

Fan Blade Optimization under Medium Bird Strike Load

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Samy Amin

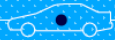
Pratt & Whitney Canada

Arjaan Buijk

Vijay Tunga

MSC. Software Corp.

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Outline

- FEM for Dytran - overview
- Forcing/Transporting Contacts
- FEM Preparation
- Bird Model - Multiple Euler Domains
- Test Calibration



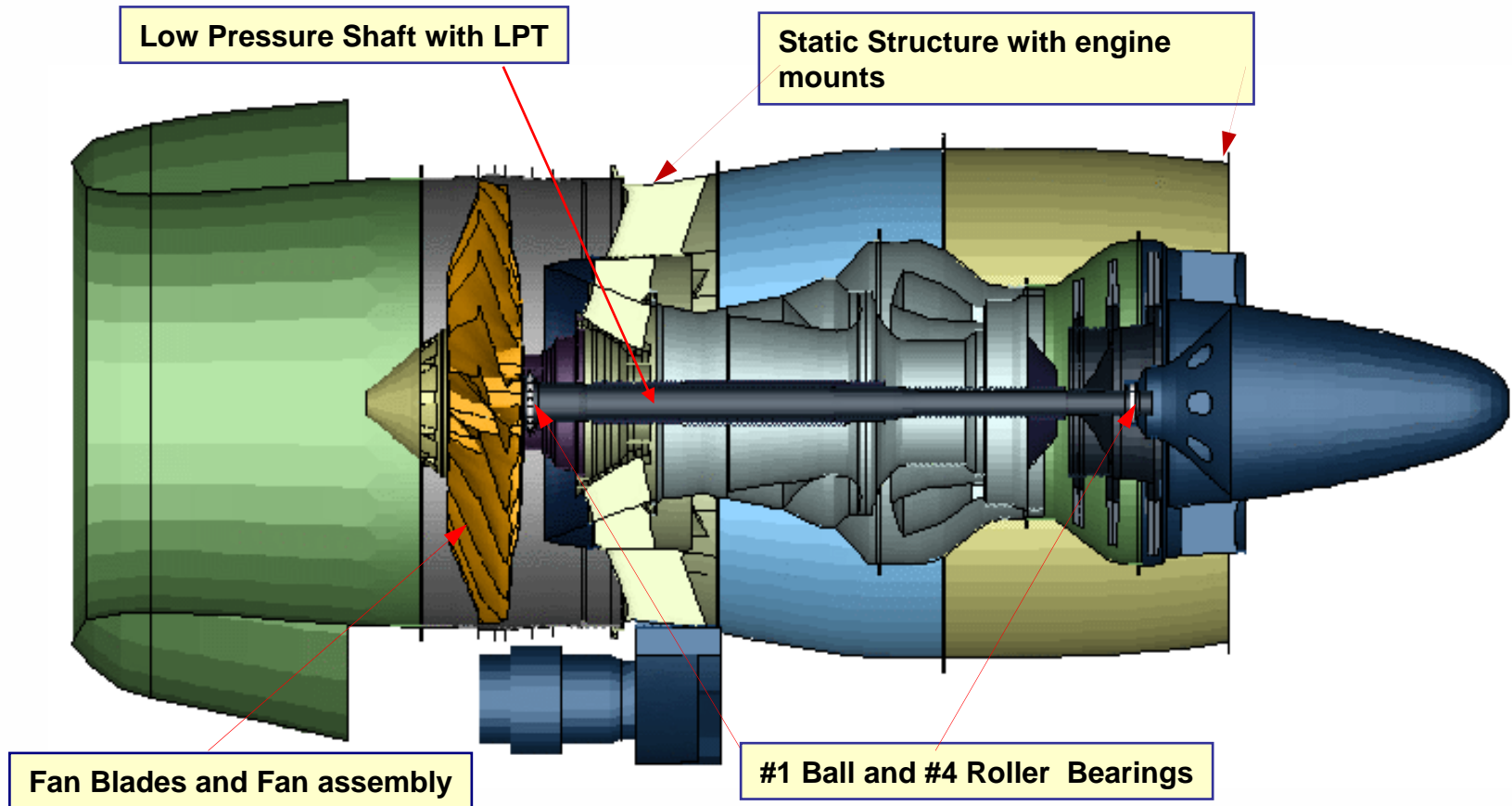
Dytran Overview



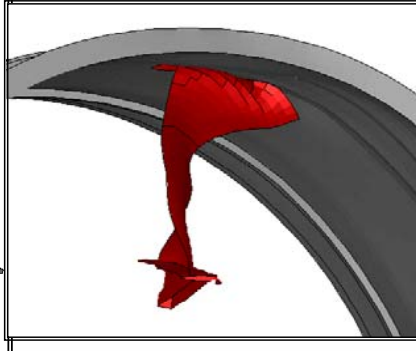
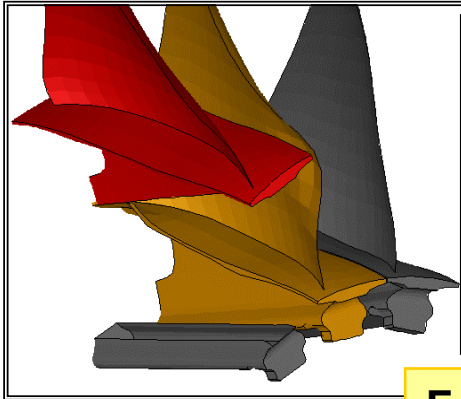
- **General Coupling Algorithm is used to define fluid structure interaction**
- **Structural section is solved by the Lagrangian solver . Fluid section is solved by the Eulerian solver.**
- **Coupling Surface created using structural elements acts as an interface , where forces are transferred between the Lagrangian and the Eulerian solver. The coupling surface has to be a closed volume.**
- **Static and Adaptive Euler mesh are created internally in Dytran**
- **Simulation is carried out in 2 phases**
 - (-) Pre-stress - Blades pre-stressed with centrifugal force**
 - (-) Transient - Bird initialized with translation velocity**
 - Blades initialized with rotational velocity**



FEM for FOD/FBO Analysis



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Forcing Contacts



0.0 ms



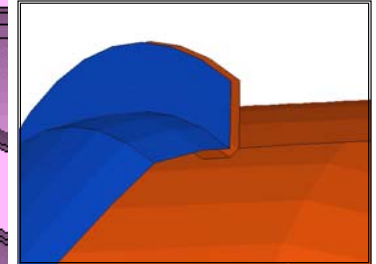
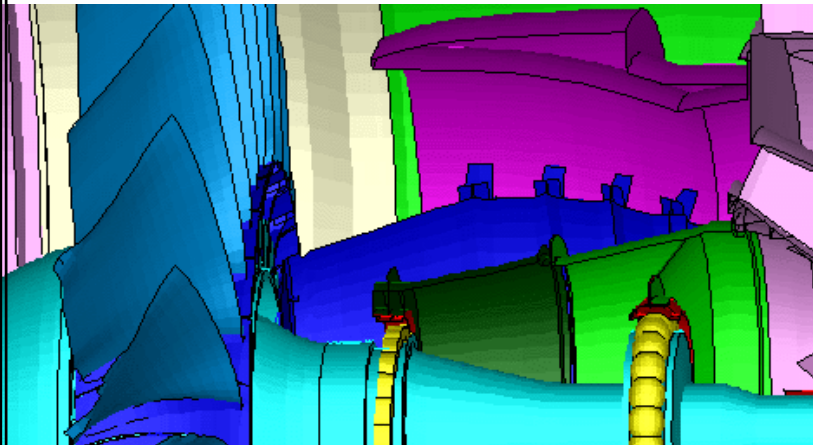
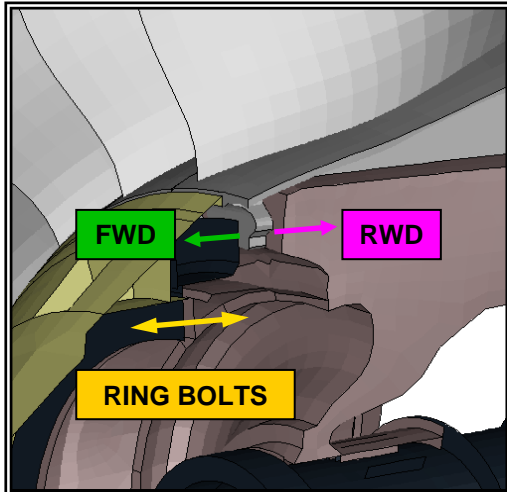
0.5 ms



1.0 ms



1.5 ms

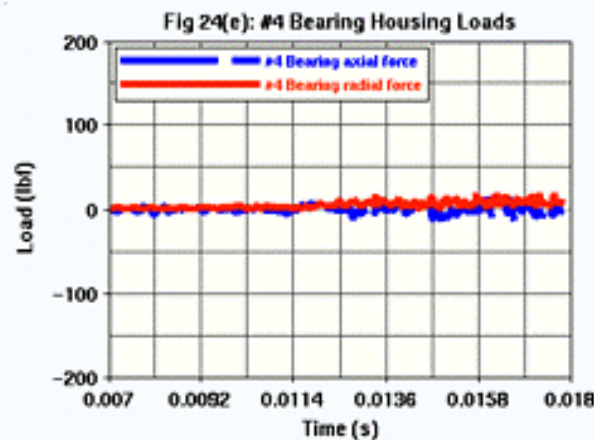
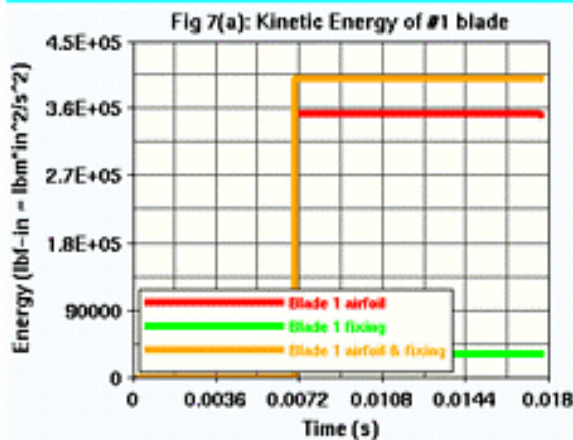
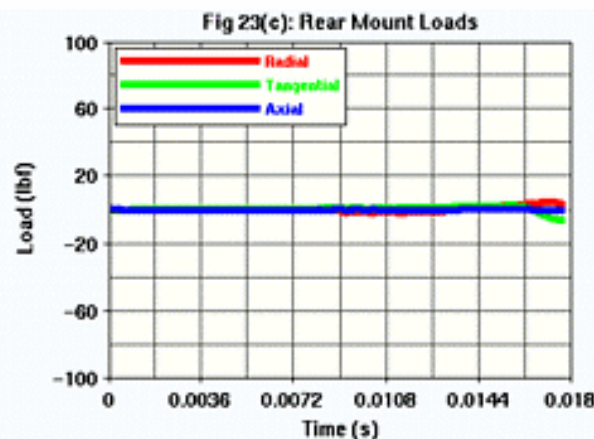
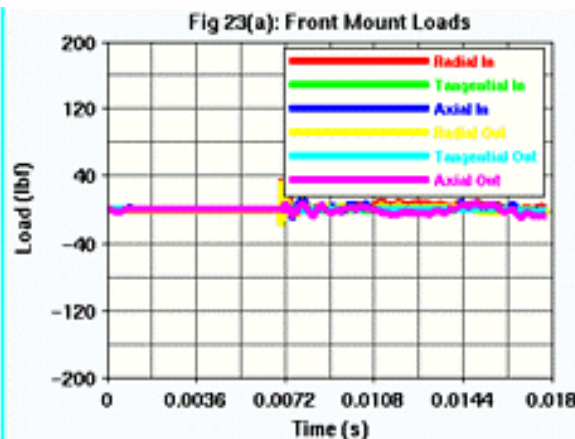
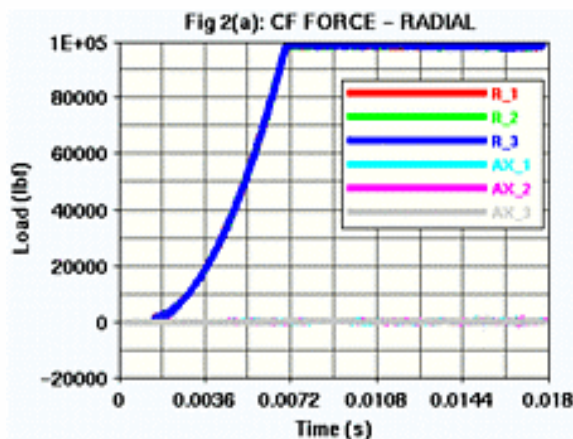


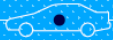
Transporting Contacts

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FEM - Full Engine Steady State Response

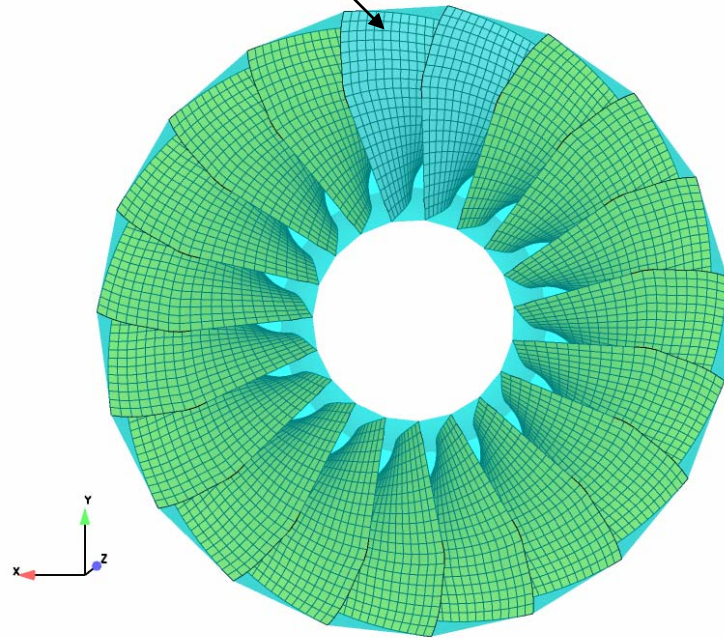
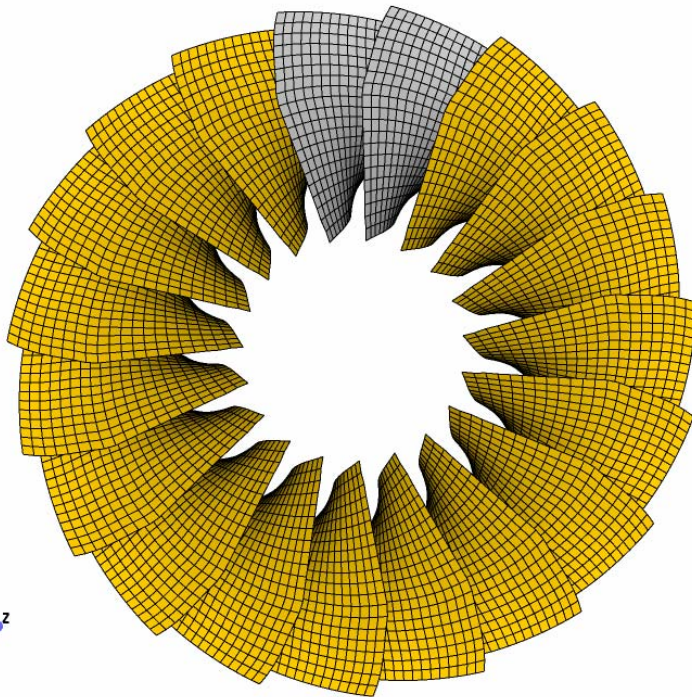
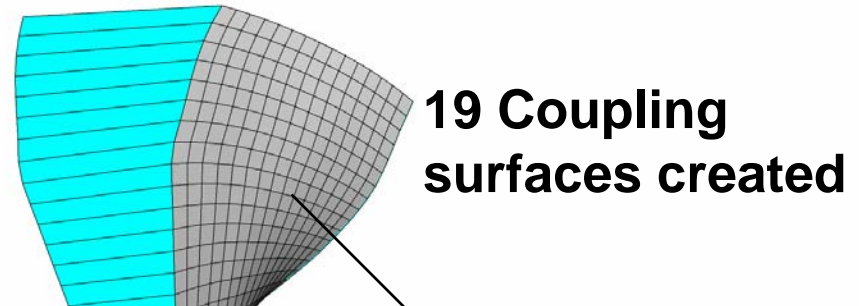




Modeling Techniques



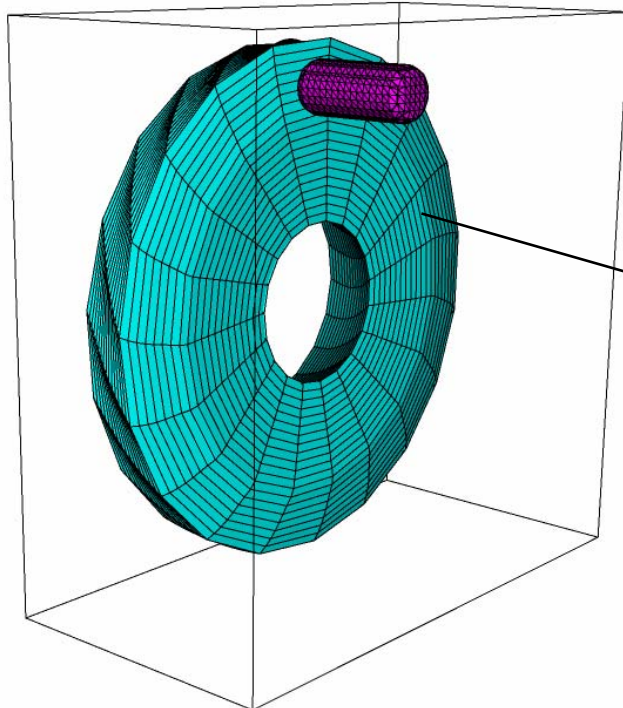
**Creating Closed Volume
between 2 blades with
dummy shells**



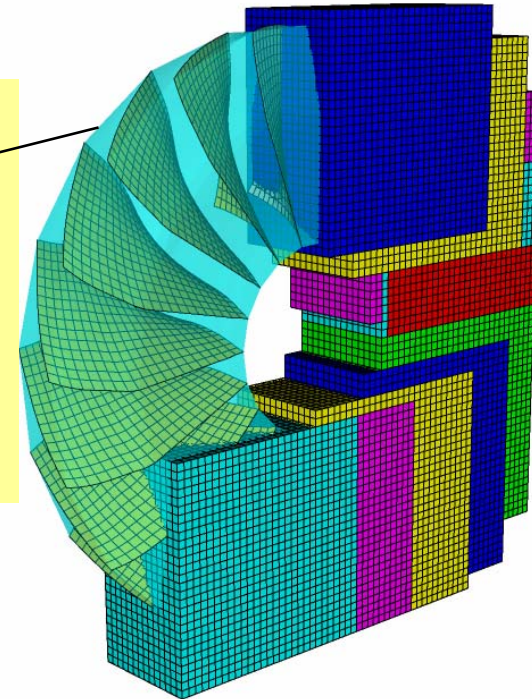


20th Outer Coupling surface created using dummy shells and its associated static euler domain initialized with cylindrical bird

19 inner coupling surfaces and its associated adaptive euler domain



Dummy shells are part of both inner and outer coupling surfaces

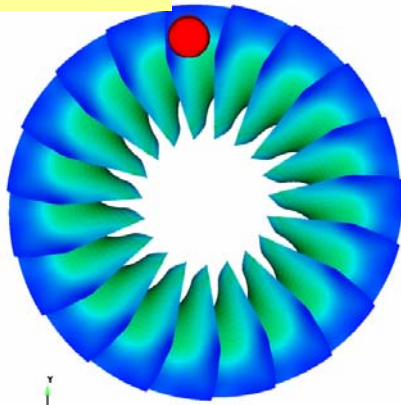


Porosity is defined for the Dummy shells through which bird material is transported from Outer to Inner euler domains and vice versa



Transient Analysis : Bird Strike Analysis

Time = 0.0s

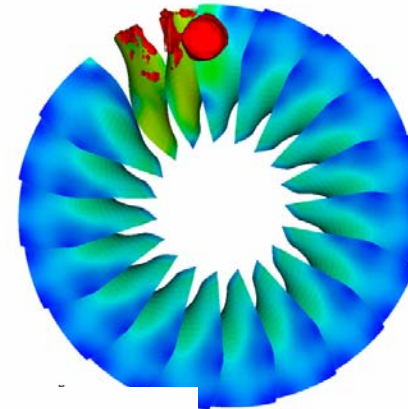


Animation: CEI EnSight



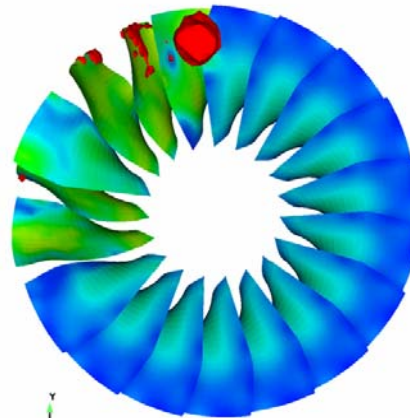
EFFST_IN
1.945e+005
1.459e+005

Time = 0.001s

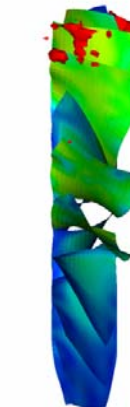


EFFST_IN
1.945e+005
1.459e+005
9.726e+004
4.863e+004
0.000e+000

Time = 0.002s



Animation: CEI EnSight



EFFST_IN
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1.459e+005
9.726e+004
4.863e+004
0.000e+000

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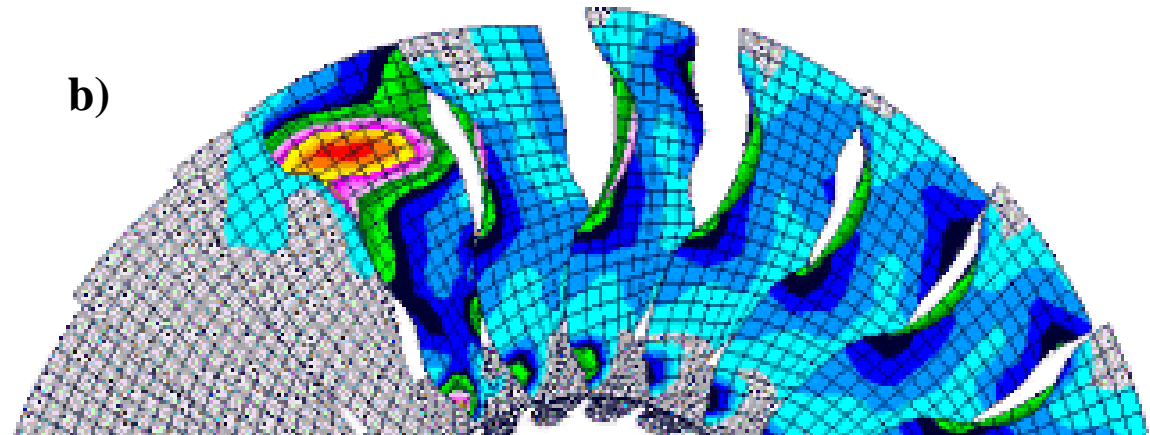


Fan Deformation

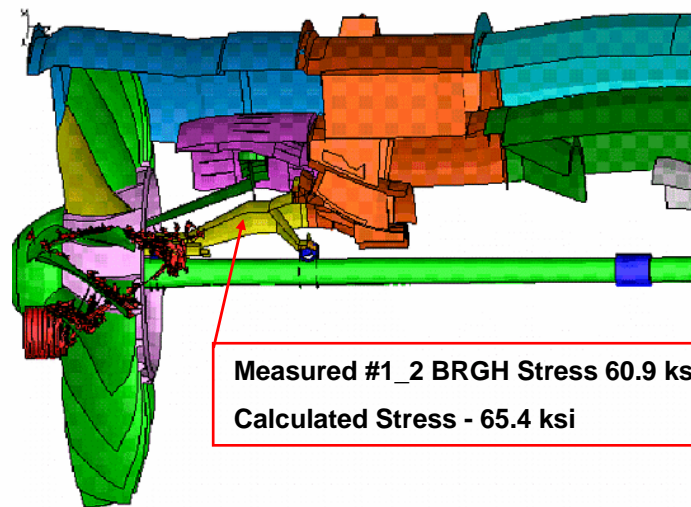
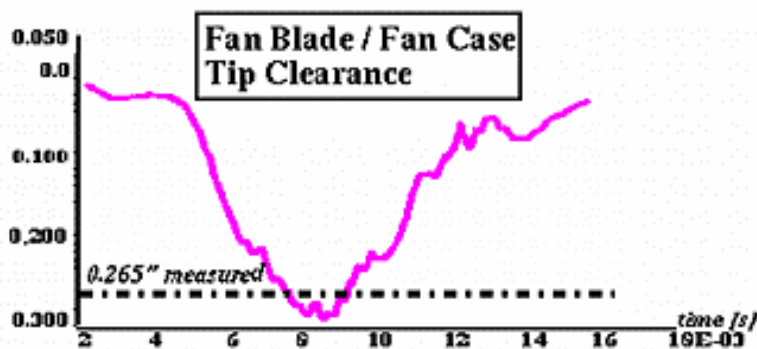
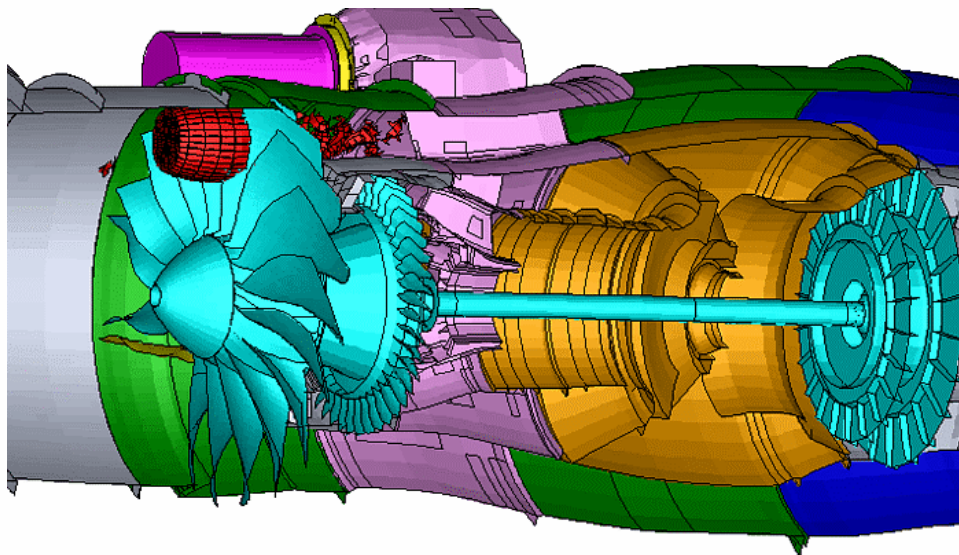


a) - tested

b) - simulation



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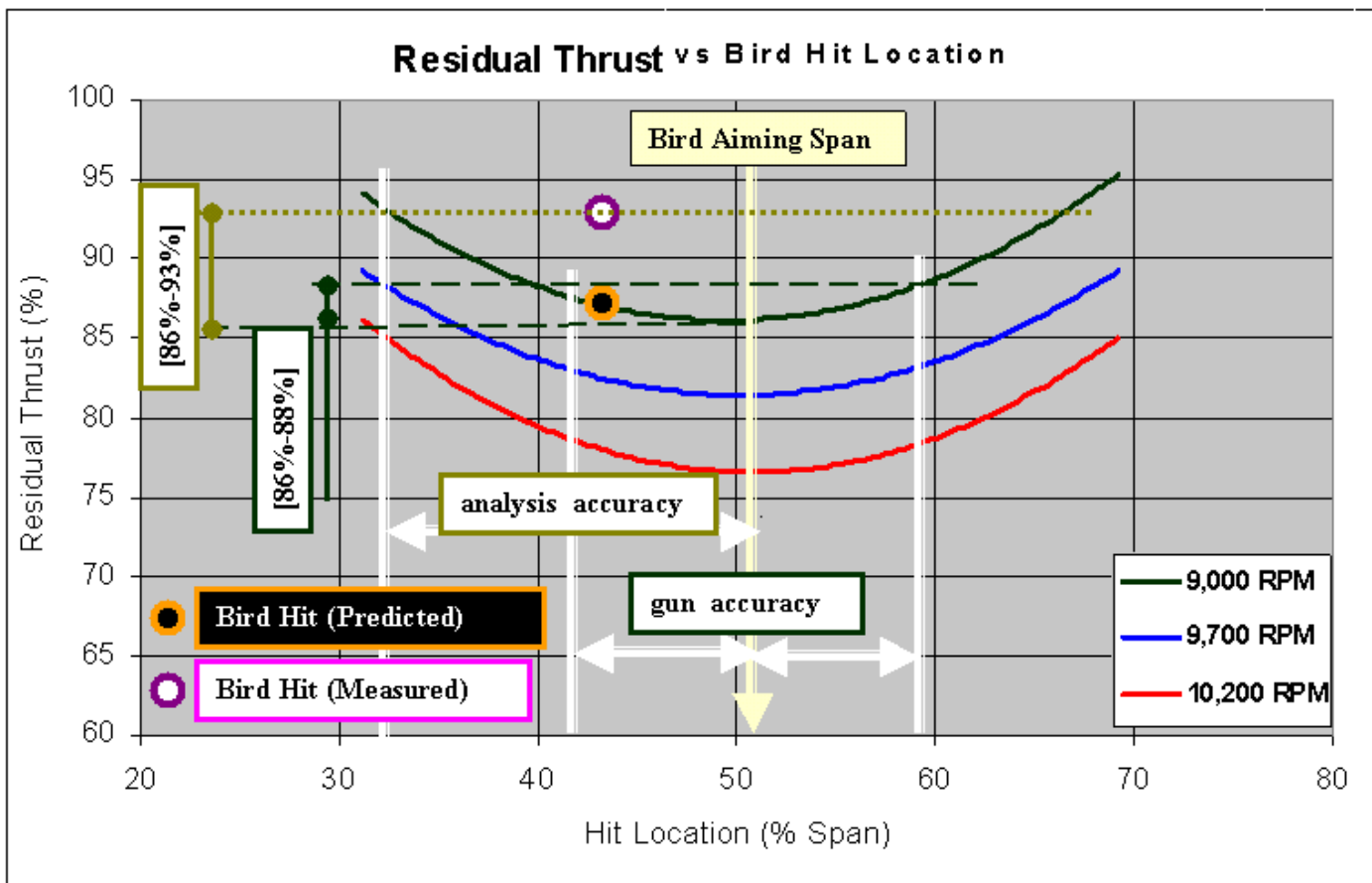
Measured #1_2 BRGH Stress 60.9 ksi
 Calculated Stress - 65.4 ksi

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Residual Engine Thrust Prediction

Medium Bird Strike





Conclusions

- FEM of the full engine model must have steady state response under standard max RPM load before modeling any transient dynamic event.
- The adaptive multiple Euler domain technique, available in MSC.Dytran2005 allows accurate prediction of the blade deformation.
- Fan blade/bird interaction is a forcing contact. Accurate prediction of fan deformation has direct effect on:
 - Unbalanced loads,
 - #1 BR housing and engine mount loads,
 - Residual engine thrust after Medium Bird Strike.