



## NASA SBIR 2012 Phase I Solicitation

### S5.04 Integrated Science Mission Modeling

Lead Center: GSFC

Participating Center(s): ARC, JPL

NASA seeks innovative systems modeling methods and tools to:

- Define, develop and execute future science missions, many of which are likely to feature designs and operational concepts that will pose significant challenges to existing approaches and applications, and
- Enable disciplined system analysis for the ongoing management and decision support of the space science technology portfolio, particularly with regard to understanding technology alternatives, relationships, priorities, timing, availability, down-selection, maturation, investment needs, system engineering considerations, and cost-to-benefit ratios; to examine "what-if" scenarios; and to facilitate multidisciplinary assessment, coordination, and integration of the technology roadmaps as a whole.

Use of System Modeling Language (SysML) is encouraged but not required. SysML is a general purpose graphical modeling language for analyzing, designing and verifying complex systems that may include hardware, software, information, personnel, procedures and facilities. As a language, SysML represents requirements, structure, behavior, and equations in nine different diagram types, and can represent both hardware and software models. The language can be extended to provide metamodels for different disciplines, and is supported by multiple commercial tools. SysML is finding increased use throughout the agency to support systems engineering and analysis.

Specific areas of interest include the following:

- *Integration of system and mission modeling tools with high-fidelity multidisciplinary design and modeling tools, supporting efficient analysis methods that accommodate uncertainty, multiple objectives, and large-scale systems* - This requires the development of robust interfaces between SysML and other tools, including CAD/CAE/PDM/PLM applications, used to support NASA science mission development, implementation and operations. The objective is to produce a unified environment supporting mixed systems-level and detailed analysis during any lifecycle phase, and rapid analysis of widely varying concepts/configurations using mixed-fidelity models, including geometry/mesh-based models when required. The human interface for such a system could be a "dashboard" (web-based is highly desirable) which initially allows for monitoring of the dataflow across a heterogeneous set of tools and finally allows for control of the data flow between the variety of applications.

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- *Modeling and rapid integration of programmatic, operational, and risk elements* - Fully integrated system model representations must include non-physics based constructs such as cost, schedule, risk, operations, and organizational model elements. Novel methods and tools to model these system attributes are critical. In addition, approaches to integrate these in a meaningful way with other system model elements are needed. Methods that consider the development of these models as by-products of a collaborative and/or concurrent design process are particularly valuable.
  - *Library of SysML models of NASA related systems* - Using a library of SysML models, engineers will be able to design their systems by reusing a set of existing models. Too often, these engineers have to begin from scratch the design of the systems. A library of verified and validated models would provide a way for the engineers to design a new spacecraft by assembling existing models that are domain specific, and therefore easy to adapt to the target system. In order to provide for seamless integration between SysML models each model must identify its level of abstraction both in terms of the modeling of time (progression: no ordering of events, qualitative ordering of events, metric time ordering of events) and the modeling of space (progression: lumped parameters models, distributed parameter models). Such levels of abstraction "certificates" for SysML will help determine integration interface requirements between any two models.
  - *Profiles for spacecraft, space robotics, and scientific instruments* - Profiles provide a means of tailoring SysML for particular purposes. Extensions of the language can be inserted. This allows an organization to create domain specific constructs which extend existing SysML modeling elements. By developing profiles for NASA domains such as Spacecraft, Space Robotics and Scientific Instruments, powerful mechanisms will be available to NASA systems engineers for designing future space systems.
  - *Requirements Modeling* - SysML offers requirements modeling capabilities, thus providing ways to visualize important requirements relationships. There is a need to combine traditional requirements management, supported by tools including but not limited to DOORS and CRADLE, and SysML requirements modeling in a standardized and sustainable way.
  - *Functional Modeling* - The intermediate data products between requirements and specification are detailed functional models that identify all of the functions required to achieve the mission profile(s). There is a critical need to model this layer as it is a key data product to provide traceability between requirements and implementation.
  - *Model and Modeling Process Synthesis* - As model-based design broadens and integrates larger and more complex models, methods for how to sequence and operate the design synthesis, evaluation (e.g., V&V) and elaboration process will become more important, as will considerations of how model-based processes are made compatible with existing review and development cycles.