Department of the Navy SBIR/STTR Transition Program

Topic # N14A-T005
Software developments for large-eddy simulations on GPU-accelerated systems
Cascade Technologies Incorporated

WHO

SYSCOM: NAVAIR

Sponsoring Program: NAWCAD Propulsion and Power; PEO (A)

Transition Target: NAWCAD Propulsion and Power; DoD High Performance Computing Modernization Program (HPCMP)

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Other transition opportunities: Aerospace Defense Industry OEM; Commercial Aerospace Companies

Notes: Colored oil smoke visualization on the outside of the CH-53K King Stallion and simulation of the engine flow performed by NAVAIR with Cascade's "CharLES" software. These efforts validated a modification mitigating Exhaust Gas Re-ingestion for the new Marine Corps aircraft.

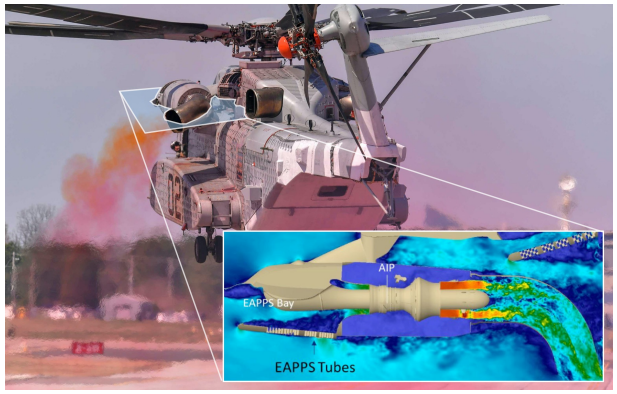

Photo courtesy of US NAVY (https://www.navair.navy.mil/news/Joint-Team-Solves-Engine-Integration-Issues-CH-53K-King-Stallion/Tue-12172019-0903). Image courtesy of NAVAIR (AIAA paper 2021-0030, NAVAIR Public Release 2020-930. Distribution Statement A -

WHAT

Operational Need and Improvement: The US government continues to invest in high performance computing (HPC) systems to advance the nation's ability to perform scientific computing workloads. In recent years, the use of accelerated architectures, e.g., graphical processing units (GPU), has become a dominant feature of these new and future systems. However the development of GPUs or other accelerators (e.g., Google/'s Tensor Processing Units) has been driven in large part by the exponential increase in the computational requirements associated with machine learning (ML) and artificial intelligence (AI) applications at a rate that has far outstripped the growth of traditional scientific workloads, such as Computational Fluid Dynamics (CFD).

Specifications Required: To ensure the best return-on-investment for these procurements, CFD software must be rewritten to optimally leverage these new architectures and provide state-of-the-art computational modeling methodologies. A key requirement is to accelerate simulation throughput and cut down on time-to-solution in order to broaden the use of the predictive large eddy simulation (LES) technology for practical fluid mechanics problems relevant to government agencies and industrial OEMs.

Technology Developed: To provide fast and accurate simulation capabilities that fully leverage existing (and future) HPC-GPU systems accessible by NAVAIR, Cascade Technologies is developing a GPU-accelerated version of its flagship high-fidelity multi-physics large eddy simulation software “CharLES”. The technology will be implemented in both static and moving-mesh flow solver and applied initially towards predictions of high-speed flows and rotorcraft aerodynamics and aeroacoustics. Compared to traditional HPC CPU-based approach, the reduction in computational cost (or increase in computational throughput) is expected to be more than an order of magnitude.

Warfighter Value: The developed GPU-accelerated simulation tools will enable the investigation of rotorcraft designs with increased performance, efficiency, and reliability at a much lower computational cost and shorter timeline. As more multi-physics capabilities are migrated into the GPU-accelerated LES framework over time, the use of the technology can expand to aircraft and engine component design studies to further reduce development schedules as well as sustainment costs.

WHEN

Contract Number: N68335-21-C-0270 **Ending on:** February 16, 2023

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Static-mesh GPU-accelerated flow solver	Low	Validation of prediction accuracy for canonical cases and high-speed flow applications; BETA-release of the static-mesh GPU-accelerated software to NAVAIR	5	September 2021
Moving mesh building on GPU architecture	Med	Implementation and testing of dynamic moving-mesh builder in the GPU-based framework. Verification of scalability and performance improvement with GPU-accelerated technology	4	May 2022
Moving-mesh GPU-accelerated flow solver	Med	Fast and accurate simulation of realistic rotorcraft configuration; Beta-release of the static and moving-mesh GPU-accelerated software to NAVAIR	5	February 2023

HOW

Projected Business Model: The business model is to license the developed GPU-accelerated LES software directly to the Navy/government and commercial customers (Aerospace and Automotive OEMs)

Company Objectives: The main objective is to transition the developed technology through software licensing, for a consistent and sustainable source of support for the software maintenance and future developments. A secondary objective is to open markets using similar moving-mesh technology adjacent to rotorcraft applications (e.g., turbomachinery) and connect to Aerospace OEM's working with the US Navy.

Potential Commercial Applications: In addition to rotorcraft simulations, there is a wide range of engineering applications of interest to both government and industry that would benefit from the significant reduction in computational cost and time-to-solution with the developed GPU-accelerated LES technology including aeroacoustics, external aerodynamics, turbomachinery and combustion dynamics applications.

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