Call for FY 2021 DoD Frontier Project Proposals

Introduction

Purpose: The Department of Defense (DoD) High Performance Computing Modernization Program (HPCMP) established DoD Frontier Projects to enable the exploration of research, development, test and evaluation (RDT&E) and acquisition engineering outcomes that would not be achievable using typically available HPCMP resources. Frontier Projects pursue outcomes aligned with DoD mission priorities and are supported by multi-year commitments of exceptional amounts of high performance computing (HPC) computational resources (i.e., 100s of millions of core-hours per year).

Eligibility: All Frontier Projects must be sponsored by a DoD government scientist/engineer and must use HPCMP resources to enhance mission impact and capability. Principal investigators for Frontier Projects may be scientists or engineers from government, industry, or academia. If the principal investigator is a DoD government scientist/engineer, there is no need to name a separate DoD sponsor.

Relation to Existing Frontier Projects: The HPCMP seeks projects with high DoD impact and encourages applicants to propose work that is not duplicative of existing Frontier Projects. Of the ten active Frontier Projects, three projects will complete in FY 2020. The seven projects that will be active in FY 2021 with their corresponding computational technology areas (CTAs), https://www.hpc.mil/index.php/technology-areas/computational-tech-areas, are

1. Validation of Turbulence and Turbulent Combustion Models for Air Force Propulsion Systems, Venkateswaran Sankaran, Air Force Research Laboratory (CFD)
2. Prediction of Hypersonic Laminar-Turbulent Transition through Direct Numerical Simulation, Jonathan Poggie, Purdue University, sponsored by the Air Force Research Laboratory (CFD)
3. Earth System Prediction Capability, Joe Metzger, Naval Research Laboratory (CWO)
4. Integrated Computational Flight Simulation in Support of the Future Naval Capabilities (FNC) Dynamic Interface Virtual Environment (DIVE) Program, Susan Polsky, NAWCAD (CFD, IMT)
5. High-Fidelity Modeling and Simulation to Support Army Aviation Acquisition Programs, Andrew Wissink, Army Aviation Development Directorate, AMRDEC (CFD)
6. CVN 78 Modeling and Simulation Validation for Full Ship Shock Trial (FSST) Alternative, Brian Lang, Naval Surface Warfare Center – Carderock Division (CSM)

7. High-Fidelity Physics-Based Simulation of Kinetic and Directed Energy Weapons Integration Strategies for Future Air Dominance Platforms, Scott Sherer, Air Force Research Laboratory – Air Vehicles (CFD,CEA)

The three projects that will complete in FY 2020 are

1. Development of Multi-scale Models for Materials Design, Mark Gordon, Iowa State University, sponsored by the Air Force Research Laboratory (CCM)
2. Terminal Ballistics for Lethality and Protection Sciences, Robert Doney, Army Research Laboratory (CSM, CCM)
3. Navy Electromagnetic Railgun, Joel Mejeur, Naval Surface Warfare Center (CSM, CFD, CEA)

A summary of all ten projects is included in Attachment 1.

Awards: A Frontier Project may be proposed for a two-to-four-year duration. Exceptional amounts of HPC computational resources will be provided to each project without regard to any quota based on the proposing Services/Agencies. Support is available from HPCMP assets such as the DoD Supercomputing Resource Centers (DSRCs), User Productivity Enhancement and Training (PET), and the Data Analysis and Assessment Center (DAAC).

Project Review: Frontier Projects will be formally reviewed twice a year by the High Performance Computing Modernization Program Office (HPCMPO). One review is a formal project review meeting for HPCMP leadership with all Frontier Project Principal Investigators (PIs) present, and the other is an in-person, on-site visit to each project site focusing on an in-depth review of the technical aspects of the project. Written quarterly progress reports are required for quarters that do not contain either of the project review meetings. Project personnel are expected to have frequent interaction with DSRC and PET support personnel.

Submission: All Frontier proposals must be submitted through the appropriate Service/Agency High Performance Computing Advisory Panel (HPCAP) principal to the HPCMPO. All proposals must be at the unclassified level. Proposals must be received by the HPCMPO by 11 May 2020; however, HPCAP principals have established earlier internal deadlines. The HPCAP points-of-contact and dates for submission of proposals to the Services/Agencies are as follows:

- Air Force: Mr. Bryon Foster (Bryon.Foster@us.af.mil) and Mr. William Quigley (William.Quigley.5@us.af.mil). Submit proposals by 13 April 2020.
- Army: Mr. Robert Sheroke (Robert.M.Sheroke.civ@mail.mil), and Mr. Eldred Lopez (Eldred.I.Lopez.ctr@mail.mil). Submit proposals by 10 April 2020.
- Navy: Ms. Kathy Hollyer (kathy.hollyer.ctr@navy.mil). Submit proposals by 27 April 2020.
- DTRA: Ms. Jacqueline Bell (jacqueline.l.bell2.civ@mail.mil). Submit proposals by 13 April 2020.

- DARPA: Dr. Nick Lemberos (nick.lemberos@darpa.mil). Submit proposals by 30 March 2020.
- MDA: Mr. Jose Rivera (jose.rivera.ctr@mda.mil). Submit proposals by 13 April 2020.

Evaluation: Selection will based on the following 3 elements:

1. Service/Agency mission impact rankings
2. OSD mission impact scores
3. A technical review panel convened by the HPCMPO. This panel will evaluate proposals using the following criteria:
   - Technical merit: Based on the project's goals, solution approach, management approach, and technical quality, what is the value of the computational work to the technical communities to which the project applies?
   - Computational merit: How efficiently can the proposed project take advantage of the high performance computing capabilities requested? Is the proposed computational approach robust and is the software (existing and/or proposed) highly scalable to achieve the desired outcomes?
   - Potential for progress: Based on the team's qualifications and previous work, does the team have the potential to complete the proposed work?

Selection: The HPCMP Director will select the FY 2021 Frontier projects. Awards will be announced in early August 2020.

Questions: Contact Mr. Michael Ausserer, HPCMP Associate Director for Resource Management, at michael.f.ausserer.civ@mail.mil or 937-255-6614.

Proposal Contents

Frontier Project proposals are limited to 15 pages (single-spaced, standard 12-point font, one-inch margins) and must be a single Word document. If a Word document cannot be submitted, please contact your Service/Agency and the HPCMPO (frontier@hpc.mil) for suitable alternative formats. The cover page, resource request sheets, and any curricula vitae do not count against the 15-page limit. Proposals must contain the following sections – ordered and numbered as indicated. Suggested lengths for each section are provided.

Cover Page: (Length: 1 page maximum, does not count against the 15 page limit; see Attachment 2)

Project Title: Provide the title of the project.

Requirements Project Number(s): Provide the project number(s) (as reflected in the HPCMP requirements database) representing the project requirements on which the Frontier Project proposal is based. A proposal cannot be considered unless its resource requirements are reflected in the HPCMP requirements database. Please contact Tameka Jones at require@hpc.mil for further details.

CTA: List the primary and associated CTAs that best fit this project (see https://www.hpc.mil/index.php/technology-areas/computational-tech-areas).

Duration: Specify the expected duration of the project, in years.

Estimated Core-hours by Year: Summarize the total estimated computational requirement described on the Project Resource Request sheets by year, in millions of core-hours (see Attachment 3).

Government Sponsor: Provide the Government sponsor's name and contact information, if the principal investigator is not a DoD government scientist/engineer.

Principal Investigator: Provide the Frontier Project's principal investigator's name and contact information. Only one person should be listed, and that person will be the lead for interactions with the HPCMP during the project.

Key Collaborators: Provide a list of organizations or personnel planned to participate in the project.

Technical Goals and Approach: Summarize the technical objectives of the project and the planned computational approach.

Major Applications Software: List major applications software that will be used.

Technical & Computational Challenges: Summarize anticipated challenges for the project and the planned computational approach.

DoD Impact: Summarize the projected DoD impact.

Community Impact: Summarize the projected impact on the scientific and engineering community.

Technical Proposal: Include the following topics in the proposal narrative:

Introduction: Introduce the project in broad terms. Include a general discussion of ongoing related work in both your organization and the scientific, technology, and/or testing community. (Length: approximately ½ to 1 page)

DoD Impact: Clearly state the DoD mission impact of the project and any current and future programs of record it will support. State the advantage to be gained by exploiting HPC capability. (Length: approximately ½ to 1 page)

Technical Approach: Clearly state the technical goals of the project and discuss the science, technology, and/or engineering activities that are required to meet these goals. Provide a plan for achieving these goals. Discuss technical challenges that will likely be encountered during the course of the project and how they will be overcome. (Length: approximately 3-6 pages)

Timeline and Anticipated Accomplishments: State clearly the duration of the project and provide a schedule in tabular form with estimated milestones and anticipated accomplishments for each year. (Length: approximately ½ to 1 page)

Computational Approach: Describe the computational methodology and algorithms, and estimate the size of the problem with as many supporting details as possible. Discuss the relationship between early year developments and later year accomplishments. Discuss applicable software efficiency on scalable systems by stating the performance as a function of the degree of parallelism. Show evidence that the software provides sufficient foundation to scale to the problem size needed to achieve the goals of the project and/or discuss software developments that will be required as a part of the project. Scalability information, including a graph of application performance for a typical test case versus the number of cores, should be included. Discuss optimal computational architectures relative to available HPCMP resources. Discuss the computational challenges that will likely be encountered during the course of the project and how they will be overcome. (Length: approximately 2-4 pages)

Progress to Date: Discuss preparatory work in the proposed technical area in this section. Elaborate on any HPC resources previously used by this project and/or efforts leading up to this proposed project. Discuss what work remains and how a Frontier Project can facilitate achieving the proposed work. (Length: approximately ½ to 2 pages)

Key Personnel: Identify the key personnel who will work on this project and summarize the background and qualifications of each participant, including each participant's projected level of effort. Provide an estimate of the size of the group that will perform this work, including an estimate of the percentage of time each team member will contribute to the project. Also include a discussion of possible incorporation of HPCMP team members into the project team. (Length: approximately 1-2 pages)

Required Computational Resources and Justification: Outline the computational resources required to accomplish this project in terms of total core-hours on HPCMP systems for all years of the project. Where possible, provide requirements on specific HPCMP systems for FY 2021 and FY 2022. These early year requirements should be definitive and reasonably accurate. Note that the HPCMP has now significantly increased the proportion of classified computing capability. For the out-years, an estimated number of core-hours on a generic system architecture expected to be available during the out-years may be stated. **A list of current HPCMP systems is available at https://centers.hpc.mil**. Justification for the required level of computational resources can be provided by documenting known run times on the same or similar architectures as proposed for the project and scaling those to address the project's goals. Include a discussion of any specialized memory, storage, networking, and/or software requirements. (Length: approximately 1-3 pages)

Computational Summary Sheet: Provide estimates of computational resources required to accomplish the proposed project. A completed DoD Frontier Project Resource Request (see Attachment 3; not part of 15-page limit) for each year of the proposed project is required. The form is divided into three sections:

- Section I: Specify the applicable year and enter the principal investigator information.
- Section II: There are two tables in Section II. The first table facilitates outlining suites of systems at various locations that can address the project's requirements. Proposals may present multiple scenarios (combinations of platforms and locations). The second table, which contains computational processor, memory, and data archive storage requirements, must be completed once for each year of the project.
- Section III: Enter the computational project titles and project numbers (as reflected in the HPCMP requirements database) associated with the project. Please contact Tameka Jones at require@hpc.mil if you need assistance with this.

Curricula Vitae: Provide a *curriculum vita* (including a list of relevant publications) for each of the key personnel. (not part of 15-page limit)

Attachment 1
Summary of Existing Frontier Projects

Development of Multi-scale Models for Material Design (Mark Gordon, Iowa State University, sponsored by the Air Force Office of Scientific Research)

This Frontier Project's goal is the development and application of a multi-scale method that seamlessly integrates electronic structure theory methods, parameter-free coarse-graining methods, and molecular dynamics/Monte Carlo simulation methods to provide accurate and efficient predictions of bulk properties of advanced materials, without the need for empirically fitted parameters. The new multiscale simulation methods will be implemented in the widely-used GAMESS code, thus making these new capabilities available to a broad user base in government, industry, and academia. The methodologies will be applied to accurate computation of the properties of ionic liquids, which, as potential new propellants, may have significant impacts to DoD, including (a) reliable and cost effective access to space, (b) improved satellite maneuverability and increased on-orbit lifetime, and (c) reduction of environmental and toxicological hazards and improved safety associated with propellant storage and handling.

Terminal Ballistics for Lethality and Protection Sciences (Robert Doney, Army Research Laboratory)

This Frontier Project seeks to advance the state-of-the-art in terminal ballistics by focusing on three themes: rigorous uncertainty quantification of ballistic events, understanding human response to ballistic loading, and breakthrough capability for materials modeling. Each area requires multi-scale continuum and mesoscale modeling capability. Successful investigation of these three themes will further develop the quality of shock physics codes which provide critical modeling capability to enable significant DoD advances in armor, lethality, and hypervelocity impact.

Validation of Turbulence and Turbulent Combustion Models for Air Force Propulsion Systems (Venkateswaran Sankaran, Air Force Research Laboratory)

The goal of this Frontier Project is the development, validation, and application of advanced turbulence and turbulent combustion models designed specifically for Air Force propulsion applications, including gas turbines, scramjets, and rockets. Reacting direct numerical simulations (DNS) and large eddy simulations (LES) coupled with existing and new turbulence, combustion, and turbulent combustion modes will be evaluated using a hierarchy of unit physics, canonical and grand challenge problems in gas turbines, augmentors, rockets, and scramjets.

Prediction of Hypersonic Laminar-Turbulent Transition through Direct Numerical Simulation (Jonathan Poggie, Purdue University, sponsored by Air Force Research Laboratory)

The objective of this project is to improve the prediction of hypersonic laminar-turbulent transition, and consequently to improve the prediction of heating rates in hypersonic flight. It will predict acoustic noise and transition in conventional hypersonic wind tunnels to make these facilities more useful for vehicle design. Direct numerical simulation (DNS) of hypersonic boundary layer receptivity will be performed to predict the acoustic noise spectrum radiated from turbulent boundary layers on wind tunnel walls and examine the effects on boundary layer transition of disturbances introduced from the free-stream and at the tunnel wall. With this new understanding of the effects of tunnel noise, conventional hypersonic wind tunnels will be useful for testing hypersonic vehicles in spite of this noise. This may would save the DoD the cost of a new hypersonic quiet facility, an investment of at least $20M with 5-10 years of development. The proposed work will impact several DoD programs in hypersonics, including the High-Speed Strike Weapon (HSSW).

Earth System Prediction Capability (Joe Metzger, Naval Research Laboratory)

The overall goal of this Frontier Project is to perform the R&D necessary to produce the Navy's contribution to the national Earth System Prediction Capability (ESPC). Specifically, this will be our first operational global long-range coupled forecast system for the atmosphere, ocean, sea ice, and waves that extends beyond a week to a month or more. The core components of this ESPC system are the Navy’s current global prediction models for seven-day forecasts. Data assimilation will also initially use the Navy's current separate atmosphere and ocean products loosely coupled via the coupled forecast model as a first approximation. We use multi-year re-analyses and re-forecasts to test and understand the system. The target for IOC is a 30-day ensemble forecast, but much of our testing will be with 45- or 60-day re-forecasts since we expect to extend the range for FOC.

Integrated Computational Flight Simulation in Support of the Future Naval Capabilities Dynamic Interface Virtual Environment Program (Susan Polsky, Naval Air Warfare Center – Aircraft Division)

This Frontier Project's goal is to predict the limits of flight envelopes for rotorcraft landing on ships. The project will use CFD coupled with Manned Flight Simulator aircraft flight dynamics models to accurately predict the non-linear aerodynamics affecting helicopter performance and pilot workload due to coupling between atmospheric winds/ship airwake, dynamic control surface motion (as controlled by the aircraft flight control laws and autonomous pilot inputs), and aircraft motion relative to the ship. These models will be further developed, tested, and validated against wind tunnel and flight test data.

High-Fidelity Modeling and Simulation to Support Army Aviation Acquisition Programs (Andrew Wissink, Army Aviation Development Directorate, AMRDEC)

The goal of this project is to integrate the CREATE-AV Helios and Kestrel high-fidelity modeling and simulation tools into Future Vertical Lift acquisitions of interest to Army Aviation to demonstrate the impact of these tools for the acquisition of major defense systems by reducing cost, development time, and risk. The project will perform high-fidelity multi-disciplinary computational modeling and simulation for the Future Attack and Reconnaissance Aircraft (FARA), Future Long Range Attack Aircraft (FLRAA), and Future Unmanned Air Systems (FUAS) acquisition programs in Future Vertical Lift (FVL), in order to characterize performance, loads, vibration, noise, and safety to inform decision teams. Frontier resources will enable high quality computational analysis of these configurations with a high-resolution digital model before the expensive manufacturing and flight test phase of the acquisition. Because FUAS has a longer-term development cycle (scheduled DoD insertion FY27), the project will focus on newly envisioned applications of the current Gray Eagle UAS configuration presently used by the Army.

CVN 78 Modeling and Simulation Validation for Full Ship Shock Trial (FSST) Alternative (Brian Lang, Naval Surface Warfare Center – Carderock Division)

NAVSEA has been tasked by SECNAV's office with performing M&S in advance of the summer 2020 USS GERALD R. FORD (CVN 78) Full Ship Shock Trial (FSST) in an effort to validate the Navy Enhanced Sierra Mechanics (NESM) software using blind, pre-trial predictions to support an FSST alternative. This task seeks to complete NESM simulations for all 3 planned FSST shots prior to the 2020 FSST. The NESM software will be validated against data that will be recorded during the next FSST, which will be conducted against the CVN 78 in late FY20. One hundred fifty shock response sensors will be installed on CVN 78 specifically for this effort, which will provide an ample data set against which to validate NESM for predicting equipment dynamic inputs under shock loading.

High-Fidelity Physics-Based Simulation of Kinetic and Directed Energy Weapons Integration Strategies for Future Air Dominance Platforms (Scott Sherer, Air Force Research Laboratory – Air Vehicles)

The goals of this project include development of robust flow-control options for integration of directed and kinetic energy weapon systems on future air dominance platforms, and demonstration of selected options on a representative maneuvering vehicle. To accomplish these goals, high-fidelity, unsteady CFD using primarily DDES to design and evaluate flow control options will be used. Novel script-based grid generation will be used to quickly develop and simulate new geometries. Overset grid techniques will be used to incorporate selected concepts onto vehicles and dynamic, moving grid simulations will be performed.

Attachment 2
FY 2021 DoD Frontier Project Proposal Cover Page

FY2021 DoD FRONTIER PROJECT PROPOSAL COVER PAGE

Project Background		
Project Title:		
Requirements Project Number(s):	CTA(s):	Project Duration (in years):
Estimated Core-hours by year: FY21- FY22- FY23- FY24-		
Government Sponsor		
Name:	Email Address:	
Organization:	Phone Number:	
Principal Investigator (may be the same as Government Sponsor)		
Name:	Email Address:	
Organization:	Phone Number:	
Key Collaborators		
Names & roles:		
Technical Goals		
Technical Approach		
Major Applications Software (e.g., ANSYS CFD)		
Technical & Computational Challenges		
DoD Impact (Specify the impact of the project's outcomes to DoD)		
Community Impact (Describe the project's impact on the scientific and/or engineering community)		
Cover material limited to one page – row heights may be adjusted to suit		

Attachment 3

DoD Frontier Project Resource Request

DoD Frontier Project Resource Request

Section I: General Information

Project Number and Title: ____

Project Year: ____

Principal Investigator:

Name:____

Service/Agency:____

Organization:____

Address, City, State, and Zip Code: ____________________________________

____

E-Mail Address: ____

Phone: ____

Section II: Overall Project Resource Requirements

Platform(s)	**Location (DSRC)**		**CPU/GPU Resources (core-hours)**	
	First Choice	**Second Choice**	**Request**	**Minimum Acceptable**

Note: If needed, insert multiple copies of the table above.

Platform(s)	Typical Number of Processors	Maximum Number of Processors	Typical Job Memory (GB)	Maximum Job Memory (GB)	Total Data Archive Storage Requirements (TB)

Total Expected Working Storage Requirements (in TB):______________________________

Annual Expected Archival Storage Requirements (per year in TB):____________________

Section III: Requirements Project Information

HPCMP Requirements Database Information:

Project Title from HPCMP Requirements Database:________________________________

Project Number from HPCMP Requirement Database:______________________________