Morphing Rotor CFD Modeling Activities at HyPerComp Inc.

DARPA Mission Adaptive Rotor Industry Day
March 3rd 2009

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HyPerComp Inc.

Technology Objective: Provider for start-to-finish CFD modeling support

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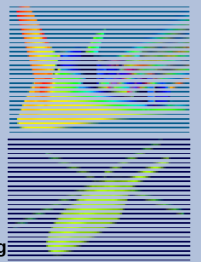
Core Competencies

Computational Electromagnetics
RCS, SAR Imagery and range profiles, Terrain modeling, Antennas, Optics

Computational Fluid Dynamics
Incompressible to Hypersonic flow, Propulsion, Rotorcraft, Acoustics, Morphing structures, Optimization

Magnetohydrodynamics & Plasmadynamics
Flow Control,
Liquid metal MHD – nuclear fusion,
Combustion control

Multiphysical Coupling
Very high order accurate solutions, parallel solvers, Comprehensive CAD-centric Computing



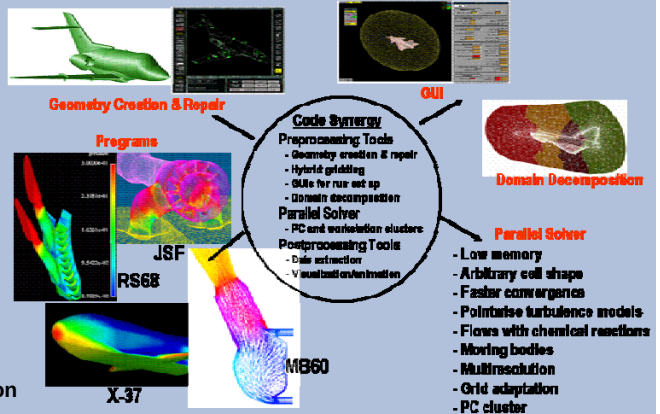
HyPerComp Specializes in the Total Solution Environment

Complete self contained code suite to serve simulation processes from start to finish

Preprocessing
- CAD modeling / repair
- Surface/volume gridding
- Import external formats
- GUI tools
- Parallel run environment

Field Computation
- High order algorithms
- physics-based modeling
- Large-scale simulations

Postprocessing
- Solution/grid visualization
- Animation



Mission
Develop, implement, validate and disseminate user-friendly, high performance computational technologies combining advances in physics-based numerical algorithms and parallel computing hardware for cost-effective simulations of complex, multidisciplinary physical processes in support of defense and commercial product design

Helicopter Quieting Program (HQP) Phase I

TELEDYNE SCIENTIFIC COMPANY
A Teledyne Technologies Company

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IOWA STATE UNIVERSITY

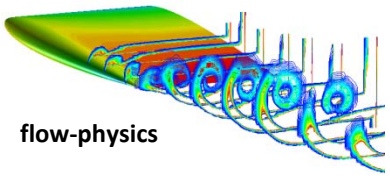
ART

OAI
Ohio Aerospace Institute

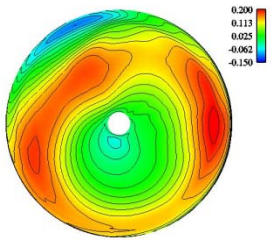
CFD development and support

HyPerComp's Contributions and Rotorcraft CFD Capability Developed

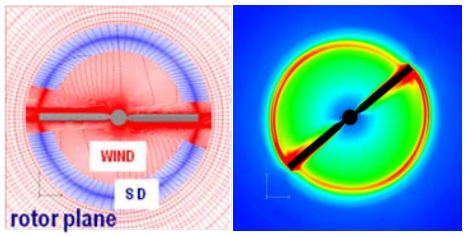
- WIND-US-HELI: Enhanced version of the industrial CFD code, WIND-US, for rotor CFD modeling
- Computational Structural Dynamics (CSD) interface for RCAS
- Acoustics interface for PSU-WOPWOP
- High-low order CFD interface for Spectral-difference code embedding
- Implementation , validation, incorporation of turbulence models including anisotropic non-linear k-ε model
- Grid generation
- Waypoint/milestone airloads and acoustics validations



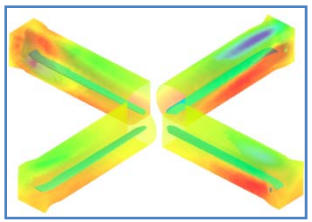
flow-physics



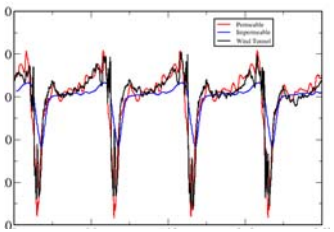
disk-loading



high-low order CFD coupling



acoustics



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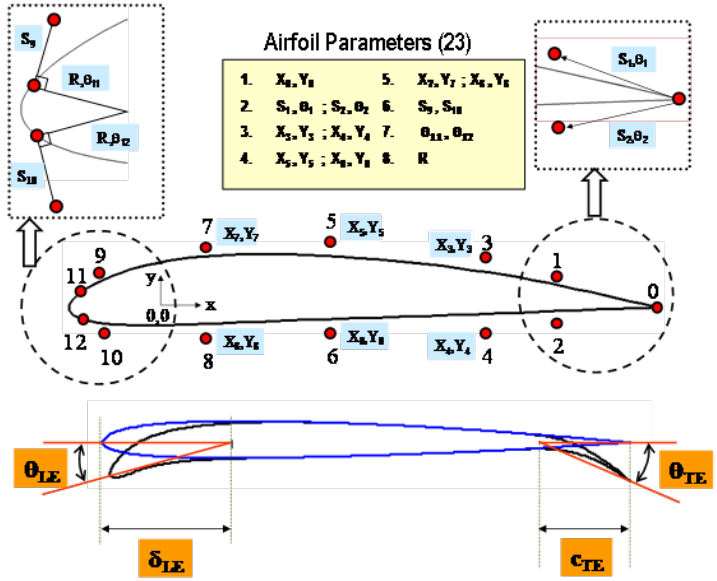
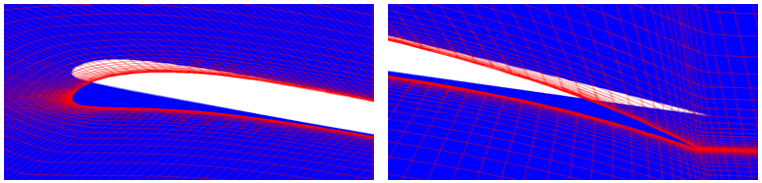
Morphing Rotor CFD Modeling

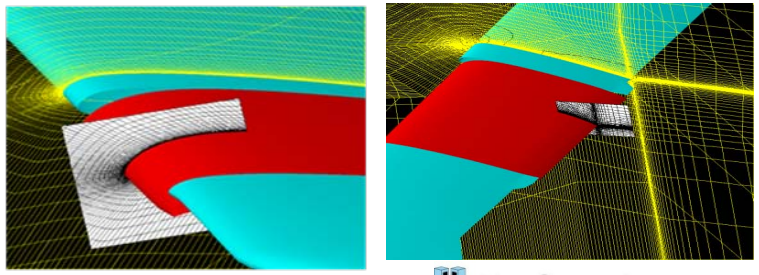
Work supported under Army SBIR Phase-II, PM: Dr. Hyeonsoo Yeo, W911W6-08-C-0061

Post-HQP, new developments in WIND-US-HELI

- Built-in NURBS based parameterization of rotor blade sections to support slow/fast-variation morphing with arbitrary periodic/non-periodic deployment schedules
- Fully supported for unstructured mesh
- Dynamic update of interpolation stencil to transfer sectional forces/moments from CFD to CSD
- MPI (mpich2)-based distributed computing tested for 128-processor-parallel computation
- Ported to 64-bit
- User interface enhancements to better manage large number of production runs







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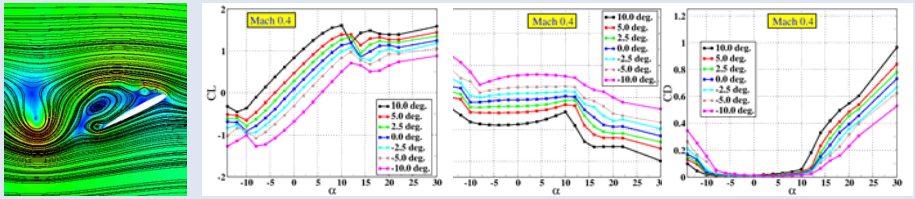
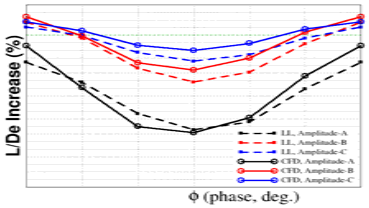
Morphing Rotors Performance Analysis

Rapid design space exploration

CFD-generated airfoil (C_L, C_D, C_M) look-up table generation for M,α,δ (WIND-US-HELI)



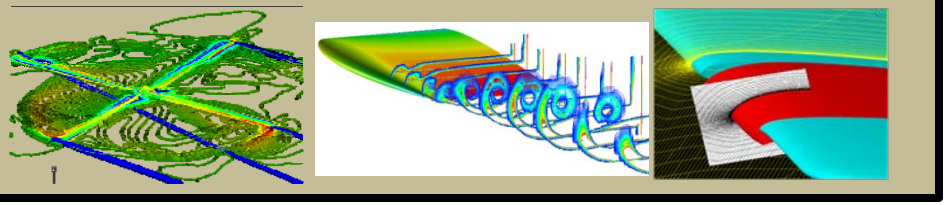
Lifting-line Aerodynamics + Free-Wake Modeling (RCAS)

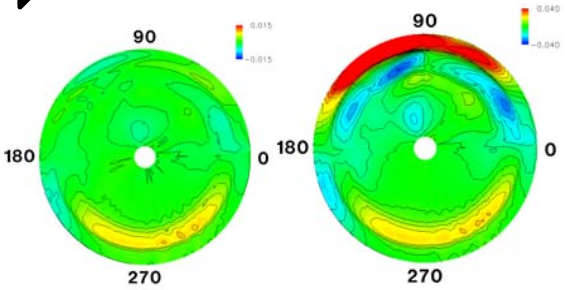


CSD Model (RCAS)

High-fidelity CFD-based Investigation of promising candidates

CFD Aerodynamics (WIND-US-HELI)





CONCEPTS

- **Leading-edge**
- **Trailing-edge**
- **Active-twist**

Expanded presentation in the upcoming 65th AHS Forum paper: "CFD-CSD Analysis of Active Control of Helicopter Rotor for Performance Improvement ", HyPerComp, Univeristy of Maryland, and AFDD, US Army.

The capability can be expanded to include other concepts: tip anhedral, diameter variation, chord extension, winglets etc.

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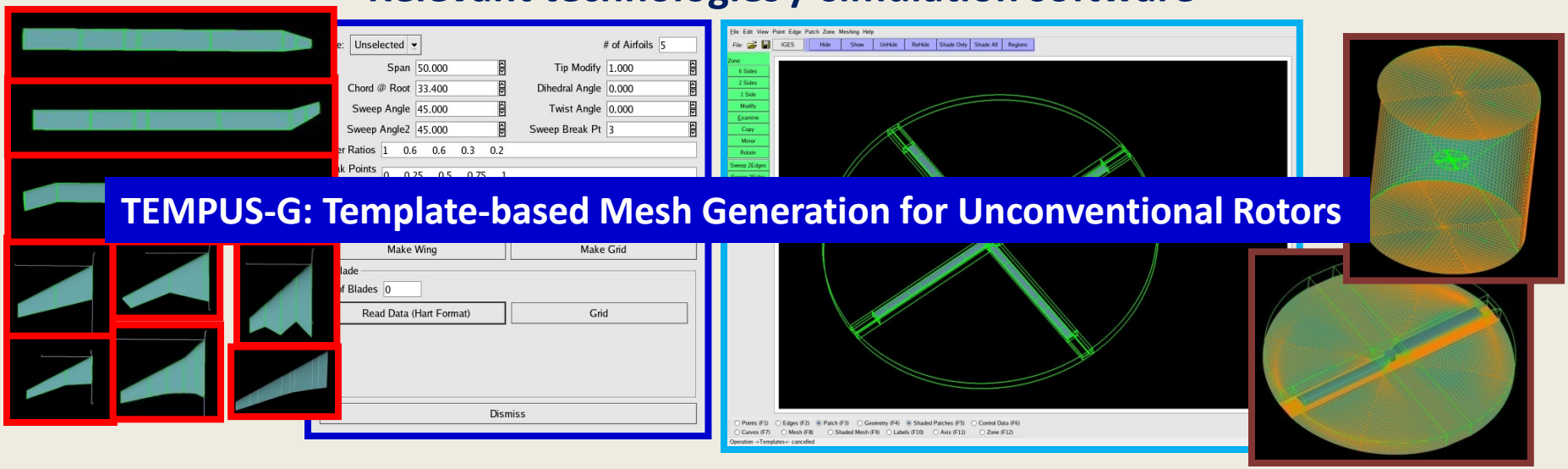
Relevant technologies / simulation software



TEMPUS-G: Template-based Mesh Generation for Unconventional Rotors

Improved surface meshing / geometry clean-up – NAVY SBIR Phase-II

Discontinuous-Galerkin based high-order CFD schemes for diffusion problems – AFOSR STTR

Reduced Basis Method for modeling of complex physical problems – AFOSR SBIR

Uncertainty Modeling in physics-based simulations – AFOSR SBIR

GPU-based programming

What we can contribute for the MAR Program:

Support performance evaluation activities during MAR conceptual/preliminary/detailed-design phases

Software customization to suit customer needs

Start-to-finish simulation support with collaboration with other discipline-specific technology providers

Rotorcraft Simulation Software Environment

TEMPUS-G: Full-featured grid tool customized for unconventional rotors

WIND-US-HELI, RCAS, wide range of CFD/multiphysics modeling codes

More than 128 cores , 64-bit, AMD/Intel based Dell modern blade-servers

DoD Security Clearance certified facility

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