Revolutionary Physics-Based Design Tools for Quiet Helicopters

Mission Adaptive Rotor Industry Day
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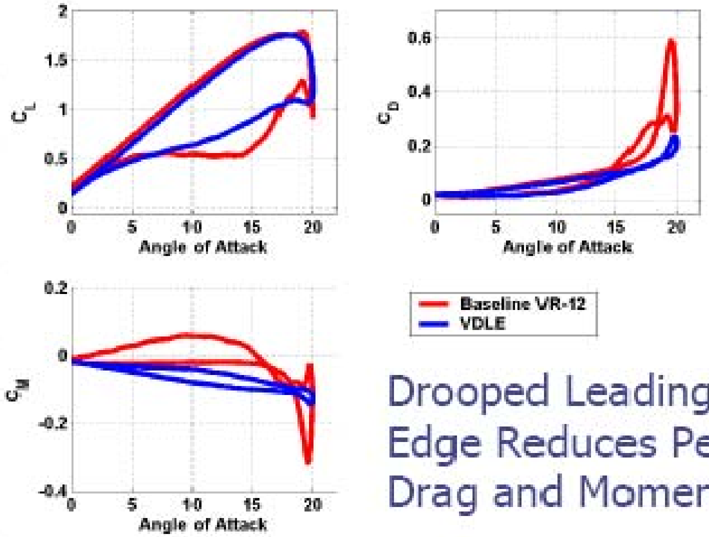
DARAP Helicopter Quieting Program

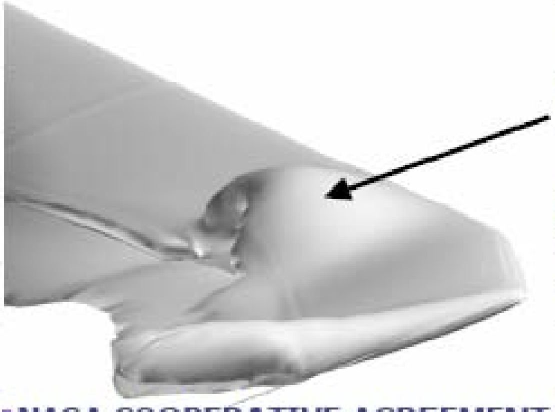
- Phase I
  - Modifications to OVERFLOW 2.Oy for elastic rotors, new turbulence models, acoustics
  - Can exchange airloads in FSI or local blade frame
  - KES Turbulence model is a hybrid RANS-LES model that has shown improved results in dynamic stall
  - Analyzed UH-60A and HART Rotors
- Phase IB
  - Boeing SMART Active Flap Rotor
  - Comanche Rotor
  - OVERFLOW Modifications for Elastic Acoustic Surfaces and SMART Rotor

Mission Adaptive Rotors

- NASA NRA currently on going to develop Control Laws for Next Generation Rotors with On Blade Concepts
- Upgraded OVERFLOW-2.Oy-GT-HQP for Morphing Rotors
  - Generic Capability for drooping leading edge or trailing edge flaps
- Use Reduced Order models based off 2-D CFD
- Integrated Neural Network models in FLIGHTLAB

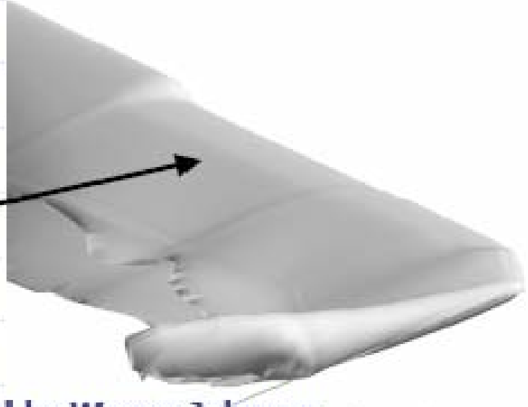


Drooped Leading Edge Reduces Peak Drag and Moment



Separated Flow on Standard UH-60A Rotor

Attached Flow on Drooped Leading Edge Rotor



- NASA COOPERATIVE AGREEMENT: NNX07AP33A Monitored by Wayne Johnson
- AIAA 2008-3872

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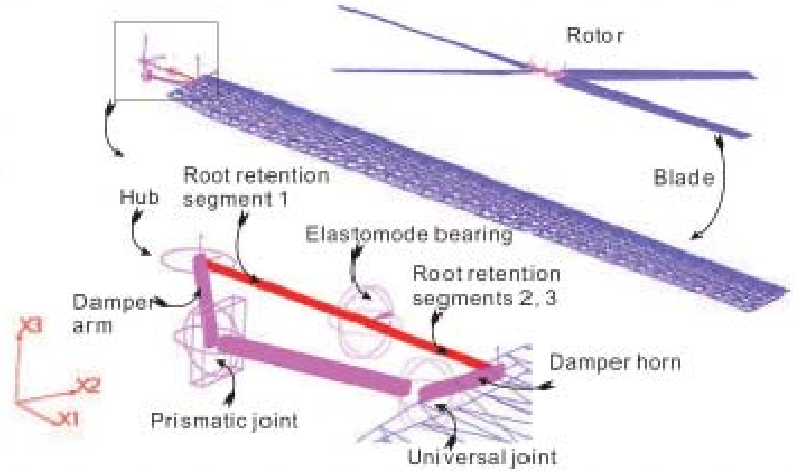
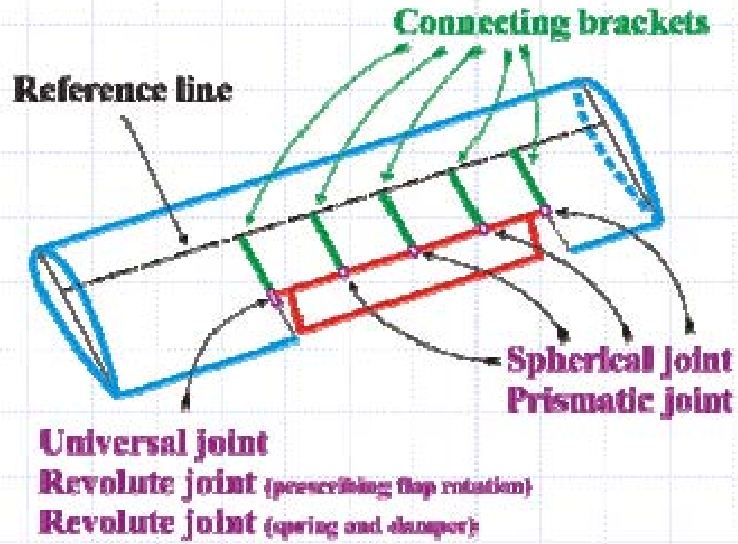
DYMORE

- 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
- Capable of Multiple Lifting Lines for Active Surfaces





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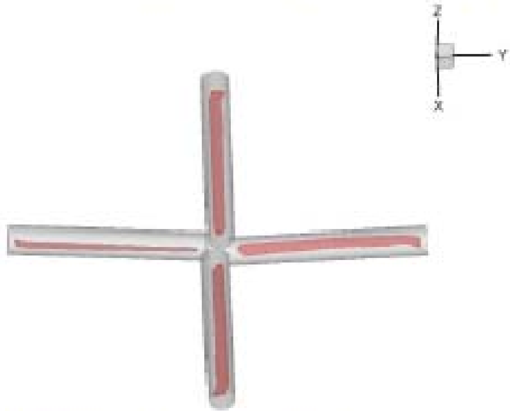
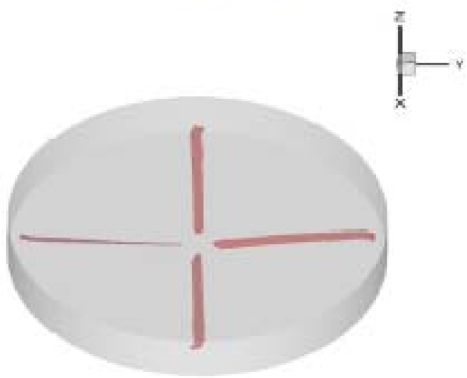
PSU-WOPWOP

- Industry Standard Acoustics Code
- Key Features:
  - Accepts Variety of Input Data Types
    - Lifting Line – fast computations, less accurate, not appropriate for HSI
    - Blade Surface Data – more accurate, best for BVI, not HSI
    - Permeable Off-Body Acoustic Surfaces – appropriate for HSI, can model jets (not turbulence noise)
  - Very complex surface motion, including blade morphing
  - Arbitrary aircraft motion, multiple rotors, maneuvering flight

Blade surface



Rotating permeable surface



Non-rotating permeable surface

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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