NASA SBIR 2020 Phase I Solicitation

H6.04   Model Based Systems Engineering for Distributed Development

Lead Center: ARC

Technology Area: TA11 Modeling, Simulation, Information Technology and Processing

Scope Title

Model Based Systems Engineering for Distributed Development

Scope Description

Systems Engineering technology is both a critical capability and a bottleneck for NASA human exploration development. NASA looks to a sustainable return to the Moon to enable future exploration of Mars, components such as Lunar Gateway and Commercial Lunar Payload Services (CLPS) will require partnerships with a wide variety of communities. Building from the success of the international partnerships for International Space Station (ISS), space agencies from multiple governments are looking for roles on the Gateway. A particular focus has been made to include the rapidly growing commercial space industry to provide an important role in supporting a sustained presence on the Moon. All of these potential partners will have their own design capabilities, their own development processes and internal constituencies to support. Integrating and enabling disparate systems built in different locations by different owners to all work cohesively together will require a significant upgrade to the core systems engineering capabilities.

In the last decade Model-Based Systems Engineering (MBSE) technology has matured as evidenced by the development of Systems Modeling Language (SysML) tools and frameworks that support engineers in development efforts from requirements through hardware and software implementation. MBSE holds considerable promise for accelerating, reducing overhead labor, and improving the quality of systems development. However, a remaining bottleneck is the coordination and integration of system development across distributed organizations, such as the multiple partners developing lunar gateway and eventual Mars exploration. This subtopic seeks technology to fill this gap.

Areas of particular need include:

- Methodologies that support integration among tools and exchange of information between multidisciplinary artifacts using automated intelligent reasoning.
- The definition of open interface standards and tools to enable inspection of distributed models across engineering domains.
- Tools or systems that allow models to be shared across development environments and trace the resulting system model back to contributions from multiple partners.
- Modeling environments that facilitate user interaction from multiple stakeholders of varying expertise in MBSE.
- Continuous integration and verification of safety critical system requirements that depend on disparate

development sources.

References:

- https://www.nasa.gov/consortium/ModelBasedSystems
- http://www.omgsysml.org
- Ensuring information exchange of digital artifacts are transferable and up to date among multiple stakeholders.
    - Digital Engineering Information Exchange Working Group (DEIX WG):
      http://www.omgwiki.org/MBSE/doku.php?id=mbse:deix
- Computational tools to augment human decision making and reasoning on complex systems with large amounts of data from disparate sources
    - Augmented Intelligence for Systems Engineering challenge team (AI-SECT):
      http://www.omgwiki.org/MBSE/doku.php?id=mbse:augmented
- Automated formal specification, formal verification, and test case generation of requirements with linked data and traceability to discipline specific (CAD, CAE, etc.) tools, particularly requirements with safety properties.
    - ReqIF: https://www.omg.org/reqif/
    - SysPhs: https://www.omg.org/spec/SysPhS/
    - FMI: https://fmi-standard.org
- Lightweight and intuitive cloud-based interfaces for CRUD (create, read, update, delete) operations on models particularly for users with limited MBSE experience.
- Open-MBEE: https://openmbee.org
- OSLC: https://open-services.net/

Expected TRL or TRL range at completion of the project: 4 to 6

Desired Deliverables of Phase II

Prototype, Software

Desired Deliverables Description

Methodologies and tools that support distributed development efforts

State of the Art and Critical Gaps

For distributed development, the state-of-the-art tends to be laboriously negotiated interface control documents and manual integration processes that are inherently slow and labor intensive. In an effort to overcome these challenges MBSE and SysML in particular has seen significant adoption at NASA (Gateway, Resource Prospector, Europa Clipper, Space Communications and Navigation [SCaN], Space Launch System [SLS]) especially after the MBSE Pathfinder ('16/'17) and MBSE Infusion And Modernization Initiative (MIAMI, '18/'19) studies. However, these pilot programs and a survey of NASA's use of MBSE conducted by NASA Independent Verification & Validation (IV&V) and Ames Research Center identified areas of critical need, including:

1. Sharing and version control of models.
2. Integration of SysML of domain specific tools
3. Steep learning curve for users with limited MBSE experience
4. Testing, Verification and Validation with SysML have limited use
5. No tools exist for formally specifying requirements and linking to model properties

With programs such as Gateway and Artemis that require coordination among multiple NASA centers, international space agencies, and commercial partnerships these needs will be amplified.   Tool infrastructures that enable integrated support of requirements tracing, design reference points, intelligent reasoning of data and interface constructs are generally not available except within proprietary boundaries. We need tools that support integrated development and model sharing across development environments and that support use across multiple vendors.

Relevance / Science Traceability

This subtopic would be of relevance to all Human Exploration and Operations Mission Directorate (HEOMD) missions, but of particular interest will be Gateway and Artemis development. Those systems have already adopted the use of MBSE tools and tools sought help reduce potential system integration bottlenecks. Over the next 3 to 5 years, there will be considerable opportunity for small business contributions to be matured and integrated into the support infrastructure as Gateway evolves from concept to development program.