IMPACT STUDIES ON RIGID AND COMPLIANT TARGETS INCLUDING THE FIRST SIMULATION MODEL OF THE BIOFIDELIC BIRD

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21.06.2023. CTS 3.Dummy.Konferenz. Muenster, Germany

Motivation

Real bird strike happens in aircraft operation but artificial birds…

- allow <u>representative and repetitive</u> impact testing
- can serve as a replacement of real bird testing
- can avoid animal tests

Artificial bird = a dummy bird, only used once

Source: SilkAir Airbus A320-200, 9V-SLJ, 13.12.2010 on approach to Brunei Airport, http://avherald.com/h?article=490d1e37&opt=0

Source: Damage after fan blade release. 02.04.2017. https://aerossurance.com/safety-management/ntsb-jt15d-birdstrike-failures/

Motivation and Requirements

- Real bird is not required by EASA CS-25/27/29.631 and CS-E.800 but if artificial bird applied evidence on representativeness is needed.

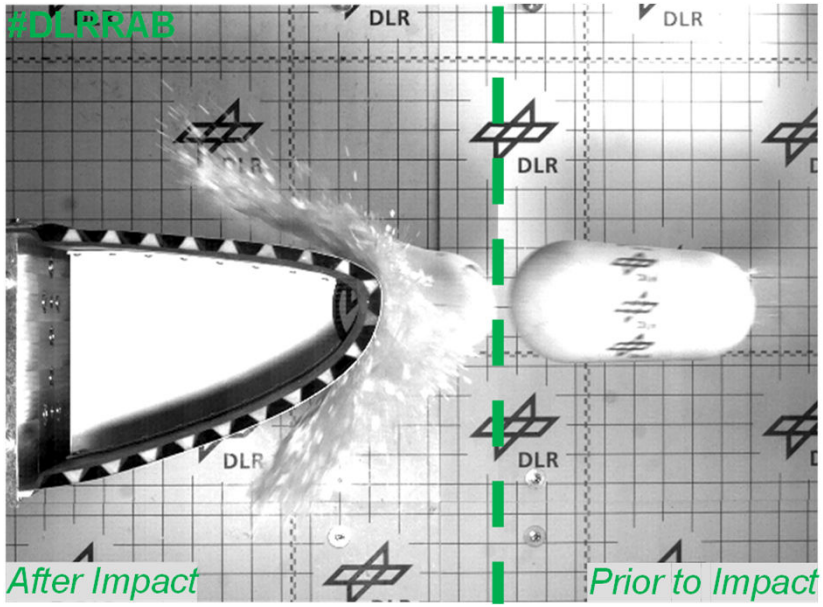
- Repeatability is the key for the artificial bird application.

- R&R together are the key for acceptance of any artificial bird, e. g. the DLR reinforced artificial bird (DLRRAB) [2,3] or the artificial biofidelic bird CTS Alpha [4].

- Ethics – an acceptable artificial bird can reduce animal experiments

State of the Art – Where are we?

- Various artificial bird recipes available but
  - not consistently tested over various load cases
  - variability not stated against real birds
  - not accepted as replacement for real birds in certification testing

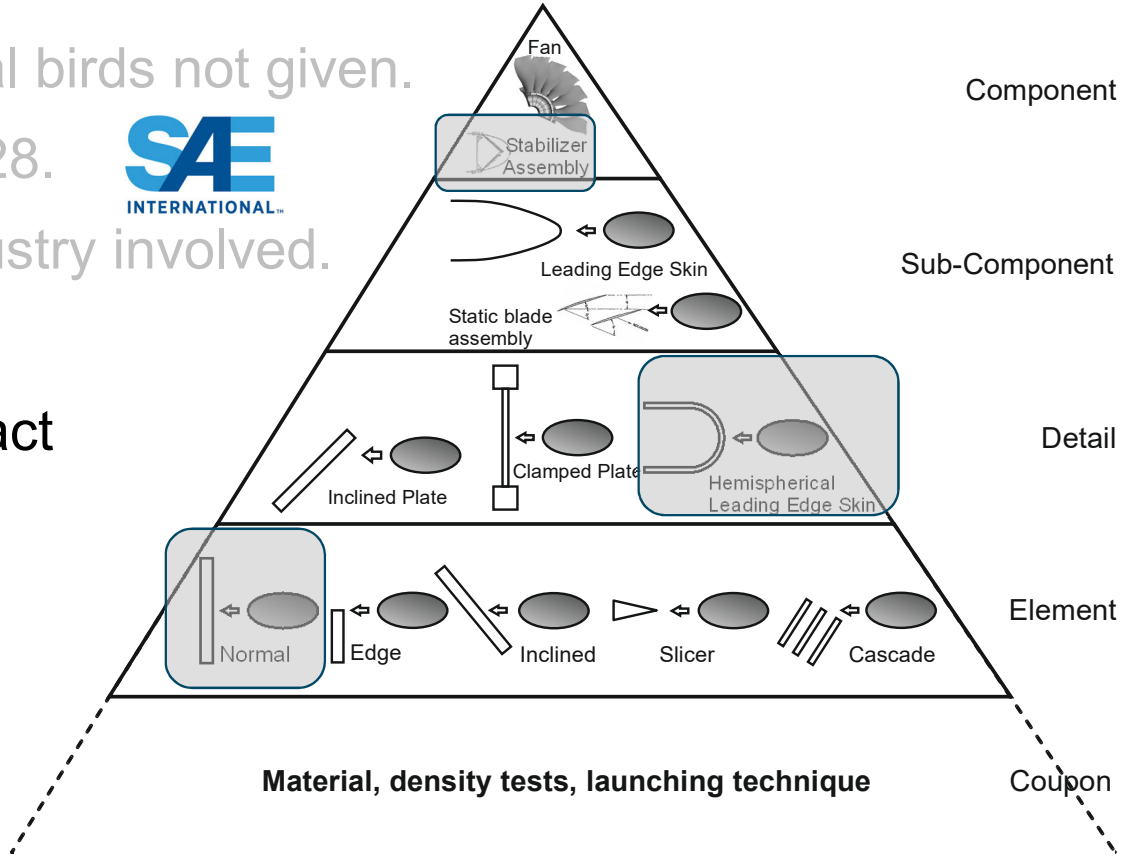


Source: Clean Sky 2 HFLC Impact Demonstrator A3 bird strike tested with #DLRRAB with 3.6 kg at 135 m/s [1]

Acceptance of Artificial Bird as MoC
Measured Evidence

- Accepted approaches for artificial birds not given.
- International committee SAE G-28.
- Acceptance as authorities & industry involved.

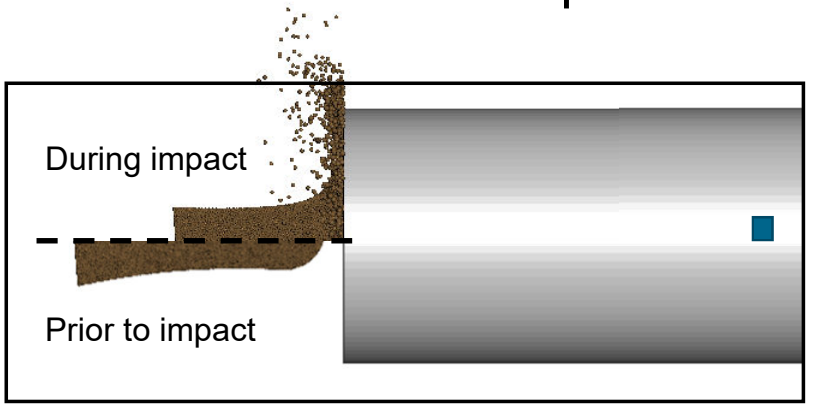
- Building block of highspeed impact dynamic tests.
- Compare artificial to real.
- Standards development within SAE G-28, e. g. normal impact testing method [5]

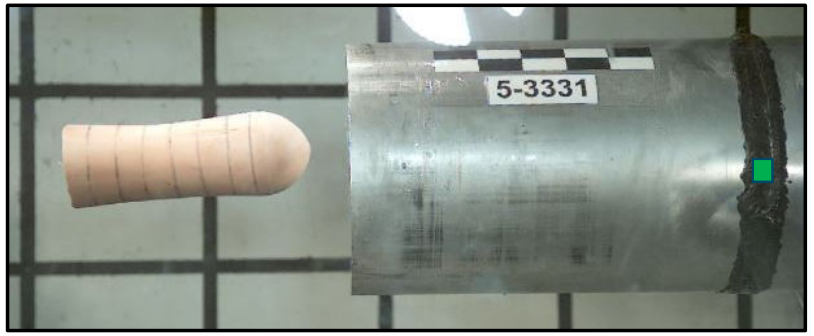


Force Footprint
Load Measurement on Rigid Target

- Normal impact testing and simulation often used to compare and calibrate virtual models

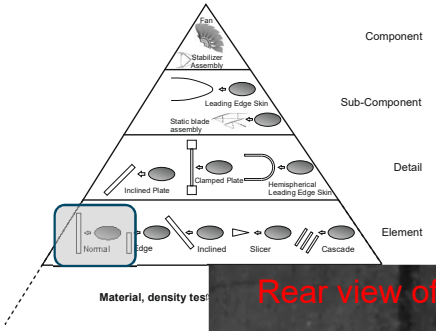
Source: Pressure sensor measurement in Wilbeck 1978 [6]



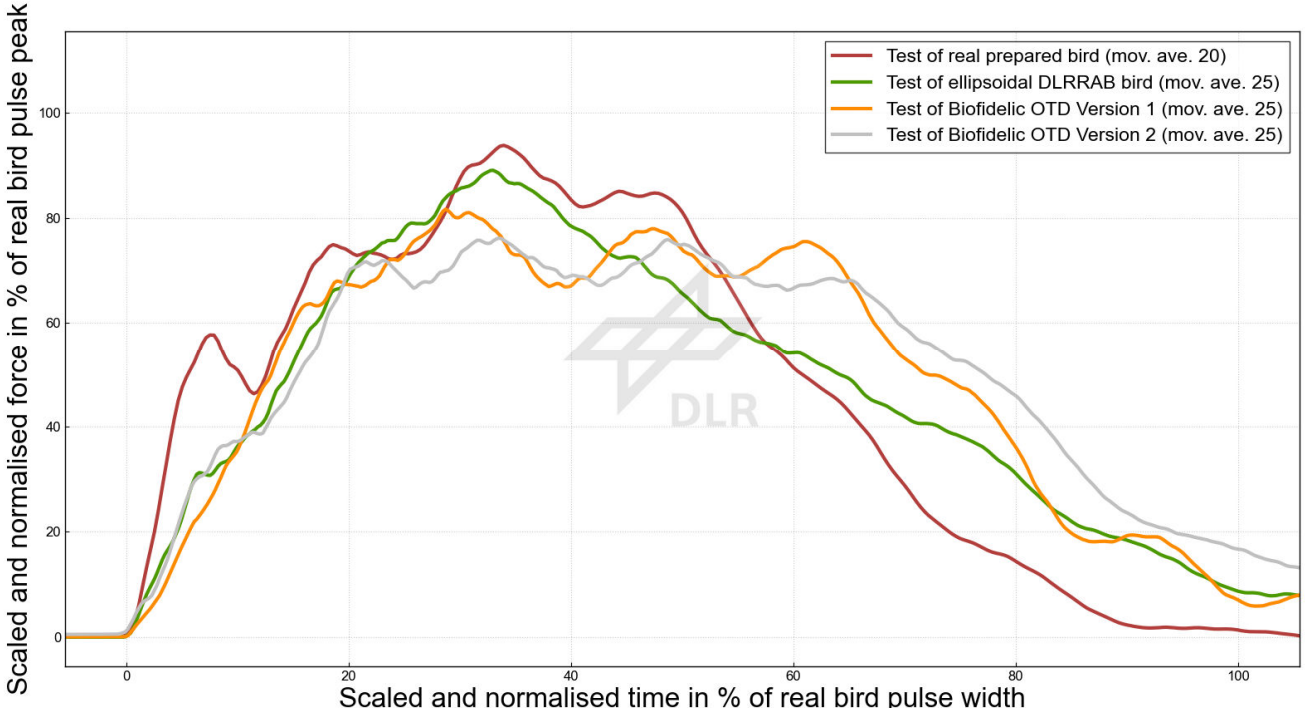


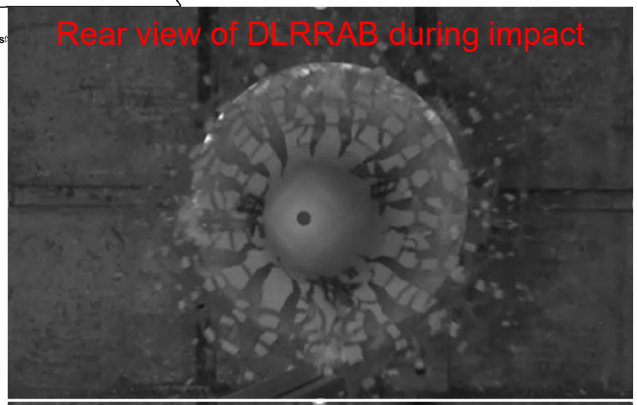
Source: Hopkinson bar measurement in Pereira et al. 2023 [7]

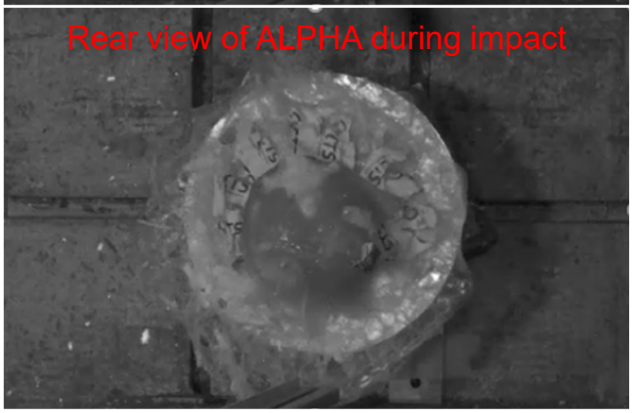
Force Footprint
Load Measurement on Rigid Target



- Effect by large bird with 1.8 kg @ 90 m/s.

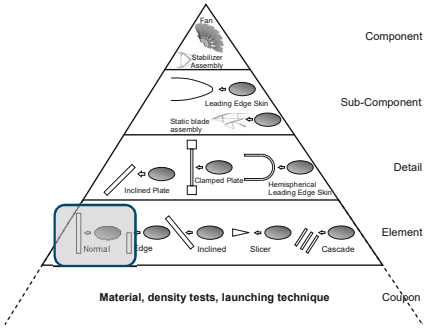






Source: Ritt S A and Schlie D. Comparative Studies of Bird Strike by Dummy Tests and Simulations. 2022. [8]

Force Footprint
Load Measurement on Rigid Target



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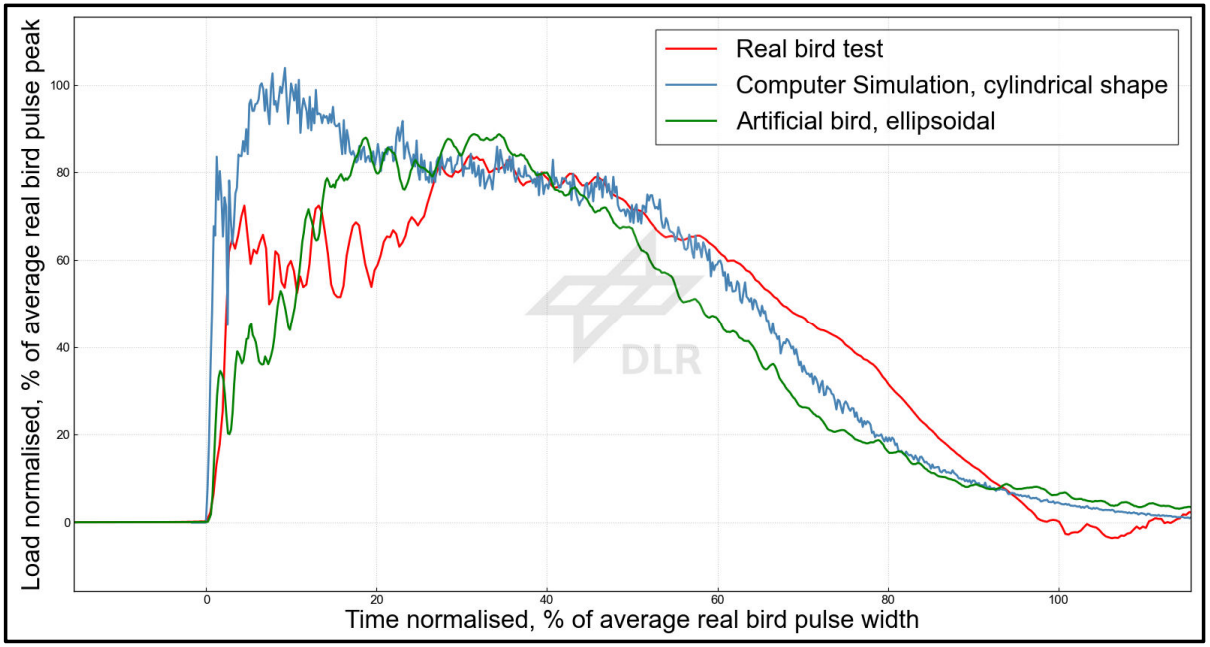
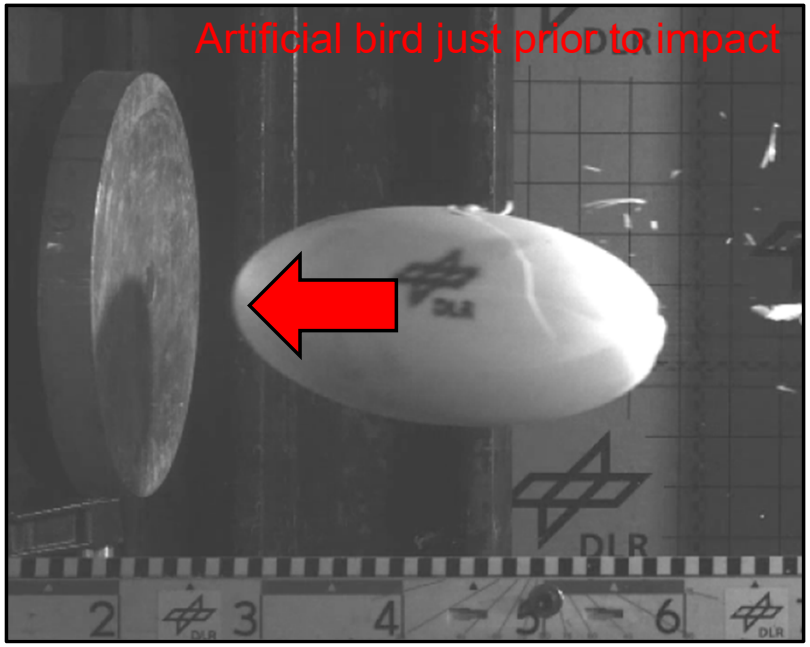




Source: Ritt S A and Vinot M. Design concepts for stabiliser leading edges with HLFC technology and bird strike resilience. 2021. [9]

Force and Deformation Footprint
Compliant Target - AS7371 Development

Basic Ideas

Reference stabiliser spar height: 150 mm

Leading edge radius: approx. 85 mm

Source: DLR

Reference stabiliser spar height: 250 mm

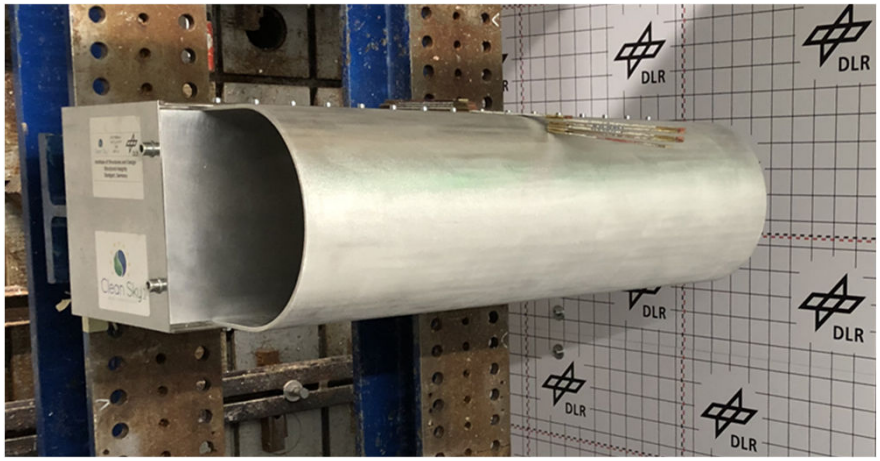
Leading edge radius approx. 125 mm

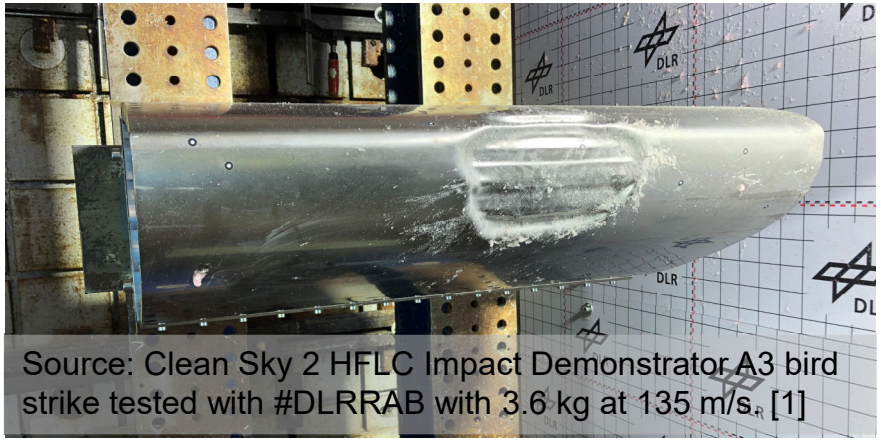
Source: DLR

- Generalised stabiliser leading edge
- Bird „catching“ vs. splitting driven by ratio of bird to leading edge size

Force and Deformation Footprint
Compliant Target - AS7371 Hemispherical Leading Edge

- Test setup developed at DLR for
  - Generalised leading edges
  - Design verification leading edges
- Applied in tests with two load cases
  - 1.8 kg at 90 to 135 m/s [EASA CS-25, FAR25
  - 3.6 kg at 110 to 165 m/s [FAR25]

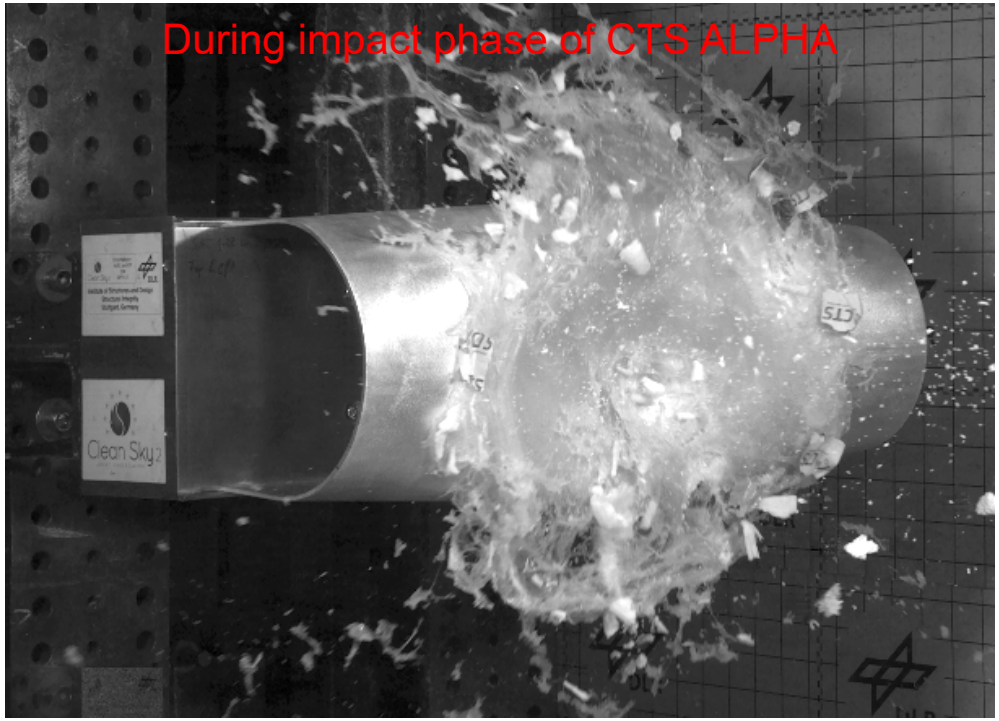


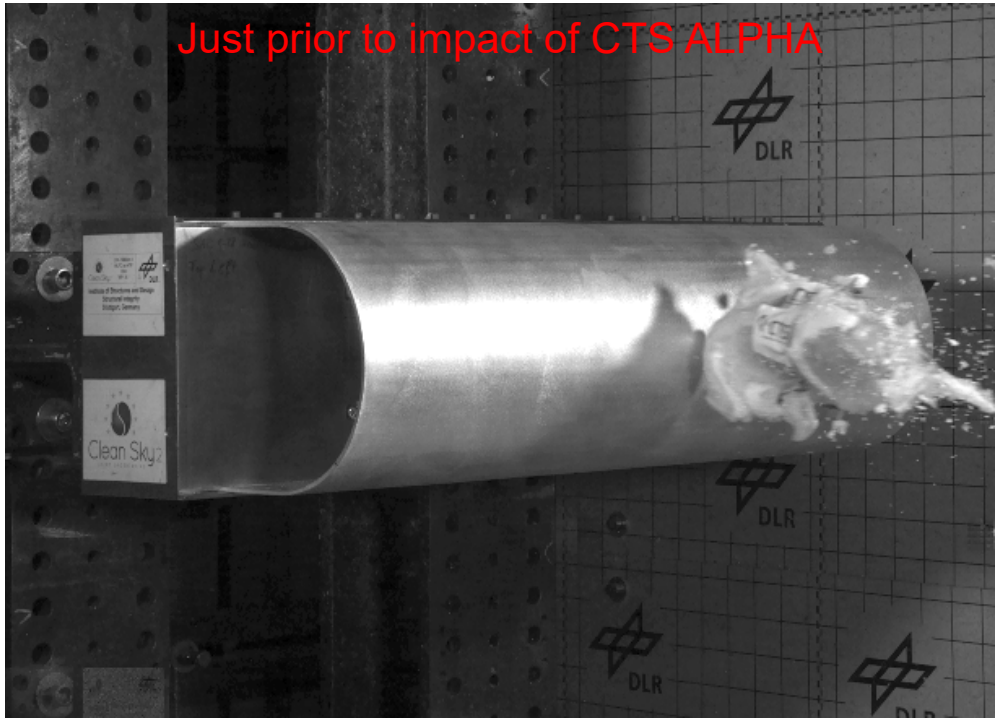


Source: Clean Sky 2 HFLC Impact Demonstrator A3 bird strike tested with #DLRRAB with 3.6 kg at 135 m/s. [1]

Force and Deformation Footprint
Compliant Target - AS7371 Hemispherical Leading Edge

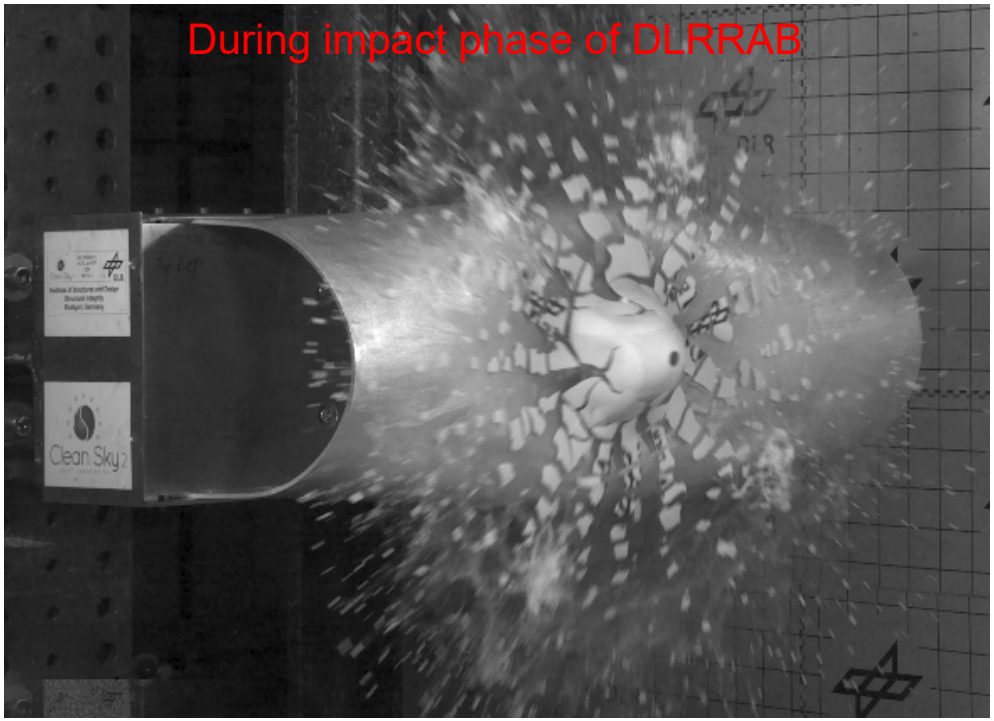
- CTS ALPHA - Biofidelic bird, 1.8 kg @ 110 m/s

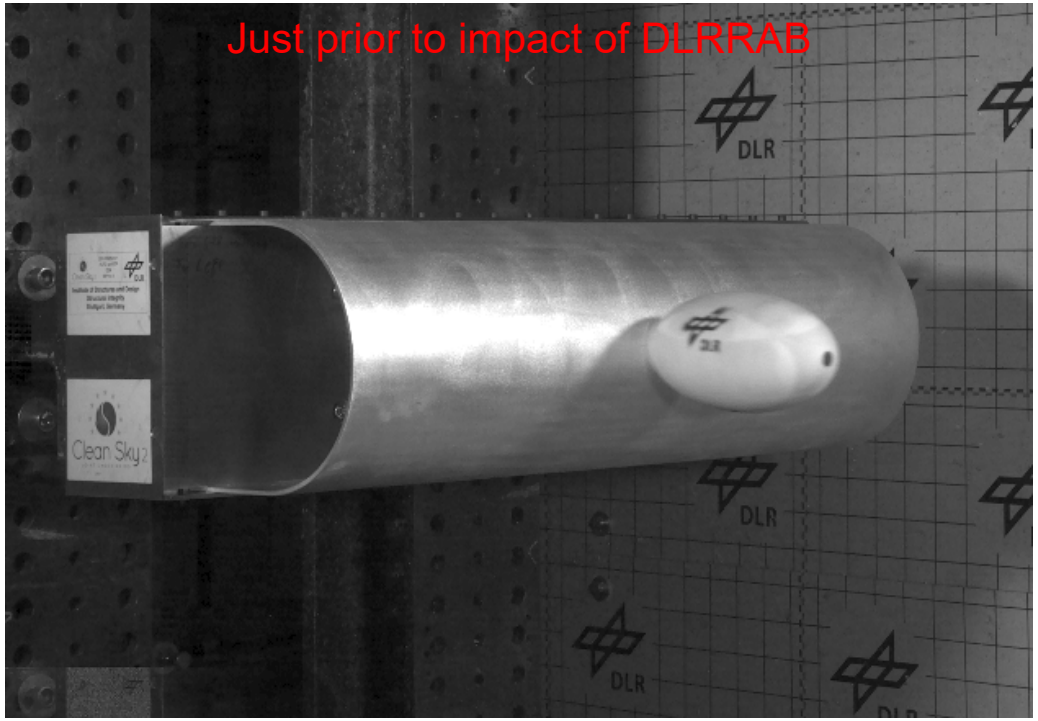




Force and Deformation Footprint
Compliant Target - AS7371 Hemispherical Leading Edge

- DLRRAB – Reinforced Artificial Bird, 1.8 kg @ 135 m/s

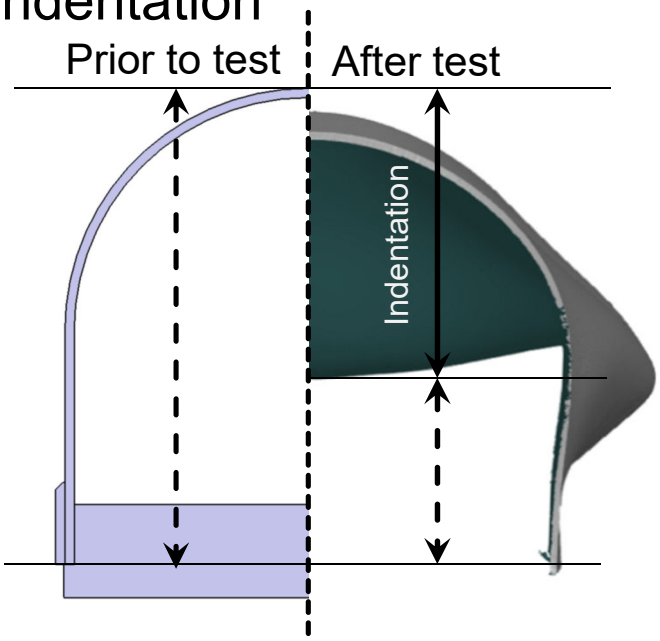




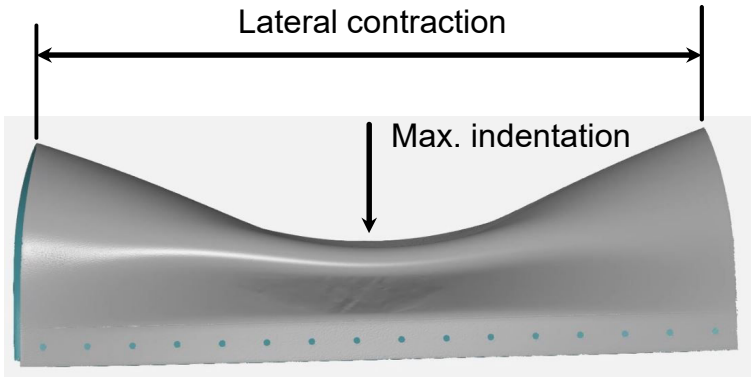
Force and Deformation Footprint
Compliant Target - AS7371 Hemispherical Leading Edge

Measurements after impact testing

- Indentation



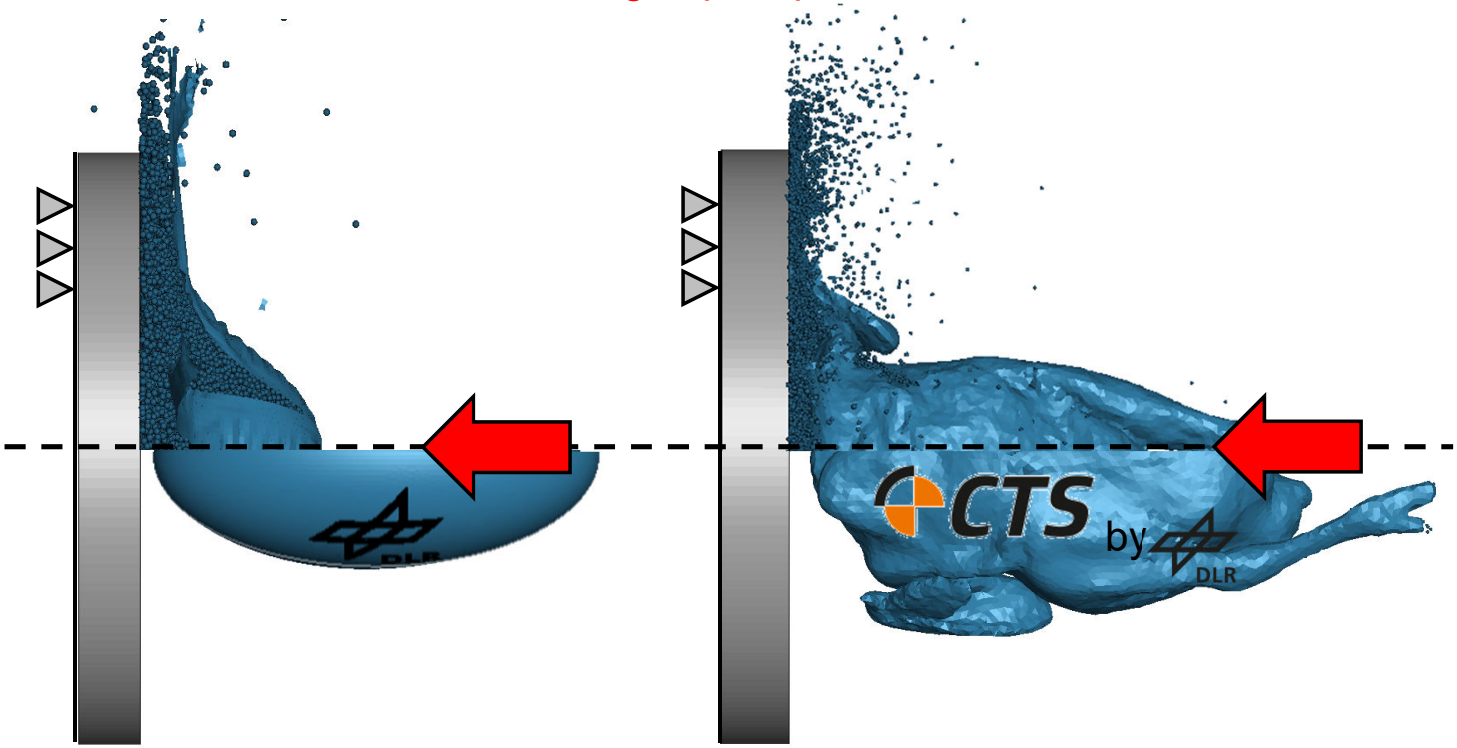
- Transversal deformation



Numerical Models of Artificial Birds
DLRRAB and first ALPHA Simulation Model

- Loadcase
  - 1.8 kg
  - 90 m/s
- Bird model
  - SPH with EWVT applied to particle modelling [10]
- Target
  - Rigid measurement device

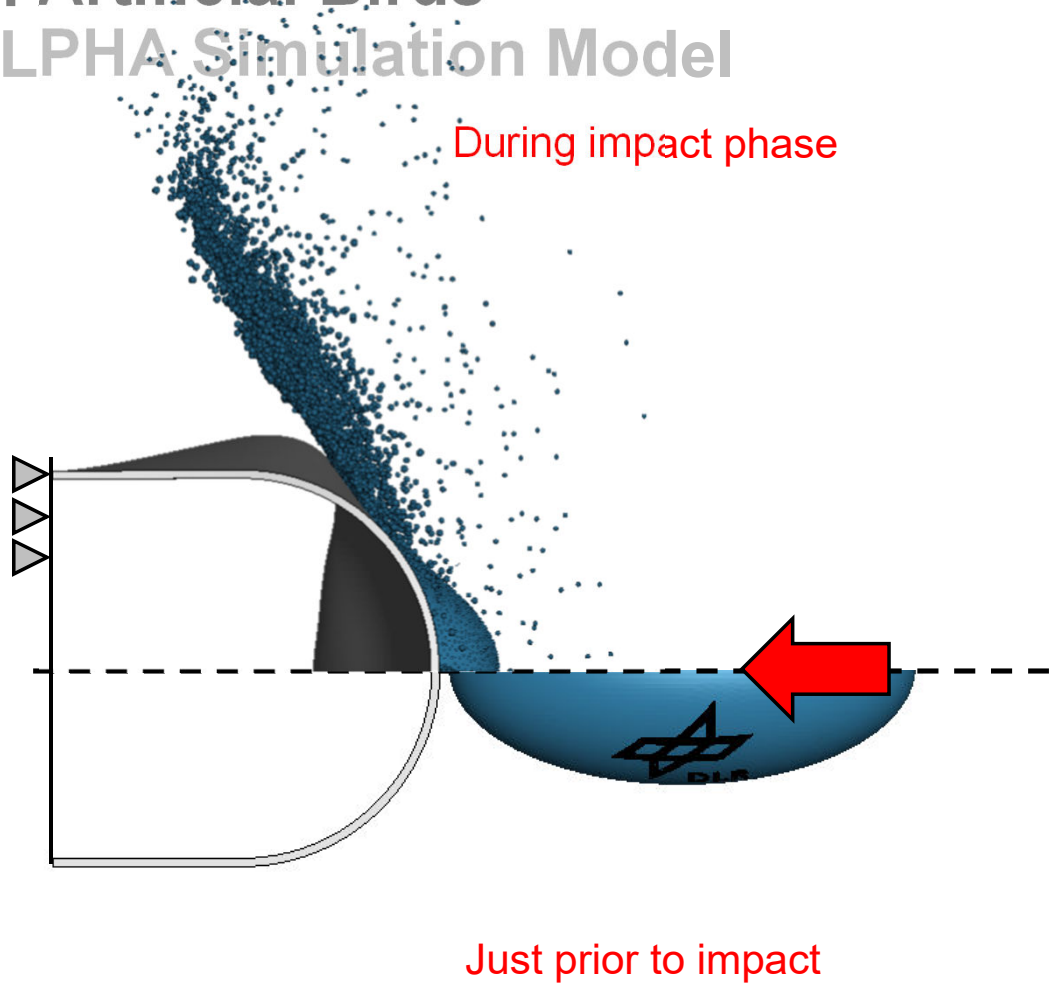
During impact phase



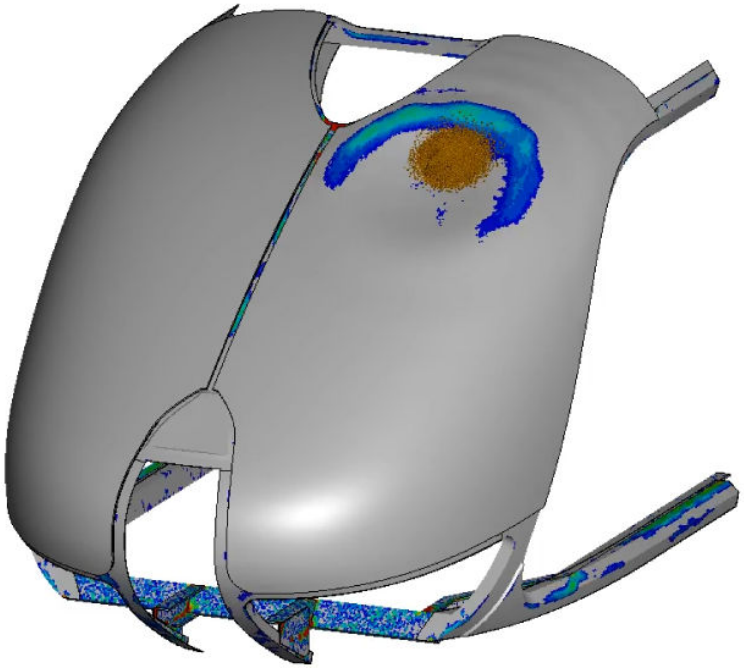
Just prior to impact

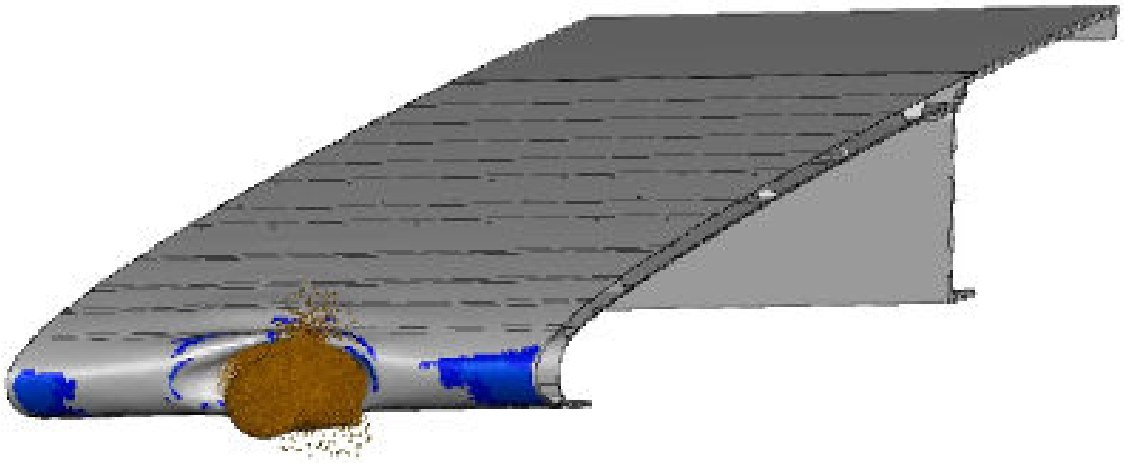
Numerical Models of Artificial Birds
DLRRAB and first ALPHA Simulation Model

- Loadcase
  - 1.8 kg
  - 110 m/s
- Bird model
  - SPH with EWVT applied to particle modelling [10]
- Target
  - Compliant generic leading edge



The Future of Bird Strike Analysis





- Correlated physical and simulation models of artificial birds
- Apply, measure and simulate artificial bird on all aeronautical applications
- Global availability of an acceptable artificial bird

Thank you for your attention!

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Clean Sky 2 JOINT UNDERTAKING

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