# Advances in Computational Algorithms for Complex Physics

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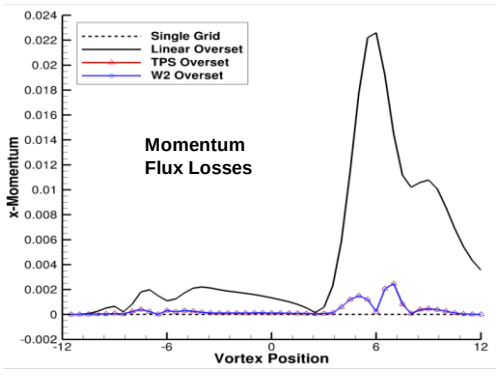
## Background and Motivation

- Understanding of and numerical simulation of complex physics associated with vertical lift requires innovative algorithm design to achieve transformative results
- Group is attacking complex issues: near and far wakes from static and rotating components; dynamic stall, transitional flows, prediction/mitigation of separation in strong adverse pressure gradients
- Approaches include:
  - Large-eddy (LES) and hybrid RANS-LES simulations with cross-flow transition
  - Mesh and temporal adaptation of time-accurate simulations with overset structured -unstructured meshes
  - Improved algorithm fidelity for overset URANS and hybrid mesh interpolation, as well as conservative, consistent fluid-structure interaction data transfer

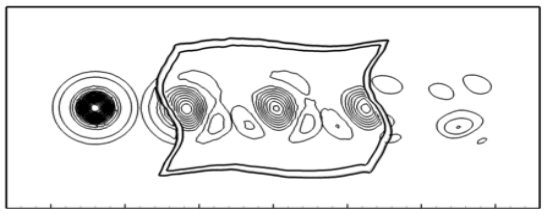
## Recent Innovations

**Cloud-based** high-order **interpolation** for structured and unstructured meshes:
- Maintains interpolation accuracy
- Eliminates orphans
- Mitigates unsteady transient conservation errors



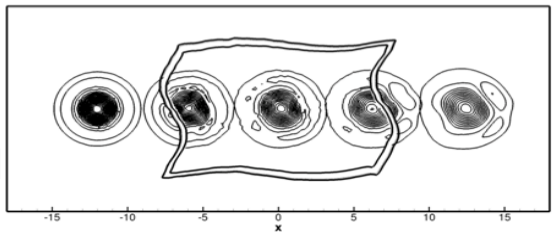

**Trilinear interpolation** between overset grids **with orphans**

**Massflow error: O($10^{-4}$)**



**RBF interpolation** between overset grids **with orphans**

**Massflow error: O($10^{-6}$)**



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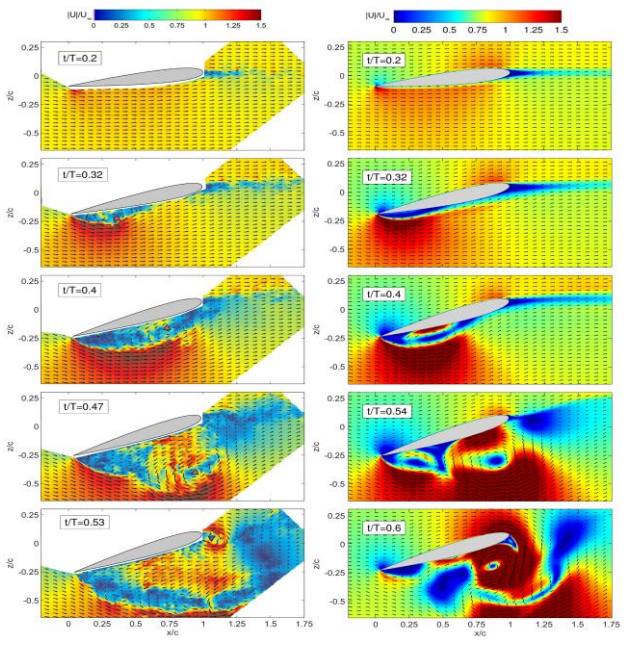


**Consistent transition and turbulence closures** for hybrid URANS-LES and LES solvers
- Maintains consistency in formulation across closures
- Locally computed coefficients – removes ad-hoc user-definitions and need for sample problem tuning
- Includes full 3D physics, including cross-flow transition
- Successful application to transient (surge) flows*; dynamic stall in reverse flows*; fuselage separation; rotor transition

*Papers at the 2015 AHS Forum

Comparison of a NACA0012 in reverse flow dynamic stall with experiment (left) and CFD (right). Experimental data courtesy of collaborators Dr. Anva Jones and Andrew Lind, UMD.

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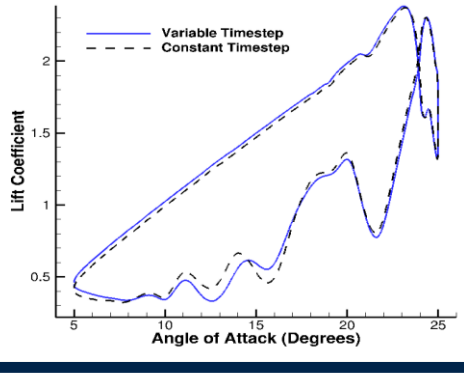


**Temporal and spatial adaptive schemes:**
- Permit 50-70% reduction in cost for dynamic stall without loss of accuracy
- Captures far wakes and overset features with LES

**Sponsor: Army Research Office (ARO)**