DRONE AND BIRD STRIKE ON A POLYCARBONATE HELICOPTER WINDSHIELD

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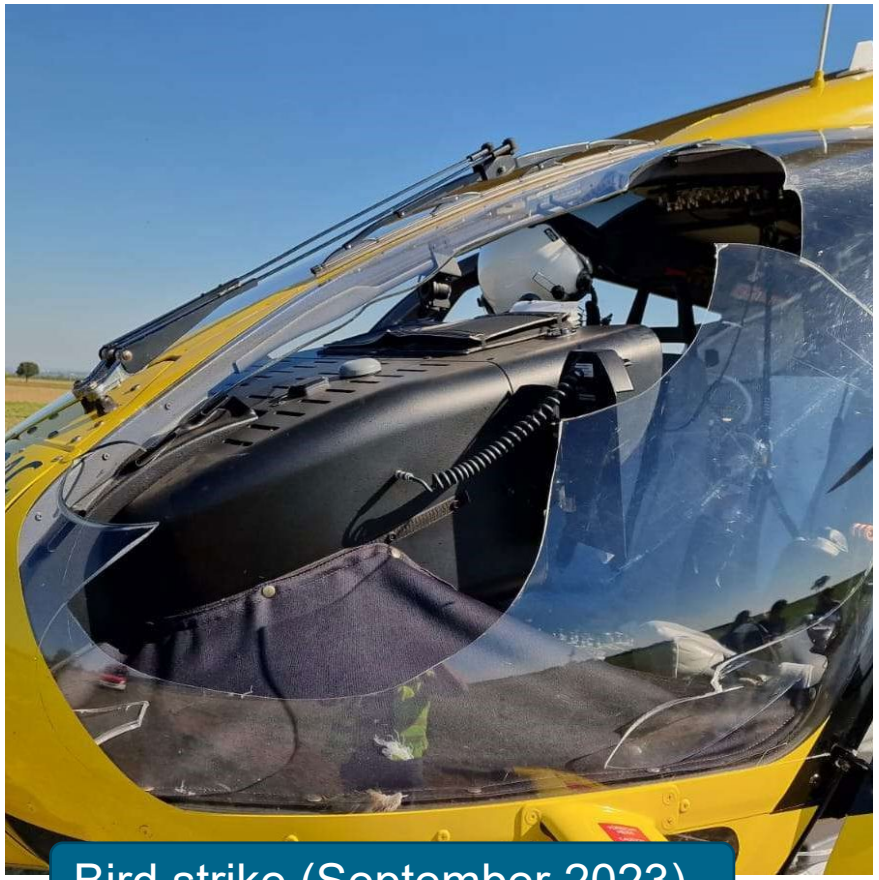
Oct. 16 2024

Introduction

Motivation - Recent incidents

Bird strike (April 2023)

Source:
https://www.rth.info/news/news.php?id=2388



Bird strike (September 2023)

Source:
https://byc-news.de/rheinhessen/ober-olm-vogel-kracht-in-windschutzscheibe-von-rettungshubschrauber/

Drone strike (January 2021)

Source: https://twitter.com/AviationSafety/status/1353336043710394369

Introduction

Structure

- Introduction
  - Motivation
  - Windshield material basics
- Modelling of polycarbonate material
  - Experimental results
  - Simulation results
- Impact on flat canopy demonstrator
- Full scale simulation
  - Canopy and impactor models
  - Results of bird and drone strike simulations

Introduction

Motivation - Requirements

CS 27.631 Bird strike

Rotorcraft with six or more passenger seats must be designed to ensure a safe landing after a strike upon the windshield by a 1.0-kg (2.2-lb) bird when the velocity of the rotorcraft relative to the bird along the flight path of the rotorcraft is equal to VNE or VH 'True Airspeed' (TAS), whichever is less, at altitudes up to 2 438 m (8 000 ft). The applicant must demonstrate compliance through tests, or analysis based on tests that are carried out on sufficiently representative structures of similar design. [1]

CS 29.631 Bird strike

The rotorcraft must be designed to ensure a continued safe flight and landing (for Category A) or a safe landing (for Category B) after a strike with a 1.0-kg (2.2-lb) bird when the velocity of the rotorcraft relative to the bird along the flight path of the rotorcraft is equal to VNE or VH 'True Airspeed' (TAS), whichever is less, at altitudes up to 2 438 m (8 000 ft). The applicant must demonstrate compliance through tests, or analysis based on tests that are carried out on sufficiently representative structures of similar design. [2]

Only 10 % of EU civilian helicopters certified with bird strike requirement. [3]

Introduction

Windshield material basics

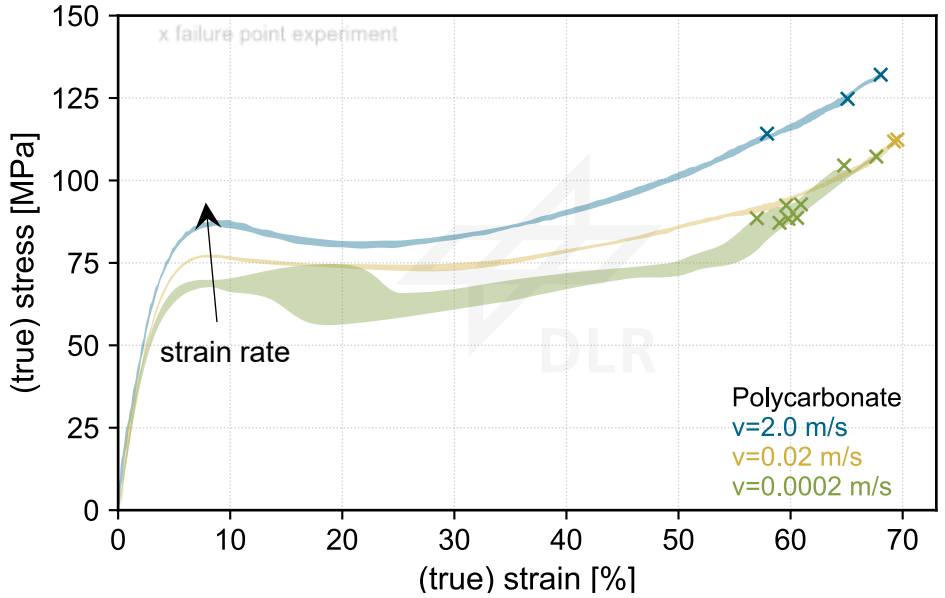
- Monolithic glazing with thermoplastics
  - Acrylic glass (PMMA) [4]
    - Density 1.19 g/cm³
    - Young's modulus 3.30 GPa
    - Elongation at break 5.5 %
    - UV stabile and possible to polish
  - Polycarbonate (PC) [5]
    - Density 1.20 g/cm³
    - Young's modulus 2.35 GPa
    - **Elongation at break > 50 %**
    - Coating for UV stability and erosion resistance
- Laminated glazing with glass and thermoplastics

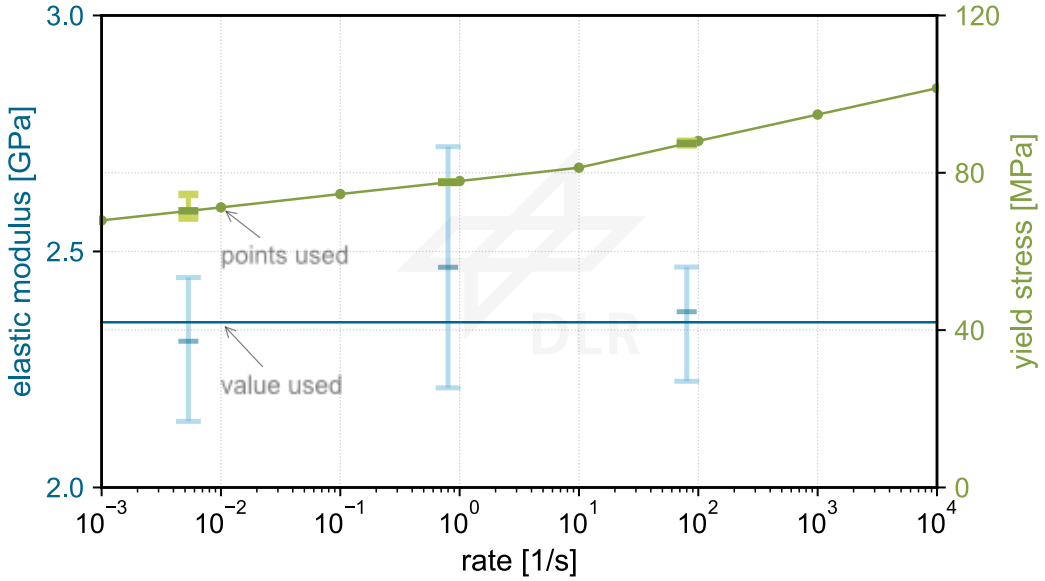
Robinson Polycarbonate windshield

Source: https://shop.robinsonheli.com/news/robinsons-impact-resistant-windshields/#

Polycarbonate material model

Tension test results





Deformation model:

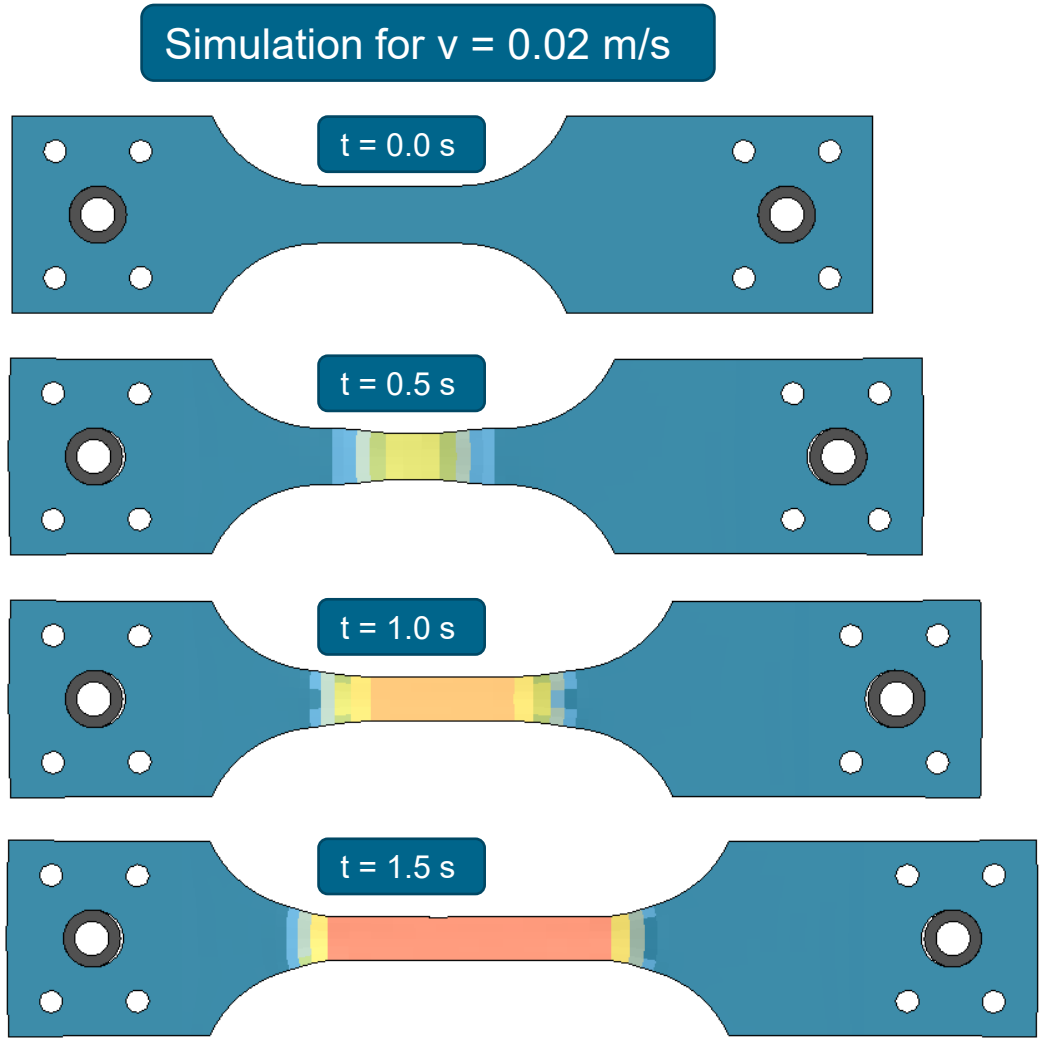
- *MAT_224 (used in [6])
- *MAT_187 and *MAT_187L → material models for plastics with non-isochoric behaviour

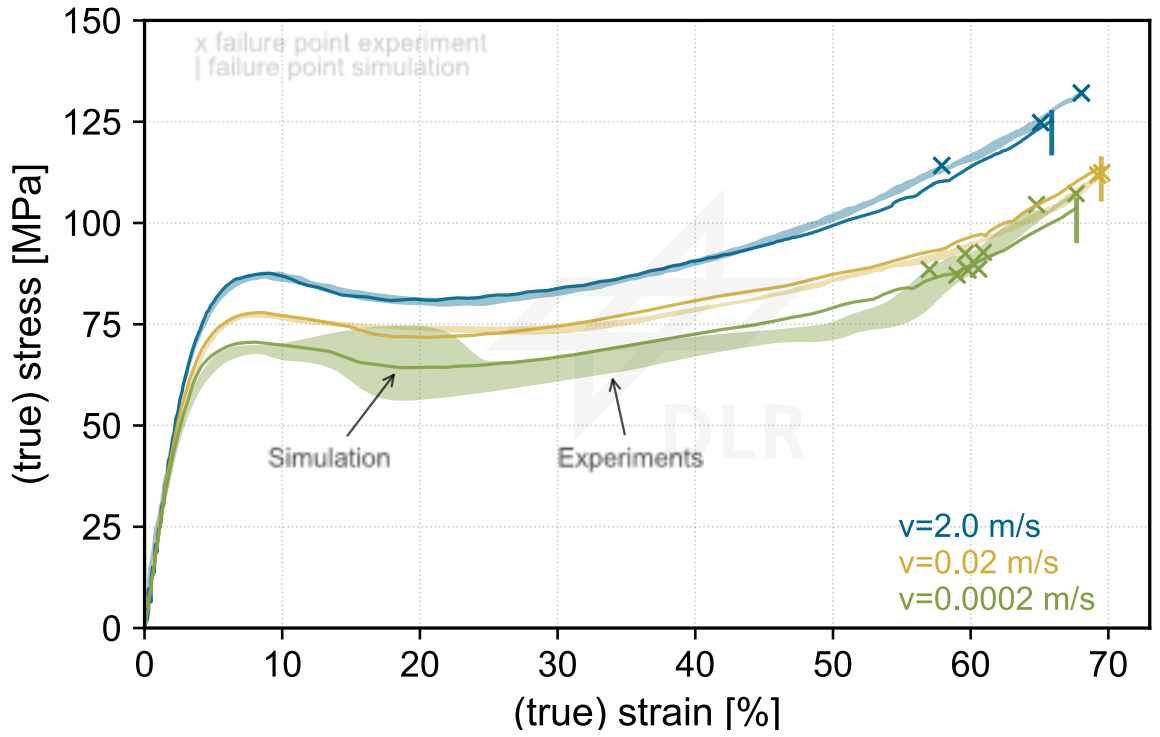
Failure model:

- *MAT_ADD_DAMAGE_GISSMO → rate and triaxiality dependent failure

Polycarbonate material model

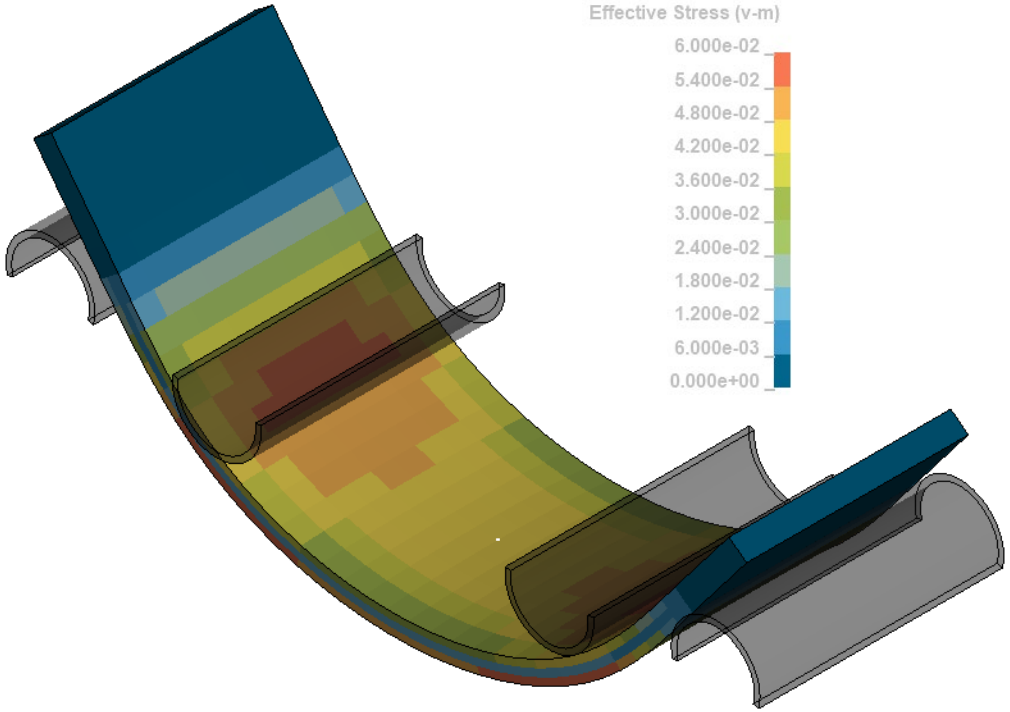
Simulation of tension tests with *MAT_187L

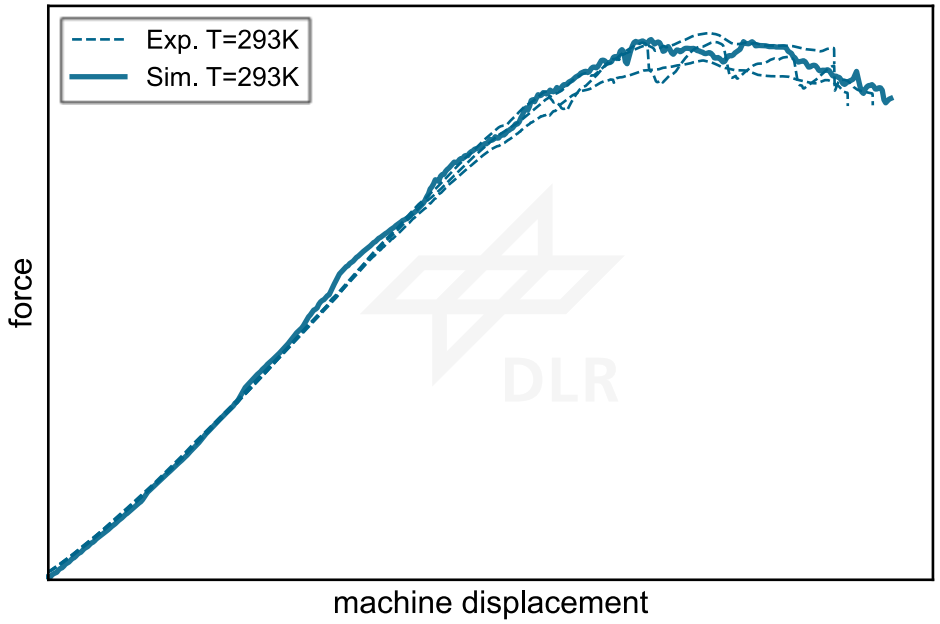




Polycarbonate material model

Simulation of bending test

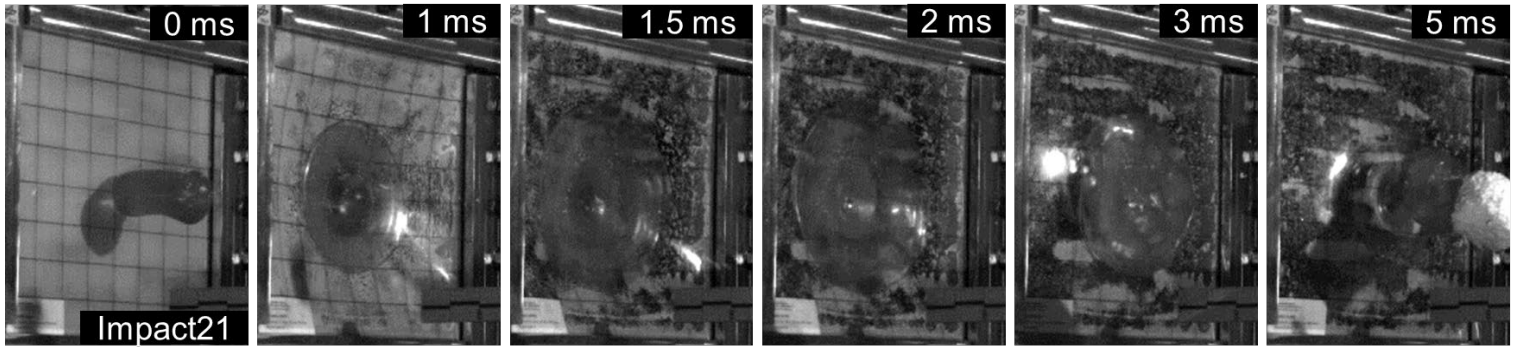


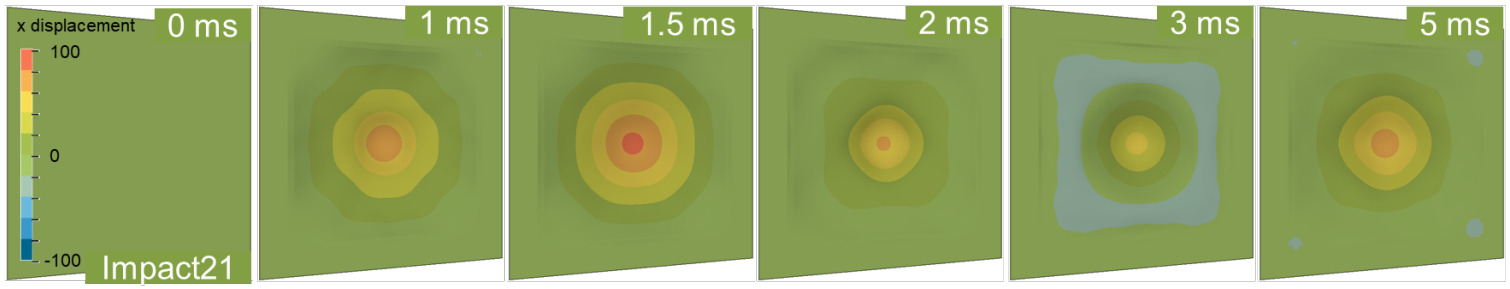


Polycarbonate material model

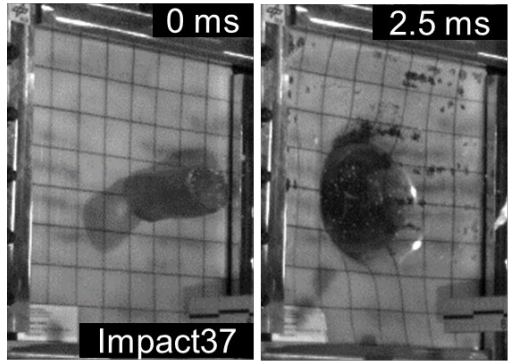
Simulation of plate impact tests

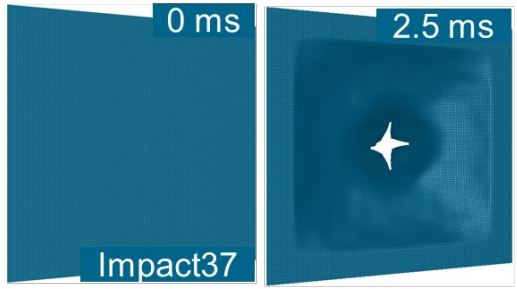
Impact21: strong deformation, no failure





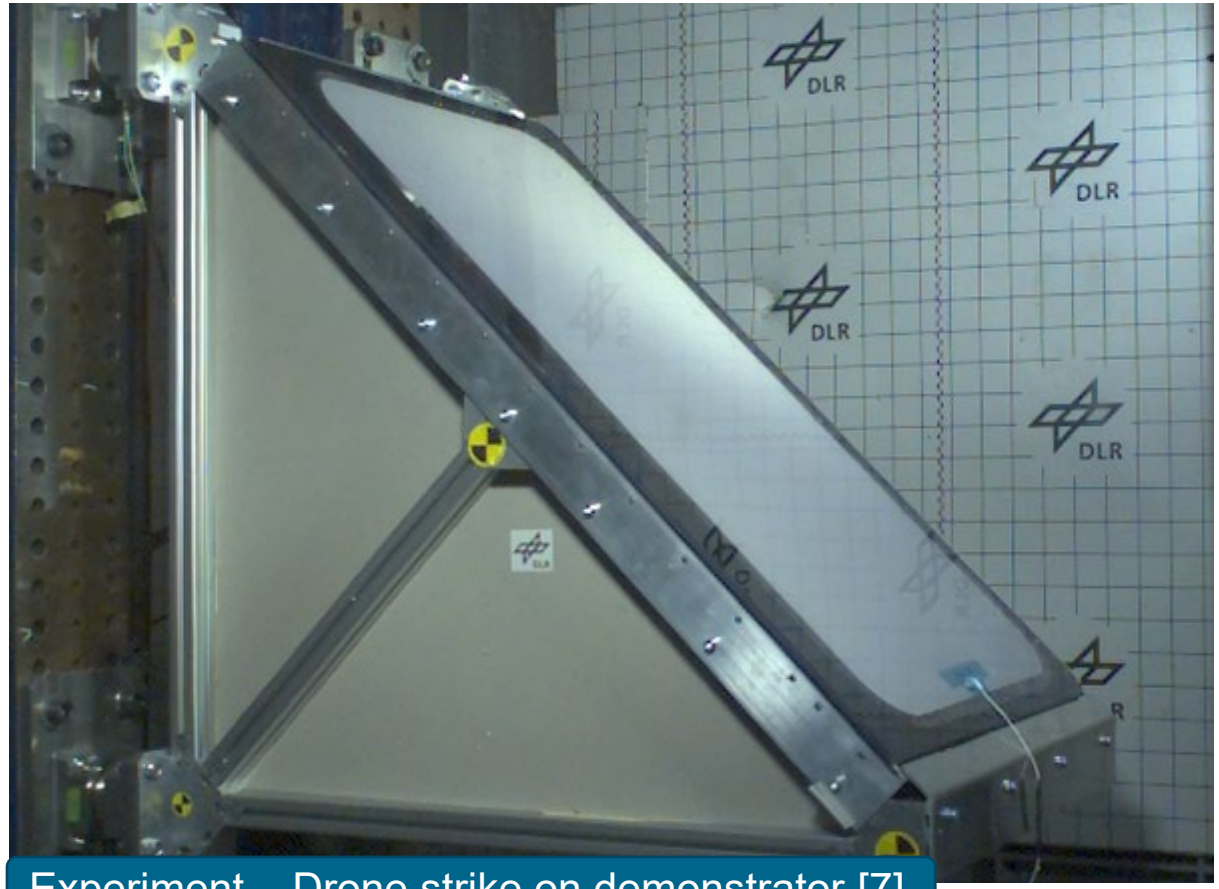
Impact37: failure



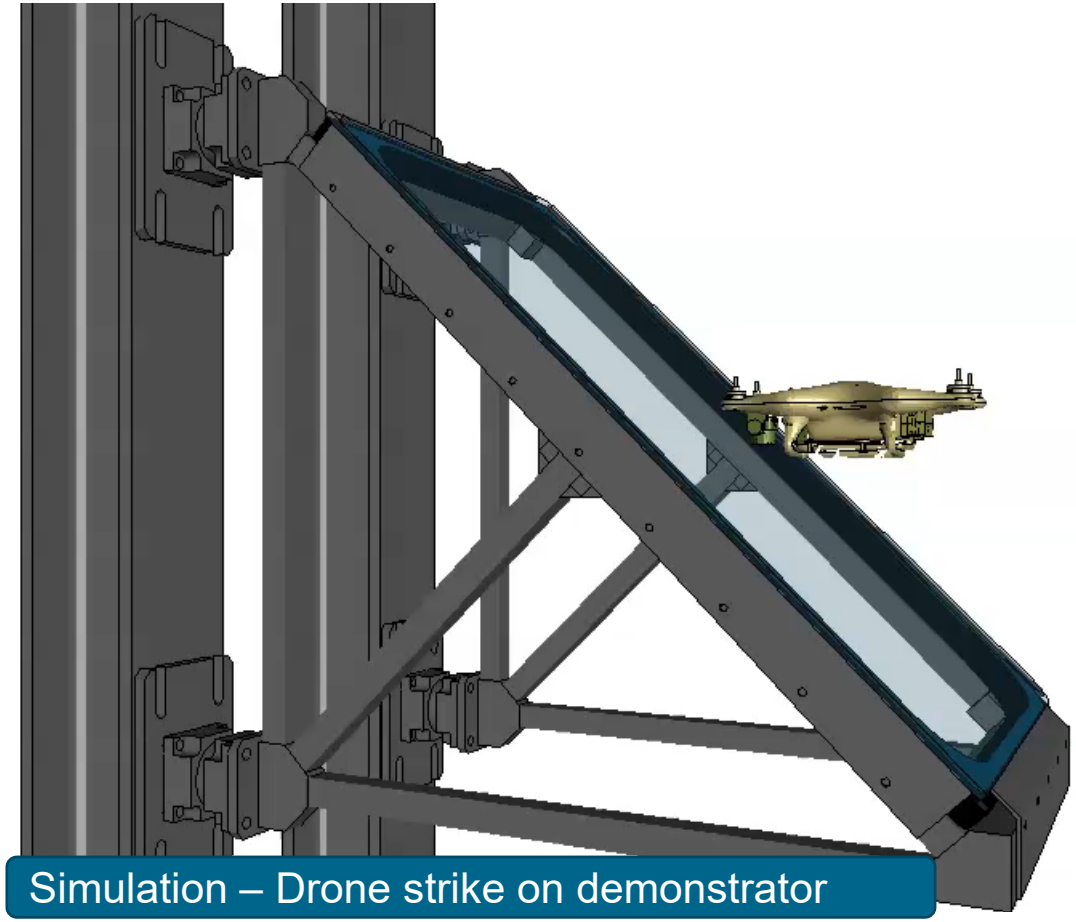


Flat canopy demonstrator

Drone strike – experiment and simulation



Experiment – Drone strike on demonstrator [7]

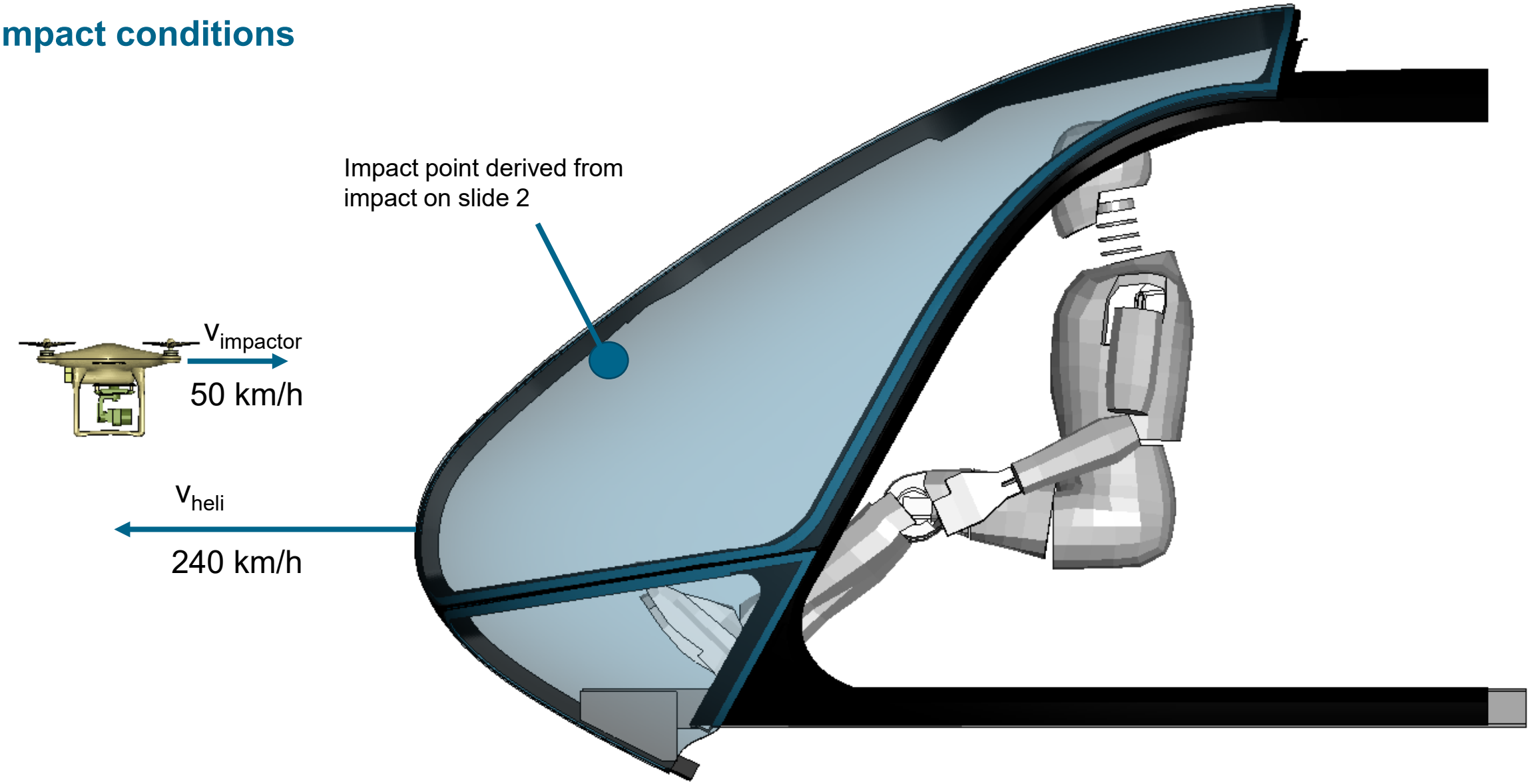


Simulation – Drone strike on demonstrator

Bird strike [8] also tested + simulated

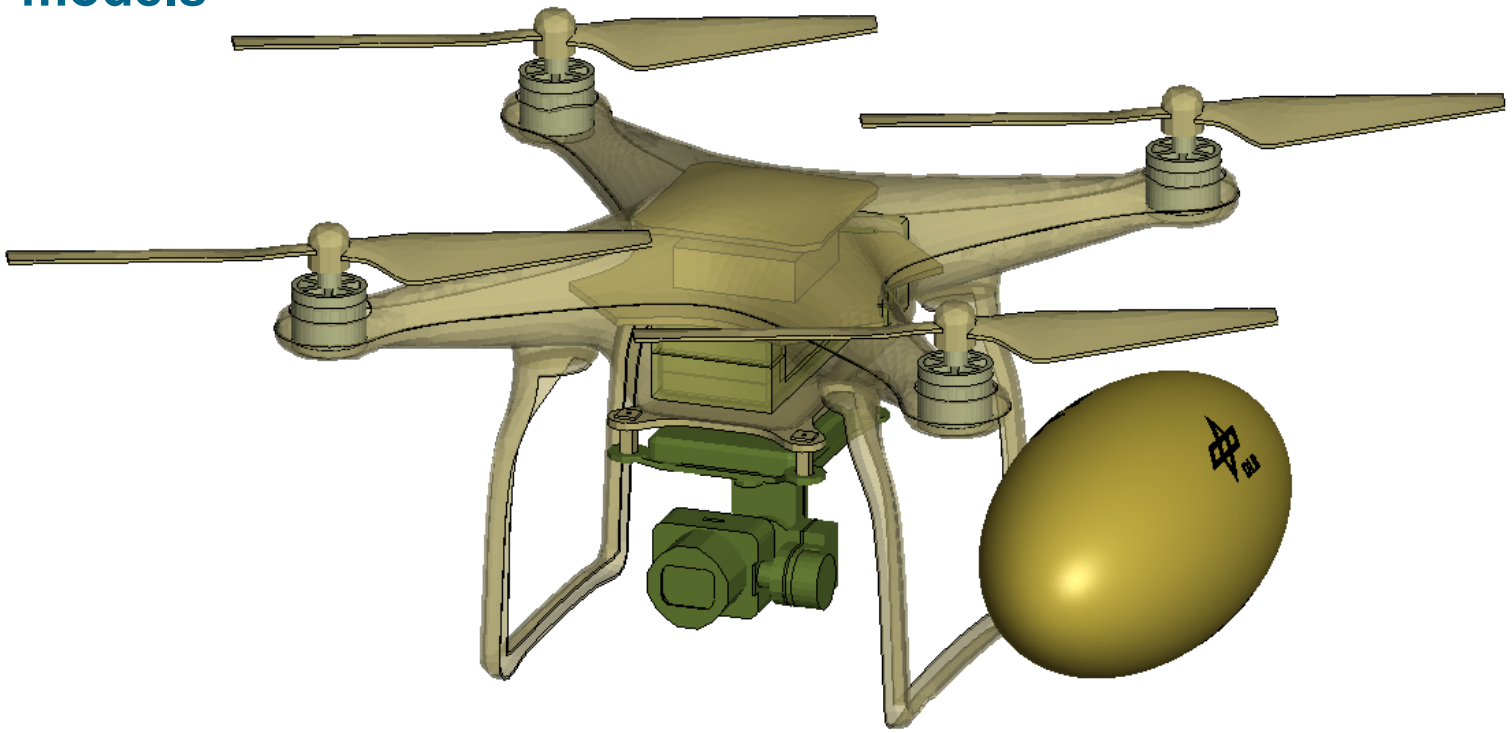
Full scale simulation

Impact conditions



Full scale simulation

Impactor models



Drone model:

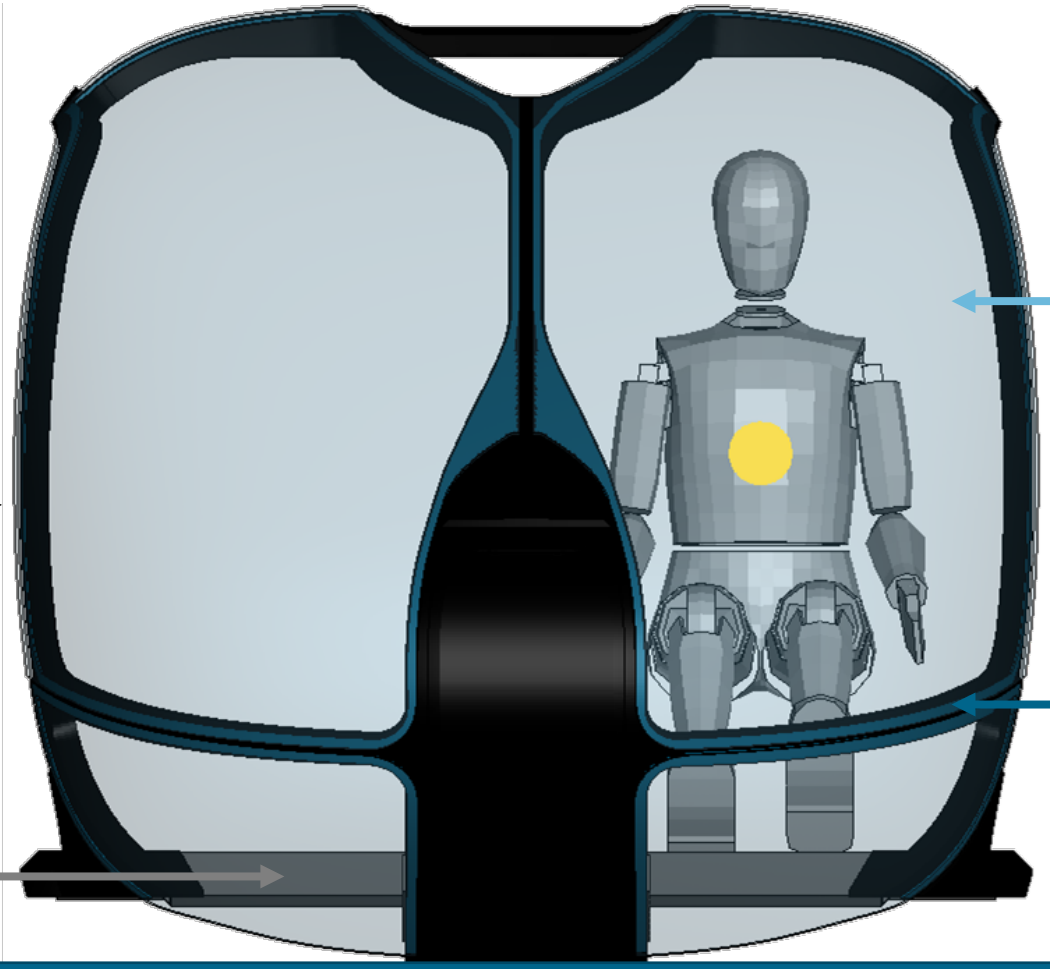
- Based on DJI Phantom 3
- Mass ca. 1.2 kg
- 40000 solid elements
- Improved version of [7-9]

Bird model:

- Ellipsoidal artifical bird model [10]
- Mass ca. 1.2 kg
- 12500 SPH particles, based on [11]
- Similar version used in [7-10]

Full scale simulation

Canopy model



CFRC frame

Steel frame

Windshield

- Material: PC or PMMA
- Thickness 6 mm

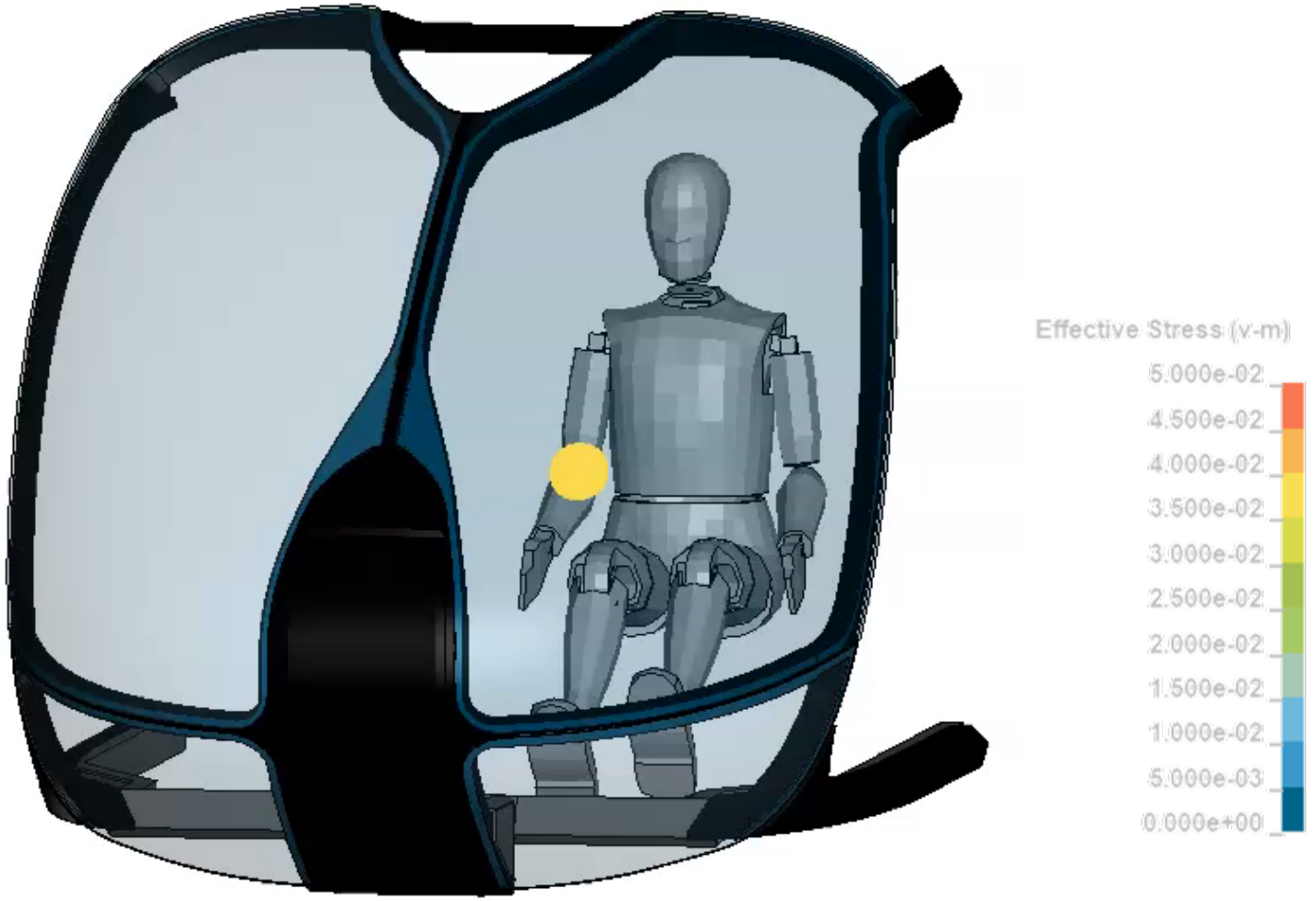
Adhesive

- Validated in [12]

Front view of the analysed canopy with bird model

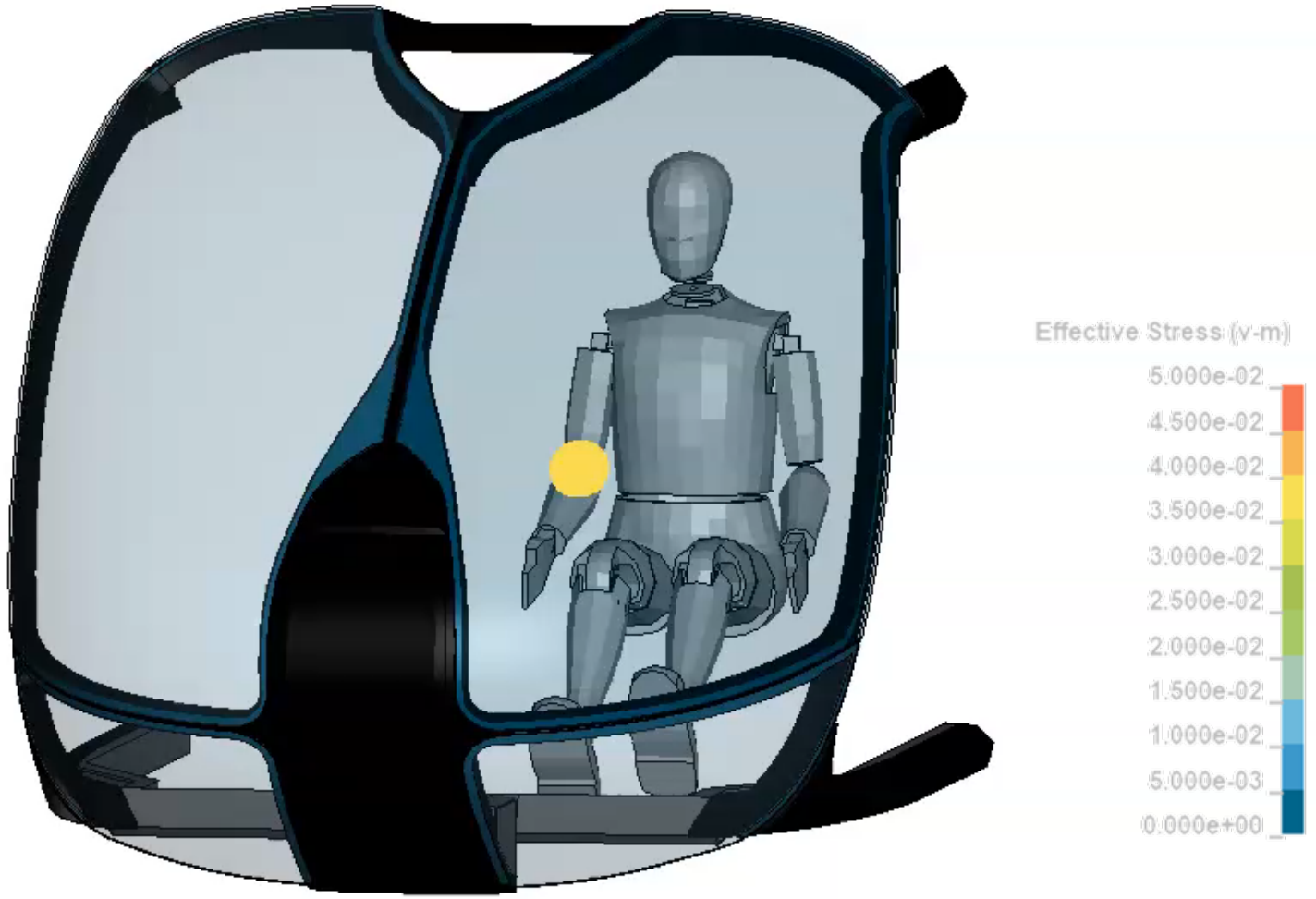
Full scale simulation

Bird strike on reference material



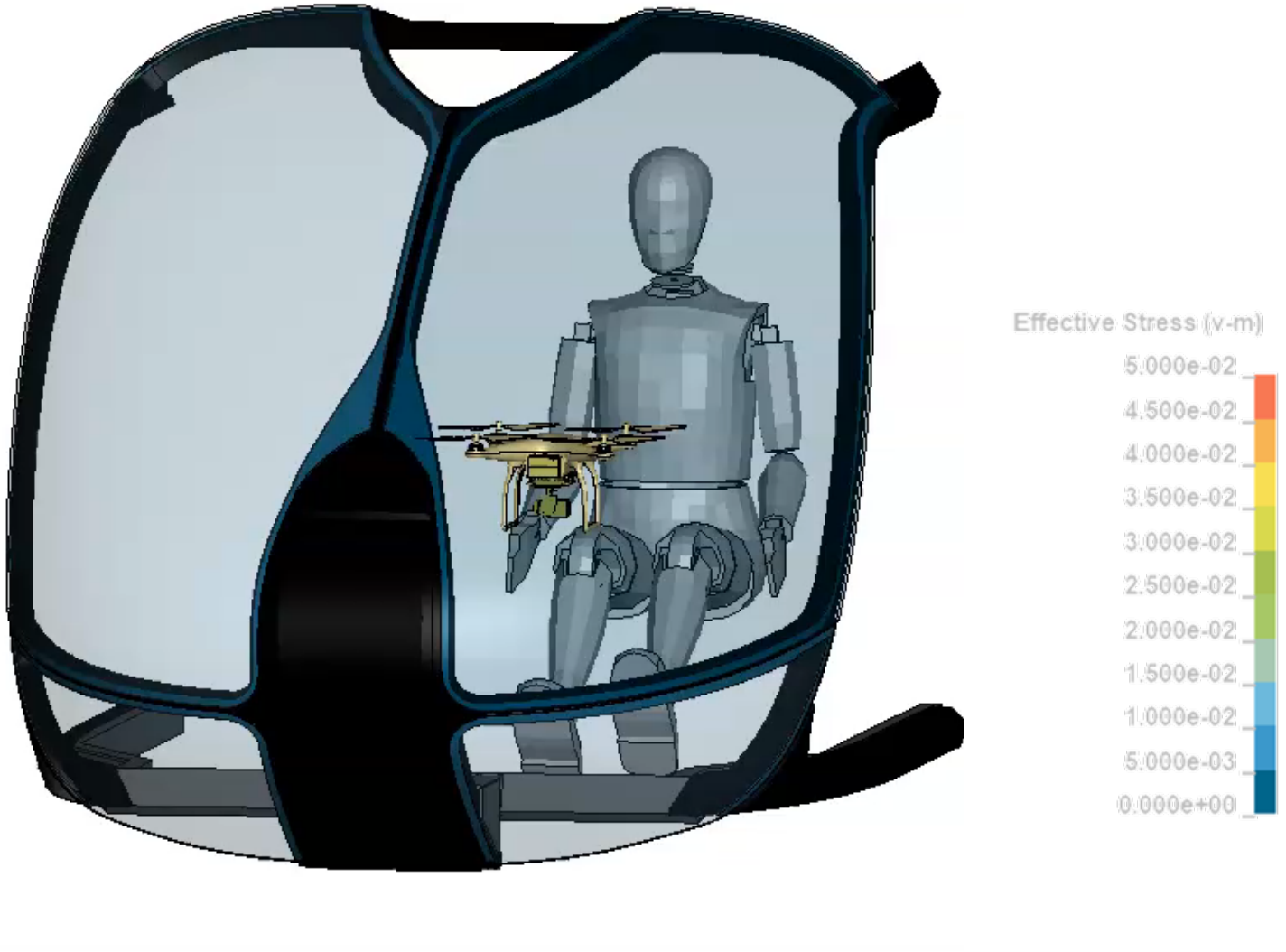
Full scale simulation

Bird strike on PC



Full scale simulation

Drone strike on PC



Conclusion

- Stress-state and rate dependent material model for polycarbonate with *MAT_187L and *MAT_ADD_DAMAGE_GISSMO.
- Similar deformation and failure behaviour of polycarbonate in different load cases over various rates in experiments and simulations.
- Full scale simulation of bird and drone strikes demonstrated the potential of polycarbonate windshields for impact scenarios.

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[12] Ritt S A (2020) Clean Sky 2 WIMPER - Demonstrator Strength Substantiation of the RACER Windshield. DLR-Internal Report.

Thank you for your attention!

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