NASA SBIR 2021 Phase I Solicitation

S5.01 Technologies for Large-Scale Numerical Simulation

Lead Center: ARC

Participating Center(s): GSFC

Scope Title:

Exascale Computing

Scope Description:

NASA scientists and engineers are increasingly turning to large-scale numerical simulation on supercomputers to advance understanding of complex Earth and astrophysical systems and to conduct high-fidelity aerospace engineering analyses. The goal of this subtopic is to increase the mission impact of NASA's investments in supercomputing systems and associated operations and services. Specific objectives are to:

- Decrease the barriers to entry for prospective supercomputing users.
- Minimize the supercomputer user's total time-to-solution (e.g., time to discover, understand, predict, or design).
- Increase the achievable scale and complexity of computational analysis, data ingest, and data communications.
- Reduce the cost of providing a given level of supercomputing performance for NASA applications.
- Enhance the efficiency and effectiveness of NASA's supercomputing operations and services.

Expected outcomes are to improve the productivity of NASA's supercomputing users, broaden NASA's supercomputing user base, accelerate advancement of NASA science and engineering, and benefit the supercomputing community through dissemination of operational best practices. The approach of this subtopic is to seek novel software and hardware technologies that provide notable benefits to NASA's supercomputing users and facilities and to infuse these technologies into NASA supercomputing operations. Successful technology development efforts under this subtopic would be considered for follow-on funding by, and infusion into, NASA's high-end computing (HEC) projects: the High End Computing Capability project at Ames and the Scientific Computing project at Goddard. To assure maximum relevance to NASA, funded SBIR contracts under this subtopic are engaged to interact with one or both HEC projects and with key HEC users where appropriate. During the project the lead PI is encouraged to interact with the technical monitor on NASA HEC needs. Projects that require access to NASA HEC resources must provide adequate justification, and proposers should realize that it takes significant amount of time to gain access to on-site resources due to security requirements, which could jeopardize Phase I deliverable timelines. In addition, these resources are heavily used and would be limited for use for SBIR projects.

The technology areas of this subtopic are aligned with two objectives of the NSCI, the National Strategic Computing Initiative, announced by the White House in July 2015. These technologies that are amenable to quick,
small efforts for advancement: (1) Technologies to accelerate delivery of a capable exascale computing system
delivering approximately 100× the performance of current systems across a range of applications (NSCI Objective
1) and (2) Technologies to increase coherence between the technology base used for modeling and simulation and
that used for data analytic computing (NSCI Objective 2).

**Expected TRL or TRL Range at completion of the Project:** 5 to 7

**Primary Technology Taxonomy:**
Level 1: TX 11 Software, Modeling, Simulation, and Information Processing
Level 2: TX 11.6 Ground Computing

**Desired Deliverables of Phase I and Phase II:**
- Prototype
- Software

**Desired Deliverables Description:**
Novel software and hardware technologies that provide notable benefits to NASA’s supercomputing users and
facilities, and to infuse these technologies into NASA supercomputing operations. Successful technology
development efforts under this subtopic would be considered for follow-on funding by, and infusion into, NASA’s
HEC projects: the High End Computing Capability project at Ames and the Scientific Computing project at
Goddard.

The expected deliverable for Phase I is research that demonstrates technical feasibility as described in a final
report, and the deliverable for Phase II is a prototype demonstration.

Offerors should demonstrate awareness of the state of the art of their proposed technology, and should leverage
existing commercial capabilities and research efforts where appropriate. Open-source software and open standards
are strongly preferred. Note that the NASA supercomputing environment is characterized by:

- HEC systems operating behind a firewall to meet strict information technology (IT) security requirements.
- Communication-intensive applications.
- Massive computations requiring high concurrency.
- Complex computational workflows and immense datasets.
- The need to support hundreds of complex application codes—many of which are frequently updated by the
  user/developer.

**State of the Art and Critical Gaps:**
The state of the art and the critical gaps of the main technologies areas are:

1. NASA science requires at least 100× more powerful supercomputers and 1000× higher application
   parallelism in 10 years, at the same power.
2. Current technologies for high-fidelity computational simulations and data analytics are distinct, and
   interfacing them is inefficient.

**Relevance / Science Traceability:**

Virtually all high-end computing systems and applications can benefit from the deliverables of this subtopic. As the
demand for high-end computing continue to grow, there is an increasing need for the solicited technologies in both
the government and industry.

**References:**
NASA High-End Computing Capability Project: https://www.nas.nasa.gov/hecc/about/hecc_project.htm