NASA SBIR 2006 Phase I Solicitation

S8  Advanced Modeling, Simulation, and Analysis for Science

Modeling and simulation are being used more pervasively and more effectively throughout NASA, for both engineering and science pursuits, than ever before. These are tools that allow high fidelity simulations of systems in environments that are difficult or impossible to create on Earth, allow removal of humans from experiments in dangerous situations, and provide visualizations of datasets that are extremely large and complicated. Examples of past simulation successes include simulations of entry conditions for man-rated space flight vehicles, visualizations of distant planet topography via simulated fly-over and three-dimensional visualizations of coupled ocean and weather systems. In many of these situations, assimilation of real data into a highly sophisticated physics model is needed. Also use NASA missions and other activities to inspire and motivate the nation's students and teachers, to engage and educate the public, and to advance the scientific and technological capabilities of the nation.

Subtopics

S8.01 Automation and Planning for Complex Tasks

Lead Center: ARC

This subtopic solicits proposals for technologies and systems that allow spacecraft and ground systems to robustly perform complex tasks in dynamic environments with minimal human direction. Areas of interest include support of decision support systems, distributed sensor webs and component systems, and the creation of automation loops connecting scientific modeling and analysis to mission planning, data collection, processing and operations. NASA is moving from a stove-pipe observational architecture to one that permits data interoperability and dynamic coordination of observational assets to generate desired data products. Technology innovations include, but are not limited to:

- Automation and autonomous systems that support high-level command abstraction;
- Efficient and effective techniques assessing gaps in data collection to assure complete coverage;
- Intelligent searches of distributed data archives, and data discovery through searches of heterogeneous data sets and architectures; and
• Automation of routine, labor intensive tasks to that either increase reliability or throughput of current process.

Specific areas of interest include the following:

• Search agents that support applications involving the use of NASA data using emerging interoperability such as Sensor Model Language;
• Methods that support the planning and scheduling of sensor webs in support of data product processing when given a set of high-level goals and constraints;
• Autonomous data collection including the coordination of space or airborne platforms while adhering to a set of data collection goals and resource constraints;
• System and subsystem health and maintenance, both space- and ground-based;
• Distributed decision making, using multiple agents, and/or mixed autonomous systems;
• Automatic software generation and processing algorithms; and
• Control of Field Programmable Gate-Arrays (FPGA) to provide real-time products.

S8.02 Distributed Information Systems and Numerical Simulation

Lead Center: ARC

This subtopic seeks advances in tools, techniques, and technologies for distributed information systems and large-scale numerical simulation. The goal of this work is to create an efficient and effective information and computing environment that enables NASA scientists to work naturally with distributed teams and resources to dramatically reduce total time-to-solution (i.e., time to discovery, understanding, or prediction), vastly increase the feasible scale and complexity of analysis and data assimilation, and greatly accelerate model advancement cycles. Areas of interest are described below.

Distributed Information Systems

• Supercomputing environment simulation, to identify or anticipate bottlenecks in the environment and to effectively engage all supercomputing program resources. The simulation could include models of application behavior, the full computing and data workload, computing and data systems, local and wide area networks, data analysis and visualization systems, the interface to various facility and user services personnel, and the interface to the remote user at their desktop.
• Services (autonomous software systems) for automated, scalable, and reliable management of distributed, dynamic, and heterogeneous computing, data, and instrument resources. Services of interest include those
for authentication and security, resource and service discovery, resource scheduling, event monitoring, uniform access to compute and data resources, and efficient and reliable data transfer.

- Science portals for cross-disciplinary discovery, understanding, and prediction, encapsulating services for single sign-on access, semantic resource and service discovery, workflow composition and management, remote collaboration, and results analysis and visualization.

**Large-Scale Numerical Simulation**

- Tools for automating large-scale modeling, simulation, and analysis, including those for managing computational ensembles, performing model-optimization studies, interactive computational steering, and maintaining progress in long-running computations in spite of unreliable computing, data, and network resources.

- Tools for computer system performance modeling, prediction, and optimization for real applications.

- Techniques and tools for supercomputing application porting, parallelization, debugging, scaling, performance analysis, and optimization.

- Tools for effective load balancing, and high reliability, availability, and serviceability (RAS) in commodity clusters and other large-scale computing systems.

- Novel supercomputing approaches using FPGAs, graphics processors, and other novel architectures and technologies.

**S8.03 On-Board Science for Decisions and Actions**

**Lead Center: ARC**

The focus of this subtopic is enhanced capabilities for NASA observatories in the sensor or platform, or early in the data stream, that can prioritize data for transmission and analysis, or summarize the data for future use. NASA's vision of a sensor-web capability will demand more onboard autonomy and content based data management to support rapid decision making and re-tasking. This subtopic is interested in methods to autonomously understand data as part of a sensor web system capable of rapid redirection and configuration.

**Onboard Satellite Data Processing and Intelligent Sensor Control**

Software technologies that support the configuration of sensors, satellites, and sensor webs of space-based resources. Examples include capabilities that allow the reconfiguration or re-targeting of sensors in response to user demand or in significant events seen in other sensors. Included are software that supports the reasoning and modeling of such capabilities for demonstration and mission simulation. Also included in this category is onboard analysis of sensor data that could run on reconfigurable computing environments as well as technologies that support or enable the generation of data products for direct distribution to users.

**Onboard Satellite Data Organization, Analysis, and Storage**
Software technologies that support the storage, handling, analysis, and interpretation of data. Examples include innovations in the enhancement, classification, or feature extraction processes. Also included are data mining, intelligent agent applications for tracking data, distributed heterogeneous frameworks (including open system interfaces and protocols), and data and/or metadata structures to support autonomous data handling, as well as compaction (lossless) or compression of data for storage and transmission.

**Simulation and Analysis of Sensor Webs for Improving Science Models or Mission Operations**

Software that allows for the simulation of a sensor web of varying platform types producing a variety of data streams. These platforms could be in various orbits (L1, L2, NEO, LEO, etc.) and suborbital (UAV) that are automatically assigned different temporal and spatial coverages. Data streams would be assigned to these platforms and the system computes how the sensor web would cover of events (e.g., volcanic eruption, fires, and crop monitoring) at user designated, particular, geospatial locations (or areas).

**S8.04 Spatial and Visual Methods for Search, Analysis and Display of Science Data**

**Lead Center:** SSC  
**Participating Center(s):** ARC

This subtopic seeks technical innovation and unique approaches to exploit spatial tools in order to increase the use of NASA research data, models, simulations, and visualizations. The goal is to facilitate NASA's Science and Exploration Missions, and outreach to the interested public. The tools should be easy to use by non-specialists, from scientists and policy makers to the general public. Tools and services will be prototyped for accessing and fusing (or mashing) image and vector data with popular Web-based or stand-alone applications. Tools can be plug-ins or enhancements to existing software or on-line services. Tools and the products might be used for broad public dissemination or for communicating within a narrower scientific community.

For example, an authoring tool may help a non-GIS expert to map a National Weather Service modeled hurricane path over a background of NASA MODIS sea surface temperatures, in turn draped on a visualization of the globe served by GoogleEarth.

To promote interoperability, tools shall use industry standard protocols, formats, and APIs. For example a tool may manipulate XML of various types, such as GML, SensorML, KML; or use standard services, such as WSDL and UDDI. Applications may subset, filter, merge, and reformat existing spatial data; provide links to attribute data; or visualize results. Combining NASA research data with popular geospatial services is encouraged. Examples of popular applications and services currently include:

- Imagery servers: e.g., NASA DAACs, OGA servers (USGS, NOAA, DOI), Microsoft Terraserver, Google Maps;
- Mapping platforms: e.g., Google Earth, NASA WorldWind;
- Map servers: e.g., Census Bureau, EPA Maps, Google Maps, MapQuest, Yahoo Maps.

S8.05 Data Management and Visualization

Lead Center: GSFC

This subtopic focuses on supporting science analysis through innovative approaches to managing and visualizing collections of science data which are extremely large, complicated, and are highly distributed in a networked environment that encompasses large geographic areas. There are specific areas for which proposals are being sought:

3D Virtual Reality Environments

- 3D virtual reality environments for scientific data visualization that make use of novel 3D presentation techniques that minimize or eliminate the need for special user devices like goggles or helmets;
- Software tools that will enable users to 'fly' through the data space to locate specific areas of interest.

Distributed Scientific Collaboration

- Tools that enable high bandwidth scientific collaboration in a wide area distributed environment;
- Novel tools for data viewing, real-time data browse, and general purpose rendering of multivariate geospatial scientific data sets that use geo-rectification, data overlays, data reduction, and data encoding across widely differing data types and formats.

Distributed Data Management and Access

- Metadata catalog environments to locate very large and diverse science data sets that are distributed over large geographic areas;
- Dynamically configurable high speed access to data distributed and shared over wide area high speed network environments;
- Object based storage systems, file systems, and data management systems that promote the long term preservation of data in a distributed online (i.e. disk based) storage environment, and provide for recovery from system and user errors.