Department of the Navy SBIR/STTR Transition Program

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Topic # N132-092

Multiscale Lagrangian-Eulerian Algorithm for Determining the Vorticity Confinement Term for Rotorcraft Computational Fluid Dynamics (CFD) Computations

D&P LLC

WHO

SYSCOM: NAVAIR

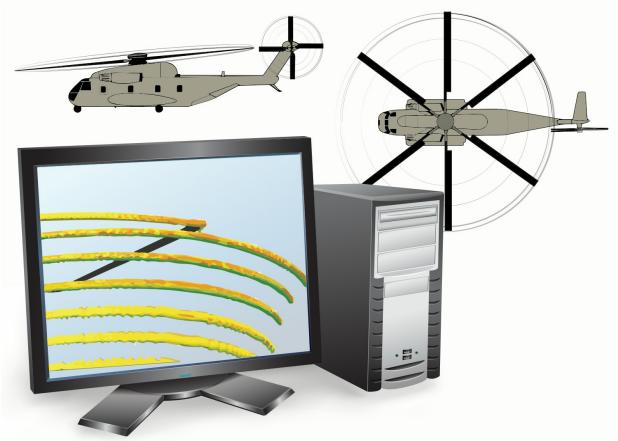
Sponsoring Program: H-53 Heavy-Lift Helicopters Program Office (PMA 261)

Transition Target: CH-53E Super Stallion, CH-53K King Stallion

TPOC:
(301)757-9638

Other transition opportunities: H-60; MH-60R Seahawk, MH-60S Seahawk; V22 Osprey;: MV-22 Osprey, CV-22 Osprey; H-1 USMC Light/Attack Helicopters: UH-1N, UH-1Y, AH-1W, AH-1Z; H-46 Sea Knight: H-46 Sea Knight

Notes: Iso-surfaces of azimuthal component of vorticity for Blackhawk blades (Tip Mach number=0.63, Collective angle=9)



The tip vortices captured by D&P's vorticity-confinement method

WHAT

Operational Need and Improvement: With rapidly growing computing power, DoN starts to actively pursue the first-principal approach like Computational Fluid Dynamics (CFD) for prediction of rotor airloads, performance, aeroelasticity and noise. However, it is well known that the tip vortex structure predicted by CFD is very diffused if there is no sufficient grid resolution in the tip vortex region. DoN needs this technology to accurately preserve the tip vortex in the computation without excessive grid refinement.

Specifications Required: No adjustable parameters for achieving an accurate prediction

Technology Developed: A multi-scale Lagrangian-Eulerian algorithm has been developed during Phase I to determine the vorticity confinement term for rotorcraft CFD computations. Similar to the Large Eddy Simulation approach, the present algorithm simulates the large scales in the flow field with the Eulerian approach and models the unresolved small scales like the tip vortices with the Lagrangian approach. The effects of the unresolved small scales are included into the governing equations as the Vorticity Confinement terms. As a result, excessive refinement in the tip vortex region is no longer needed to achieve an accurate computation. The feasibility study of the UH-60A main rotor with the Blackhawk blades was successful, demonstrating the capability of the proposed algorithm for accurate prediction of both size and location of the rotor tip vortices. During Phase II, we will further refine this algorithm and apply it to simulate the heavy-lift helicopter CH-53E rotor blades.

Warfighter Value: This technology can significantly reduce the required computational effort and the turn-around time from months to days. A mechanism is also embedded in this approach to achieve the accurate prediction of the wake trajectory. This technology can be used to optimize designs, improve reliability and increase performance of helicopters.

WHEN

Contract Number: N68335-15-C-0103 **Ending on:** January 30, 2017

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Prototype methodology/Proof-of-concept Study	N/A	Blackhawk blade case (4 blades)	3	April 2014
Extension to heavy-lift rotor case	Med	CH-53E blade case (7 blades)	4	March 2016
Extension to viscous flows	Med	Blackhawk blade case (4 blades)/CH-53E blade case (7 blades)	4	March 2016
Extension to the complete helicopter	Low	CH-53E helicopter	6	January 2017

HOW

Projected Business Model: D&P will implement this technology into our flagship CFD software, FlowSimulator(TM). While we provide this software to NAVAIR free of charge, we plan to license the software to the primes like Sikorsky aircraft, Bell helicopter, and Boeing.

Company Objectives: D&P is looking for potential customers to test our CFD software product, FlowSimulator(TM), with the goal to license it.

Potential Commercial Applications: Aerospace engineers in helicopter industry can use this software for helicopter designs and mechanical engineers in wind turbine industry can use this software to design the turbine blades

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