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Numerical Validation of a Sailplane Fuselage Crash Test

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Agenda

1. **Motivation**
2. Design and model creation
3. Material models and characterization
4. Test and measurement equipment
5. Validation
6. Conclusions and outlook

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für Wirtschaft
und Klimaschutz

aufgrund eines Beschlusses
des Deutschen Bundestages

1 Motivation

- Sailplane and small engine plane accidents account for 5 to 10 fatalities throughout Germany every year

- Under which circumstances?

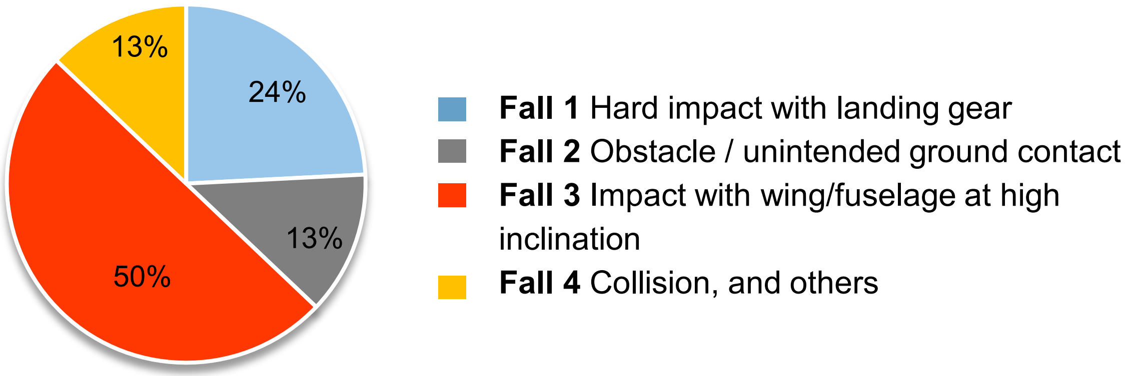

Fig. 1: Classification of crash scenarios [1]

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2 Design and model creation

Flight loads → Lay-up Optimization

Crash concept → Lay-up Optimization

Lay-up Optimization → Validation in fuselage simulation

Fig. 4: Antares safety concept [3]

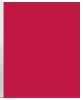

Fig. 6: Optimized nose cone in deformable barrier [5]

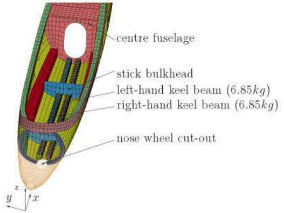

Fig. 5: Keel beam concept [4]

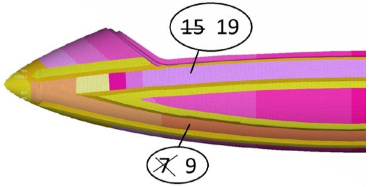

Fig. 7: Adaption after concept validation [6]

2 Design and model creation

- Fuselage shell
- Keel beams and canopy frame reinforcements
- Ribs and landing gear box
- Side panels
- Seat shell
- Substitute wing mass
- Dummy and belt

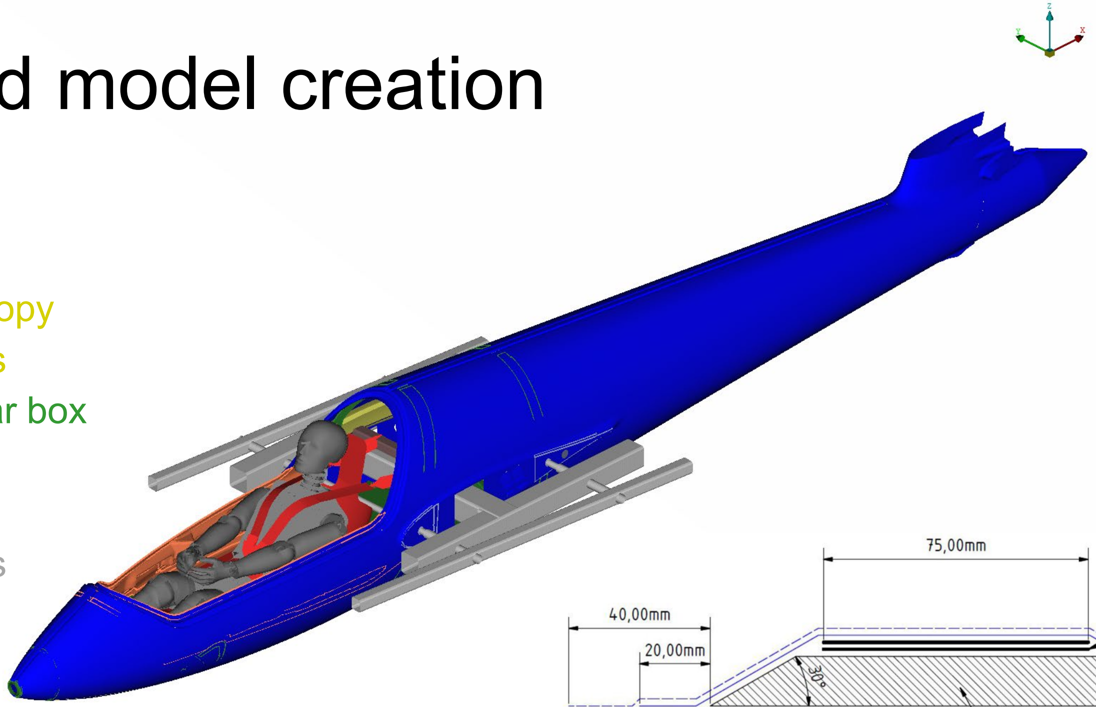

Fig. 2: Overview of the fuselage structure

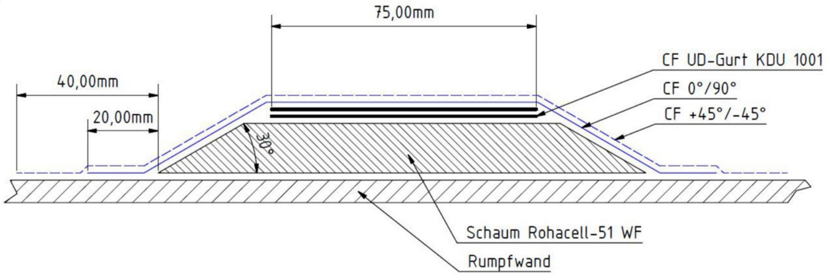

Fig. 3: Cross-section of the reinforcement structure [2]

2 Design and model creation

600,000 shell elements
(850,000 with dummy)

55,000 cohesive elements

140,000 solid elements
(370,000 with dummy)

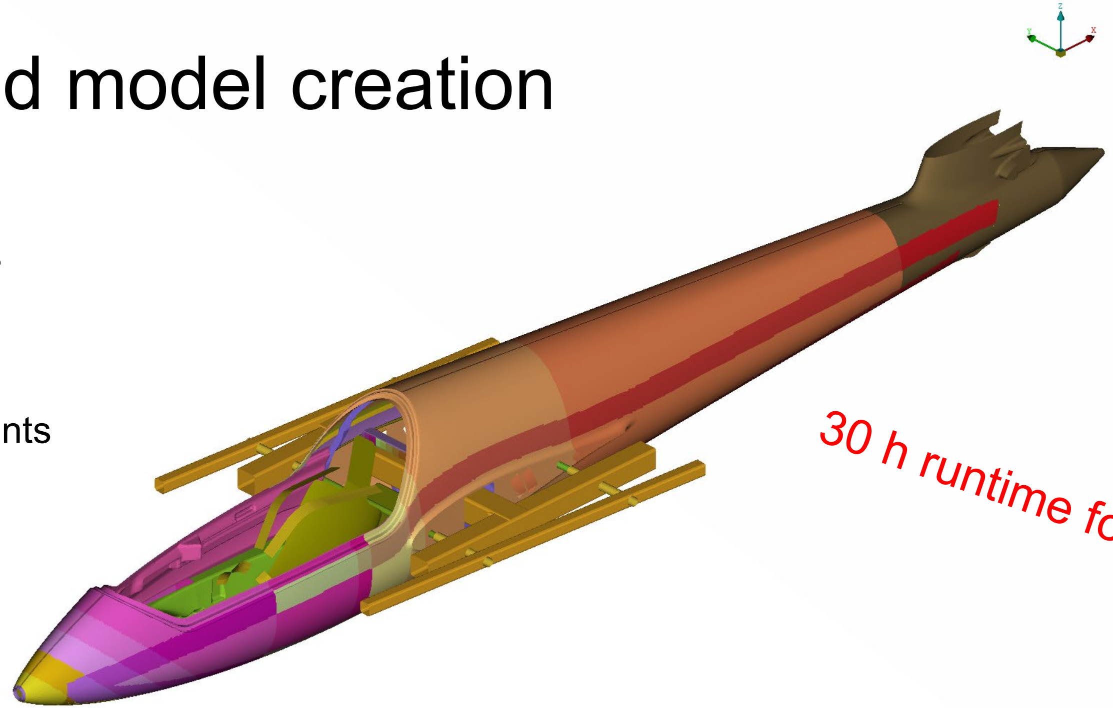

Fig. 8: Overview of the structural FE model

30 h runtime for 150 ms

28 Intel Xeon E5-2690 v3
cores (2.6 GHz)

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3 Material models and characterization

Primary crash structure

- Composite materials (*MAT_058=*MAT_LAMINATED_COMPOSITE_FABRIC)
- Adhesive bonds (*MAT_240=*MAT_COHESIVE_MIXED_MODE_ELASTOPLASTIC_RATE)
- Core material (*MAT_154=*MAT_DESHPANDE_FLECK_FOAM)

Secondary crash structure and occupant safety environment

- Belt material (*MAT_34=*MAT_FABRIC, *MAT_B01=*MAT_SEATBELT)
- Steel (*MAT_36=*MAT_3-PARAMETER_BARLAT)

3 Material models and characterization

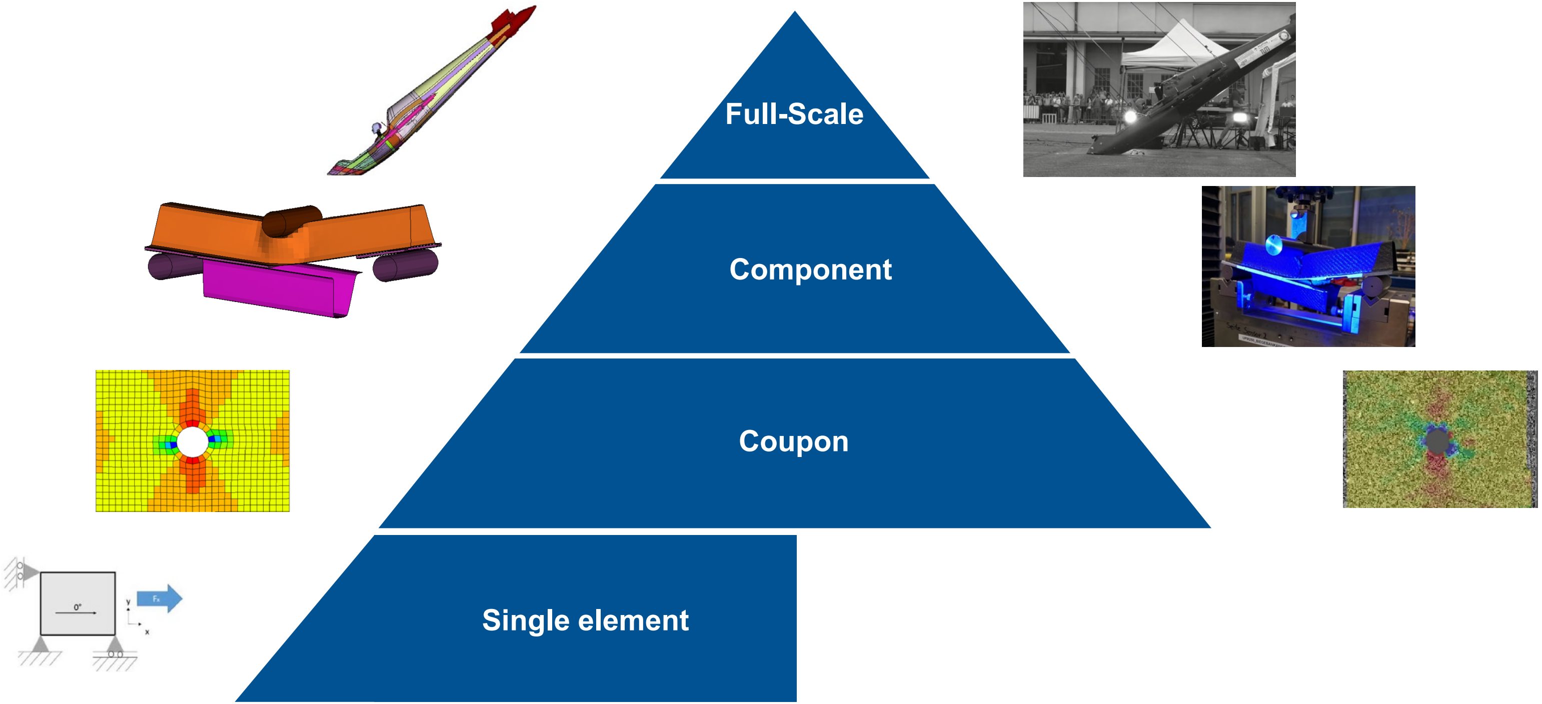

Fig. 9-15: Builiding block approach in experiment and simulation

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4 Test and measurement equipment

- Impact angle 45°
- 5° yaw angle against barrier
- Impact velocity 15 m/s

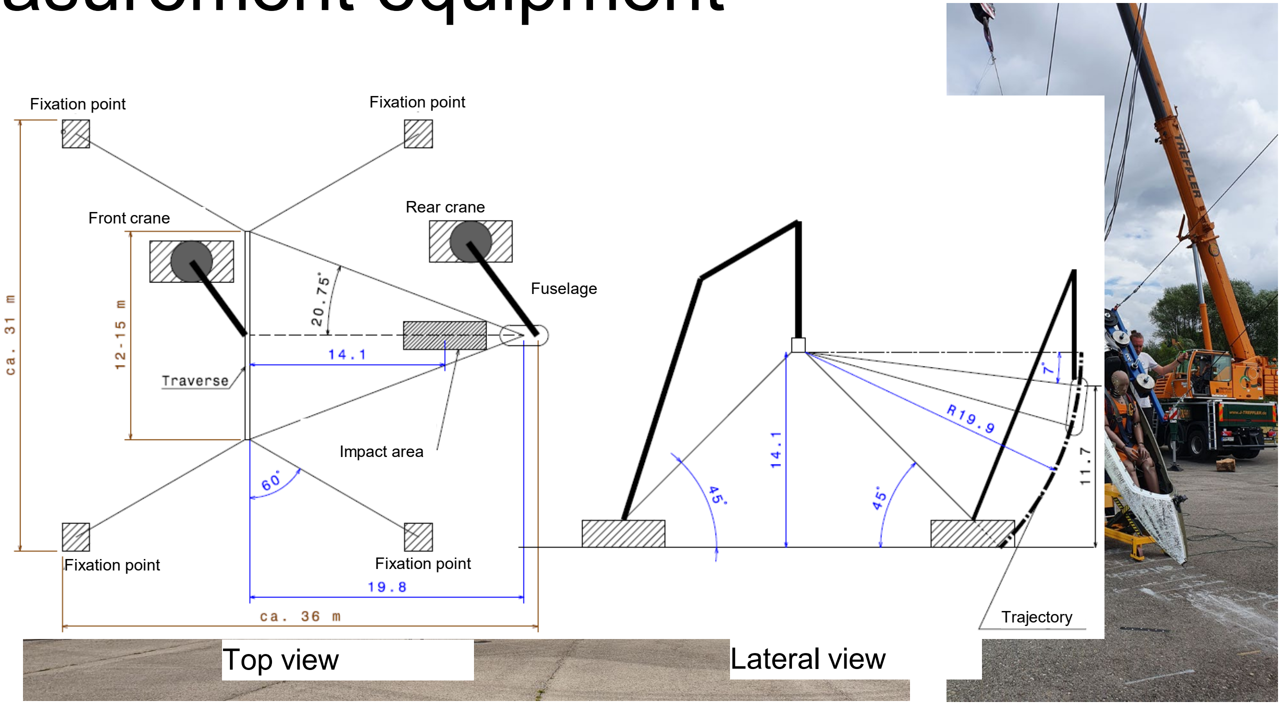


Fig. 16: Technical drawing of the test setup
Fig. 17: Sailplane positioning before the execution of the test

4 Test and measurement equipment

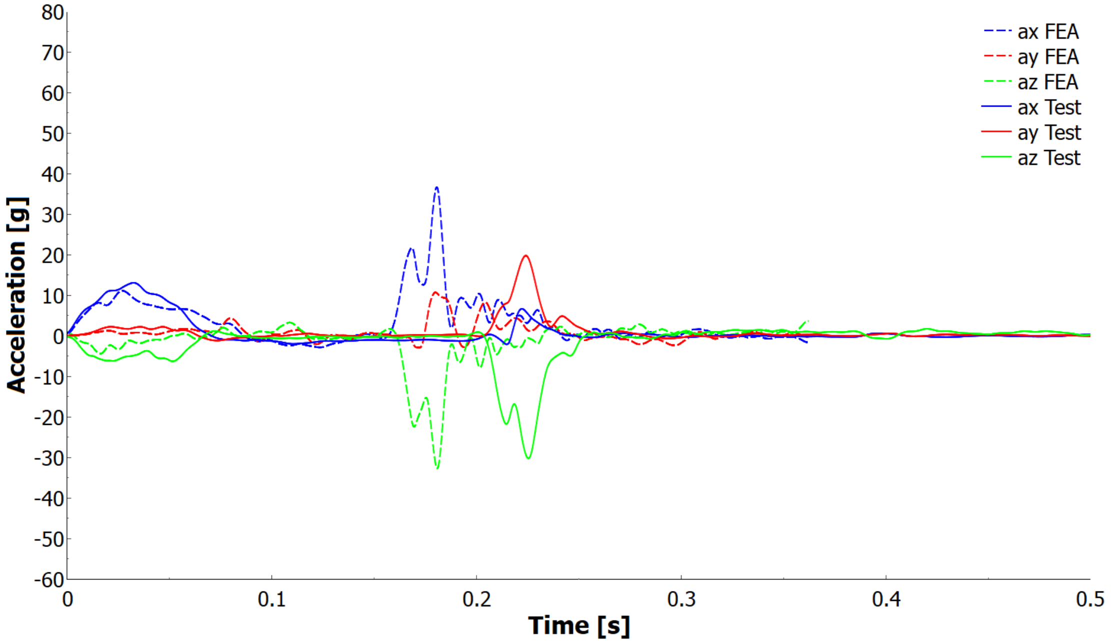
- H3 dummy
- Inertial measurement unit
- Digital-Image-Correlation system
- 6 high-speed cameras
- Strain gauges in the cockpit area

Fig. 18: H3 crash dummy before crash the test

5 Validation

Fig. 19: Side view of crash test vs simulation

5 Validation



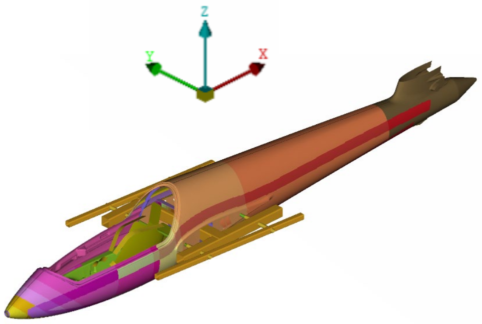


Fig. 21: IMU acceleration, BW50

5 Validation

Fig. 24: Crash at Shoreham Airshow [8]

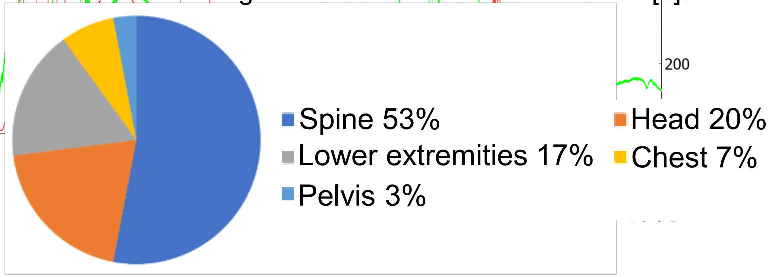


Fig. 25: Injury classification of sailplane accidents [9]

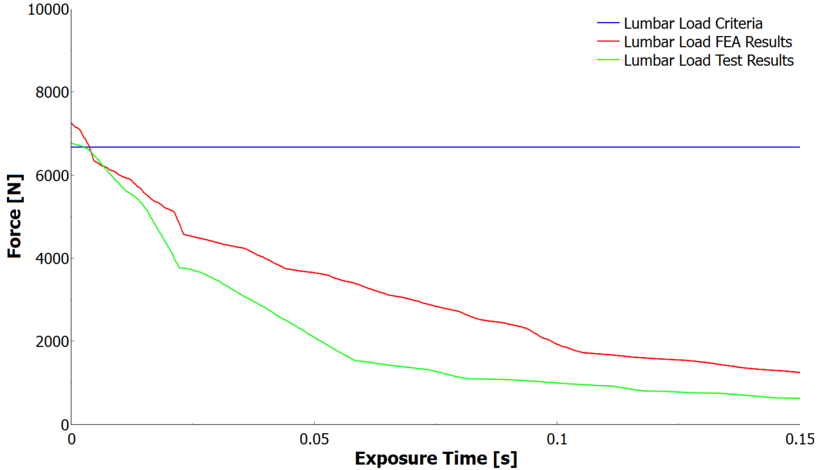


Fig. 23: Lumbar Load Criterion, CFC1000

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6 Conclusions and outlook

- First step towards virtual certification in aerospace sector
- Analysis of sudden deceleration at the second impact
- Numerical studies of the crash test and dummy
- Optimization of crashworthiness

6 Conclusions and Outlook – Simulation with 20 m/s

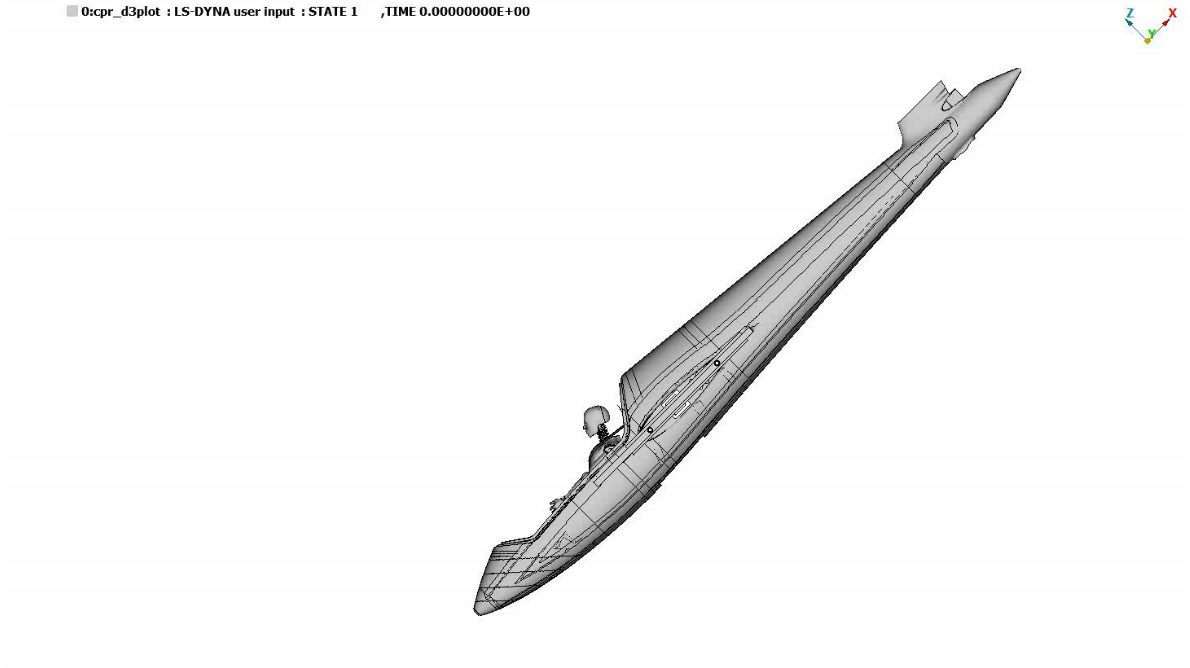

Fig. 27: Simulation with 20 m/s

Thank you for your attention!

Questions?

References

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