Revolutionary Physics-Based Design Tools for Quiet Helicopters

Georgia Institute of Technology | PENNSTATE 1855

Mission Adaptive Rotor Industry Day
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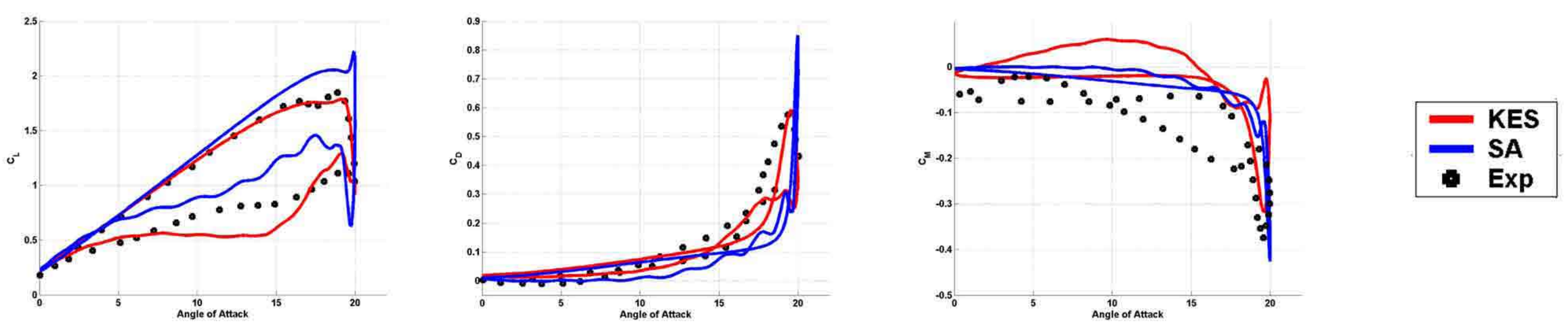
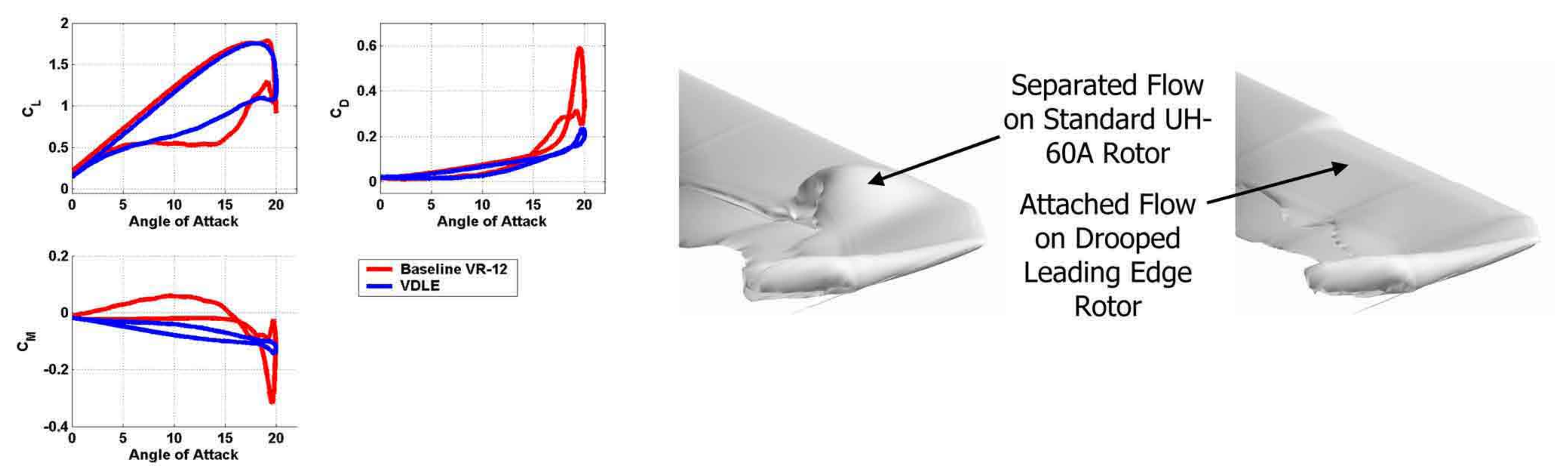
OVERFLOW 2.Oy-GT-HQP

- Modified for Elastic Rotors and CFD-CSD Coupling
- Advanced KES Turbulence Model is a hybrid RANS/LES model for improved dynamic stall (NACA 0012, NACA 0015, SC1095, VR-12) and separated flow prediction
  - VR-12 Dynamic Stall with Wind Tunnel Walls

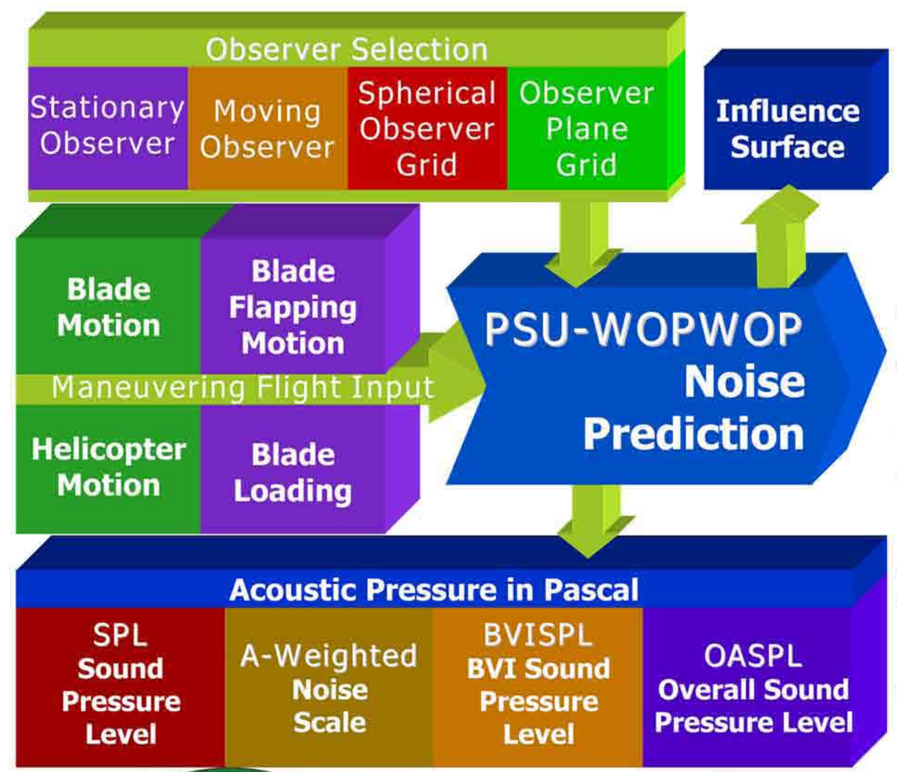


- Elastic Off-body Acoustic Surfaces for High Speed Impulsive Noise Prediction around flexible rotors
- Additional Morphing Rotor Capability validated for drooped leading edge case
  - Tested on a UH-60A Based Rotor showed reduction in stall severity

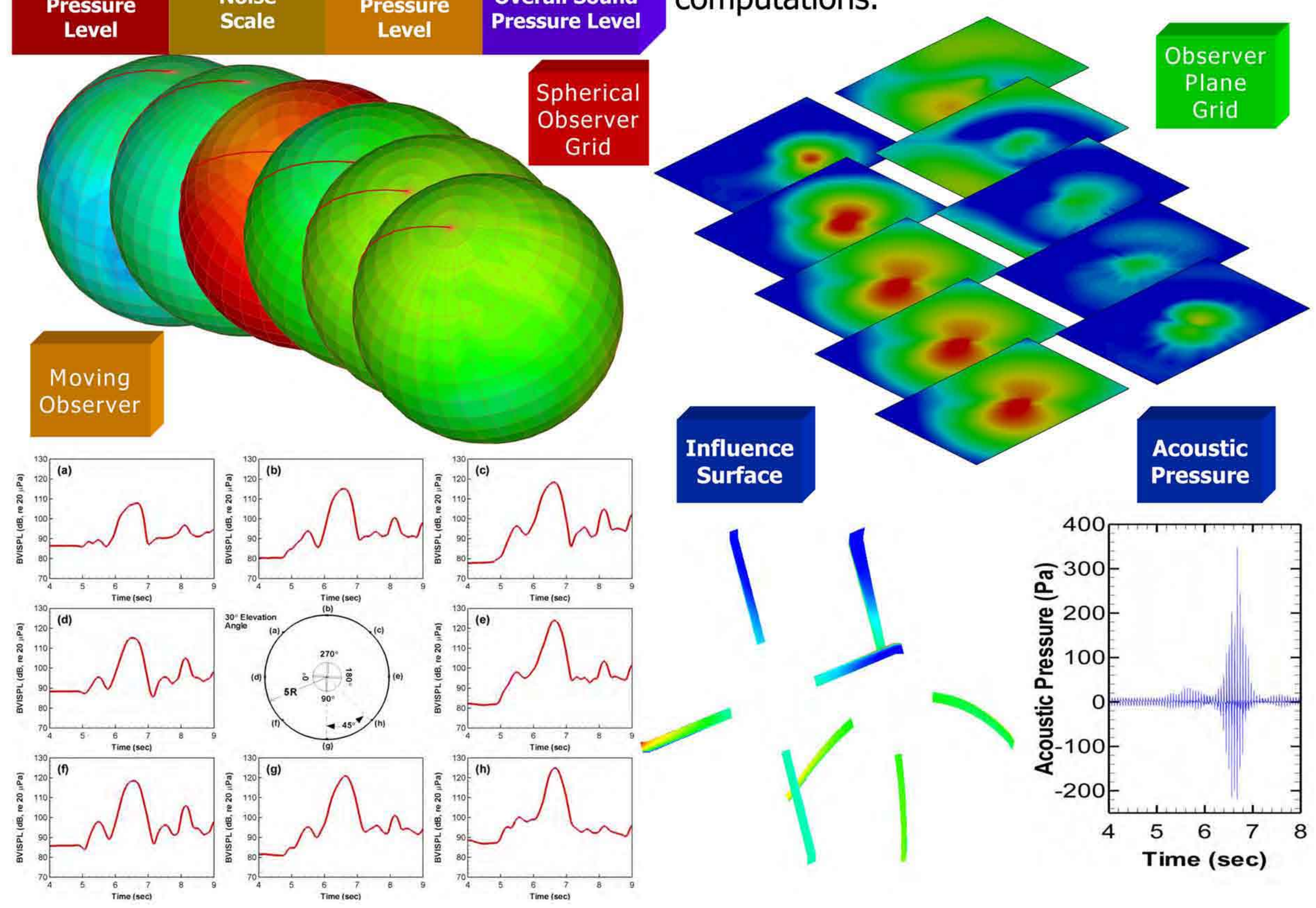


- Configurations Analyzed include:
  - UH-60A Rotor (Baseline and Drooping Leading Edge)
  - HART
  - Comanche
  - Boeing Active Flap SMART Rotor

PSU-WOPWOP

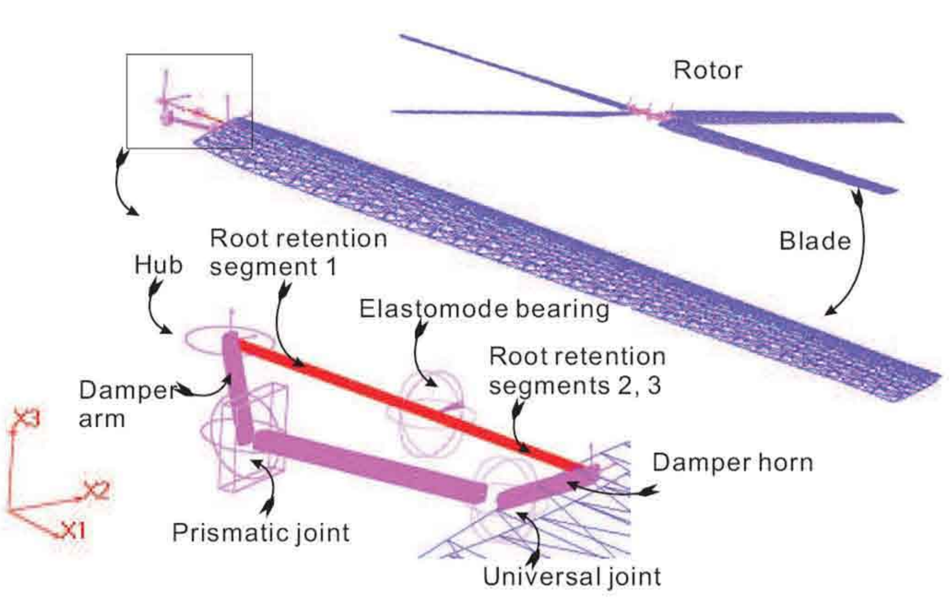


PSU-WOPWOP is a rotor noise prediction code developed for maneuvering flight. It adopts Farassat's retarded-time Formula 1A of Ffowcs Williams-Hawkings equation. PSU-WOPWOP is capable of predicting rotational, BVI, and HSI noise in an efficient way. It can perform near-real time noise prediction for single stationary observer. It is architected to perform noise prediction in both **serial** and **parallel** computations.

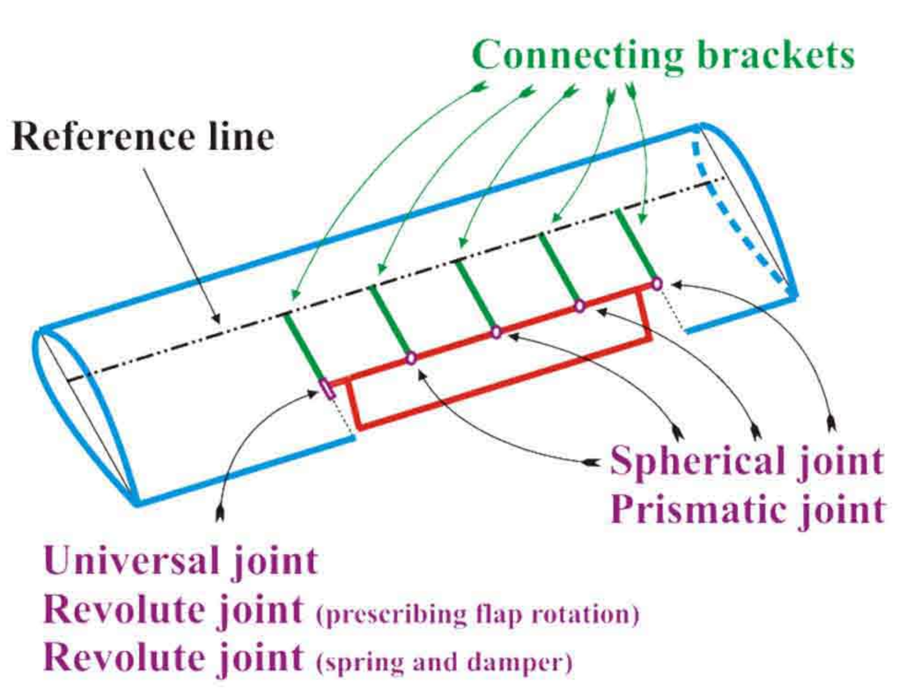


DYMORE

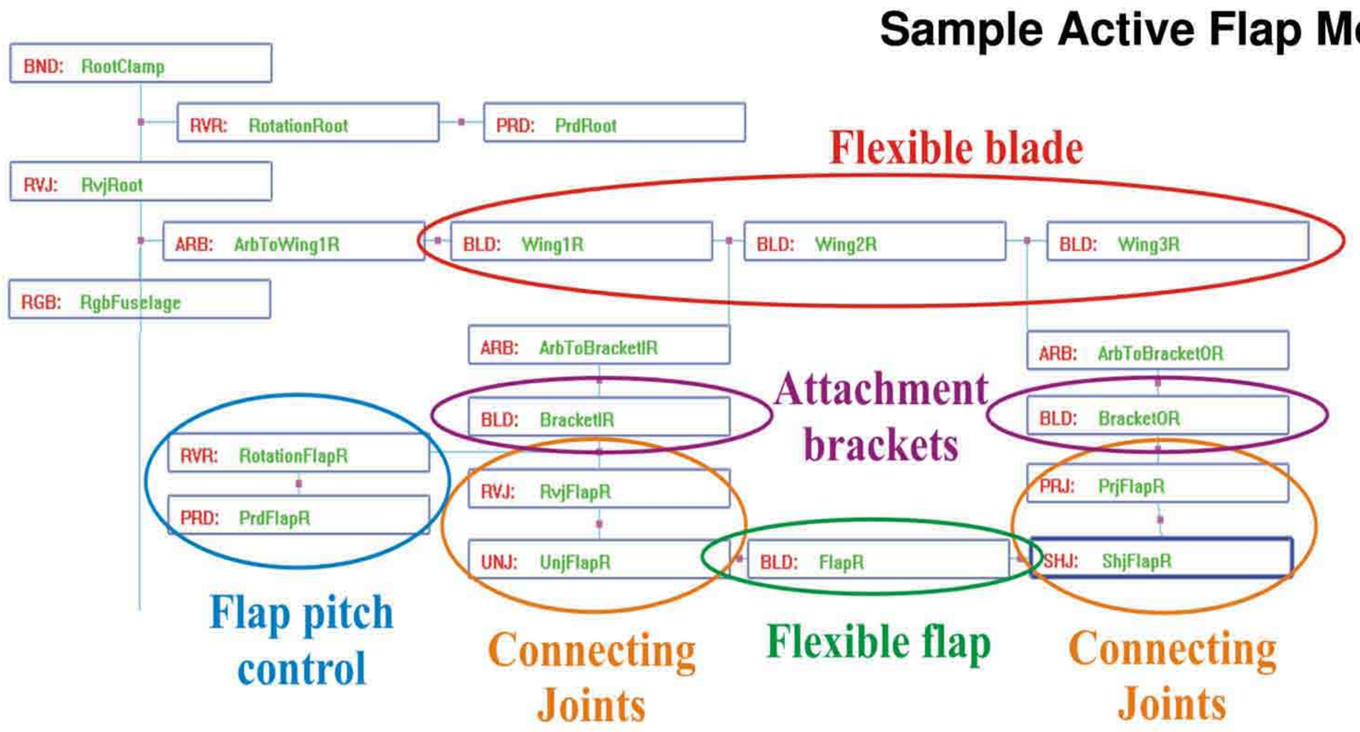
- Developed at Georgia Tech by Dr. Bauchau
- Finite Element Based Multibody Dynamics Tool
  - Large library of simple parts allows detailed physical modeling of active devices
- Sensors can be placed in model to gather forces and displacements
- Autopilot trims rotor using lifting line and/or CFD airloads
- Multiple Lifting Lines for Active Surfaces



Sample Articulated Rotor Hub Model



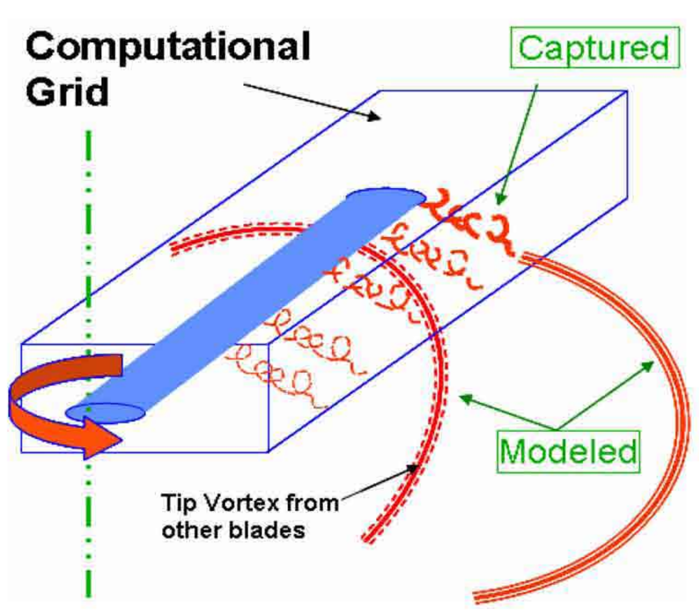
Sample Active Flap Model



Topological configuration of a multibody model

Related Tools

- In House Georgia Tech Hybrid CFD Solvers model the rotor wake using a free wake which reduces the computational and setup time by an order of magnitude to quickly explore the design space
- Gurney Flaps have been shown to reduce the Autorotative Rate of Decent by 35%



		Baseline	30 deg. GF
C_T		3.6×10^{-03}	3.6×10^{-03}
Descent Rate	Shaft Angle	28.9	17.5
	$V_\infty \sin(\alpha_s)/\Omega R$	0.0735	0.0457

- NASA NRA currently on going to develop Control Laws for Next Generation Rotors with On Blade Concepts
  - Active Twist
  - Active Flap
  - Drooping Leading Edge
- Use Reduced Order models based off 2-D CFD
- Integrated Neural Network models in FLIGHTLAB

Summary

- DARPA HQP tools are well suited for analysis of next generation rotor systems
  - High fidelity flow field, airloads, structural dynamics, and noise prediction
  - Added Capability for Morphing Rotors
- DARPA HQP tools have already been used on active flap and leading edge droop rotors
- Surrogate tools have be coupled in this system for faster but lower fidelity predictions