Bell Helicopter Bird Strike Virtual Testing

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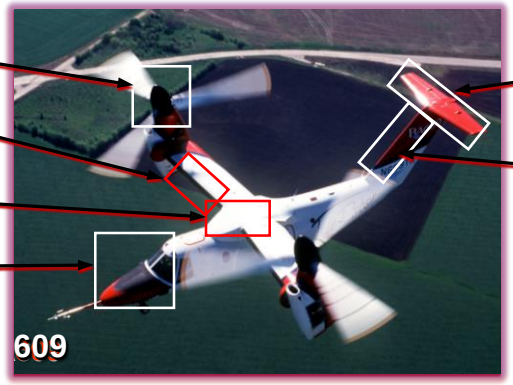
EASA Rotorcraft Symposium, December 6-7, 2016

Bird Strike Virtual Testing

- **Bell Helicopter has matured a method that provides reliable, accurate bird strike simulation using the general-purpose nonlinear explicit finite element code, LS-Dyna®**
- **Bird model was developed using the following methods; both are suitable for large material deformation and disintegration:**
  - **Arbitrary Lagrangian-Eulerian (ALE)**
  - **Smooth Particle Hydrodynamics (SPH)**
- **Conducted extensive study on composite material models and failure degradation criteria subjected to bird strike**
- **Conducted coupon tests to characterize material properties**
- **Conducted multiple test correlation cases to validate the developed bird strike simulation method**

Validation with Multiple Test

1. Rotor Spinner & Control
3. Wing Leading Edge
6. Over-Wing Fairing
2. Cockpit Nose Cone
4. Horizontal Stabilizer
5. Vertical Fin
10. Tail rotor blade & controls
7. Windshield
11. Main rotor blade & pitch link
8. Pitch Link
9. Tail Rotor Blade
12. Nose & windshield
13. Empennage (V-fin, H-stab)



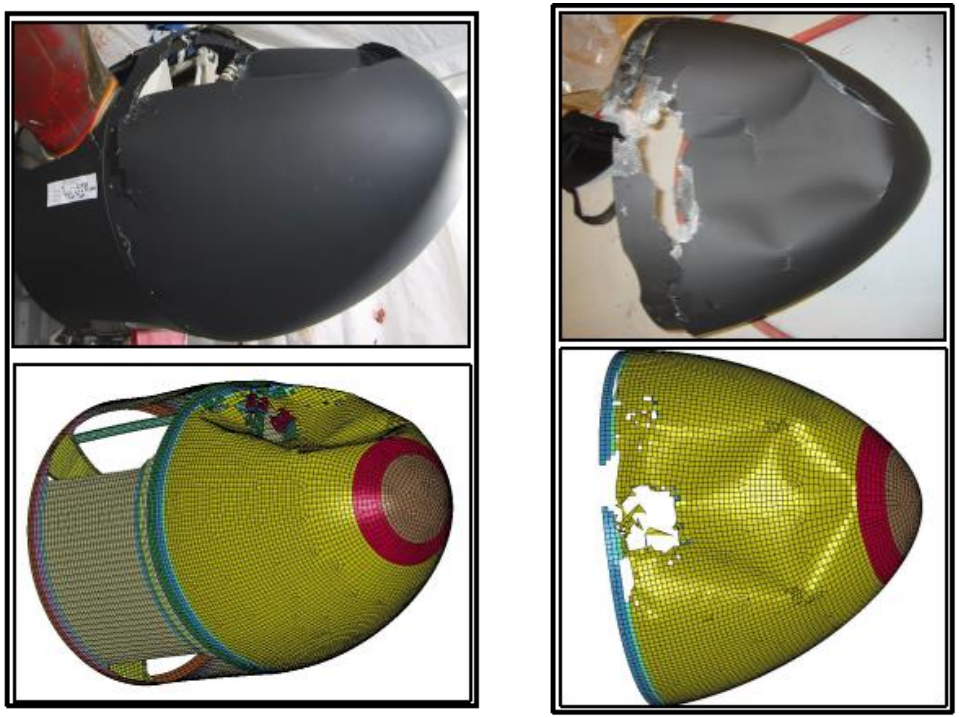
- C.H. Tho, M.R. Smith, "*Accurate Bird Strike Simulation Methodology*", Journal of the American Helicopter Society, Journal of the American Helicopter Society, Volume 56, Issue 1, Jan 2011.
- Z. Lu, J. Schadler, C.H. Tho, "*Applying FEM for Development of an Impact Resistant Aircraft Windshield*", Proceedings of the 68th American Helicopter Society Annual Forum, Fort Worth, Texas, May 2012.
- M.M. Suran C.H. Tho, M.R. Smith, "*Bird Strike Simulation for Helicopter Rotor Blades*," Proceedings of the 69th American Helicopter Society Annual Forum, Phoenix, Arizona, May 2013.

Airworthiness via Bird Strike Simulation

- **Italian Airworthiness Authority, ENAC, granted 609 flight release with redesigned rotor spinner based on bird strike simulations in lieu of physical tests in 2007 and 2008**

Test

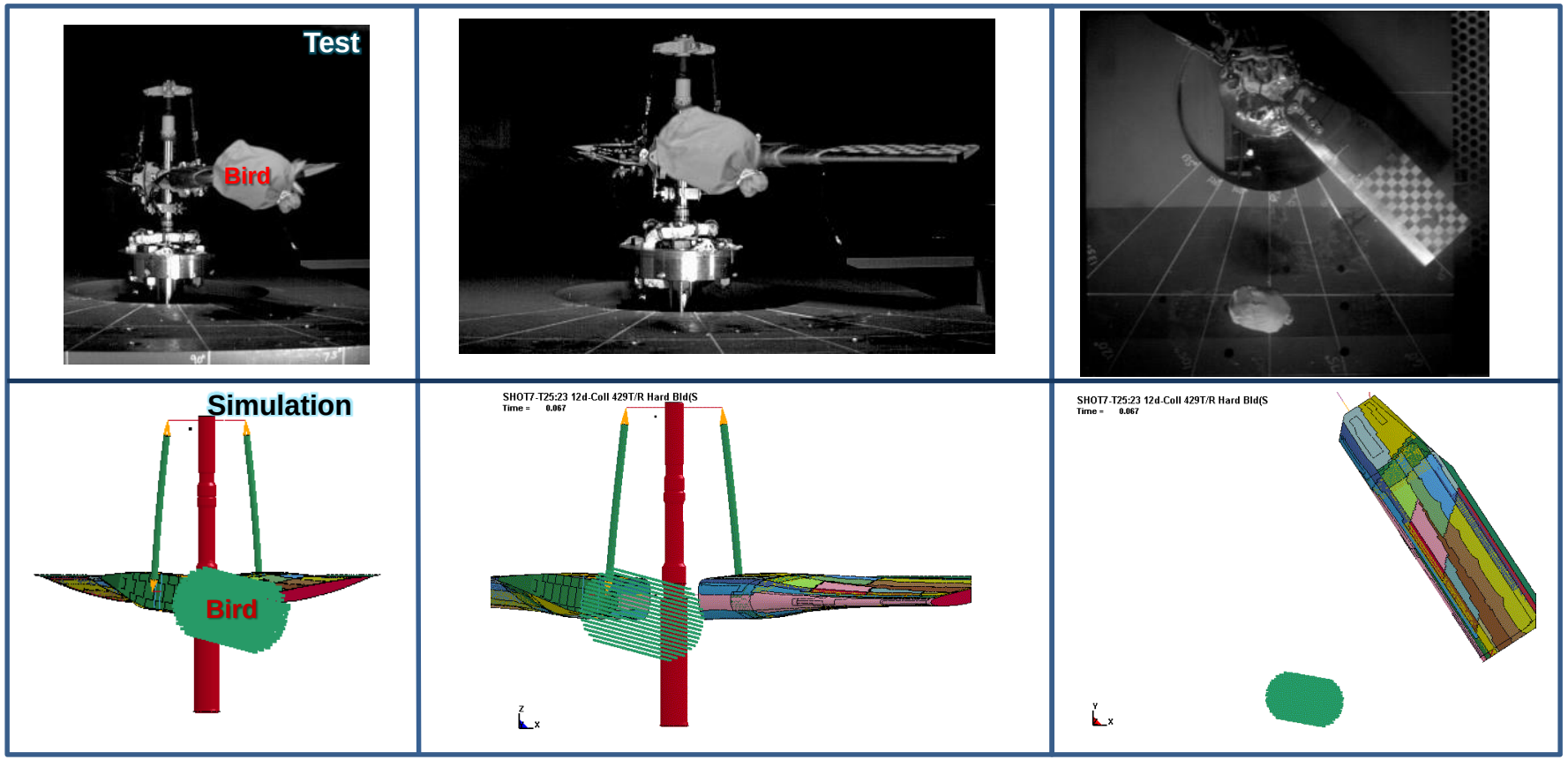
Analysis



Rotor Spinner

Achieved favorable spinner cone and side panel composite failure mode correlation

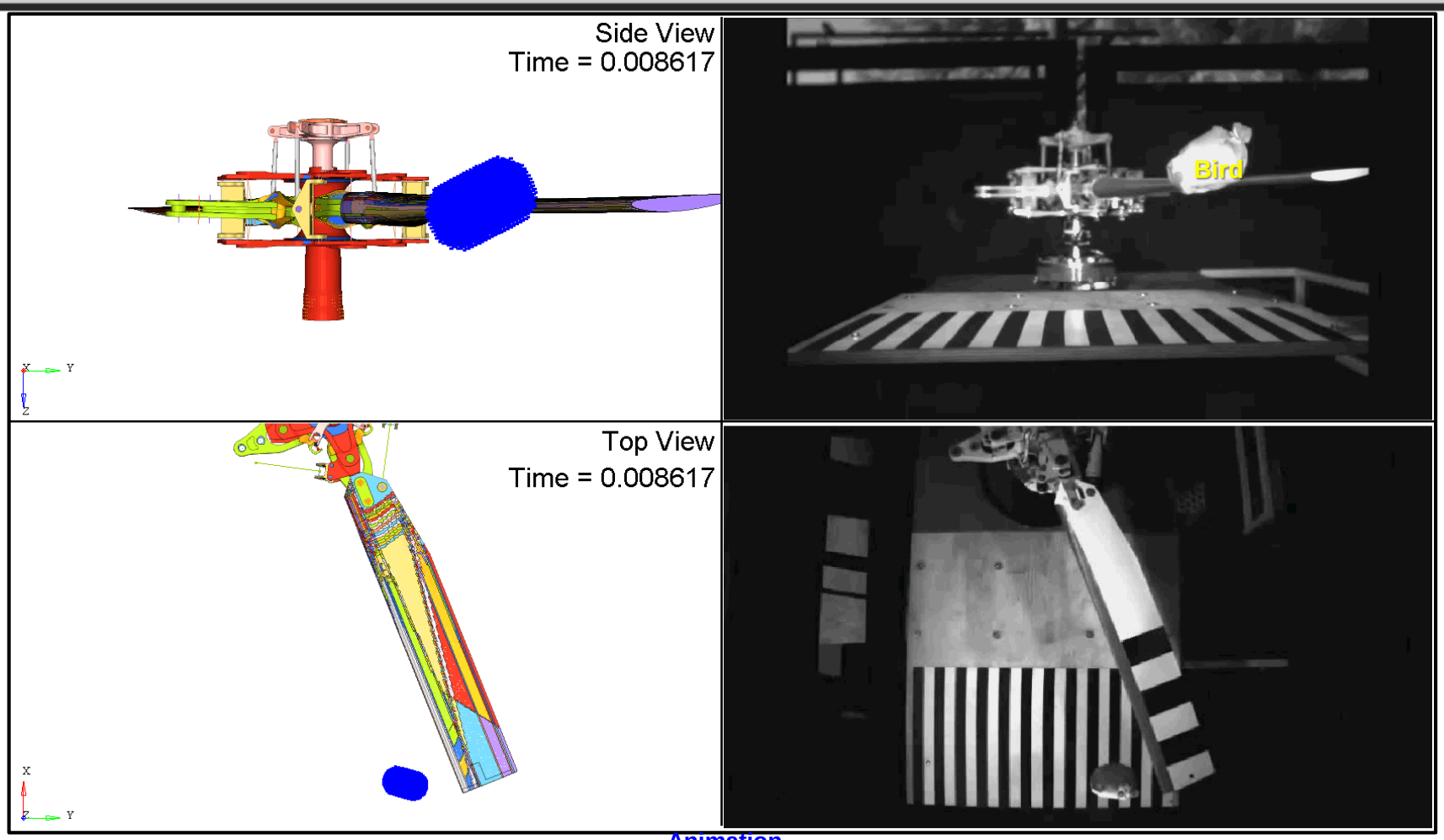
Part 27 Tail Rotor Simulation vs. Test



- **Correlated both 0° and 12° collective angles**
  - ❖ **2.2-lb bird @ 2,604RPM**
- **Both test and analysis indicated no damage on blade structure**

Bird splitting behavior replicates test → Similar Momentum Transfer

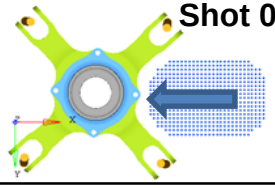
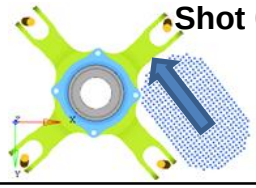
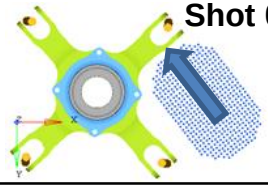
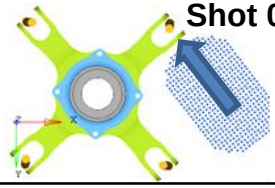
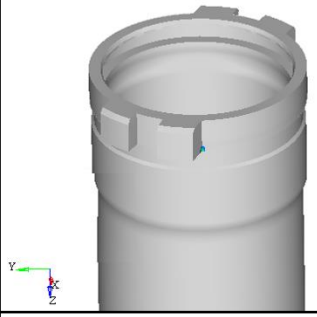
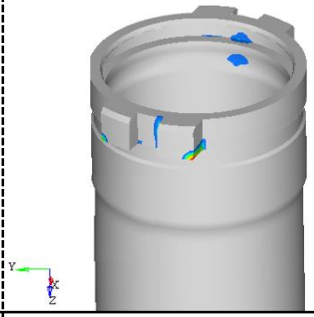
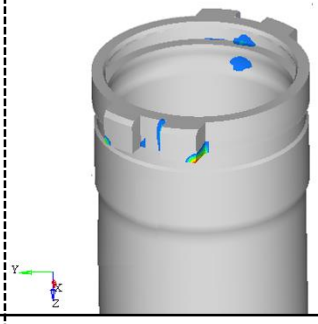
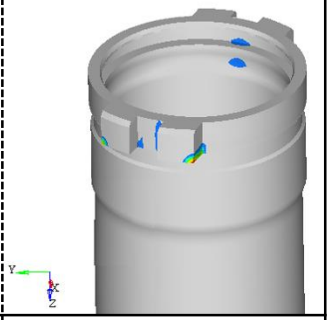
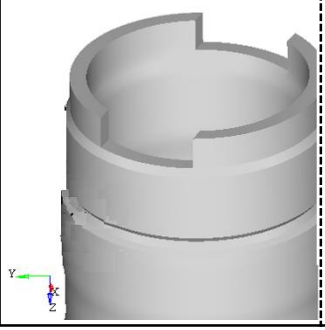
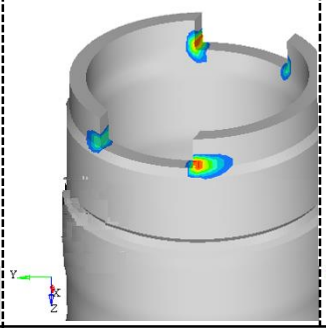
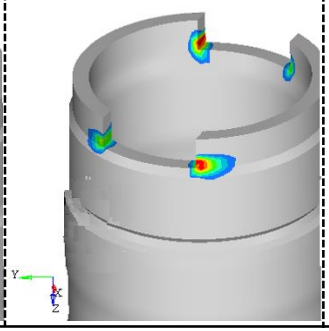
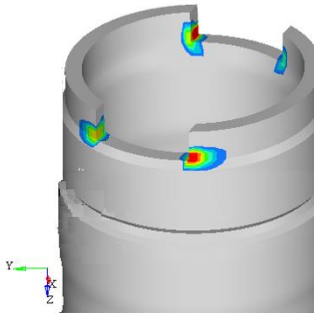
Part 29 TR Simulation vs. Test at Impact

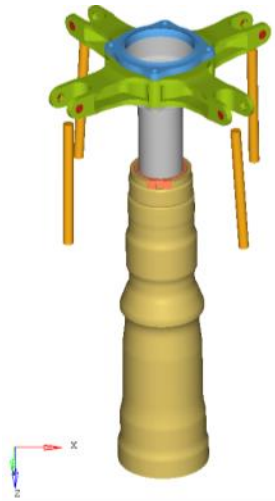


Animation

Bird deformation is similar between analysis & test → Similar Momentum Transfer

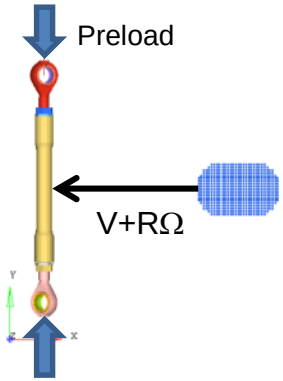
Tail Rotor Crosshead Test

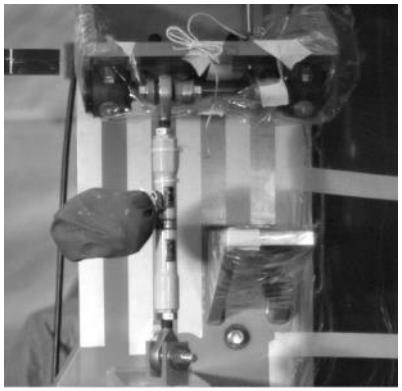
	Shot 01	Shot 02	Shot 03	Shot 04
Shot				
Bronze insert	Shot_01 Insert Time = 0.015 	Shot_02 Insert Time = 0.015 	Shot_03 Insert Time = 0.015 	Shot_04 Insert Time = 0.015 
TR Mast	Shot_01 TR Mast Time = 0.015 	Shot_02 TR Mast Time = 0.015 	Shot_03 TR Mast Time = 0.015 	Shot_04 TR Mast Time = 0.015 

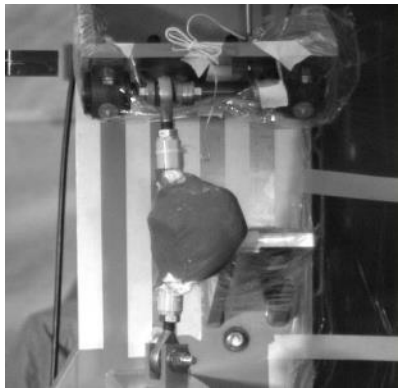


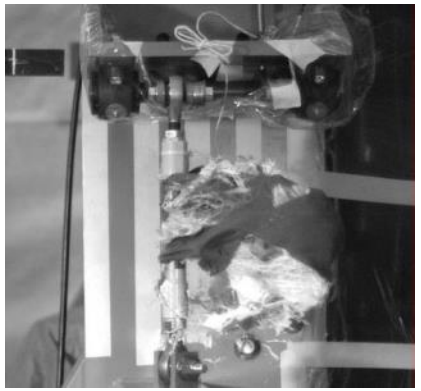
Simulation enables evaluation of most critical shot & part

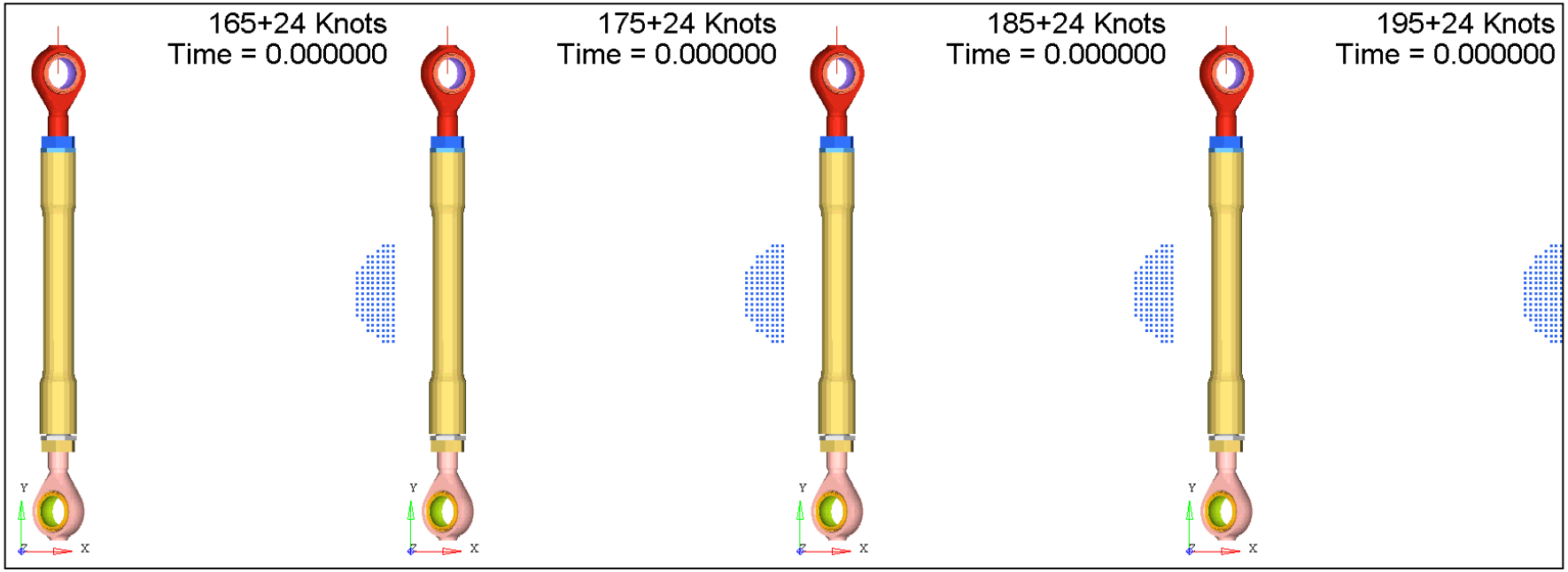
Part 29 MR Pitch Link



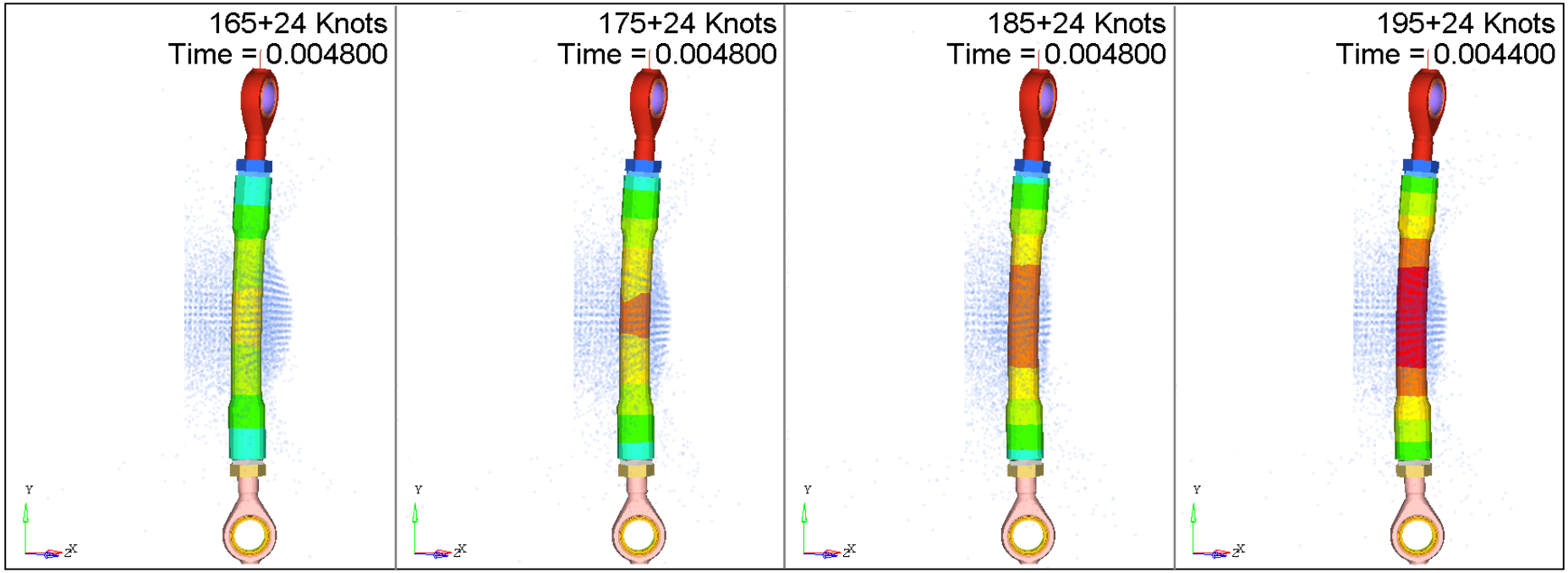








MR Pitch Link – Maximum Displacement

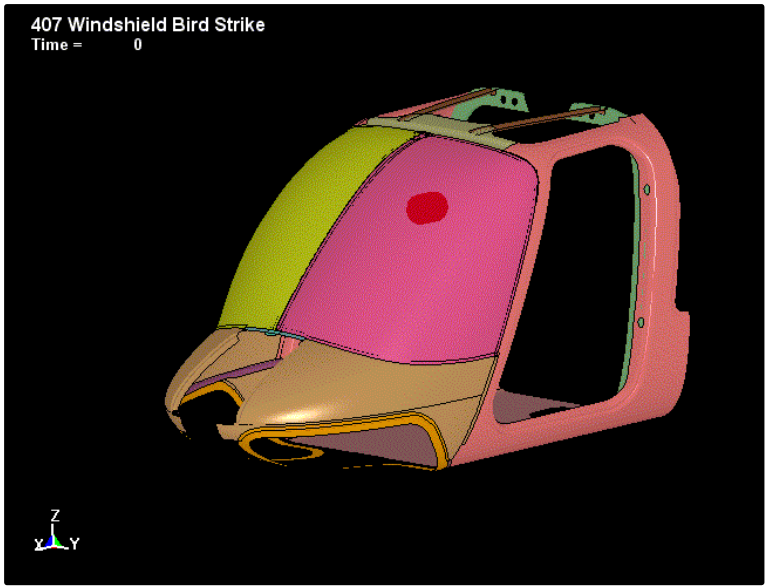


- **Deformation**
  - **Simulation at 188.8 knots predicted max deformation of 0.60 inch, with no permanent plastic deformation**
  - **Test at 188.8 knots confirmed no permanent deformation**

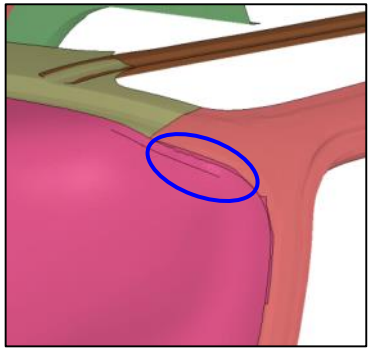
Pretest simulation confirmed by test

Part 27 Windshield Bird Strike

Impact location: upper outboard



Test



Analysis

Simulation closely predicted response with no damage

Bird Strike Virtual Testing

- **Bell Helicopter has matured a method that provides reliable, accurate bird strike simulation.**
- **This method has been validated on airframe and rotor components, composite structures, metallic structures, and windshield transparencies.**
- **Currently being used in certification programs to:**
  - **Optimize designs for bird strike tolerance**
  - **Guide physical bird strike test setups for most critical shots**
- **Enables a path to achieve bird strike certification by analysis, using a validated model.**
  - **Approach could be similar to AC 20-146A *Methodology for Dynamic Seat Certification by Analysis for Use in Parts 23, 25, 27, and 29 Airplanes and Rotorcraft***


Bell
Helicopter
A Textron Company