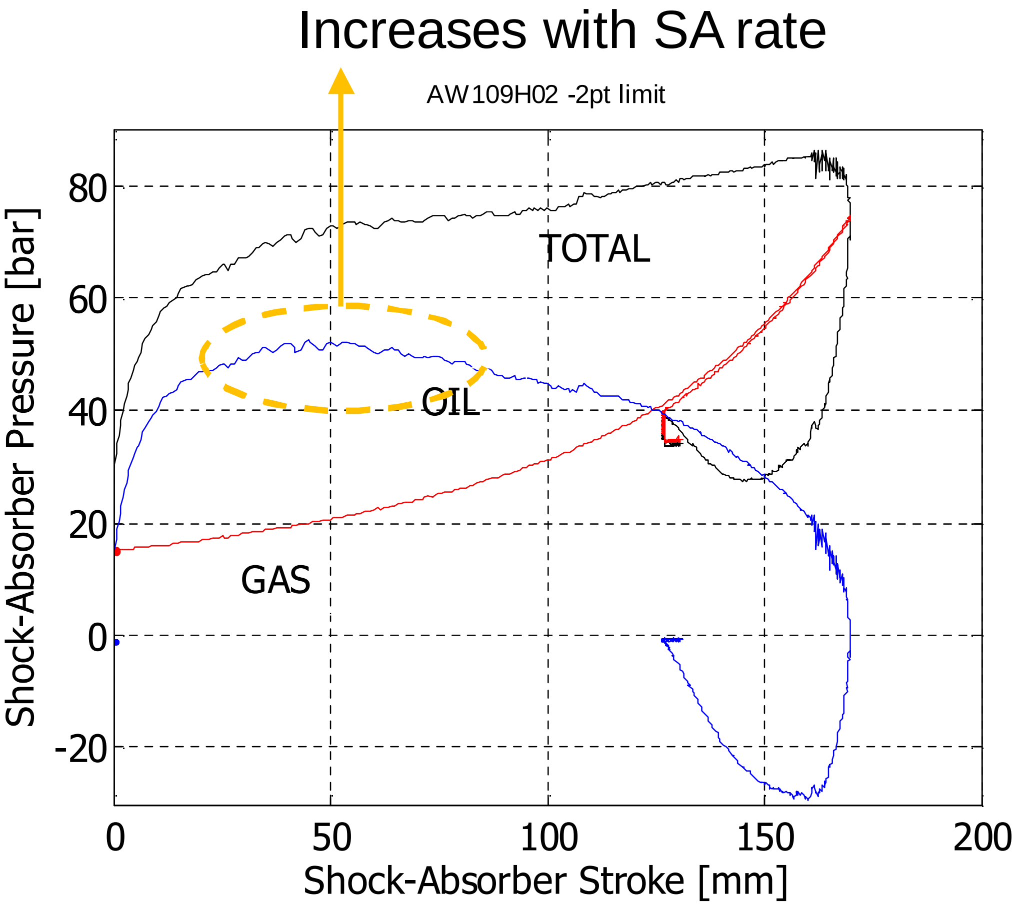






Landing gear



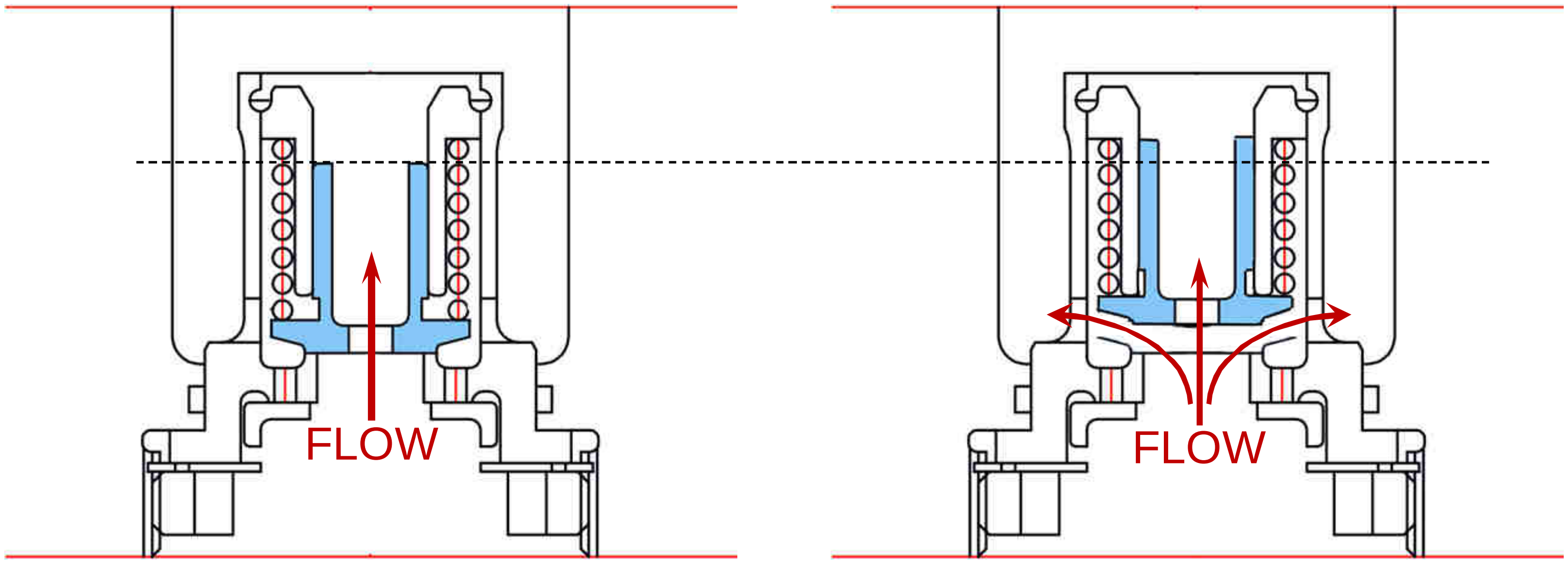


<u>Adaptive shock absorber</u>

Metering of the side orifice areas by electrically-controlled shutters

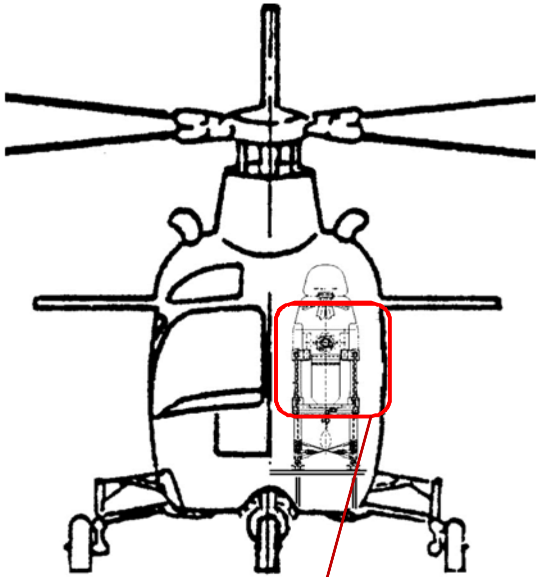
Control of max spool displacement

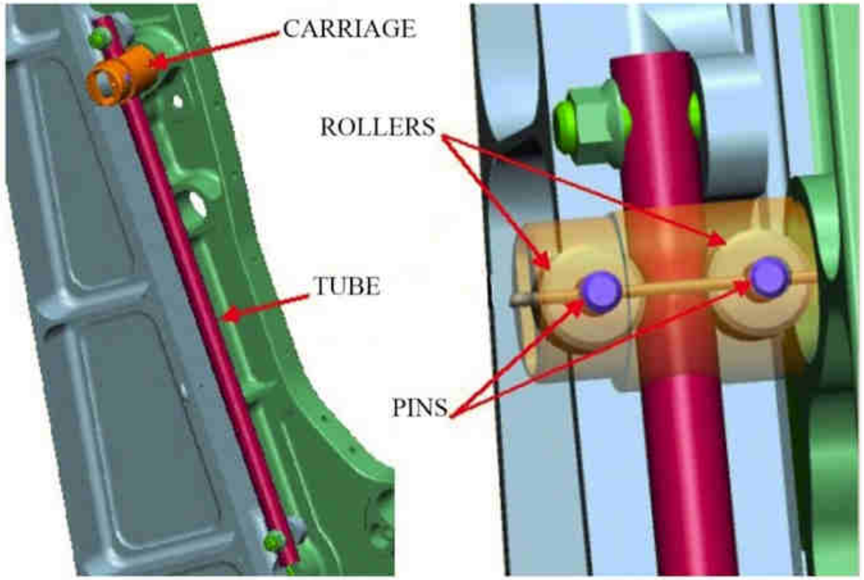
Magneto-rheological fluids

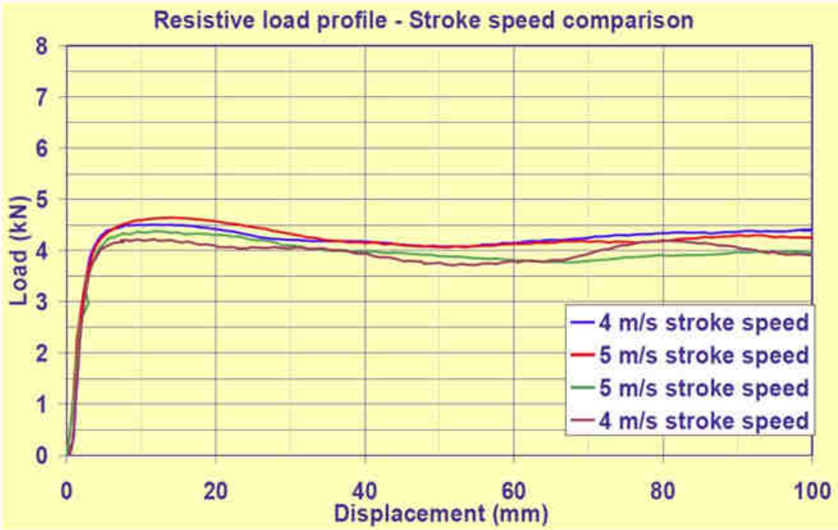


CLOSED OPEN

Seat

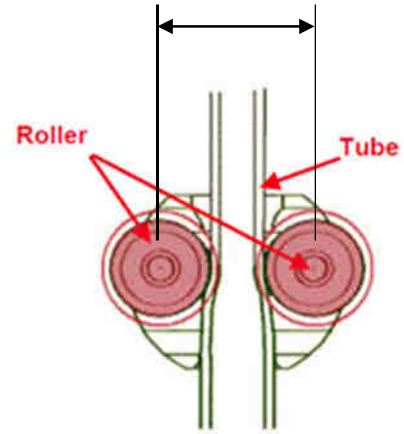


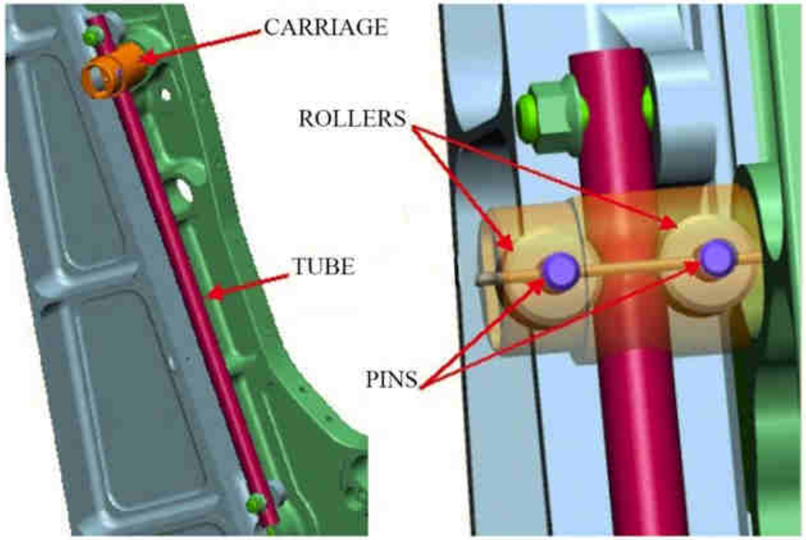

CARRIAGE
ROLLERS
TUBE
PINS

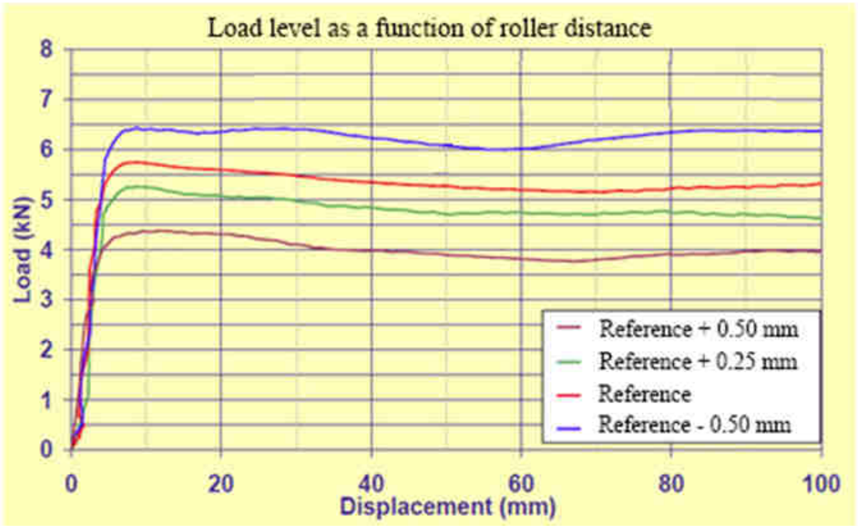

Resistive load profile - Stroke speed comparison
Load (kN)
0
1
2
3
4
5
6
7
8
0
20
40
60
80
100
Displacement (mm)
4 m/s stroke speed
5 m/s stroke speed
5 m/s stroke speed
4 m/s stroke speed

Adaptive energy absorber

Roller distance calibrated by a micro-actuation system



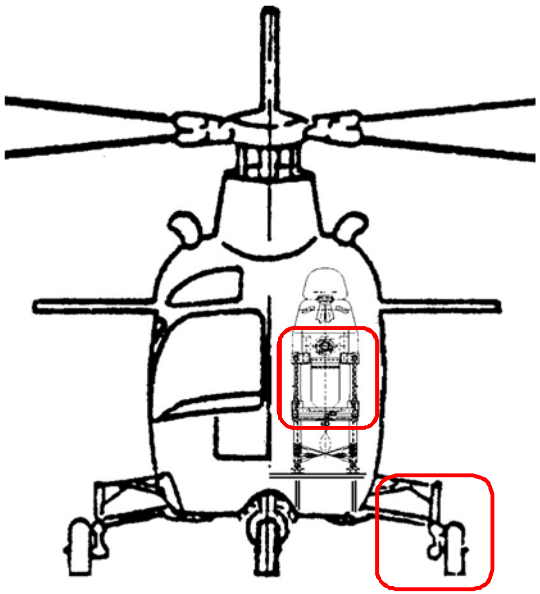


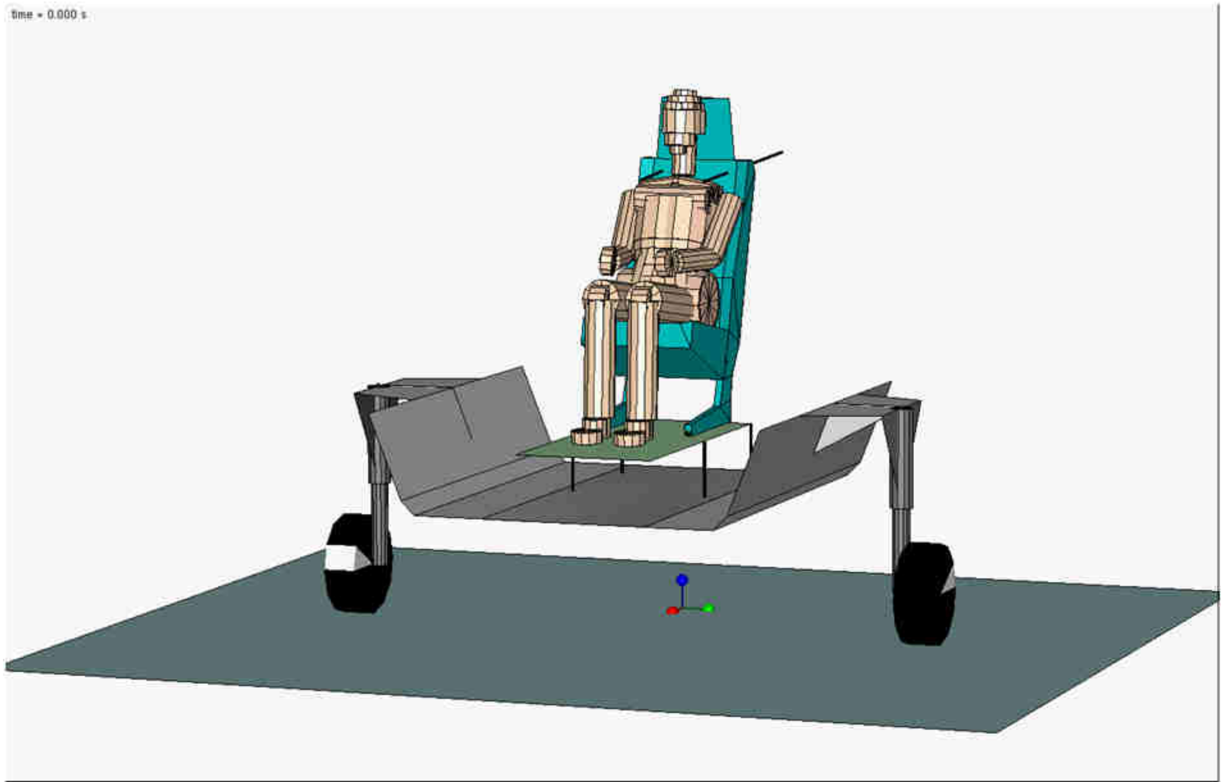


Numerical model

Simplified model based on lumped parameters approach

Anthrpomorphic Test Dummy, Seat system and Landing Gear validated against experimental data in certification dynamic conditions





Sensitivity analysis - response surface:

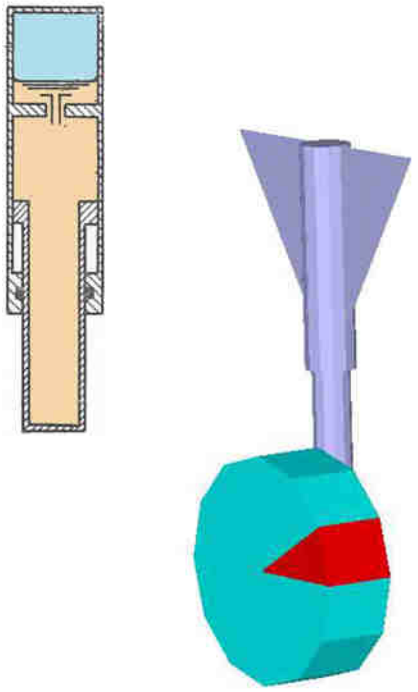
- max lumbar spine loads as functions of the mechanical characteristics of landing gear shock absorber and seat energy absorber

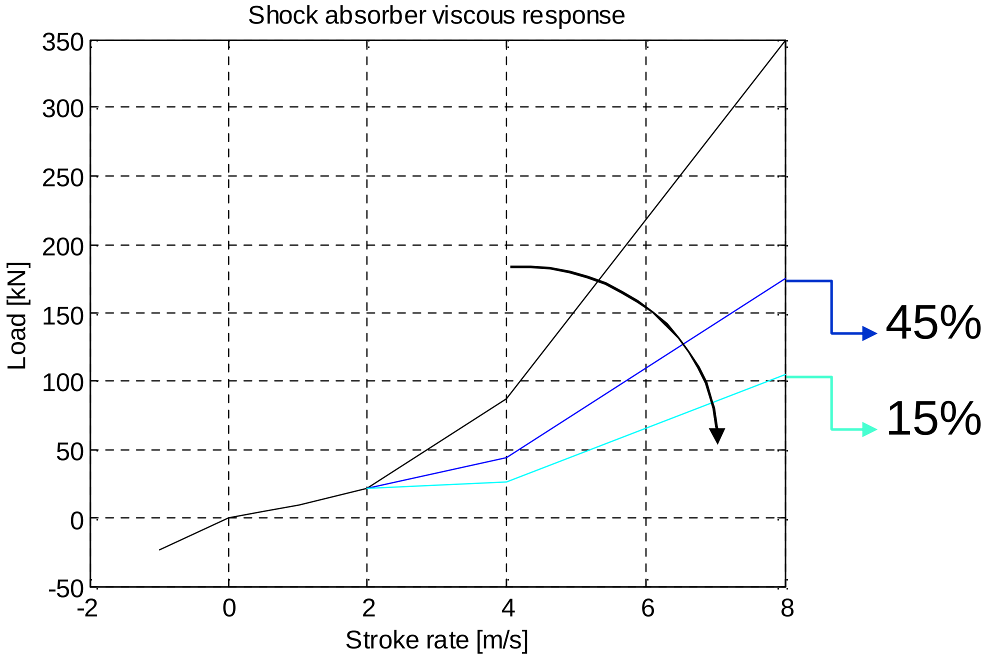
Landing gear

3 rigid bodies: wheel, piston block and cylinder block

Polytropic response: fixed

Viscous response: from 0 to 2 m/s from experimental data
from 2 to 4 m/s extrapolated but fixed
from 4 to 8 m/s variable



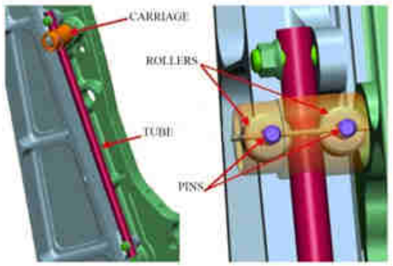


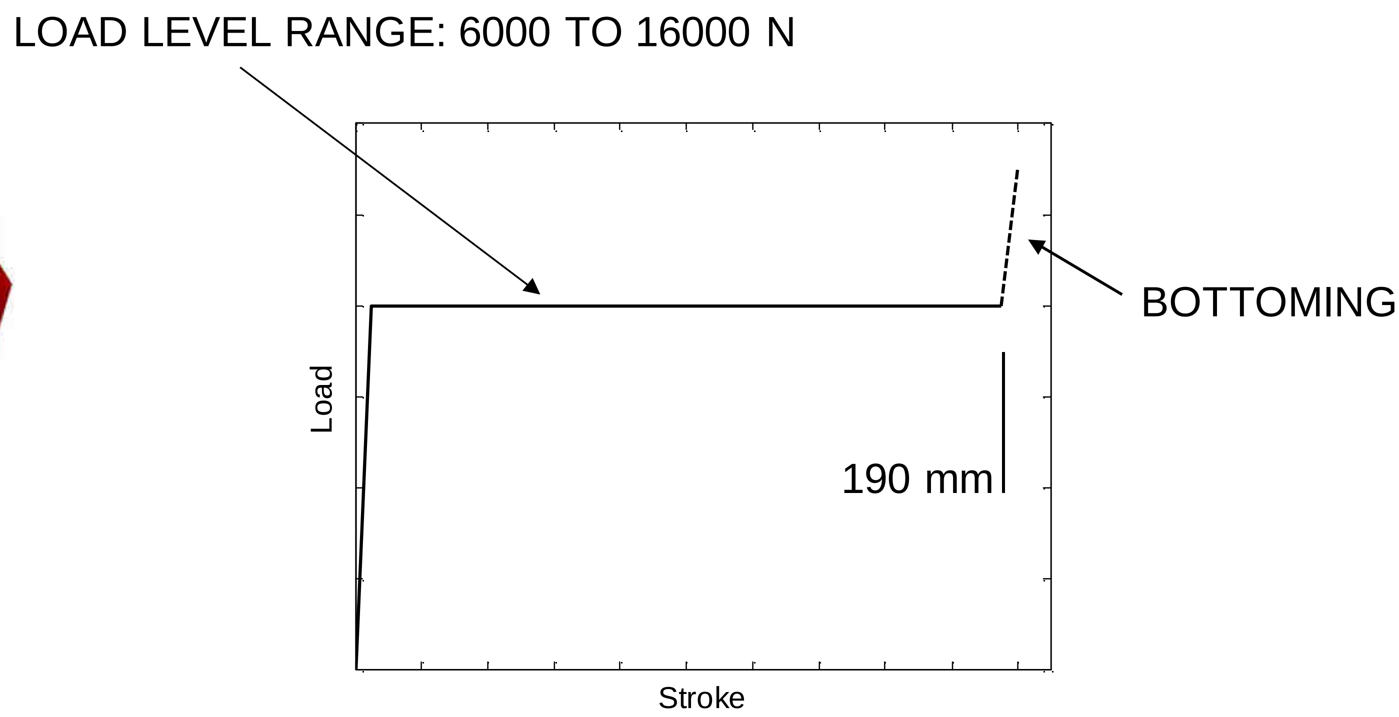
Numerical analysis: model and definition of parameters

<u>Seat energy absorber</u>

2 rigid bodies: lower fixed part and upper moveable part

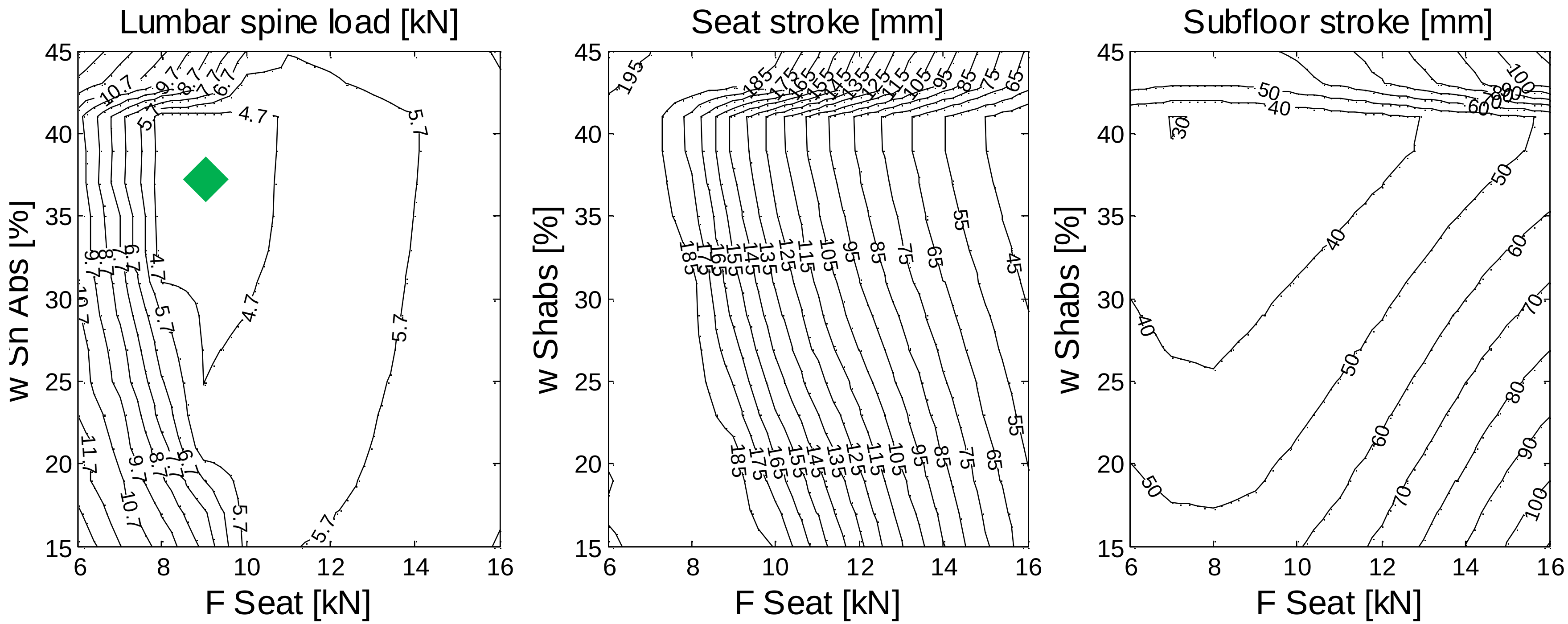
Elastic – perfectly plastic response





Numerical analysis: results

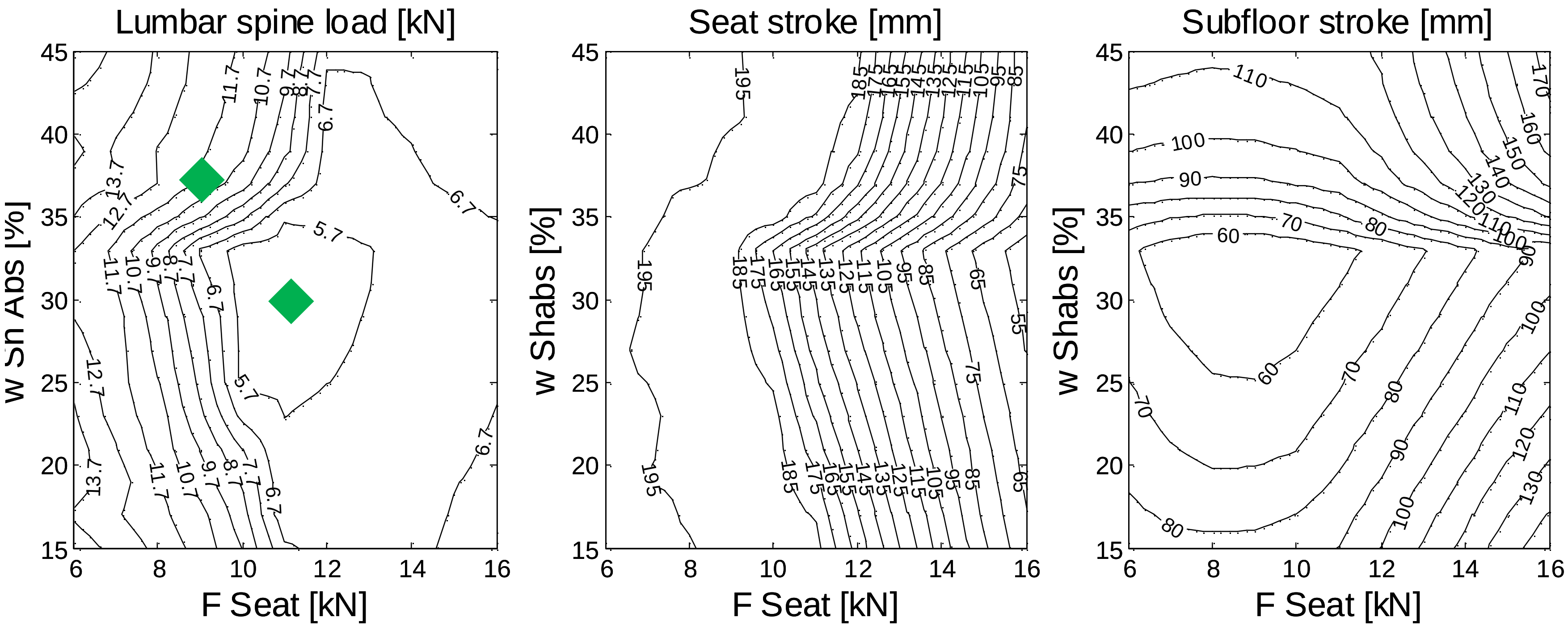
Response surfaces vs. impact speed from 11 to 15 m/s (std speed for seats v = 9.15 m/s)



11 m/s

Numerical analysis: results

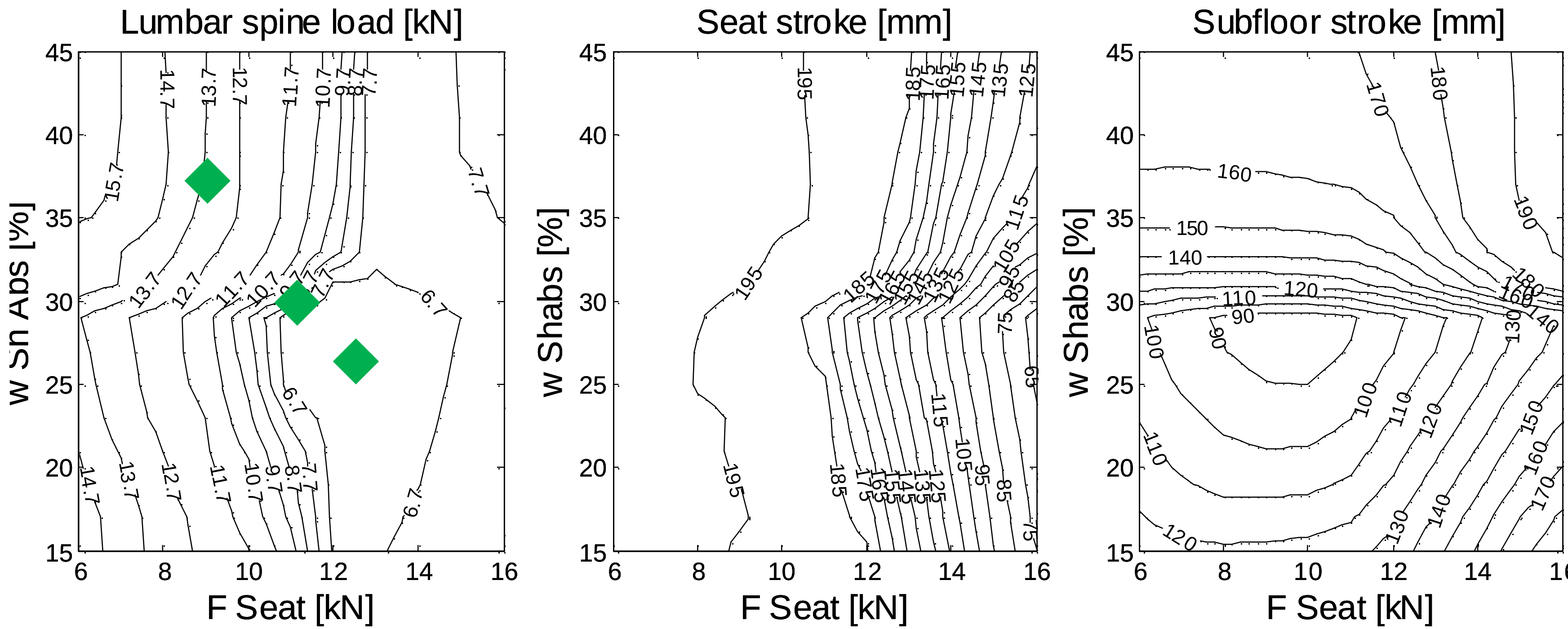
Response surfaces vs. impact speed from 11 to 15 m/s (std speed for seats v = 9.15 m/s)



12 m/s

Numerical analysis: results

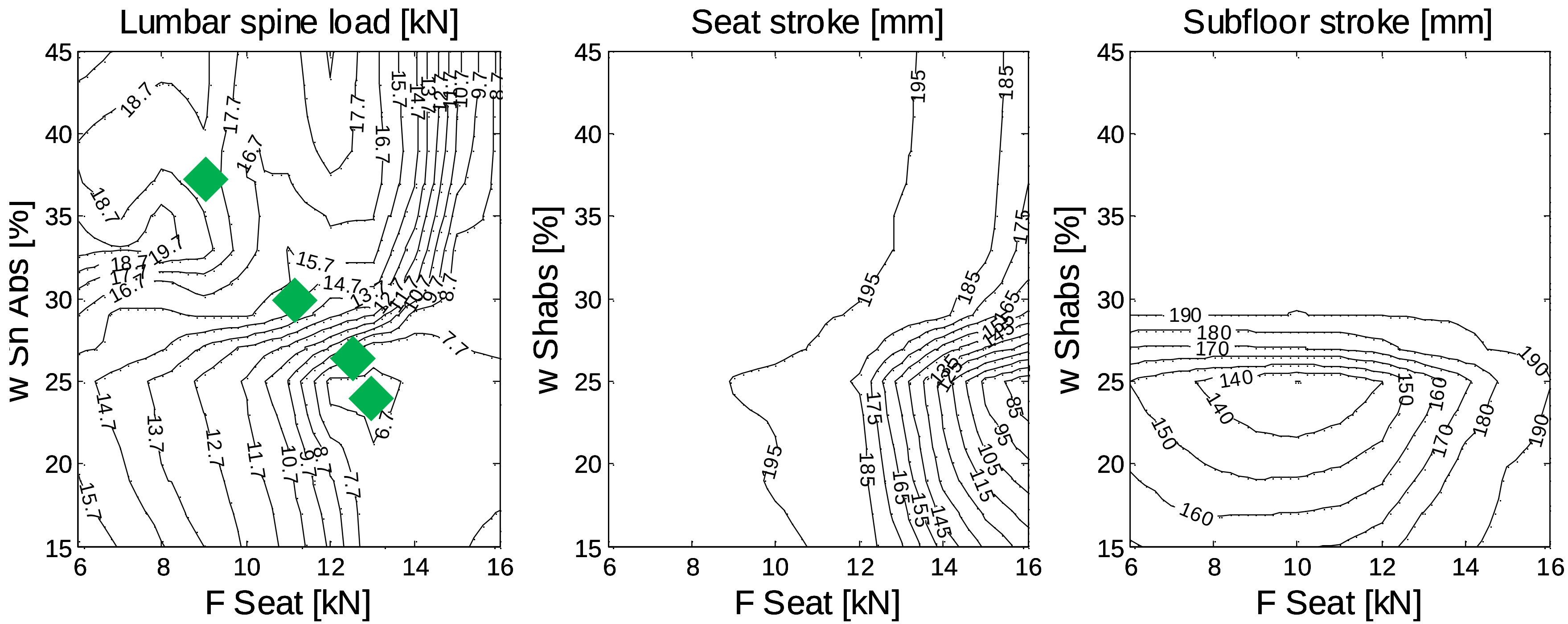
Response surfaces vs. impact speed from 11 to 15 m/s (std speed for seats v = 9.15 m/s)



13 m/s

Numerical analysis: results

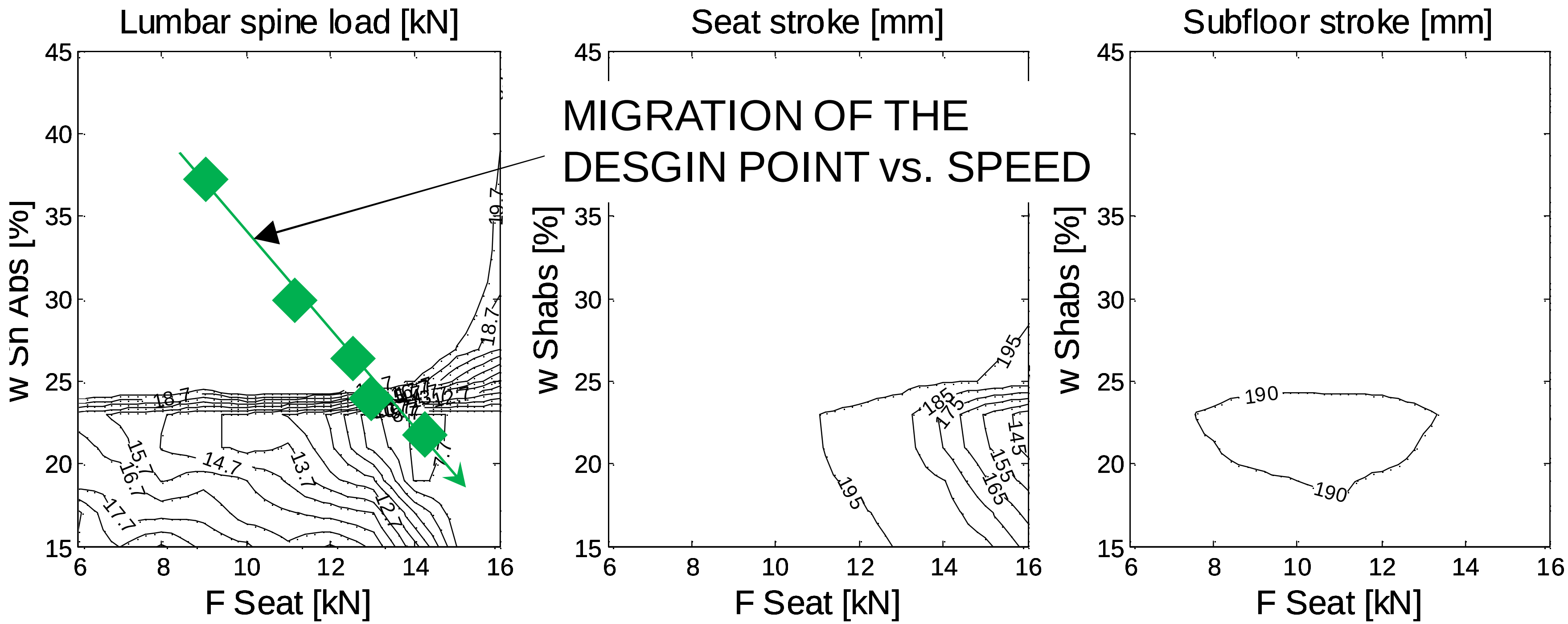
Response surfaces vs. impact speed from 11 to 15 m/s (std speed for seats v = 9.15 m/s)



14 m/s

Numerical analysis: results

Response surfaces vs. impact speed from 11 to 15 m/s (std speed for seats v = 9.15 m/s)



15 m/s

System arming

Crash landing condition triggered by ground proximity and vertical velocity detection

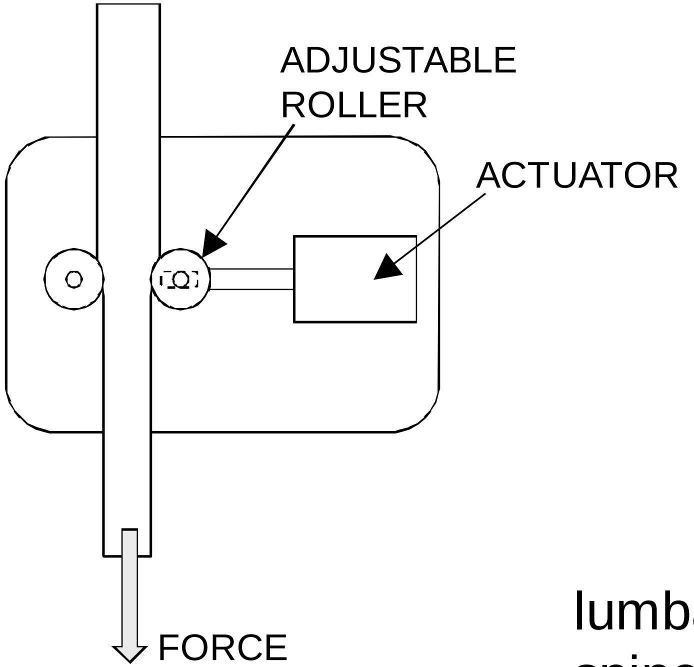
Pre-setting of landing gear shock absorber and seat energy absorber as a function of velocity (and occupant weight)

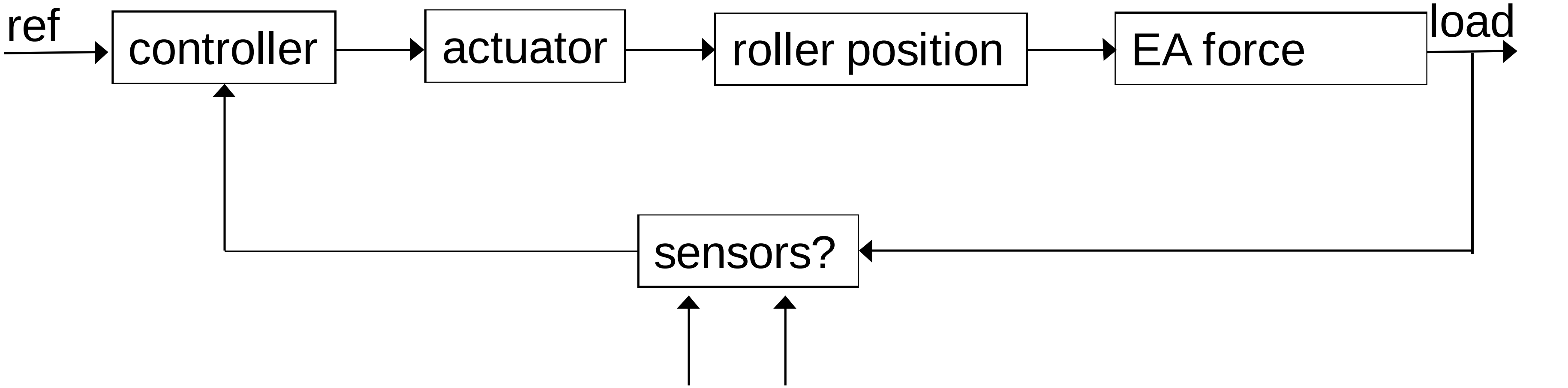
or

Closed-loop control?

Work in progress

Test rig for adaptive seat energy absorber



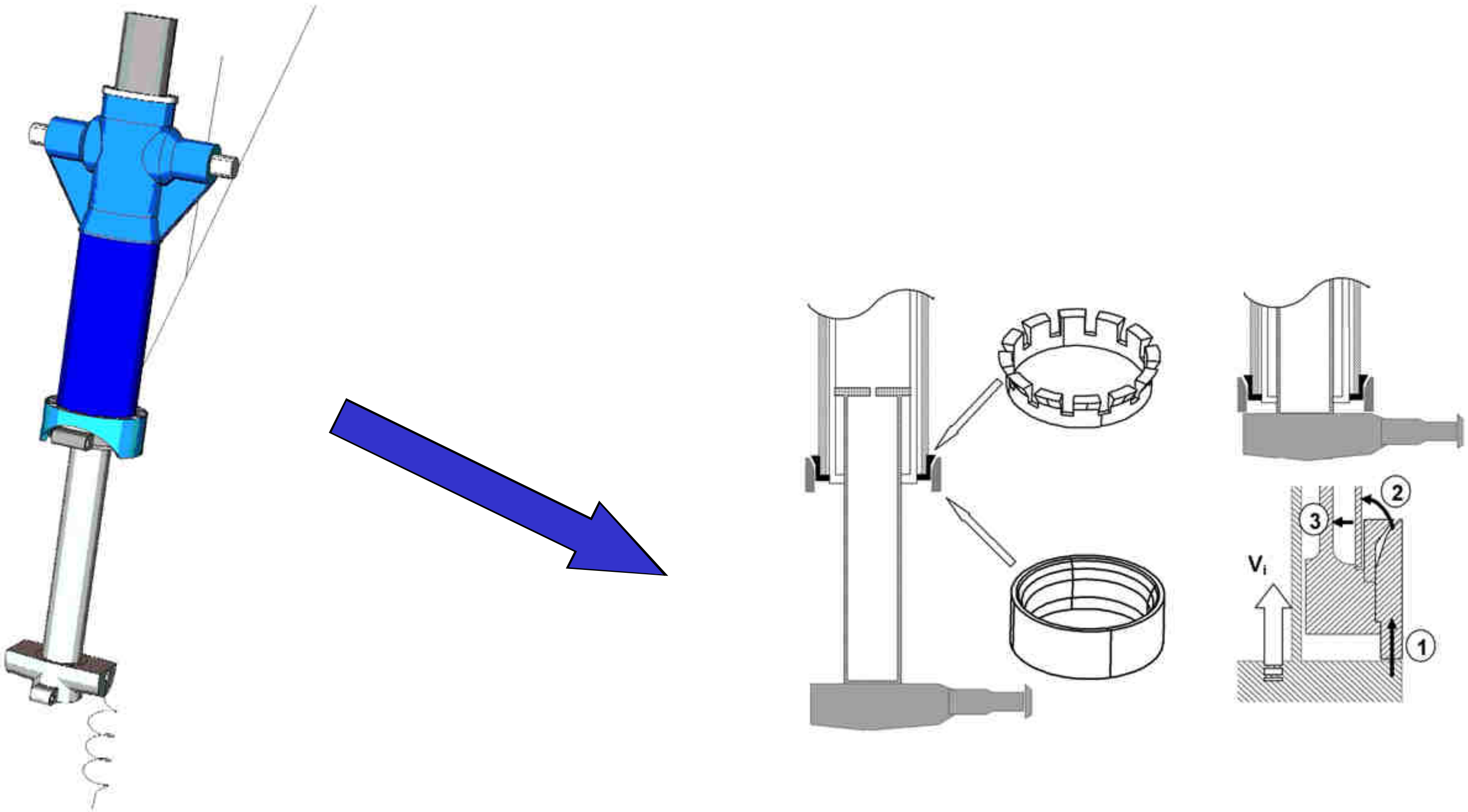


Extra slides

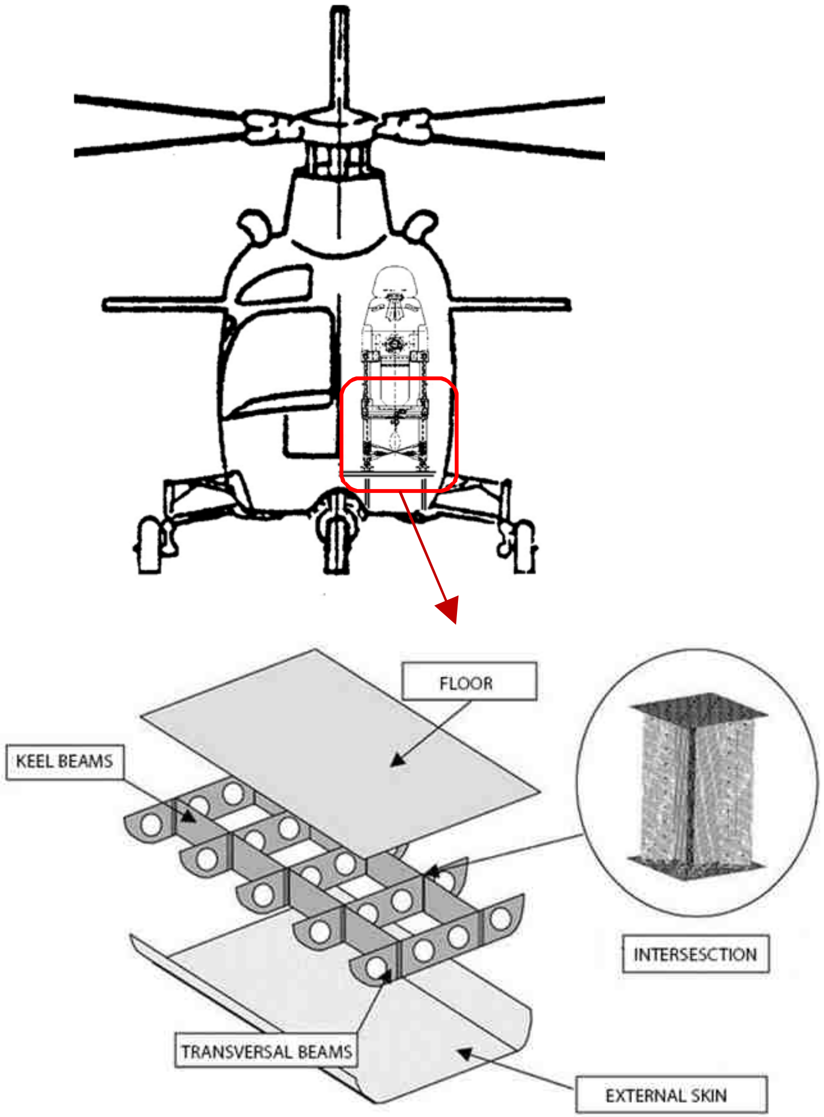
Full-scale test

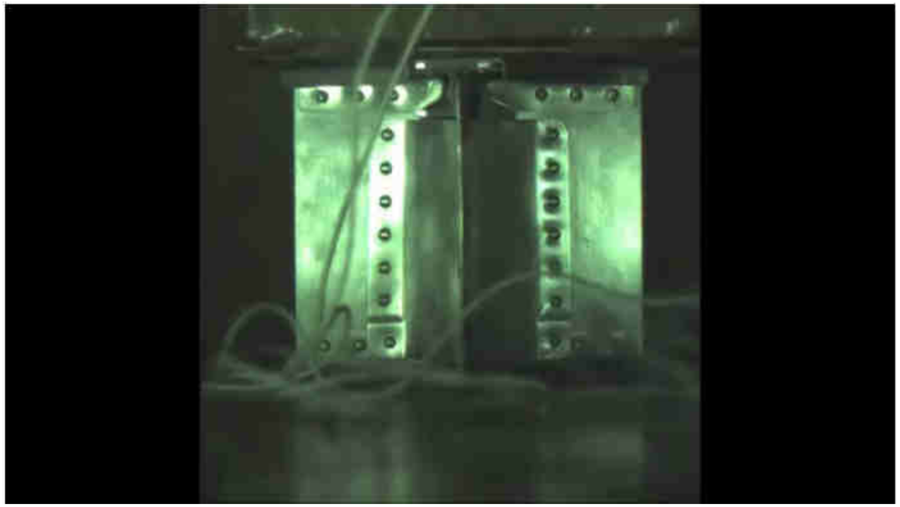
Helisafe TA EU project, full scale UH-1 crash test, 15 m/s, 32°

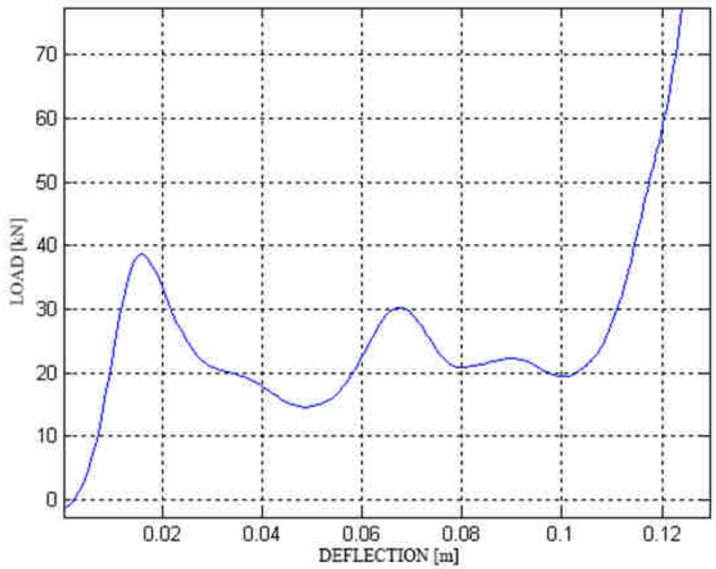
Introduction of a passive crash stage



Subfloor


FLOOR
KEEL BEAMS
INTERSESCTION
TRANSVERSAL BEAMS
EXTERNAL SKIN




LOAD [kN]
DEFLECTION [m]
0
10
20
30
40
50
60
70
0.02
0.04
0.06
0.08
0.1
0.12

Numerical analysis: model and definition of parameters

<u>Subfloor</u>

1 rigid body: floor

Elastic – perfectly plastic response

Mechanical structure made of joined components ⇒ adaptive system hardly feasible

CRUSHING LOAD FIXED TO 6000 N (OPTIMUM IN HIGH SPEED CONDITION)