Department of Defense
High Performance Computing Modernization Program

Modernizing the Warfighter

HPCMP ANNUAL HIGHLIGHTS FY2019/2020

The DoD HPCMP provides science and technology (S&T), test and evaluation (T&E), and acquisition engineering community customers with a full ecosystem to address their most challenging problems.

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Department of Defense
High Performance Computing
Modernization Program

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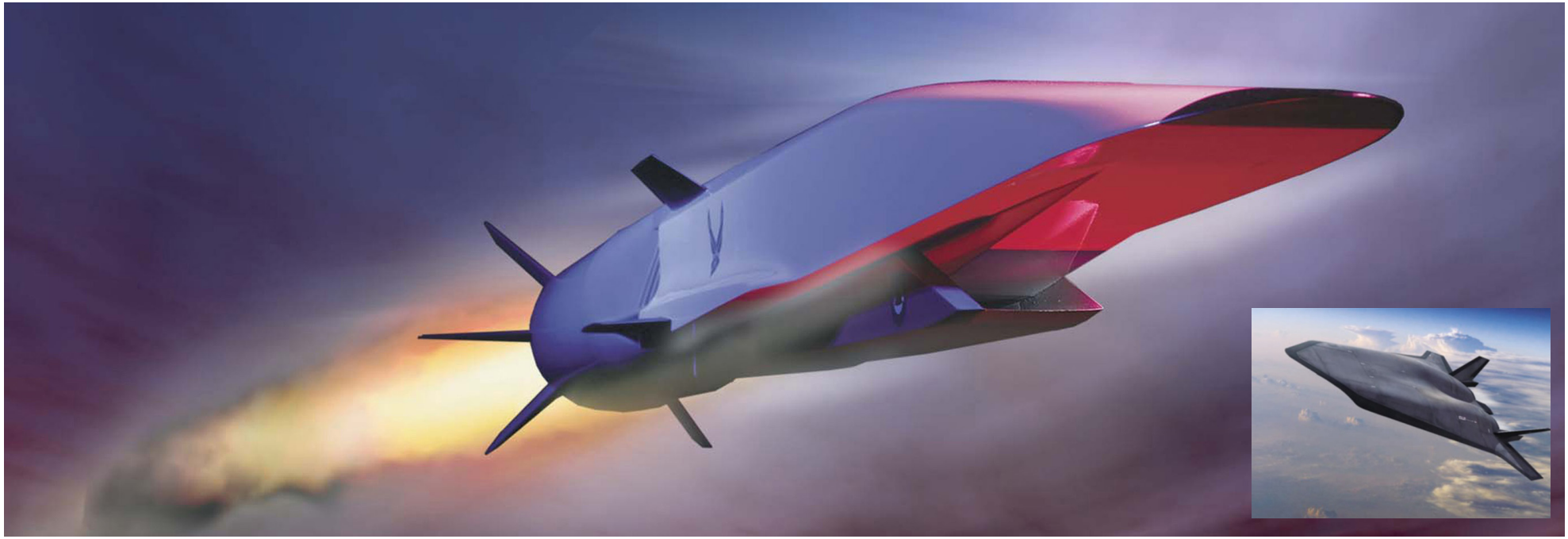

DoD HPCMP HIGHTLIGHTS

ABOUT FY2019/2020

Each year, there are a plethora of successes that are brought about through the Department of Defense High Performance Computing Modernization Program's (DoD HPCMP's) resources and expertise, but what are they?

Starting with this new yearly publication, it is our hope to bring you the highlights of the year that have been critical for the DoD research, development, test and evaluation (RDT&E) and acquisition engineering communities.

The DoD HPCMP is committed to revolutionizing the Warfighter. Our goal is to solve the hard problems.

2019 AND 2020 - YEARS OF ACCOMPLISHMENT

Dear Friends and Colleagues,

I am excited to share with you the DoD High Performance Computing Modernization Program (HPCMP) Annual Highlights for 2019 and 2020. As you will see, the HPCMP has had another outstanding 2 years of accomplishments and growth. Using the 2018 National Defense Strategy as a guidepost, we have focused on supporting our customers from the government, industry, and academia with state-of-the-art high-performance computing (HPC) services and resources to help them find solutions to the most challenging science and technology (S&T), test and evaluation (T&E), and acquisition engineering problems facing our Department of Defense. With national defense priorities shifting to potential conflict with near-peer adversaries like China and Russia, the HPCMP ecosystem that has been developed for the past 25 years has proven it is ideally suited to these challenges.

Within this report you will see how the HPCMP has not only met the demand signals of its constituents, it has continued to grow its core capabilities in HPC hardware, networking, security, and software applications. The HPCMP is now heavily involved in many of the DoD's top critical modernization technologies such as hypersonics, artificial intelligence and machine learning, and big data analytics. The HPCMP also continues to lead in areas of virtual prototyping and evaluation of key DoD acquisition programs that are working to design the next generations of warships, fighter jets, new helicopter designs, submarines, combat ground vehicles, and state-of-the-art radars and RF antenna systems. Our collaborative HPC environment has set the standard for others to follow.

All of these accomplishments could not have happened without our superb HPCMP workforce—they are truly the most valuable assets we have. Their expertise and dedicated support to our HPC users is impressive and they continue to earn high praise and recognition from fellow colleagues and professional organizations outside of the DoD. I encourage you to contact me or any of the HPCMP leadership to see if we can help you with your challenges through the use of our HPC services and resources.

Date: January 2021

Will McMahon, PhD, PE

HPCMP LEADERSHIP

LEADERS IN THE FIELD

"Leadership is not a position or a title, it is action and example."

DoD HPCMP History

The DoD HPCMP is an Office of the Secretary of Defense (OSD) program established in 1992. In October 2011, the Program transitioned to the Assistant Secretary of the Army for Acquisition, Logistics and Technology (ASA(ALT)), and is managed by the Engineer Research and Development Center (ERDC) of the US Army Corps of Engineers (USACE) in Vicksburg, Mississippi. Since its inception, the Program has realized great success in establishing world-class, state-of-the-art high-performance computing (HPC) capabilities within the Department's laboratories and test centers.

DR. WILL MCMAHON
Program Director

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Deputy Director &
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Chief Technologist

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PET

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Business and Contracts

DR. ROBERT MEAKIN
CREATE

MR. MICHAEL AUSSERER
Resource Management

THE DoD HPCMP

OUR VISION, MISSION, AND VALUE

The DoD HPCMP provides science and technology (S&T), test and evaluation (T&E), and acquisition engineering community customers with a full ecosystem to address their most challenging problems.

The HPCMP amplifies the creativity, productivity, and impact of the DoD RDT&E and acquisition engineering communities by providing a virtual environment for design, analysis, and testing. The insights gained by HPC capabilities are often too costly, too dangerous, and/or too time-consuming to obtain through observation and experimentation in the physical world alone.

The HPCMP Ecosystem

The HPCMP ecosystem enables the development and use of physics-based modeling and simulation, and high-performance data analytics to optimize the development, acquisition, and sustainment of innovative weapons systems. The HPCMP ecosystem consists of:

- **expertise in applying hpc,**
- **advanced, leading-edge computational resources,**
- **world-class software applications, and**
- **a nationwide research and engineering network.**

Keeping AMERICA Strong

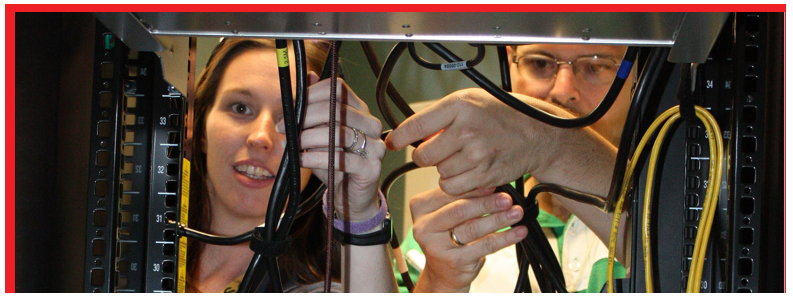
HPCMP personnel provide supercomputing technology delivered with a portfolio of services and capabilities that the Department's scientists and engineers use every day to develop, test, and field the new technologies that keep America strong.

OUR SERVICES

THE HPCMP ECOSYSTEM

01. EXPERTISE

The HPCMP leverages specialized **expertise** from DoD, industry, academia, and non-DoD federal agencies to tailor advanced, leading-edge computational resources to DoD use-cases, create and mature world-class software applications, and maintain a secure data network, with sufficient versatility to address the complex needs of the RDT&E and acquisition engineering communities.



02. HPC CENTERS

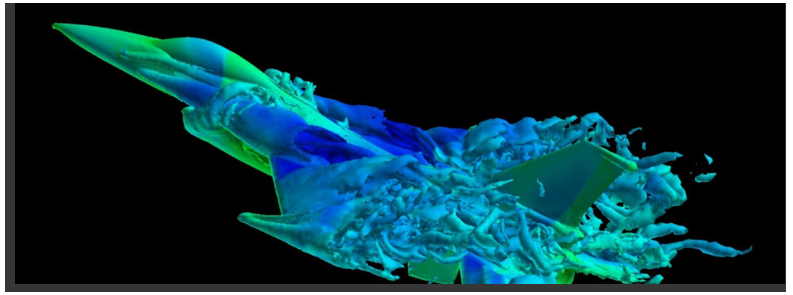
The HPCMP delivers world-class commercial, high-end, high- performance computational capabilities to the DoD's RDT&E and acquisition engineering communities through its four **DoD Supercomputing Resource Centers (DSRCs)** and one **Vangaurd Center**. Each DSRC and Vanguard provides a robust complement of HPC capabilities.

03. NETWORKING

The **Defense Research and Engineering Network (DREN)** is the HPCMP's information-assured wide-area network that minimizes the impact of distance on DoD missions supporting the RDT&E and acquisition engineering communities anytime, anywhere with a versatile, low-latency, high-throughput communications network.

04. SOFTWARE APPLICATIONS

The HPCMP's **Software Applications** and user experience efforts provide a suite of software development and support services aimed at optimizing software capabilities to design, develop, test, and deploy superior DoD capabilities.



HPC CENTERS AND SUPERCOMPUTING RESOURCES

THE BIG IRONS

The HPCMP delivers world-class high-performance computational capabilities to DoD's S&T, T&E, and acquisition engineering communities and supports four DoD Supercomputing Resource Centers (DSRCs). The DSRCs operate and maintain high-end computing systems and provide supporting services to DoD scientists and engineers who execute compute-intensive and data-intensive applications for physics-based simulation, artificial intelligence, and machine learning. The comprehensive HPC eco-system enabled by the DSRCs includes: large-scale high-end/high-performance computing platforms, high-speed network interconnections, hierarchical data storage with high-capacity archival, and various software utilities and applications well-suited for HPC. Complementing the DSRCs are a Vanguard Center at the Maui High Performance Computing Center (MHPCC) and four Affiliated Resource Centers (ARCs). The Vanguard Center and ARCs provide HPC expertise and smaller-scale resources in support of exploratory HPC projects that are not yet ready for production in the DSRCs.

DSRC Breakdown

	Location	Available Processors (Cores and Accelerators)	FY20 Peak Performance (TeraFLOPS)
Air Force Research Laboratory (AFRL)	Wright-Patterson AFB, Ohio	209,984/736	13,012
Army Research Laboratory (ARL)	Aberdeen Proving Ground, Maryland	316,592/1,020	15,971
Army Corps of Engineers, Engineer Research and Development Center (ERDC)	Vicksburg, Mississippi	226,360/64	7,874
Navy	Stennis Space Center, MS	186,496/396	11,199

MHPCC Vangaurd Center

Mission (not a DSRC with allocated HPC systems, executes exploratory technology projects for the HPCMP and provides customer-reimbursed services and resources):

- Lowering barriers to HPC by providing simple, yet secure access to DSRC systems
- Developing HPC-backed solutions for high-priority use cases in data analytics
- Reducing risk and improving performance of DSRC production systems

HPCMP SUPERCOMPUTING RESOURCES

PROVIDING COMPUTATIONAL CAPABILITIES

DoD Supercomputing Resource Centers (DSRCs)

4 DSRCs

Vanguard Centers

1 Vanguard

Affiliated Research Centers (ARCs)

4 ARCs

ARCs are not funded by the HPCMP and provide in-kind services and resources as requested by DoD organizations:

- Air Force Research Laboratory Information Directorate, Rome, NY
- Army Space and Missile Defense Command (SMDC), Huntsville, AL
- Naval Research Laboratory (NRL), Washington DC
- Naval Information Warfare Center (NIWC) Pacific, San Diego, CA

AFRL DSRC

Thunder: SGI ICE X *(D Feb 2020)*
Mustang: HPE/SGI 8600
Voodoo (C): HPE/SGI 8600
Spectre (C): HPE/SGI 8600
Shadow (C): HPE/SGI 8600

ARL DSRC

Excalibur: Cray XC40
Centennial: SGI ICE XA
SCOUT: IBM P9 (Deployable)
Hellfire (C): SGI ICE XA
Betty (C): Cray CS500

ERDC DSRC

Copper (Open Research): Cray XE6 *(D Jul 2020)*
Onyx: Cray XC40
Sard (C): IBM iDataPlex

NAVY DSRC

Conrad: Cray XC40 *(D Sep 2020)*
Gordon: Cray XC40 *(D Sep 2020)*
Gaffney: HPE/SGI 8600
Bean (C): Cray XC40 *(D Sep 2020)*
Koehr: HPE/SGI 8600
Durham (C): HPE/SGI 8600

Open Research (New FY20)

Jasper Solutions: AWS GovCloud
Texas Advanced Computing Center (TACC): Frontera

D = Decommissioned

NETWORKING AND CYBERSECURITY

DEFENSE RESEARCH AND ENGINEERING NETWORK (DREN)

The DREN is the HPCMP's information-assured wide-area network that minimizes the impact of distance on time to solution in support of the RDT&E and acquisition engineering communities anytime, anywhere with a versatile, low-latency, high-throughput communications network. In conjunction with DREN, the HPCMP Cybersecurity team executes its mission to apply security intelligently to ensure proactive protection and promote a productive computational environment.

DREN III is the third-generation instantiation of networking capability for HPCMP and includes Internet Protocol (IP) services, as well as next-generation transport technologies such as Ethernet and Optical Services. DREN III includes bandwidth capacities starting at 50 Megabits per second (Mbps), and increasing by four orders-of-magnitude up to 100 Gigabits per second (Gbps).

DREN use-cases include:

HPC ACCESS

Connects the HPCMP's supercomputing resources to the users of those systems.

RDT&E AND AE ACCESS

Provides connectivity to the DoD RDT&E and acquisition engineering communities.

TEST EVENTS

DoD T&E community operates numerous test events over the DREN backbone; many are classified and are conducted over the SDREN.

CLOSED COMMUNITIES

Supports several DoD Services and Agencies in creating a closed community of interest over the DREN backbone.

NETWORKING HIGHLIGHTS

AS OF SEPTEMBER 2020

190

Active DREN Sites

Plus an additional seven sites on order, but not yet active. DREN sites are located across the continental United States (CONUS), plus Alaska and Hawaii.

81

Active Secret DREN (SDREN) Sites

The SDREN is implemented as a network overlay on the DREN backbone for classified communications at the Secret level.

10 Gbps

Connectivity at each of six DREN peering points and two Internet transit points

DREN currently peers with 40 other national and international networks including, research and education (R&E) networks and regional R&E networks.

4.1 Gbps

Aggregate bandwidth

At three DoD private peering points for direct NIPRNet connectivity. DREN currently peers with NIPRNet on the east coast, west coast, and in Hawaii.

405.7 Gbps

Total aggregate bandwidth

From October 2017 to September 2020, aggregate bandwidth increased by 17% from 347 Gbps to 405.7 Gbps.

ACCOMPLISHMENTS

- IAP Security Gateway Enhancement Project
- DREN Joint Sensors (DJS)
- Software-Defined Networking (SDN) Pilot Project
- SDREN Technology Refresh
- DREN Highway to the Cloud
- DREN Technical Interchange Meeting (TIM)
- DREN Support to DoD Acquisition Engineering
- DREN 4 Acquisition in progress (contract has not yet been awarded)

CYBERSECURITY

PROVIDING SECURITY

As the HPCMP continued its commitment to provide secure, trustworthy and protected HPC resources, and an enterprise network to the research, development, test, and evaluation (RDT&E), and acquisition engineering communities, the HPCMP Cybersecurity Team matured functional capabilities and the leading-edge research and development initiatives. The execution of the HPCMP Cybersecurity mission to apply security intelligently, ensure proactive protection, and promote a productive environment for the RDT&E and acquisition engineering communities was most evident.

Cybersecurity Service Provider Authorization

The achievement of the renewal of the DoD HPCMP's authority to operate (ATO) as one of twenty-five CSSPs throughout the DoD reflects investments made to modernize capabilities and infrastructure purpose-built for the DREN and SDREN cyber terrain. Adeptly applying cybersecurity to ensure secure, trustworthy, and reliable HPC resources are made available to RDT&E and acquisition engineering communities on a high-capacity, low-latency enterprise network is central to the mission of the DoD HPCMP.

DREN Cybersecurity Engagements

As the cyber terrain provider for the DREN and SDREN, the DoD HPCMP is actively engaged with the Joint Force Headquarters–DODIN (JFHQ-DODIN), and Services, Agencies, and field activities with a presence on the DREN and SDREN, in an effort to support a DoD-level initiative to organize and synchronize cybersecurity for DoD networks.

Research Activities

The HPC Architecture for Cyber Situational Awareness (HACSAW) is intended to drastically increase the HPCMP's current and predictive understanding of cyberspace on the DREN, which entails the collection of unclassified data sources from the edge of the network, such as Internet Access Points (IAP), down to the host level. Through the application of HPC resources, HACSAW will explore novel and innovative analytical capabilities based on a comprehensive data set.

DoD HPCMP CYBERSECURITY SERVICE PROVIDER (CSSP)

HPCMP CSSP SERVICES

PROVIDING

ACAS/Security Center

Assured Compliance Assessment Solution performs network and host-based vulnerability scanning and compliance reporting.

Jigsaw

Jigsaw collects and aggregates CSSP data feeds in order to identify and prioritize organization risks.

HBSS/ePO

Host-Based Security System provides endpoint security (IPS), vulnerability scanning, and enterprise antivirus.

Radix

Radix performs Linux host-based security scanning and compliance reporting.

Incident Response Tracker

Captures cyber incident data and manages reporting and response workflows for subscribers.

CEDAR

Cybersecurity Environment for Detection, Analysis, and Reporting sensor network and IDS platform.

CSSP Service Tracker

CSSP Service Tracker manages and tracks critical business functions.

SOFTWARE APPLICATIONS AND USER EXPERIENCE

WHAT WE DO

Providing a suite of software development and support services

The HPCMP's Software Applications and user experience efforts provide a suite of software development and support services aimed at optimizing software to deliver superior DoD capabilities for weapons systems design, development, validation, and deployment. These efforts and services include:

- Computational Research and Engineering Acquisition Tools and Environments (CREATE)
- Frontier Projects
- User Productivity Enhancement and Training (PET)
- Data Analysis and Assessment Center (DAAC)

COMPUTATIONAL RESEARCH AND ENGINEERING ACQUISITION TOOLS AND ENVIRONMENTS (CREATE)

IMPROVING THE DOD ACQUISITION PROCESS

Services

The HPCMP CREATE™ program is designed to improve the DoD acquisition process by developing and deploying five sets of advanced computational engineering design tools for acquisition programs: (1) Military air vehicle design (CREATE-AV), (2) Foundational Technologies (CREATE-FT), (3) Ground vehicle design (CREATE-GV), (4) RF antenna design and integration with platforms (CREATE-RF), and (5) Military ship design (CREATE-SH). CREATE also includes an educational software suite called (6) Genesis, for undergraduate and graduate student application of computational fluid dynamics learned in the classroom.

Enabling physics-based virtual prototyping and testing analysis for major Defense weapons programs

The CREATE portfolio was established by the DoD HPCMP to: meet the challenge of significantly reducing acquisition time, risk, and cost, and Increase weapon system agility, flexibility, and performance.

● Air Vehicles (AV) Design Tools	CREATE-AV
● Foundational Technologies	CREATE-FT
● Ground Vehicles (GV) Design Tools	CREATE-GV
● Radio Frequency (RF) Antenna Design and Integration Tools	CREATE-RF
● Ship (SH) Design Tools	CREATE-SH
● Educational Outreach Software Suite	CREATE Genesis

FRONTIER PROJECTS

THE PROCESS

WHY

Enabling the exploration of RDT&E and acquisition engineering outcomes that would not be achievable using typically available HPCMP resources.

WHAT

These projects are DoD high-impact RDT&E computational efforts that are selected through a rigorous evaluation process that includes both OSD and Service/Agency mission relevance and technical excellence.

HOW

The Frontier Project portfolio represents the Program's most computationally-demanding, resource-intensive set of projects that require sustained and extensive assistance from the entire HPCMP ecosystem (DSRCs, user support, software development, PET, and networking) to fully succeed.

The HPCMP seeks projects with high DoD impact. Each project falls into a computational technology area (CTA).

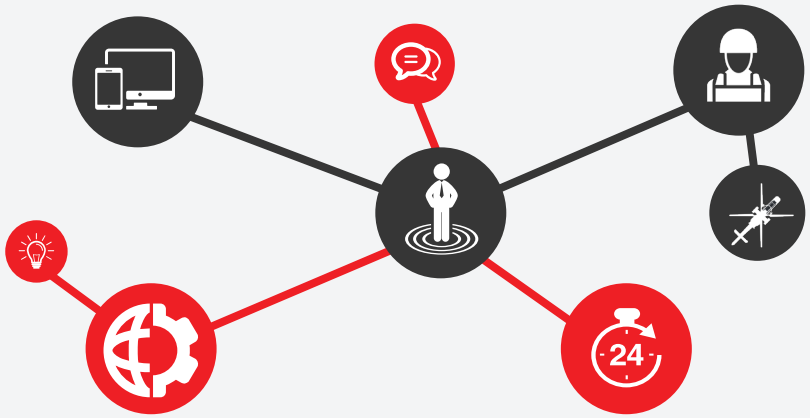
USER PRODUCTIVITY ENHANCEMENT AND TRAINING (PET)

ADVANCED USER SUPPORT

The HPCMP PET program gives users access to computational experts with experience spanning many HPC technology areas. These PhD HPC application experts are available to help HPC users become more productive using HPCMP supercomputers. The PET initiative also leverages the expertise of academia and industry experts to leverage new technologies, and provides training on HPC-related topics. Help in specific computational technology areas is available providing a wide range of expertise including algorithm development and implementation, code porting and development, performance analysis, application and I/O optimization, accelerator programming, pre-processing and grid generation, workflows, in-situ visualization, and data analytics.

Conducted 124 training events with 3,405 attendees

Three Modes of User Support



Mission Projects (MPs) | Special Projects (SPs) | Training

- PET provides user-focused training both online and in person.
- PET creates training on specialized topics keeping HPCMP users at the forefront of technology
- Training Leverages Academic and Industrial Partnerships and Collaborations

Knowledge Management and Learning System

Launched a Knowledge Management and Learning System (KMLS) on 2 April 2018 that had 1,708 users as of 30 September 2020.

1,708 Users

DATA ANALYSIS AND ASSESSMENT CENTER (DAAC)

CREATING SCIENTIFIC VISUALIZATIONS

While supercomputers generate enormous quantities of data, transforming those data into insight through scientific visualization is the mission of the HPCMP Data Analysis and Assessment Center (DAAC). Scientific visualization is a branch of data science that is concerned with visually analyzing and interpreting data. The data being analyzed may be the product of an experiment, observation (such as information collected from sensors), or computational simulation. The goal of analyzing and interpreting data, and hence scientific visualization, is to gain insight and understanding into the processes being studied.

TOOLS	TALENT	COMMUNICATE

01.	Making visualization software resources available for use by HPCMP users.
02.	Working closely with users on custom projects that include animation, narration, and video production.
03.	Helping DoD scientists and engineers gain insight into problems of interest to the Department and the nation, and effectively communicate these insights to decision makers and stakeholders.

WORKFORCE DEVELOPMENT

DEVELOPING FUTURE LEADERS

A key challenge for the Department of Defense is identifying, developing, and retaining leaders, engineers, and scientists with HPC skills. The HPCMP contributes to those efforts through the Workforce Development effort with the Service academies and the HPC internship program (HIP) for US students at colleges and universities across the country. The HPCMP provides funding to support faculty and cadet/midshipman research, HPC conference attendance, and summer internships with DoD laboratories. The HPC internship program provides funding to the DoD laboratories to support summer internships for high school students, undergraduates, and graduate students to work with the Department's top researchers on projects key to maintaining US military superiority.

> ***"I believe this year was very successful for WSMR, and a beneficial experience for the interns. They said from day one they were engaged, challenged, had fun, and gained perspective on the field of Computer Science and parallel systems in particular. Thanks again to everyone for making this opportunity available to our interns as well as to WSMR."***
>
> **Rick Vinyard, Jr.**
> 1st year HIP mentor from
> White Sands Missile Range

HPC Internships

The HPC Internship Program (HIP) provides an introduction to the knowledge and skills needed to employ high-performance computing during a career in science and engineering that many students would otherwise not obtain.

The HPC Internship Program provides funds to pair a promising undergraduate or graduate student with a Department of Defense scientist or engineer in a DoD laboratory or test center, to conduct research supporting a key Service mission priority or program of record. The research must use HPC tools, resources, and methods.

Deliverables for each HIP project include a research paper, and a presentation (attended by members of their organization and HPC Workforce Development personnel), as well as a quad chart from the mentor summarizing the project efforts and results.

SUCCESS STORIES

We are a technology-led, innovation-focused program committed to extending HPC to address the DoD's most significant challenges.

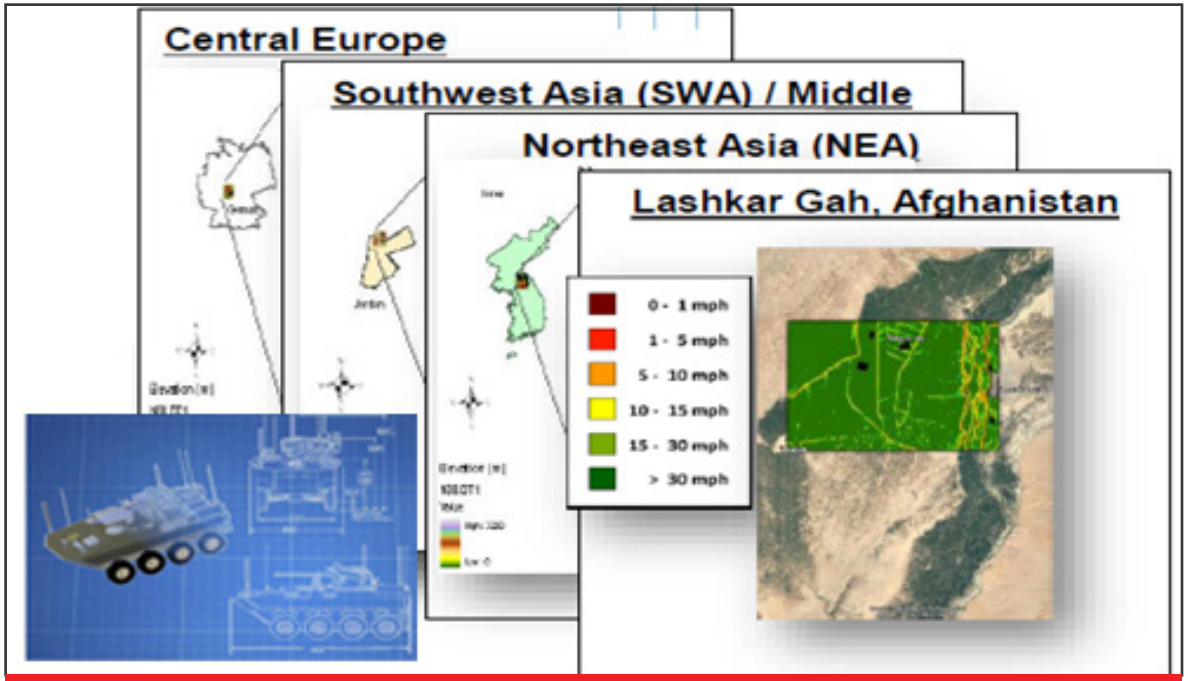
We have seen its impact: **in research**, where HPC enables the DoD to explore new theories and evaluate them well beyond what is practical using experiment alone; **in acquisition**, through the use of validated applications in design and testing, which significantly reduce the time and cost of developing weapon systems, and improve the quality of their designs; and test and evaluation **in operations**, where real-time calculations produce just-in-time information for decision makers on the battlefield.

High-performance computing amplifies the creativity, productivity, and impact of the DoD Research, Development, Test and Evaluation (RDT&E) community by giving them access to insight about the physical world, and human actions within it, that would otherwise be too costly, too dangerous, or too time-intensive to obtain through observation and experiment alone.

US MARINE CORPS ARV AoA STUDY

Success Story - Army

Attribution: *US Marine Corps, USMC, and US Army CombatCapability Development Command - Ground Vehicle Systems Center (CCEDC GVSC)*



ARV 'Heavy Variant' Concept Illustration, and the HPCMP CREATE™-GV MMU GIS Mapping Capability

PROBLEM

As a member of the US Marine Corps, USMC Working Integrated Product Team (WIPT) engaged in an Analysis of Alternative (AoA), and the US Army Combat Capabilities Development Command - Ground Vehicle Systems Center (CCEDC GVSC) conducted analyses in support of two Armored Reconnaissance Vehicle (ARV) variants ('new starts': Light and Heavy) to assess the potential of these lines-of-effort (LOEs) to satisfy a set of validated operational capability needs and requirements.

SOLUTION

As part of this AoA effort in 2019, the HPCMP CREATE™-GV tools were used by the AFC CCDC Ground Vehicle Systems Center's WIPT members to produce objective analyses of off-road mobility performance for six vehicle configurations, consisting of legacy and proposed ARV variants, across different regions of the world.

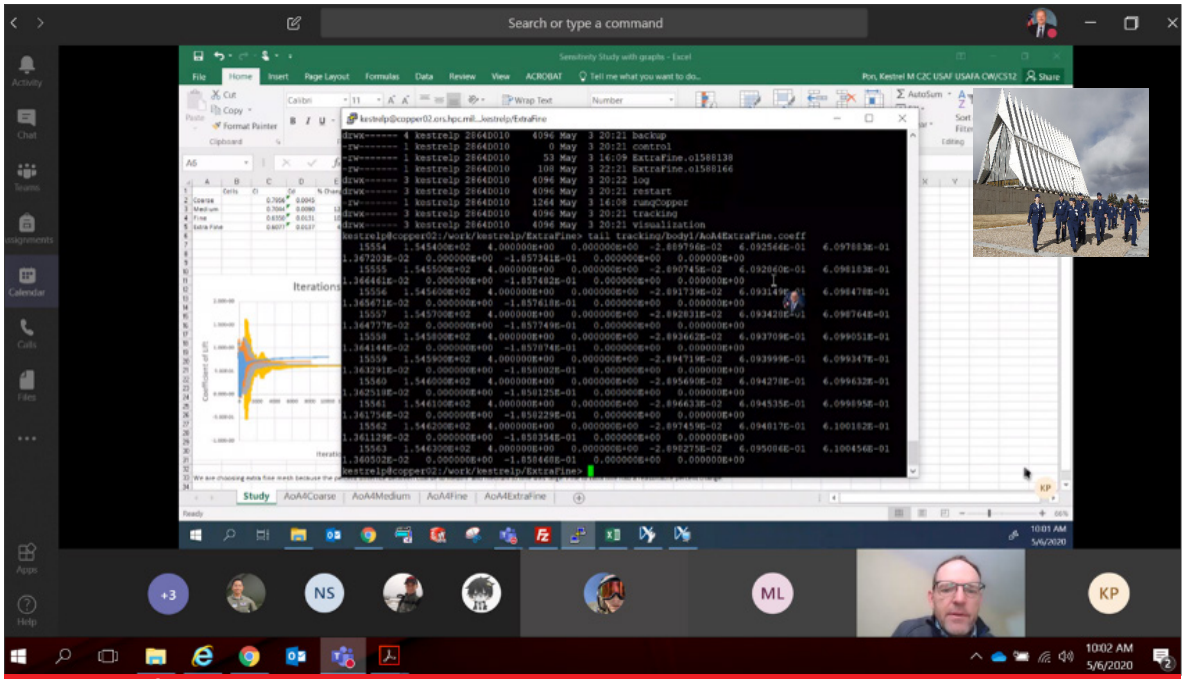
IMPACT

HPCMP CREATE™-GV tools provided decision-quality analyses for mobility assessments within an AoA context. Utilized HPCMP CREATE™-GV tools to predict terrain traversability metrics (e.g., VCI1, %NOGO, and V50 speeds) in various seasonal and weather condition scenarios across four regions as applicable. Results presented in the final report to leadership informed the mobility operational capabilities of the ARV concepts via mobility metric decomposition and map visualization. Output from the HPCMP CREATE™GV tools was critical in providing acquisition decision makers key information necessary to determine the optimum line-of-effort to pursue.

HPCMP CREATE™ GENESIS SUPPORTS USAFA CADETS DURING COVID-19 QUARANTINE

Success Story - Air Force

***Attribution**: US Air Force Academy*



Snapshot of a remote teaching session with Dr. Jurgen Seidel as he had a Cadet open their Genesis user interface

PROBLEM

Due to the COVID-19 pandemic, the US Air Force Academy, like most universities, is teaching their classes remotely right now. One of the courses being taught is AE342, the CFD (Computational Fluid Dynamics) course where the Cadets learn to use the HPCMP CREATE™ Genesis software suite and high-performance computers.

SOLUTION

The HPCMP CREATE Genesis software suite delivers powerful capabilities for educational purposes. Using Genesis, 67 Cadets in the CFD course ran jobs at 100% with faculty interaction being limited to one class period every other day (via Microsoft TEAMS), while electronically contacting instructors for help as needed.

IMPACT

Cadets have submitted and run the majority of their jobs for their final project in AE342. This means Cadets were able to do the following without any physical contact:

- Obtain their own HPCMP Defense Supercomputing Resource Center (DSRC) accounts,
- Download software needed to access HPC systems,
- Transfer files, create meshes, submit jobs, and download results.

All of this has happened with limited difficulty.

NEXT-GENERATION SENSOR SYSTEMS FOR TARGETED PLATFORMS

Success Story - Air Force

Attribution: *Air Force Research Laboratory (AFRL) and Air Force Life Cycle Management Center (AFLCMC)*

Examples from the DIRSIG simulation of the various targets along with confusers such as 3D geometrical shapes. Right –Notional targeted platform

PROBLEM

The Air Force Research Laboratory (AFRL) has been collaborating with Air Force Life Cycle Management Center (AFLCMC) on building next-generation sensor systems for targeted platforms. While Digital Engineering has been employed for aircraft and ship design, it has never been used for Intelligence, surveillance, and reconnaissance (ISR) systems.

SOLUTION

Digital Engineering for ISR with the Digital Imaging and Remote Sensing Image Generation (DIRSIG) code is being performed by using digitized sensor designs then simulating those designs with DIRSIG on HPCMP systems Mustang, Centennial, and Thunder (now retired). The synthetic data helps to train the machine learning systems to obtain maximum recognition performance for machine learning at the edge for the notional targeted platforms.

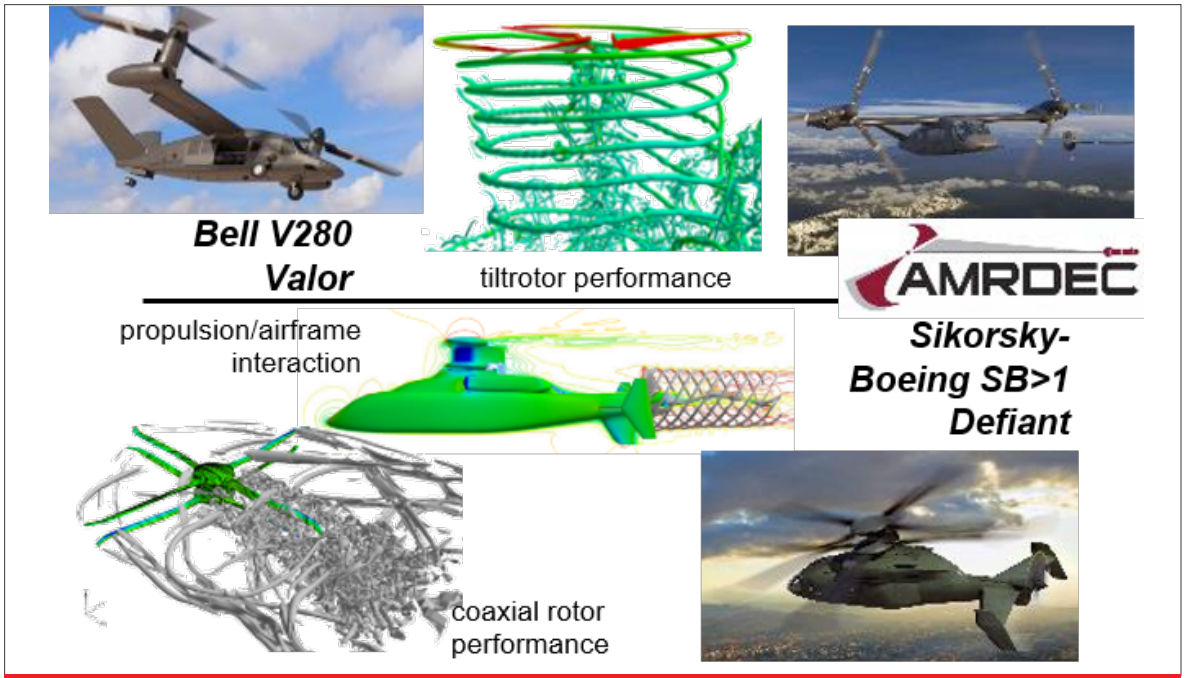
IMPACT

To date, 660,000 synthetic chips have been generated simulating various sensor modalities. These sensors have never flown on an aircraft, but the Digital Engineering process has helped the USAF understand how the sensors would perform before a flight test. The team has been using the HPCMP systems, along with the Defense Research Engineering Network, to distribute synthetic data to multiple performers across the United States.

FUTURE VERTICAL LIFT

Success Story - Army

Attribution: *Combat Capabilities Development Command Army Research Laboratory (CCDC ARL) and U.S. Army Aviation and Missile Research, Development and Engineering Center (AMRDEC)*



Pictures and digital models of the two FVL down-selected helicopter designs

PROBLEM

Helicopter design is one of the most complex of aviation design challenges because many of the physics-based elements that impact the platform are difficult to understand and observe until after a physical model is built and tested. An accurate, repeatable virtual prototyping method was required to allow physics-based, finite element analysis (FEA) of various platform designs for the program to test and compare several industry design options in a controlled, digital environment.

SOLUTION

HPCMP CREATE™-AV Helios software used to model the Joint Multi-Role Technology Demonstrator (JMR TD) aircraft to predict performance in helicopter design, testing and comparing design options in a controlled, digital environment.

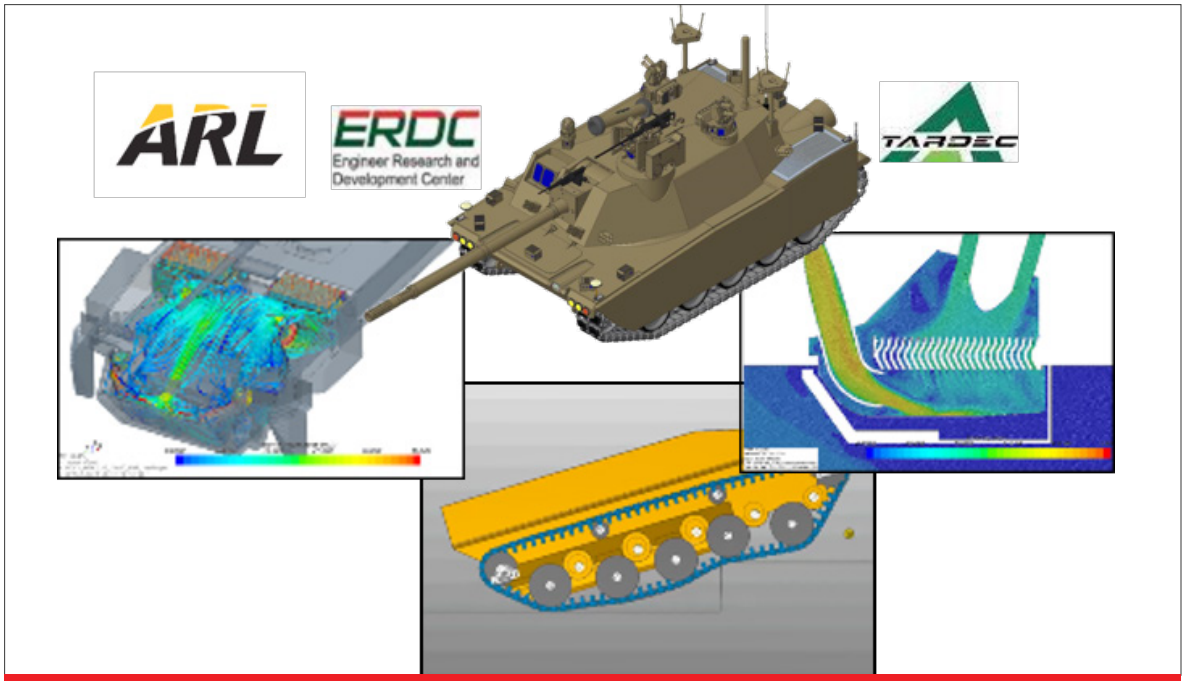
IMPACT

Future Vertical Lift has reduced the risk though independent technical assessments provided to the JMR TD Program Office. Helios software enables physics-based, finite elements to analyze capabilities for helicopter acquisition.

NEXT-GENERATION COMBAT VEHICLE

Success Story - Army

Attribution: *Army Research Laboratory (ARL), U.S. Army Engineer Research and Development Center (ERDC) and U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC)*



HPCMP digital models of the Army Next-Generation Combat Vehicle components

PROBLEM

The US Army required a way to conduct multiple tests and analysis of tracked vehicle designs in various environmental conditions without incurring excessive costs and time delays in fielding physical prototypes. A virtual prototype surrogate was needed that could be easily modified and then fully tested in a digital environment many hundreds of times to collect critical data in refining the final vehicle design elements prior to initiating physical prototype construction, thereby saving initial manufacturing costs and time.

SOLUTION

HPCMP DSRC resources and CREATE-GV software enables design, predictive analysis and evaluation of next-generation combat vehicle (NGCV) concepts. HPCMP enabled TARDEC to model blast and structural durability of various prototype concept designs.

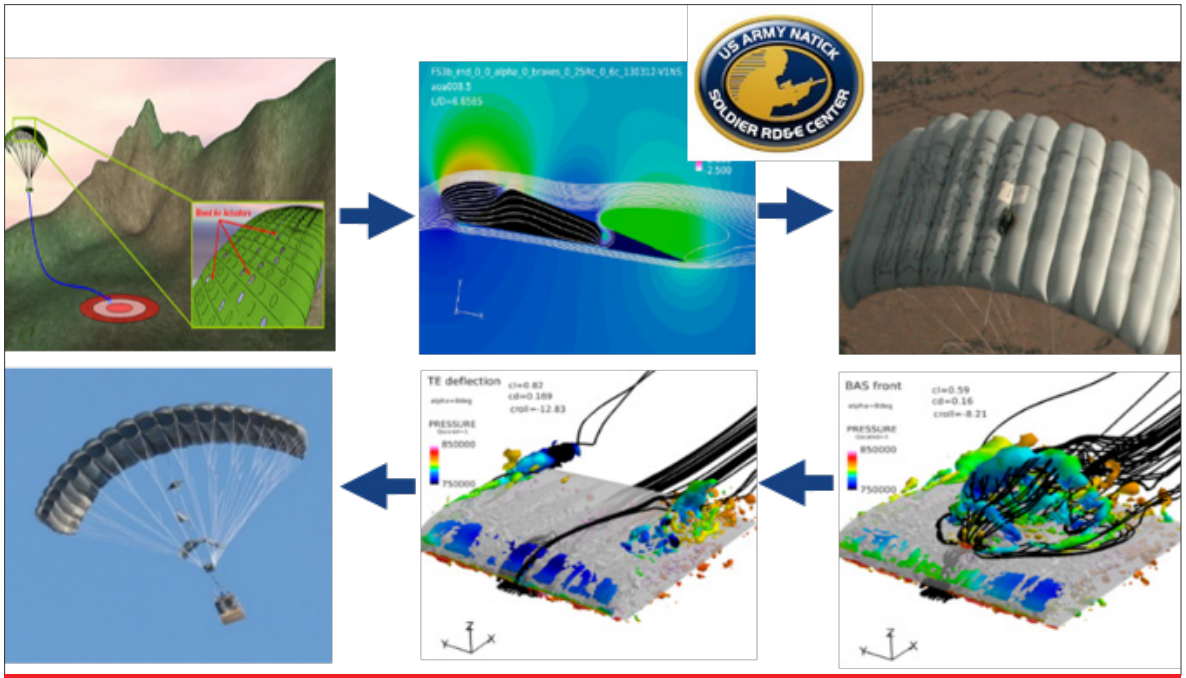
IMPACT

HPCMP CREATE™-GV software used to provide virtual prototype to collect critical data used in final vehicle design by conducting multiple tests and analysis in a timely and cost-effective manner.

SOLDIER LETHALITY

Success Story - Army

***Attribution**: Army Research Laboratory (ARL) and U.S. Army Natick Soldier Systems Center (NSSC)*



HPCMP digital modeling and aerodynamic analysis of Army parachute logistics loads

PROBLEM

The US Army required a method of modeling the complex geometry of parachuting large combat logistics loads into various environments and climatic conditions in order to improve parachute design and operational utilization under combat conditions. A virtual prototype model coupled with the power of supercomputing resources was required to accurately analyze the physics-based performance of various parachute designs, thereby saving costs, reducing risk to combat loads, and saving production time.

SOLUTION

HPCMP DSRC resources and CREATE-AV Kestrel and CREATE-FT Capstone software enables high-fidelity modeling for precision aerial insertion of personnel and cargo by parachute. Capability supports cost-effective, time-saving analyses, thereby reducing risk to parachute loads.

IMPACT

Virtual prototype model and resources of HPCMP DSRCs provides Army organizations supporting the Soldier Lethality Cross-functional Team (CFT) with effective analysis of performance of parachute design under environmental and combat conditions in a cost-effective manner reducing risk to combat loads.

IMPACT OF HPC ON ARMOR - MINE-RESISTANT AMBUSH PROTECTED (MRAP)

Success Story - Army

Attribution: *Army Research Laboratory (ARL), Aberdeen Test Center (ATC), and Combat Capabilities Development Command, (DEVCOM)*

Thousands of Armor Equiped Vehicles in < 2 years

PROBLEM

The US Army required a digital model to conduct multiple tests of various MRAP armor designs prior to fielding physical prototypes that might not protect soldiers in case of an IED attack. A virtual prototype would allow for hundreds of repeatable tests to be conducted, thereby allowing for engineering design improvements to be made prior to going into full physical production.

SOLUTION

HPCMP resources and expertise in physics-based modeling and simulation enables US Army to conduct multiple tests of armor designs that will ultimately protect soldiers on the ground from IED attack.

IMPACT

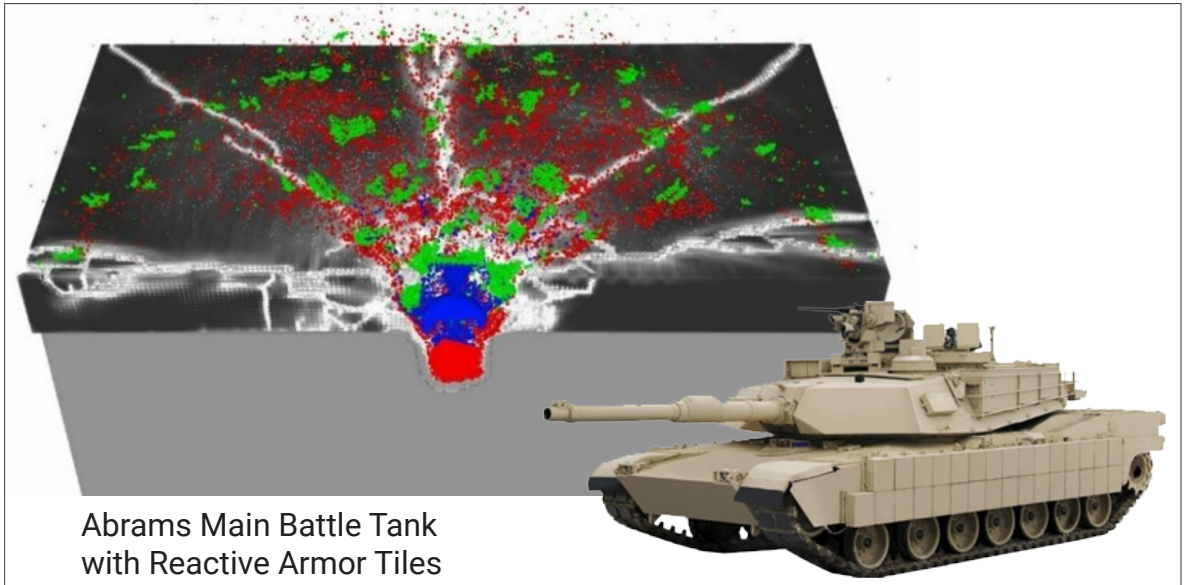
IFK6 was impetus for robotic combat vehicle (RCV) and MRAP research. Multiple alternative technologies examined through coupled HPC and experimentation. HPC used to examine mechanisms, screen design options, and optimize solutions. Verification testing proved HPC design methodology and validated accelerated fielding by reliance on a closely coupled HPC/ experimental approach.

~15,000,000 CPU-hours consumed
- ~ 17 CPU Centuries
- > 2,000 simulations
- > ~ Thousands of MRAPs now fielded with armor upgrades

IMPACT OF HPC ON ARMOR - ABRAMS SEPV3 SURVIVABILITY

Success Story - Army

Attribution: *U.S. Army Combat Capabilities Development Command (DEVCOM) Armaments Center and General Dynamics Corporation*



Abrams Main Battle Tank with Reactive Armor Tiles

Detailed HPC Modeling of EFP Penetration

HPCMP tools, resources and expertise are critical in analyzing penetration effects on tank armor

PROBLEM

Use the power of HPC to enhance and augment the Abrams SEPv3 live-fire testing for the MUVES Survivability Analysis.

SOLUTION

HPCMP tools and resources enable critical analysis of live-fire tests on effects of explosively formed projectiles on armored vehicles.

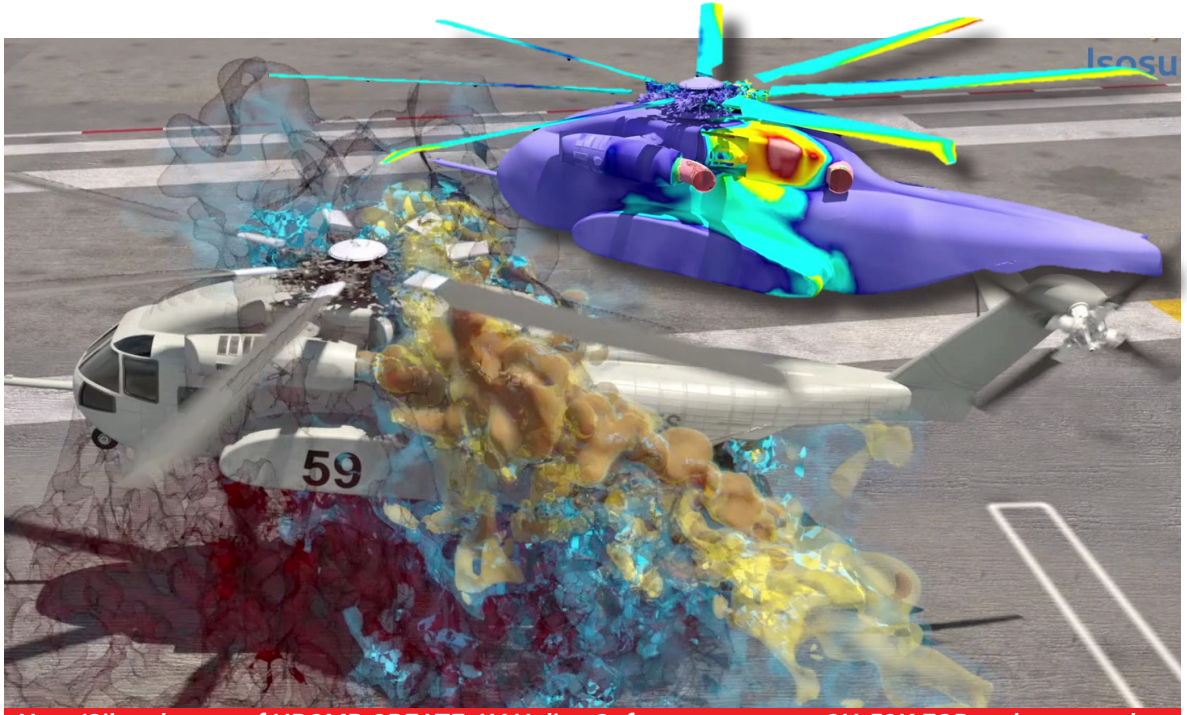
IMPACT

Ability to make informed decisions about candidate armor designs. Insight into the fundamental Material Science and Physics of armor designs (High level of detailed time-dependent data). Ability to focus and define optimum live-fire testing strategy.

HPC simplifies the ability to evaluate difficult/ impossible to acquire foreign threats against US systems.

CH-53K EXHAUST GAS RE-INGESTION

Success Story - Navy



Navy/Sikorsky use of HPCMP CREATE-AV Helios Software to assess CH-53K EGR and proposed remedial actions. Visualization by PCMP/DAAC.

PROBLEM

The CH-53K program has identified exhaust gas re-ingestion (EGR) as a significant concern for performance, safety, and engine life. EGR can cause compressor stalls and leads to reduced engine life and higher lifecycle costs. Computation is challenging due to problem onset being substantially influenced by wind direction and height above ground. Additionally it takes time for problem to build up in the compressor.

***Attribution**: Naval Air Systems Command (NAVAIR) and Sikorsky*

SOLUTION

At the Navy's request, 30M CPU-hours specially allocated to allow for critical path testing by end of June 2019. The program is now relying solely on HPCMP CREATE-AV Helios for a proposed design.

IMPACT

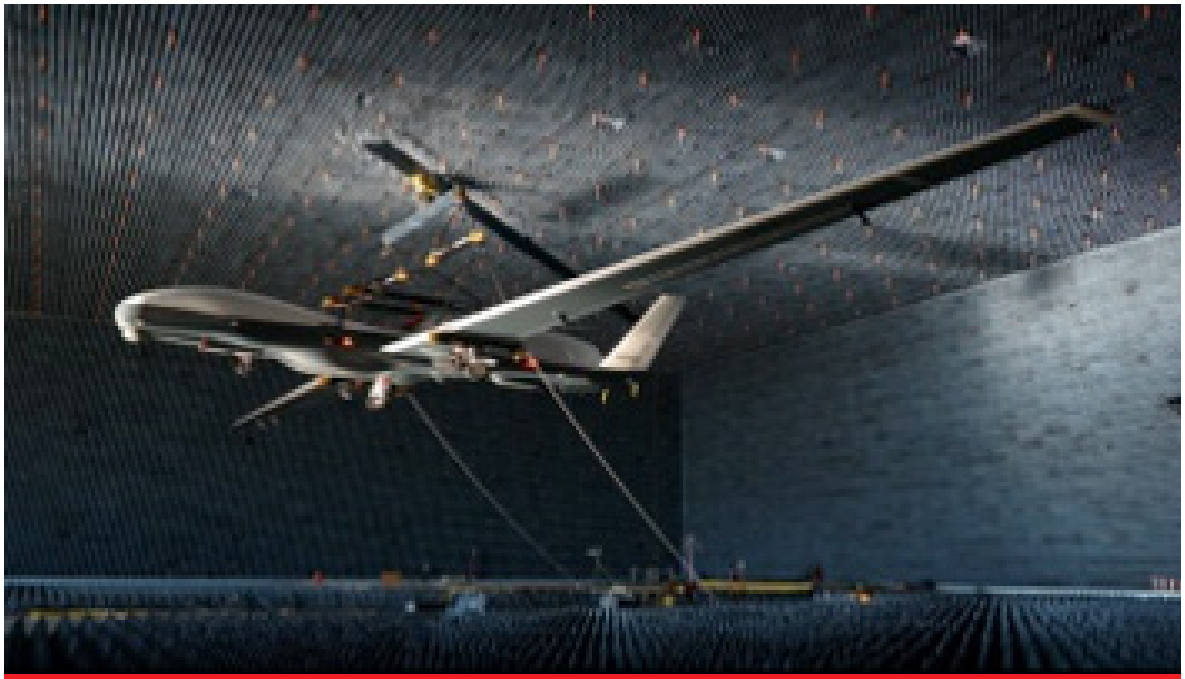
Based on the physics-based virtual testing with Helios and HPCMP computers, the EGR fix was validated with a flight test, and the program is now on track..

HPC modeling saved months of flight test costs and allowed reprogramming of more than $100M to other priorities. Digital modeling kept the test program on schedule.

MQ-4C TRITON - MARITIME PATROL UAS

Success Story - Navy

***Attribution**: Naval Air Systems Command (NAVAIR) and Northram Grumman*



RF analysis of TRITON UAS model

PROBLEM

MQ-4C Triton is a maritime surveillance unmanned aerial system (UAS), under developmental test and evaluation by the US Navy and Northrop Grumman. Initial operational capability (IOC) was achieved in 2018. The MQ-4C Triton provides real-time intelligence, surveillance, and reconnaissance (ISR) including vessel detection, tracking, and classification over vast ocean and coastal regions.

SOLUTION

Flight and ground tests between the UAS and ground support stations are conducted daily and rely on HPCMP DREN/SDREN for connectivity.

MQ-4C Triton Capabilities and Test Successes: Conducts wide-area surveillance to identify potential targets and allows manned aircrews to focus on prosecution missions.

IMPACT

Trition's test program depends on the high-speed and low-latency of the HPCMP DREN/SDREN to deliver real-time ISR to the US Navy over differing ocean and coastal regions.

NAVY RAILGUN

Success Story - Navy

***Attribution**: Naval Surface Warfare Center (NSWC)*

Full-size Navy railgun experimental model at NSWC Dahlgren, VA

PROBLEM

The US Navy has been researching rail gun technology for more than 10 years as one of several potential "game changer" technologies for modern warfighting. HPCMP provides critical HPC resources in support of this effort.

SOLUTION

The HPCMP created a trusted, essential computational capability within the electromagnetic railgun design project. The Program developed and validated models to perform end-to-end simulations of realistic railgun systems and impact design of those systems.

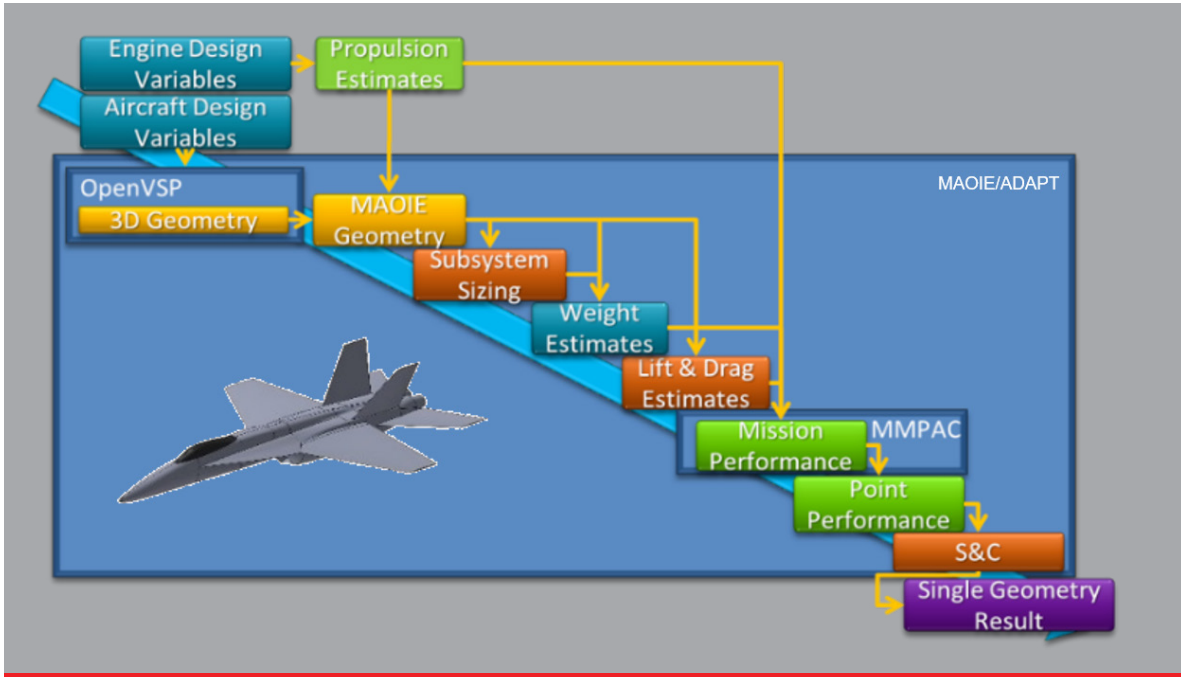
IMPACT

Analyses of structural integrity of Rep-Rate Composite Launcher (RCL) cooling channels were used to impact the design of cooling channels for follow-on launchers. Performed analysis of new muzzle hardware design to improve robustness of this component. Simulations of the breech design for the RCL-1 railgun were used to explore design options and assess the design proposed by the contractor for the RCL-2 railgun.

NAVY NEXT-GENERATION AIR DOMINANCE (NGAD) AoA

Success Story - Navy

***Attribution**: Naval Air Systems Command (NAVAIR)*



The MAOIE/ADAPT methodology was applied to obtain performance assessments for over 5 million aircraft geometries

PROBLEM

The NGAD analysis of alternatives (AoA) studied family of systems materiel solutions to the capacity and capability gaps left by the retirement of the F/A 18E/F and EA-18G in the early 2030s. The AoA needed to conduct technical feasibility assessments of aircraft conceptual designs across a broad tradespace.

SOLUTION

The HPCMP CREATE™ software ADAPT was used to provide high-quality analysis of technical feasibility, and provide high-confidence inputs to both cost and effectiveness analysis.

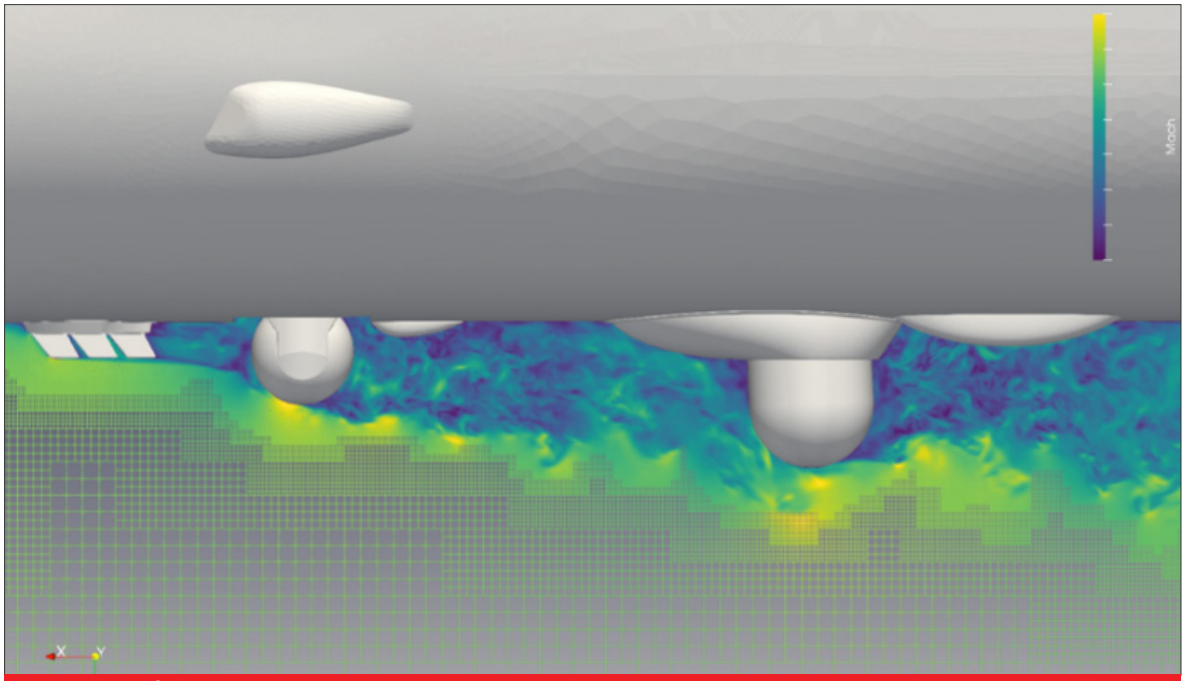
IMPACT

Performance estimated for over 5 million aircraft design geometries during the AoA. Analytically rigorous models from this software improved the fidelity of both cost and effectiveness estimates. Because of this capability, the AoA team was able to provide more options to OPNAV and OSD CAPE.

P-8A SENSOR FLOW EFFECT ANALYSIS

Success Story - Navy

Attribution: *Naval Air Warfare Center – Aircraft Division (NAWC-AD)*



Side view of P-8 with Mini-REA, MX-20 EOIR, and SPEAR-1. Solution by Navy using HPCMP CREATE-AV Kestrel.

PROBLEM

A new turret (SPEAR-1) being incorporated under the fuselage of the P-8A. For flight clearance, performance impact (drag), and unsteady structural loads were needed.

SOLUTION

HPCMP CREATE™-AV Kestrel was used by the Navy to provide this data and ultimately support flight clearance. KCFD near-body with SAMAIR off-body was used to resolve the unsteady flow fields and provide unsteady forces at 30 kHz, pressures at 1 kHz.

IMPACT

The Kestrel results were performed in lieu of windtunnel testing due to time and cost constraints. Reduced the total number of initial flight test requirements resulting in significant cost savings.

AIRCRAFT CABIN RESPIRATORY DROPLET PROPAGATION

Success Story - Air Force

***Attribution**: Air Force research Laboratory 711th Human Performance Wing (AFRL 711th HPW)*

Respiratory droplet dispersion and surface deposition model analysis in a C-130J

PROBLEM

While many precautions are being taken to prevent the spread of SARS-CoV-2, aircraft cabins during flight present a unique transmission risk environment that is not well understood. Talking, coughing, and sneezing are known to generate microscopic microorganism-bearing respiratory droplets which travel through air currents and cause infection transmission when inhaled. In the event an Aeromedical Evacuation operation requires high-capacity SARS-CoV-2 infected passenger airlift, transmission is likely but could be mitigated with efficient air exchange and disinfection procedures.

SOLUTION

A series of high-fidelity CFD simulations aboard seven transport aircraft were completed investigating unsteady airflow and respiratory droplet propagation and deposition patterns. Timelines for the simulations were accelerated due to JUON for high-capacity SARS-CoV-2 patient airlift and as such HPC CPU-hour usage was essential.)

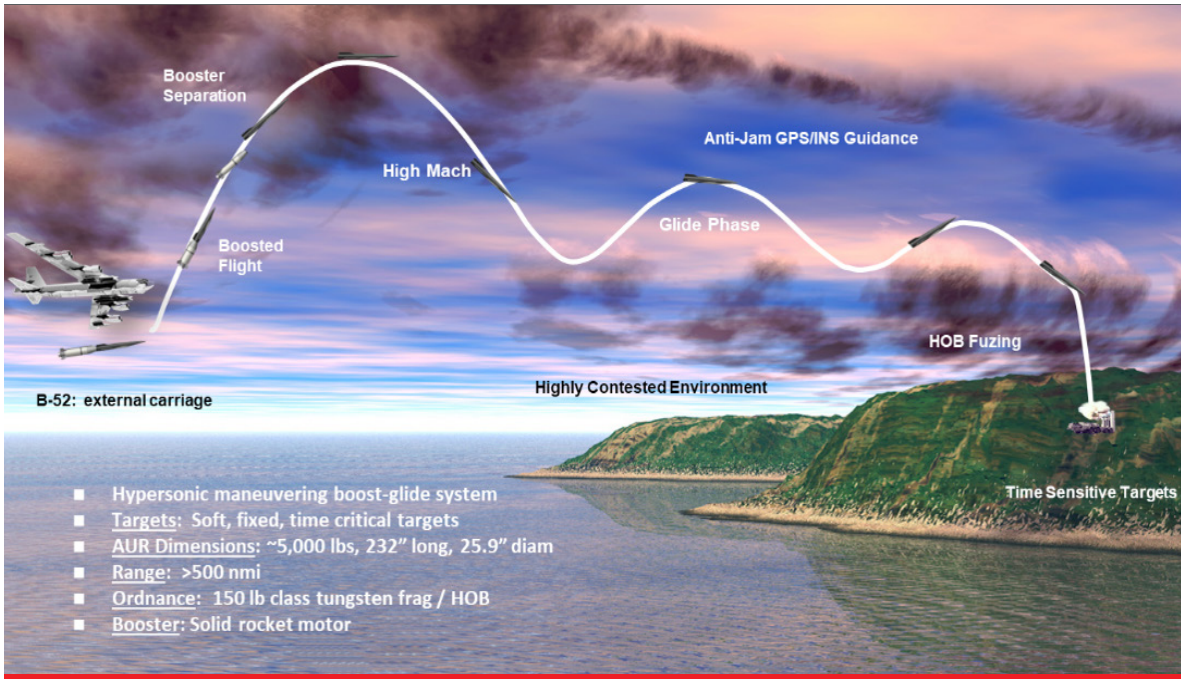
IMPACT

These computational models are being used to inform decision-makers on airframes which are most efficient at clearing respiratory droplets from air currents. These models can be manipulated in a high-throughput manner to mimic different cargo and bioaerosol release scenarios, ultimately informing protective actions to mitigate infection.

AIR FORCE HYPERSONICS ENABLED BY HPC

Success Story - Air Force

***Attribution**: Air Force Life Cycle Management Center (AFLCMC) and Lockheed Martin*



Air Force conceptual flight path for Air-Launched Rapid Response Weapon (ARRW) system

PROBLEM

Air Force Hypersonics is the rapid prototyping effort to field hypersonic strike capability within Future Years Defense Program (FYDP). This game-changing capability provides survivable, time-critical strike capability for standoff platforms. It's a high-risk, high-reward program requiring HPC resources to succeed.

SOLUTION

HPC-driven physics analysis of key flight parameters for Air-Launched Rapid Response Weapon (ARRW).

- Generated Booster & Glider Trajectories for Aerothermal Analysis
- Developed Glider Aerothermal Interpolation Code to Accelerate Thermal Analysis
- Performed Booster Pitch Sweep for Aerodynamic Force & Moment Coefficient Data
- Ran Shroud Separation Cases for Time-Dependent Loads

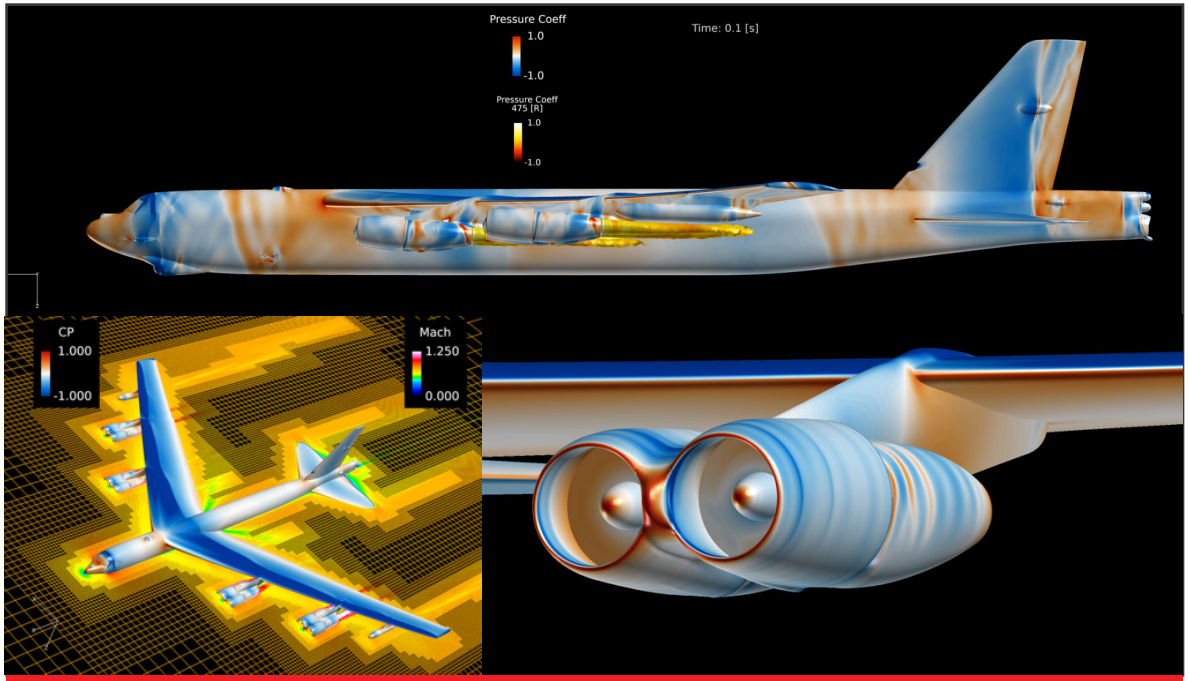
IMPACT

DoD HPCMP resources are enabling the rapid prototyping effort to field hypersonic strike capability, providing time-critical strike capability for standoff platforms.

B-52 CERP COMPUTATIONAL MODELS

Success Story - Air Force

***Attribution**: Air Force Life Cycle Management Center (AFLCMC)*



B-52 Integrated engine models

PROBLEM

Air Force needed a way to accurately model several different new engine designs for the B-52 program. The ultimate goal is to have the capability to virtually fly the aircraft, with modifications, early in the acquisition process in order to conduct trade-space analysis.

SOLUTION

The Air Force LCMC is using HPCMP CREATE-AV Kestrel to provide detailed knowledge of complex aerodynamics and aircraft performance. Integrated engine models can dynamically adjust individual throttles. Engine models delivered by original equipment manufacturer (OEMs).

IMPACT

Results:

- Models flow properties (Velocity, Temperature, Pressure, etc.) at all points in discretized space and time
- Integrates forces & moments
- Reduces risk ahead of engine selection, integration, and flight testing

AIR FORCE TECHNICAL APPLICATIONS CENTER (AFTAC)

Success Story - Air Force

***Attribution**: Air Force Technical Applications Center (AFTAC)*

9th Maintenance Squadron aircrew egress Airmen install a U-2 Dragon Lady egress seat. Photo by Airman 1st Class Luis A. Ruiz-Vazquez

PROBLEM

AFTAC's mission is to operate and maintain the United States Atomic Energy Detection System (USAEDS), using scientific means to obtain and evaluate technical data on the nuclear treaty monitoring and compliance of foreign government nations, and to conduct research and development to improve USAEDS capabilities, and apply USAEDS resources and capabilities to other suitable purposes of the United States governement.

SOLUTION

HPCMP resources have provided supercomputing hours, engineering expertise, and network connectivity in supporting and enabling the AFTEC mission, allowing more accurate and faster turnaround time of sensitive information analysis than could be gained from non-HPC systems.

IMPACT

"Expanded, large-scale classified HPC is a high-priority enabling technology that will allow AFTAC to capture dramatic advances in scientific computing that yield new levels of awareness to our national leaders in treaty monitoring and nuclear forensics."
- Dr. Glenn Sjoden, Chief Scientist, AFTAC

ENABLING KC-46 FLIGHT DATA ASSESSMENTS FOR SIMULATOR CERTIFICATION - UNPRECEDENTED CERT FOR ANY AIR REFUELING PLATFORM SIMULATOR

Success Story - Air Force

***Attribution**: Air Force Life Cycle Management Center (AFLCMC)*

B-52 Integrated engine models

PROBLEM

"Air Mobility Command is expanding our virtual training…with the Air Refueling Aircraft Simulator Qualification…(to) conduct all air refueling training virtually.... (to) bridge warfighter requirements and limited resources."

- AMC Commander, April 2017

SOLUTION

HPC's development environment - "GIRDER" – is the linchpin:

- Facilitating USAF collection of objective flight test data from instrumented tanker/receiver platforms for assessment
- Enabling the merging and synchronization of tanker/receiver files with MATLAB on hosted GIRDER environment
- Value already demonstrated in dry-run assessments to posture the USAF KC-46 simulators for certification
- Level of Certification - Unprecedented for any USAF aerial refueling airplane simulator (not just KC-46)

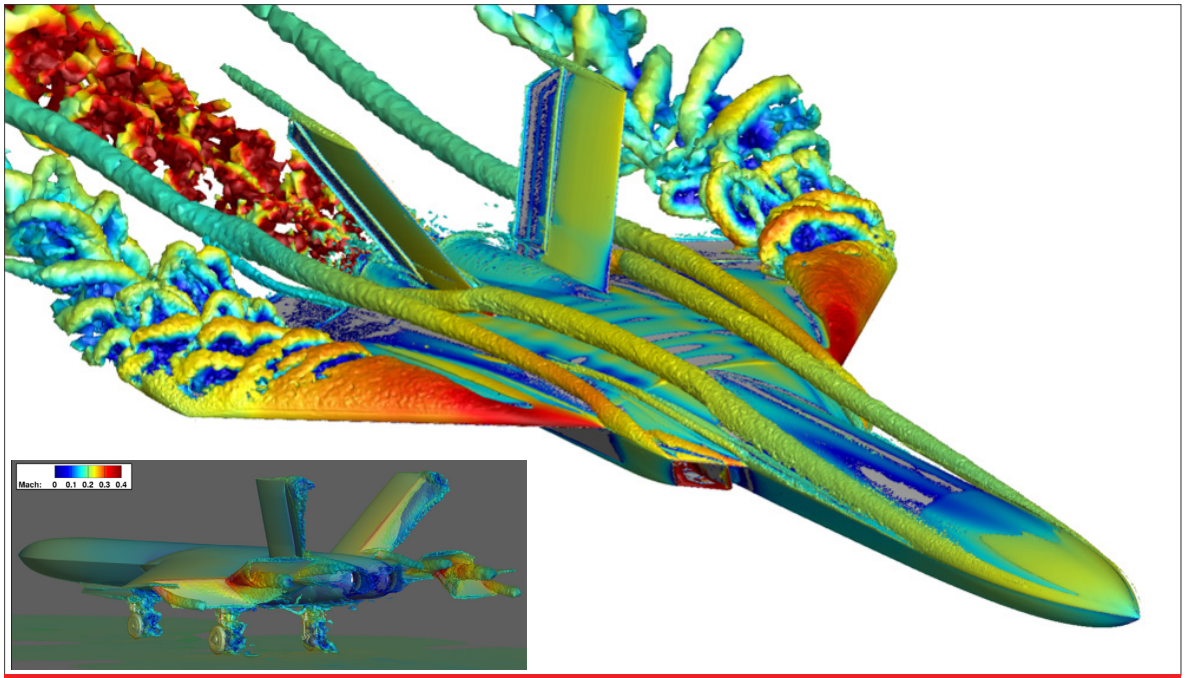
IMPACT

The payoff will reduce operations and support (O&S) costs by moving training (initial, currency, and continuation) from the aircraft into the simulators, saving $111M in iniitial training alone. Without this simulator certification type, 100% of formal and continuation training would be conducted in aircraft, and simulator would be relegated to procedure familiarization for A/R training.

5TH GENERATION AERIAL TARGET (5GAT)

Success Story - Air Force

***Attribution**: Arnold Engineering Development Complex (AEDC) and QuantiTech Inc.*



Air Force initial modeling and simulation of airflow dynamics using HPCMP CREATE-AV Kestrel

PROBLEM

Sierra Technical Services (STS) selected to design, build, ground, and flight test a demonstrator/prototype aircraft – ~30 months to first flight, government-owned design.

SOLUTION

The project objectives are to demo low flyaway cost -> "Break the cost curve", demo low-RCS, demo basic flight performance, and rapid prototype and flight test. HPCMP CREATE™'s Kestrel applications:

- Termination maneuver selection (airworthiness)
- High Mach directional stability / rudder effectiveness
- Engine bay cooling analysis
- Takeoff/landing dynamics: control effectiveness in-ground effect, speed brake effectiveness

IMPACT

The HPCMP developed digital model of the 5GAT aero vehicle to include integrated J85-5 engine; optimal maneuver/control settings for complex flight phases; and risk reduction in support of first flight which:

- defined the optimal termination maneuver,
- defined the effect of actuator covers on aero/S&C, and
- defined ground effect on controllability.

HPC ACCELERATING HEAVY-LIFT LAUNCH CAPABILITY FOR DoD

Success Story - Air Force

Falcon heavy launch

Attribution: US Air Force and SpaceX

PROBLEM

Since 2016, SpaceX has used the HPC allocations to investigate flow phenomena and supplement the knowledge of the aerodynamics of its space launch vehicles and associated hardware.

SOLUTION

In 2019, HPCMP allocated 17M core-hours to SpaceX through the US Air Force.

CFD simulations were used on launch vehicle configurations at various conditions and vehicle orientations. Data output from these simulations were very impactful to: integrated aerodynamic coefficient databases, aerodynamic and aerothermal loads analyses, wind tunnel test data correlation, localized flow investigation, and miscellaneous investigations of flow phenomena.

IMPACT

HPCMP resources enabled reduced risk through direct simulation of vehicle aerodynamics vice extrapolation, and provided detailed launch geometry analyses otherwise unobtainable in the time available.

The recent DoD Space Test Program-2 (STP-2) launch of Falcon Heavy was a resounding success for both SpaceX and the Air Force. This mission delivered 24 satellites to space on the DoD's first ever SpaceX Falcon Heavy launch vehicle.

HPCMP ACCESS

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Any government employee, contractor, or academic researcher who is actively supporting the DoD's RDT&E and/or acquisition engineering mission may request access to HPCMP resources.

Information on how to get started can be found at:

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Further assistance can be obtained by contacting require@hpc.mil.

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HPCMP ANNUAL HIGHLIGHTS FY2019/2020

The HPCMP amplifies the creativity, productivity, and impact of the DoD RDT&E and acquisition engineering communities by providing a virtual environment for design, analysis, and testing. The insights gained by HPC capabilities are often too costly, too dangerous, and/or too time-consuming to obtain through observation and experimentation in the physical world alone.