Experimental Methods in Materials for Structural Impact Dynamics

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Characteristics of Structural Impact Dynamics

- Usually involves high rate transient loading on a structure
- Rates are such that both material properties and inertial properties are significant
- Often involves some kind of non-recoverable deformation
- Solutions usually analytically intractable

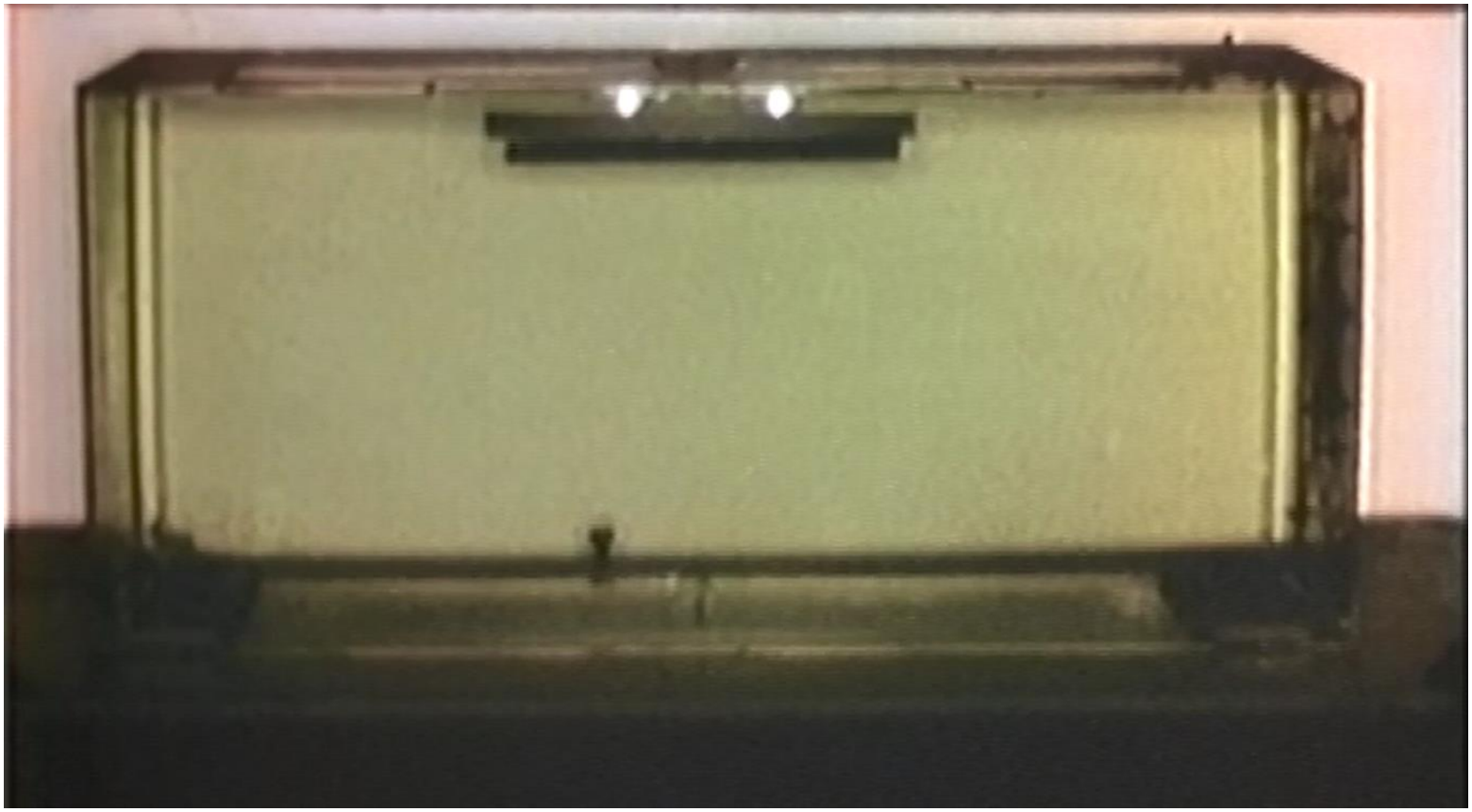
Historical Techniques in SID Testing

- Development of empirical methods
- Creative and innovative instrumentation techniques
  - Examples – Capacitive velocity measurement (SHB), pressure sensors, etc.
  - Analog recorders – aliasing not an issue
  - Inability to visualize structural response

High Speed Film Cameras

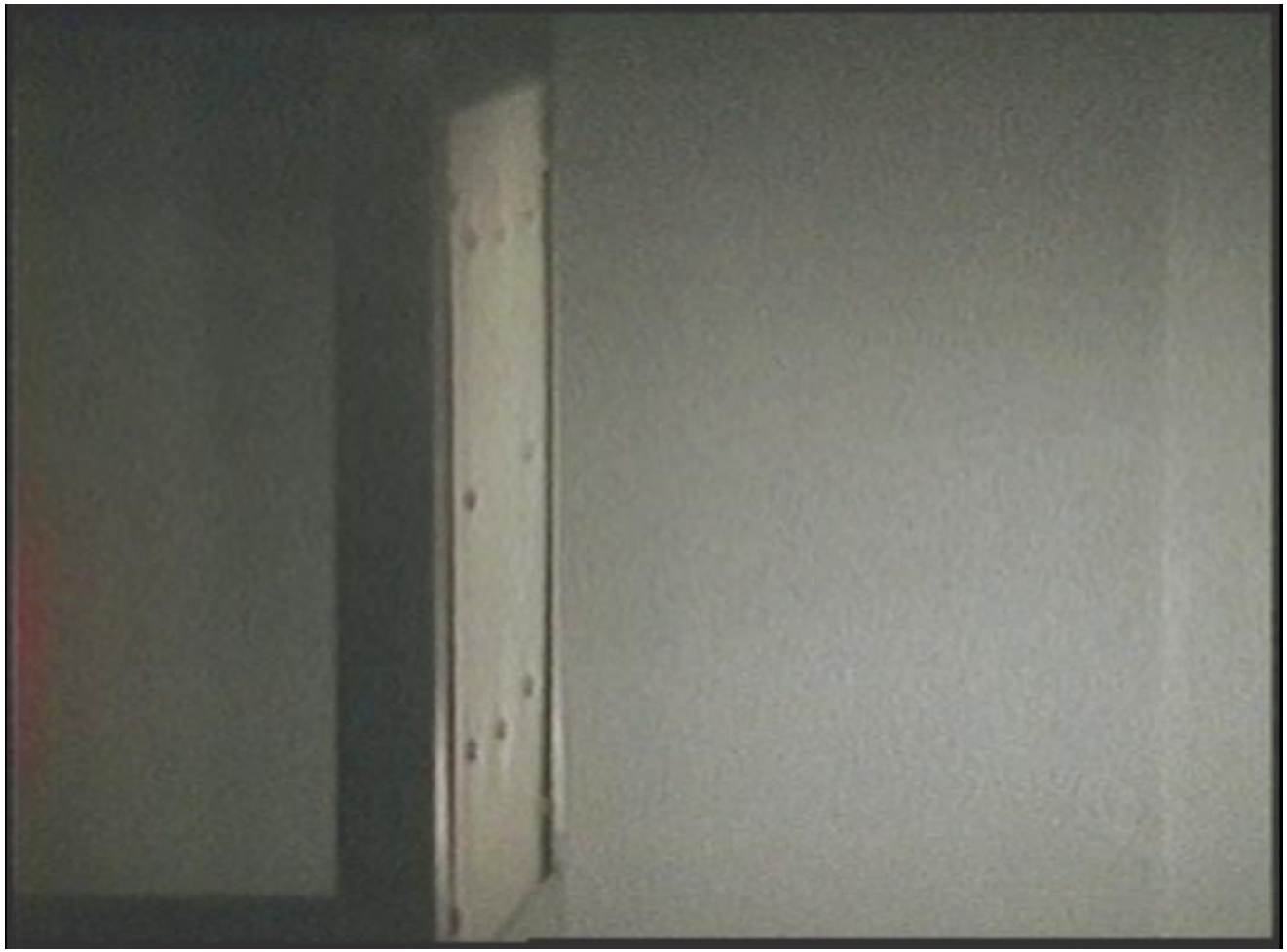
- NAC E-10 16mm high speed film cameras
- 120 m of film in 1 sec
- 0.7 sec to get up to 10,000 frames/sec
- At end, film moving at 75 m/sec
- It took several days to see the results

High Speed Film Cameras



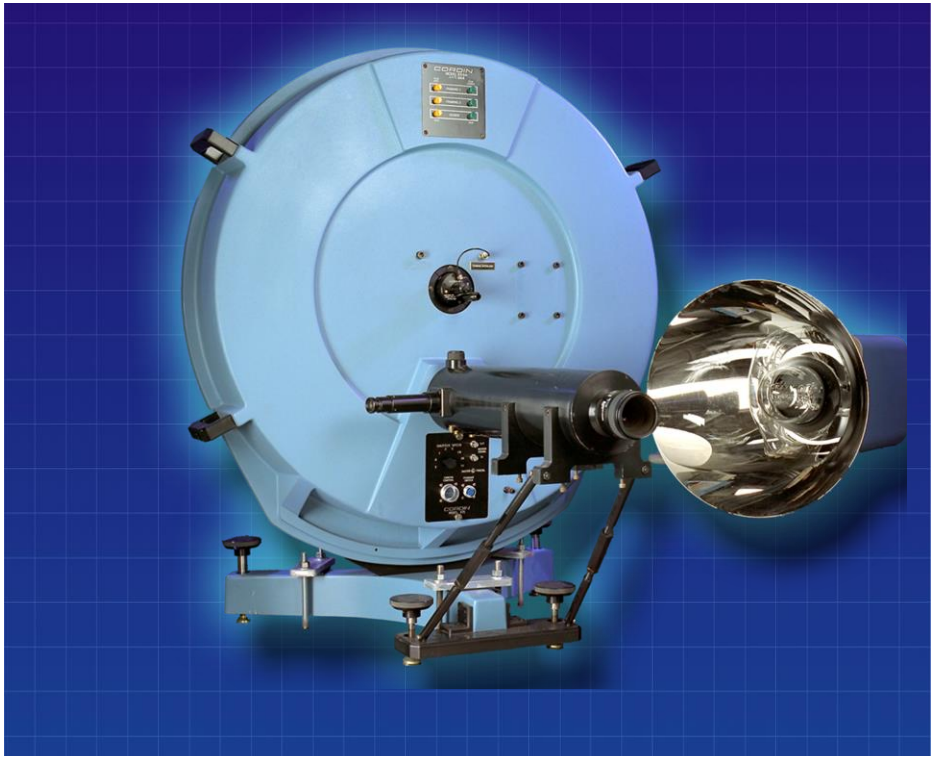
Water Tank Impact Test

High Speed Film Cameras



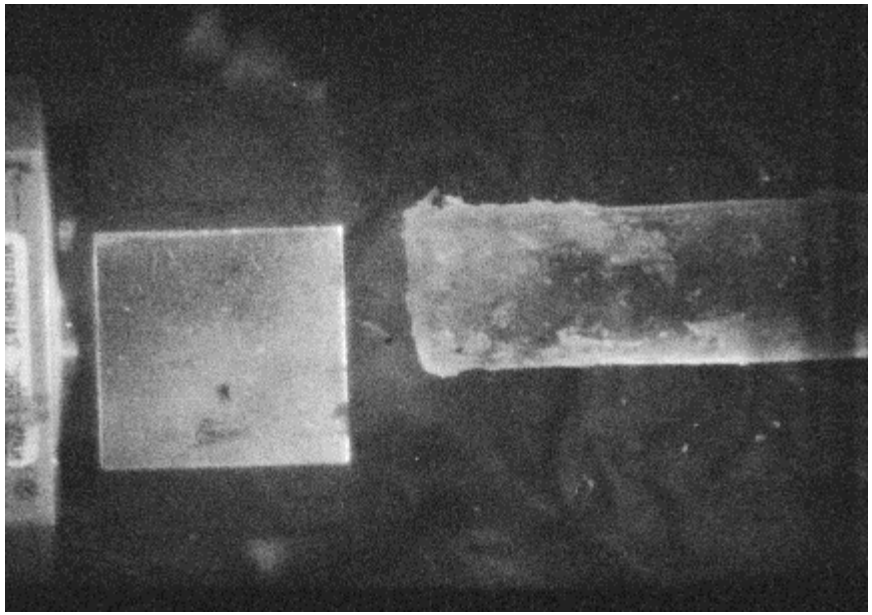
Water Tank Impact Test Video

High Speed Film Cameras



Cordin Model 330A

- 2M frames/sec
- Used to rolls of 35 mm still film
- Rotating lens on a Helium-driven turbine engine
- 40 microsecond recording time
- High intensity flash xenon light source



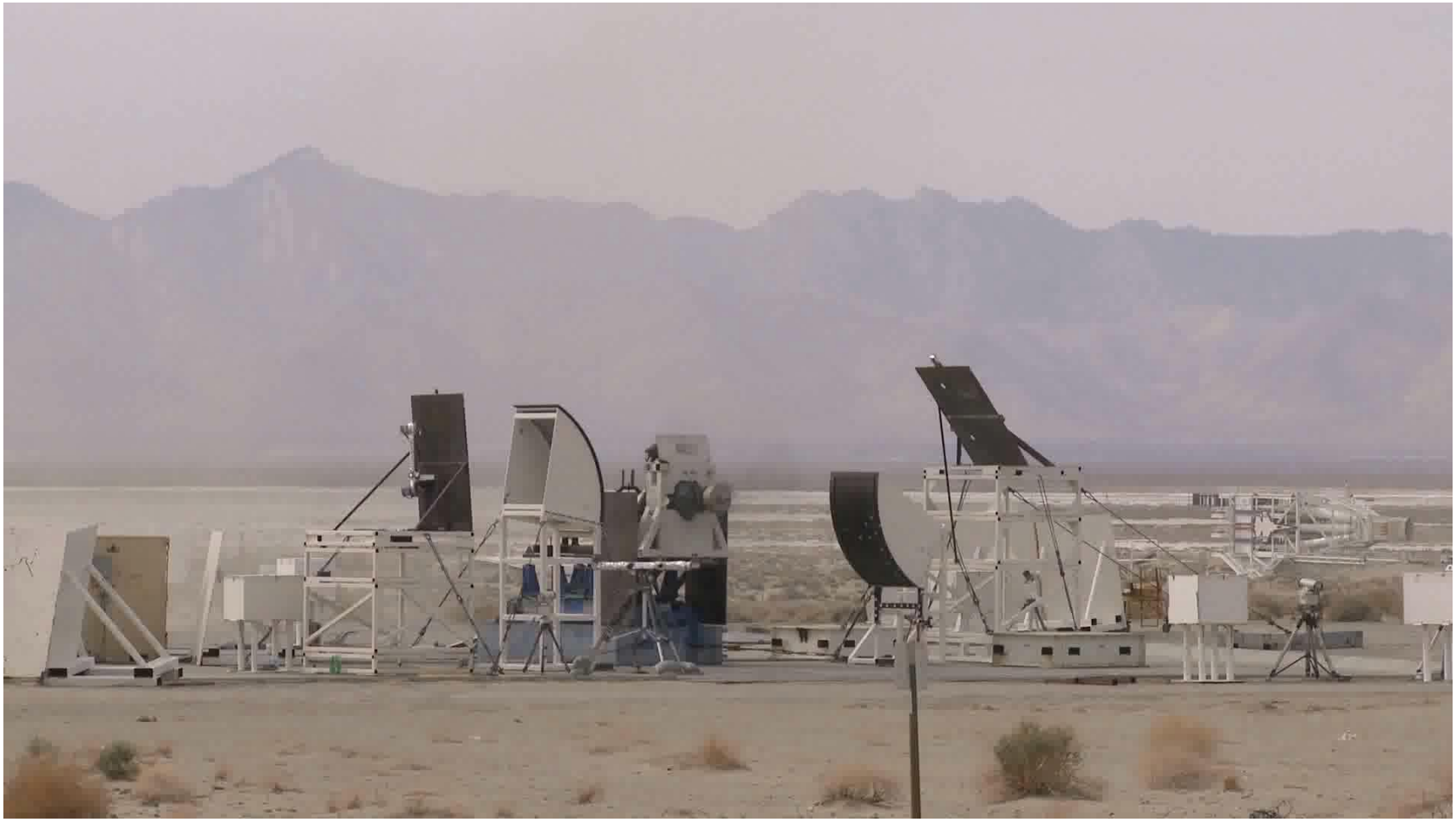
Ice Impact Video

Recent Developments

- In the last 20 years two developments have occurred that have significantly changed how we conduct impact testing and other developments have occurred that have changed why we do impact testing
- How:
  - High speed digital video cameras
  - Digital Image Correlation and High Speed Photogrammetry
- Why:
  - Advanced computational modeling techniques which require high quality material property and validation test data

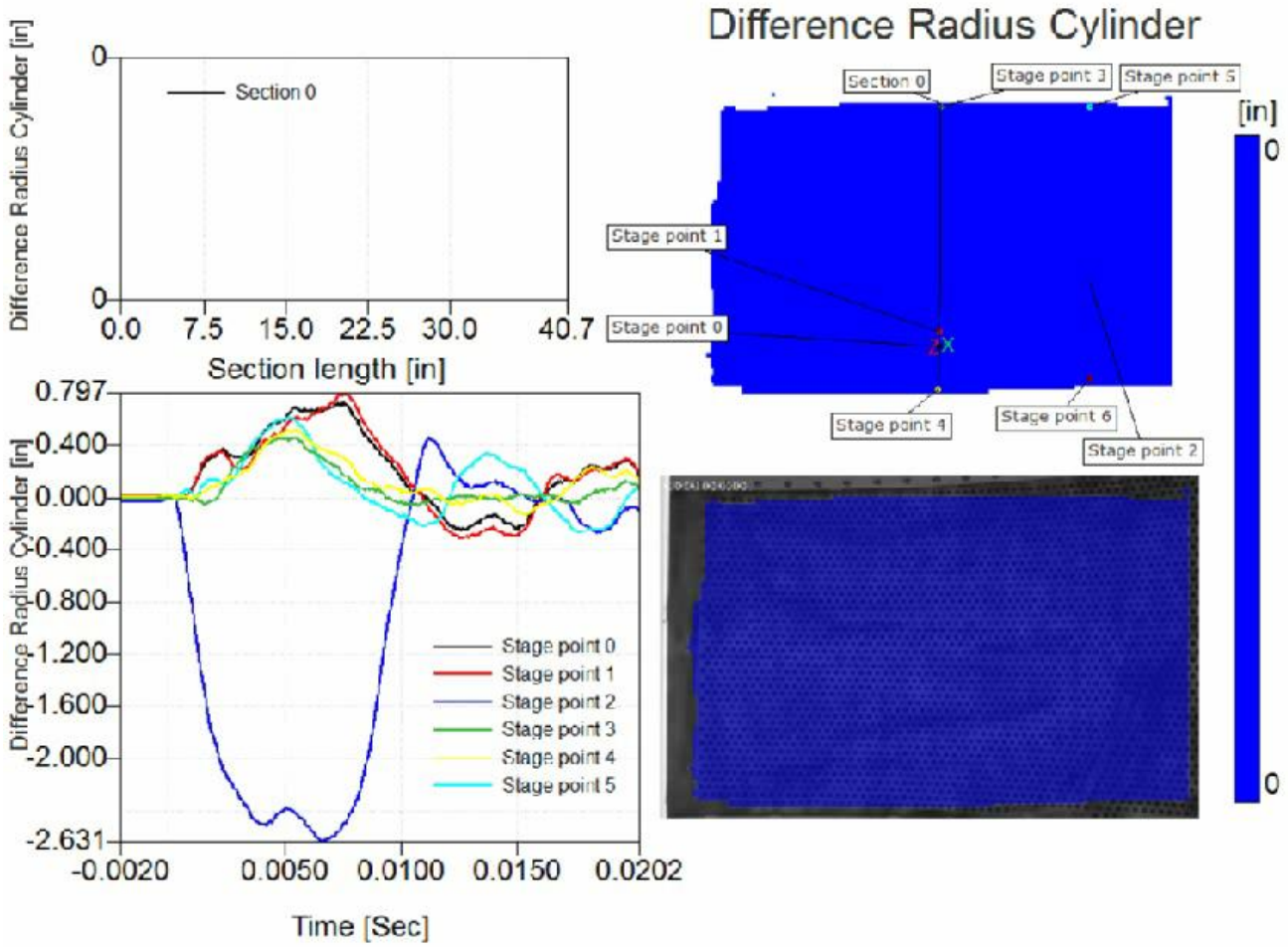
Advances in Measurement Techniques

Example: Open Rotor Test



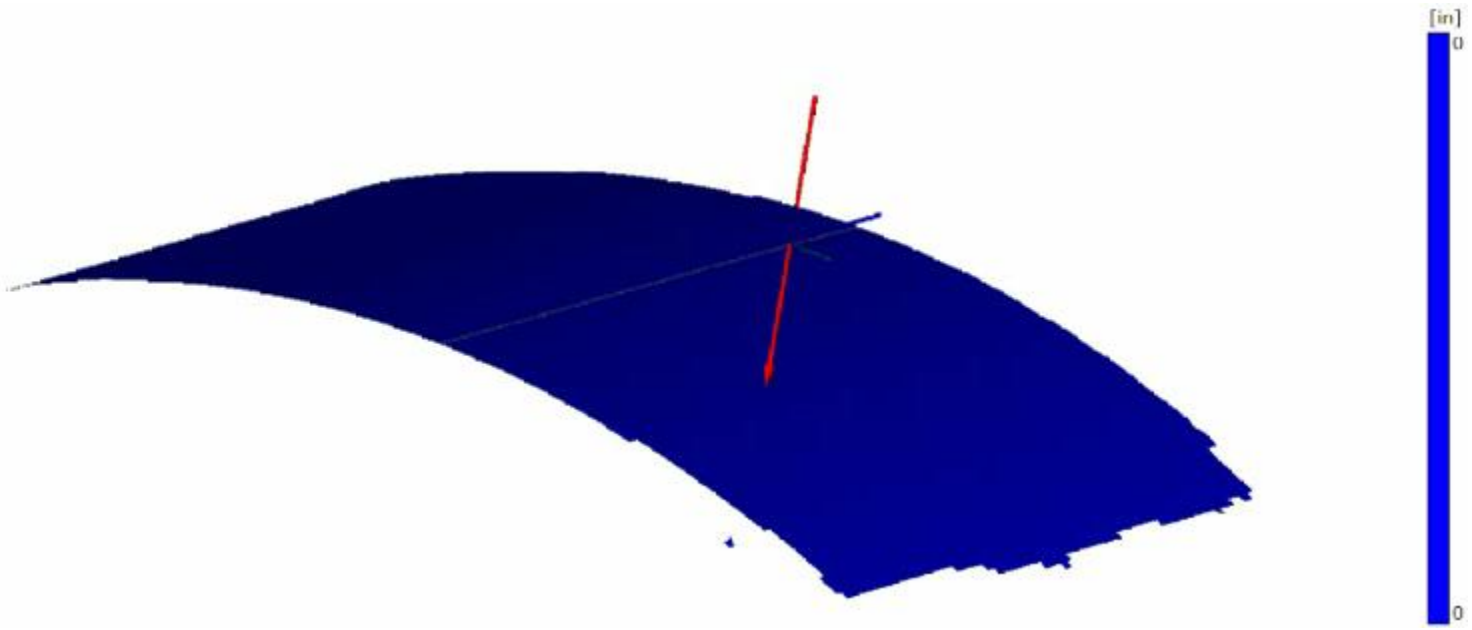
Open Rotor Test Video

Example: Open Rotor Test



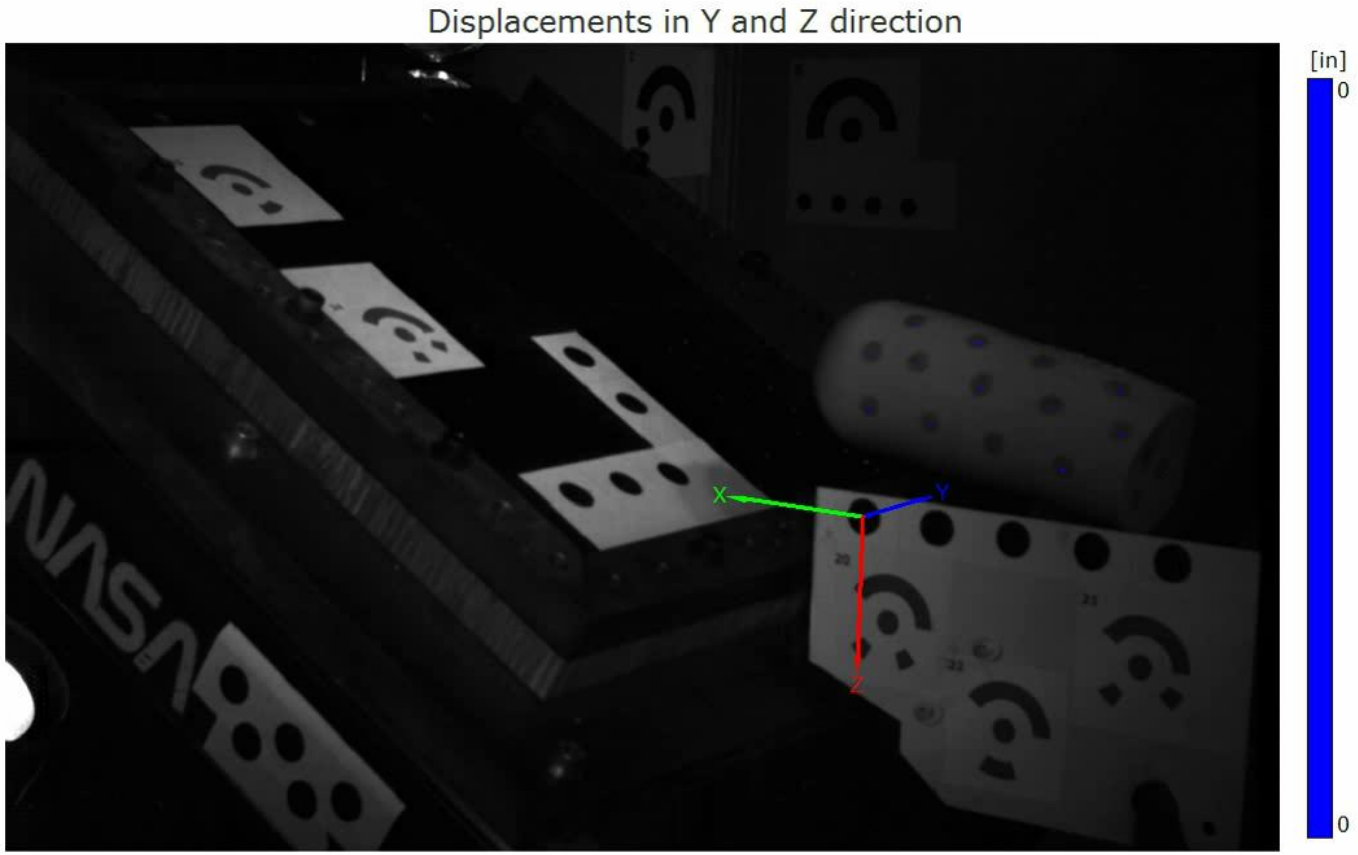
Open Rotor Analysis video

Example: Open Rotor Test



Open Rotor Analysis video

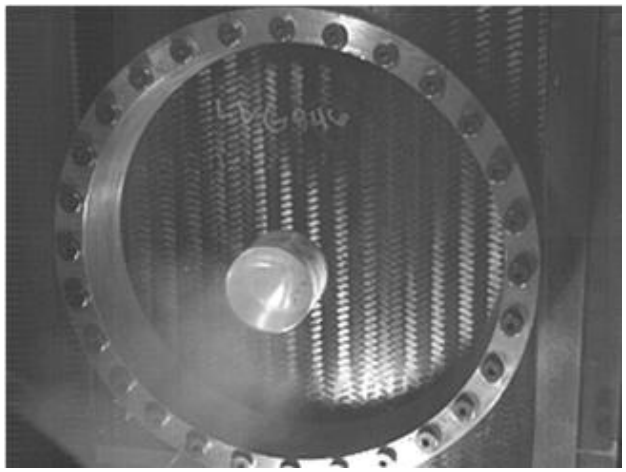
High Speed Photogrammetry

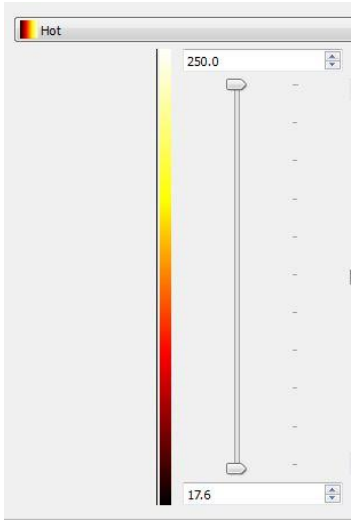


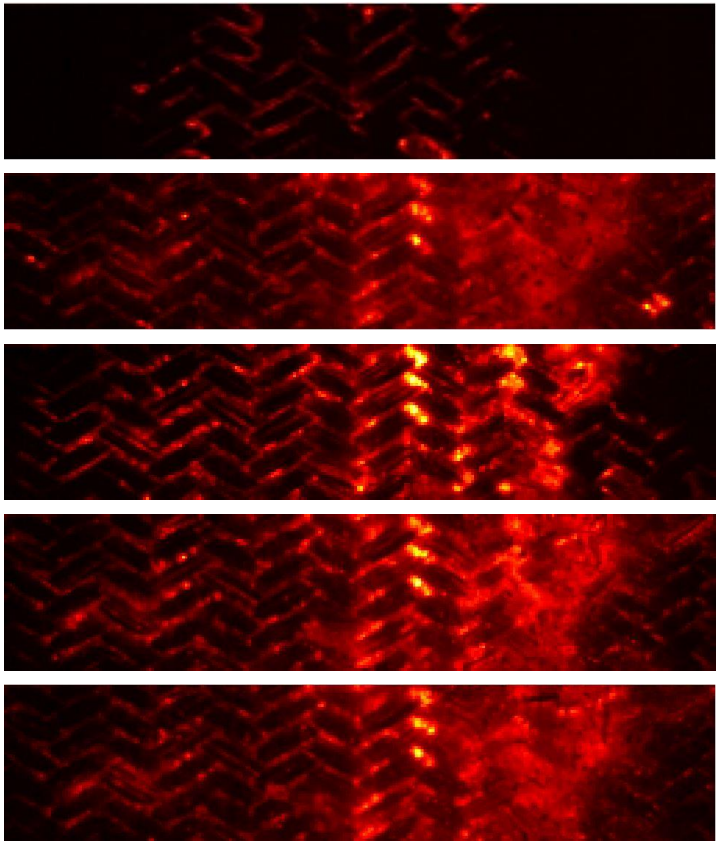
Quantitative Velocity and Orientation Measurements

Other Developments

High Speed Infra-red Thermal Measurements



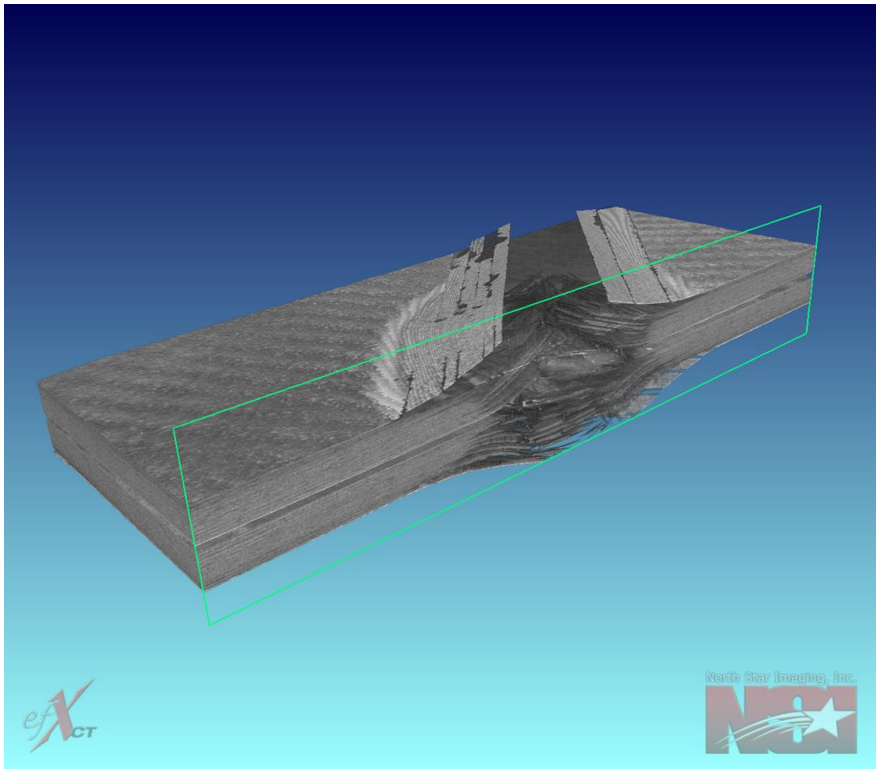




T700S/3502 Triaxially Braided Composite
Impact velocity: 190 m/sec
Max temp recorded: 240 C
10000 frames/sec, 156 x 56 pixels

High temperatures during impact will have consequences on new advanced composite impact models

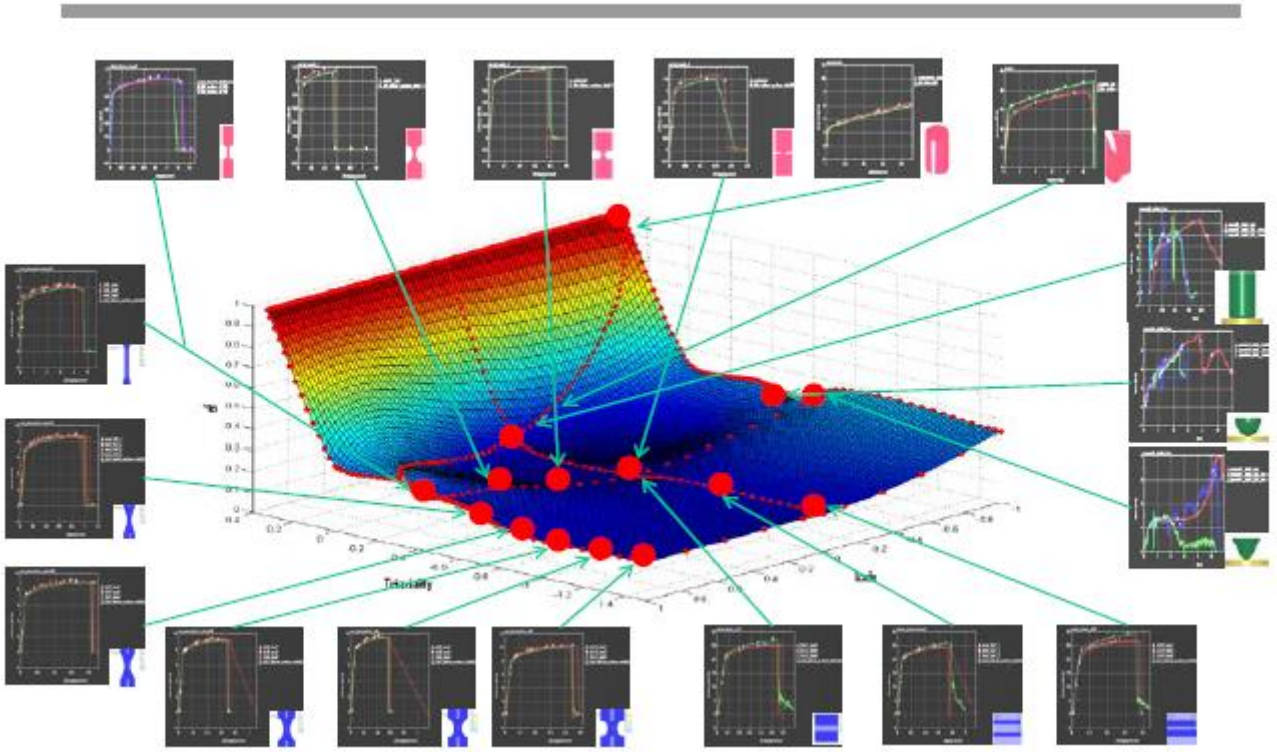
In-Situ Computed Tomography



Advances in Computational Modeling have required advancements in experimental techniques

- Advanced DIC methods:
  - Elevated temperature
  - Very high speed
- Combined stress loading
- Elevated temperature
- High speed infra-red measurements combined with DIC

Advanced Computational Modeling



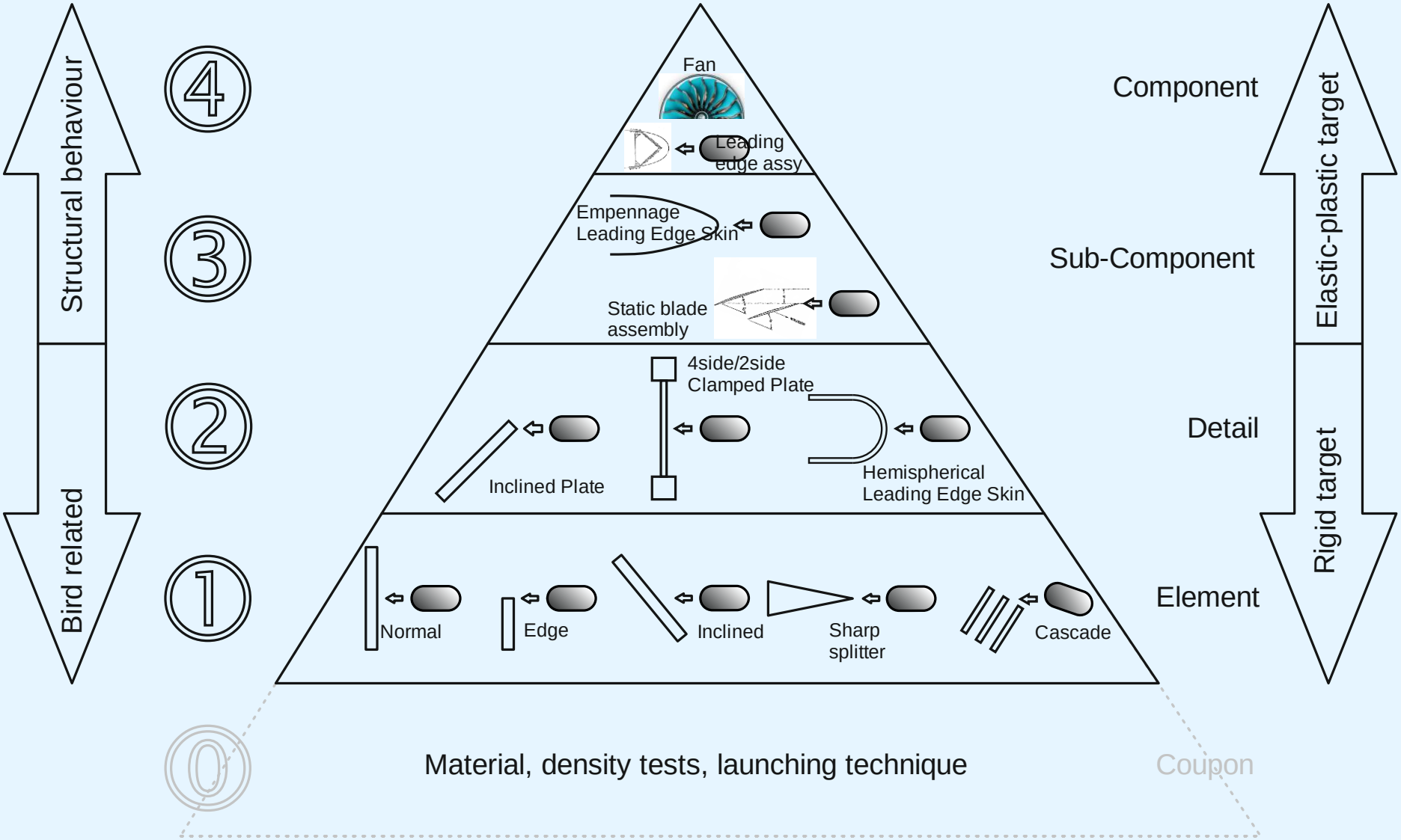
LS-Dyna MAT224 Failure Surface for Al2024 T3/T351

Artificial Bird Development

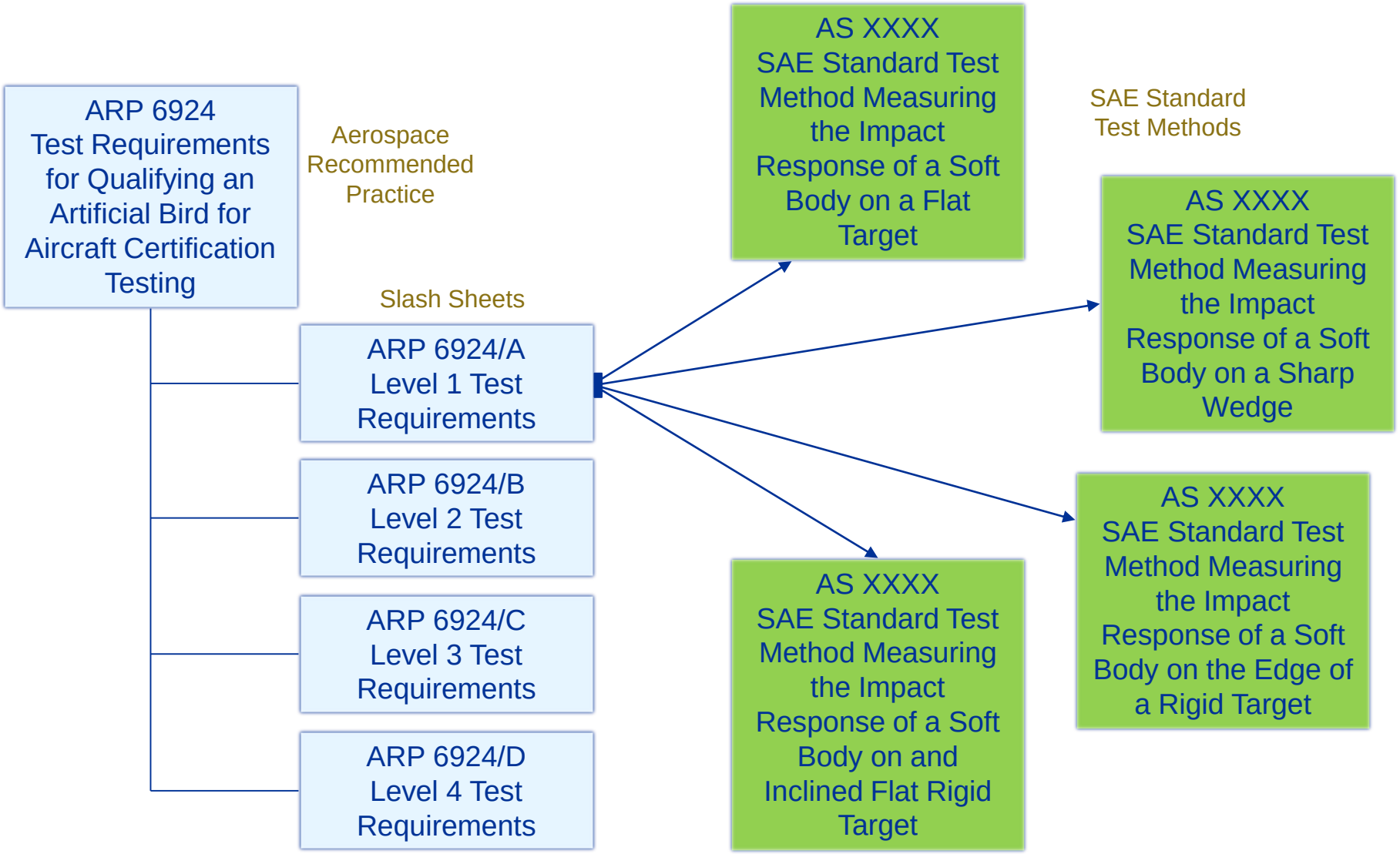
SAE G-28 Committee
Simulants for Impact and Ingestion Testing

- The committee has established a set of twelve tests that must be completed to demonstrate that an artificial bird responds in the same way as a real bird
- The tests range in complexity from relatively simple to very complex
- It may be possible to perform just a subset of the tests if a bird is being qualified for just non-rotating, or just rotating applications
- The committee has established a set of documents that are required as shown on a following slide:
  - Main Aerospace Recommended Practice
  - Four slash sheets, each representing one of the levels of the test pyramid
  - One Aerospace Standard Test Method corresponding to each of the twelve tests
- We are currently in the process of developing the Aerospace Standard Test Methods

G-28 Building Block for Testing



SAE G-28 Proposed Document Organization



Questions?