NASA SBIR 2008 Phase I Solicitation

S4 Low-cost Small Spacecraft and Technologies

The Low-Cost Small Spacecraft and Technologies Topic focuses on the technologies, subsystems, methodologies, and mission concepts for space missions which lower the over-all cost for scientific exploration. The "Small" of spacecraft and missions refers to small spacecraft that have "wet" masses below 500 Kg. (compared to micro satellites 10-100kg, nano satellite 1-10kg, or pico satellite <1kg), are substantially less expensive, and will require different approaches to solve traditional problems in development, operations and capability. The goal of these low-cost missions is not to replace the major missions, but rather to reduce the risks to, as well as the costs of, future major missions. Low-Cost Small Spacecraft and Technologies Missions will be used as test beds for new technologies, provide flight "heritage" for new instruments and components. Increasing the number of flight opportunities per year enables missions to be designed and flown during typical graduate and post-doctoral tenures, provide training for a new generation of scientists and engineers. These small spacecraft missions can also accomplish specific scientific investigations that would be too narrow for a major mission but still scientifically important. This topic is divided into two categories of subtopics: Small Spacecraft Technologies and Enablers and Small Spacecraft Build.

Small Spacecraft Technologies and Enablers: These subtopics will lower the barrier to entry for small spacecraft missions by encouraging launch opportunities and creating open design and spacecraft management tools. These subtopics include: 1. Nanosat launch vehicles and technologies, 2. Rapid End-to-end Mission Design and Simulation 3. Cost modeling.

Small Spacecraft Build: When used together, SBIR subtopics could create a small spacecraft mission. The subtopics required to accomplish this effort extend beyond the Low-cost Small Spacecraft and Technologies topic, and definition for such an effort is in progress (see 2.0, Mission Concept). In FY08, there will be multiple subtopics across the topic portfolio participating toward this mission concept.

Mission Concept: NASA announced a mission concept at a Mission Concept Review (MCR) held February 8, 2008. The spacecraft is a modular spacecraft that operates using standard protocols (high speed: Ethernet, SpacewireTM; low speed: RS-422, I2C) and at 28V +/- 6V. With this modularity, a requirement for the Low-Cost Small Spacecraft and Technologies, components can be interchanged from a basic spacecraft design to tailor for specific missions.

The Low-Cost Small Spacecraft and Technologies topic will invite to subsequent reviews those awardees current at the time of the review; review titles and respective tentative dates follow: a) System Requirements Review (SRR), tentatively August 2008; b) Mission Definition Review (MDR), tentatively November 2008; c) Preliminary Design Review (PDR), tentatively August 2009; Critical Design Review (CDR), tentatively September 2010. NASA intends to make SBIR Phase 1 and Phase 2 awards to this effort, which NASA understands are a best effort by the SBIR awardees and NASA alike. By 1QFY11, all Phase 2 and Phase 3 SBIR teams are encouraged to deliver to NASA the hardware to be integrated and ready for launch in 4QFY11. The Low-Cost Small Spacecraft and Technologies topic is envisioned to launch one satellite per year or every other year, starting in FY11, kicking off a new team at each cycle. NASA cannot direct SBIR awardees to conform to the provisional schedule outlined above, however when brought together this could create the opportunity for a spacecraft build. This topic will give significant priority to offerors that take full advantage of standard interfaces, protocols, methodologies, open source software and Commercial off the Shelf (COTS)-derivative hardware.Â

Subtopics

S4.01 NanoSat Launch Vehicle Technologies

Lead Center: ARC

The space transportation industry is in need of low-cost, reliable, on-demand, routine space access. Both government and private entities are pursuing various launch systems and architectures aimed at addressing this market need. Significant technical risk and cost exists in new system development and operations - reducing incentive for private capital investment in this still-nascent industry. Public and private sector goals are aligned in reducing these risks and enabling the development of launch systems capable of reliably delivering payloads to low Earth orbit. The NanoSat Launch Vehicle Technology subtopic will particularly focus on higher risk entrepreneurial projects for dedicated nano and small spacecraft launch vehicles. This subtopic is seeking proposals in the following, but not limited, areas:

- Conceptual designs of system/architectures capable of reducing the mission costs associated with small payload delivery to LEO.
- Maturation of hypersonic and small launch vehicle design and analysis tools or tool-sets aimed at increasing the state-of-the-art while reducing the required design cycle time and human interaction.
- Maturation of key technologies/processes for hypersonic and small launch vehicles including, but not limited to:
    - Thermal protection systems;
    - Airframe and subsystem structures that increase system performance and propellant mass fraction;
    - Vehicle sensor networks.
- Novel, low-cost modular adapters and release mechanisms.
- Lightweight interstage designs.

Applications of wireless networking technologies for small launch vehicles are also specifically of interest to this subtopic. This technology could be used for vehicle to ground communications (spread-spectrum and non-licensed technologies), as well as within the vehicle itself. We desire new architectures for intelligent on-board communications as well as satellite-to-satellite communication using machine-to-machine (M2M) solutions. The traditional wire harness architecture could be replaced by the wireless technology for command and control, which would reduce vehicle mass and improve reliability. Also stage-to-stage interfaces and vehicle-payload interfaces are of interest. These wireless technologies can include but are not limited to WIMAXTM and ZIGBEETM.

Non-propulsive approaches and architectures for new launch vehicles can also achieve increases in launch vehicle payload mass delivered to orbit for small spacecraft missions. Offerors should consider development, test, and operational factors to show improvements in development and operational costs, payload mass fraction, and mission assurance. Special attention should be given to improved integration between the launch vehicle and payloads to further reduce operational costs. Furthermore, non-propulsive launch vehicle technologies have a dramatic impact on launch vehicle performance and constitute a large percentage of development and operational costs.

They include, but are not limited to:

- Robust on-board Guidance, Navigation and Control (GN&C) avionics. GN&C should be modular (including modular software architectures) and make use of modern architectures, including high-performance low-

weight avionics hardware, and modern software tools. Emphasis is on low-weight architecture to allow maximum payload capacity.
- Range safety solutions and operational concepts to lower costs. These may include alternative solutions to expensive explosive destruct packages, including, but not limited to propulsion-cutoff systems, autonomous flight-abort systems, etc.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration, and when possible, deliver a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

Phase 2 emphasis should be placed on developing and demonstrating the technology under relevant test conditions. Additionally, a path should be outlined that shows how the technology could be commercialized or further developed into space-worthy systems.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.Â

S4.02 Rapid End-to-End Mission Design and Simulation

Lead Center: ARC

Participating Center(s): GSFC

This subtopic addresses the need to rapidly and efficiently analyze, design, simulate, and evaluate competing mission concepts.

The traditional mission design process involves multiple tools and trades, resulting in design data being generated and stored in various proprietary formats, making iterative trades cumbersome. Current mission design and simulation environments require dedicated personnel that execute mission simulations for mission projects, but at a significant cost to project budgets. For efficient mission design and simulation activities, particularly for small satellites and other missions with small budgets and cost margins, there is a need for user-friendly tools that will provide seamless data flow between simulation environments with little overhead.

This subtopic seeks proposals for a toolset that shall integrate legacy engineering software with user-generated design and simulation tools into a single, user-friendly environment. The toolset shall automate the flow of data between analysis, design, and simulation applications with minimal user manipulation. The data shall also be preserved through the various design phases from initial concept to execution.

Data resources to be linked include cost tracking spreadsheets, task plans, risk management databases, requirements databases, technical performance metrics and margins sheets, top level and WBS element schedules, and standard monthly status reports from WBS elements. The tool should be easily scalable for large or small projects and the number of WBS elements and features included or excluded for a given project should be user-selectable. User and group permission and access controls are required.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration, and when possible, deliver a demonstration application for NASA testing at the completion of the Phase 2 contract.

Phase 2 emphasis should be placed on developing and demonstrating the technology under relevant test conditions. Additionally, a path should be outlined that shows how the technology could be commercialized or further developed.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.Â

S4.03 Cost Modeling

Lead Center: ARC

Participating Center(s): GSFC, JPL

An integrated cost-design model is required, one that incorporates the regression analysis and statistical validity of historical parametric cost models with the flexibility and relevance of a ground-up, or grassroots, cost model. By explicitly focusing on the prime cost determinant, labor, as opposed to the spacecraft parameters, and determining the historic relationships between the tasks on the WBS and cost for a given institution/firm, as opposed to space industry in general, a cost model can be produced that is specific to the production process used by an institution. Such a cost model would predict the cost of individual tasks at sub-system and component levels within a given institution, enabling cost to be included as an endogenously determined variable in the design process.

Such an integrated cost-design model is currently embodied only as human capital in individual managers who have, through their personal experience, accumulated knowledge of cost-design relationships. When these experienced managers leave, the institution loses the understanding of the relationship between cost and design choices that the manager had built up through years of experience. Without this experience, ground-up cost models can be wildly inaccurate and as a result, only parametric cost models such as the NASA/Air Force Cost Model (NAFCOM) and the Small Satellite Cost Model (SSCM) are accepted for Technical Management and Cost (TMC) reviews. This is particularly problematic for small low-cost spacecraft where designs are rapidly evolving, management structures are more varied, and the entire purpose is to provide spacecraft at costs lower than what has historically been considered possible.

This subtopic seeks proposals to define management system requirements and develop software that would enable cost (and schedule) data at the task-level to be collected and centralized creating a base dataset for institution-based cost models and cost management research. The system would codify cost information of projects ensuring it is preserved beyond the careers of individual managers and would, over time, accumulate long time-series of task-level cost information that would enable ground-up institution-based cost models to stand on a rigorous statistical framework. This would enable the development of a generic institution-based design-cost model that can then be tailored for individual institutions and used across the industry.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration, and when possible, deliver a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

In Phase 1, research should provide examples of proven cost benefits and project successes based on the use of integrated management tools for management of multiple simultaneous distributed projects. Architectures should be proposed for implementation of an integrated multi-project management tool.

In Phase 2, a management tool set will be implemented and demonstrated as part of an actual small satellite management project. The tool will be evaluated for ease of use, effectiveness as a NASA project set-up tool, management information tool, and reporting tool. Feasibility for a single manager to effectively manage and report on multiple simultaneous projects will be assessed. Project users from the WBS elements of the satellite project will evaluate ease of use of uploading data.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.Â

S4.04 Reusable Flight Software

Lead Center: ARC

Participating Center(s): GSFC

There is a need to rapidly develop and deploy small satellites and easily adapt new payloads in a cost effective manner. The cost of flight software, including algorithms and data management, is continuing to increase and multiply in complexity.

Spacecraft software applications are typically customized, however, development costs can be driven down and a plug-and-play capability can be fostered through repeated use of reusable software and functional libraries that are developed once and updated only to enhance performance or correct deficiencies.

Small satellites can be effectively designed for multiple uses of the same nominal hardware set to perform multiple missions. Interfaces between differing payloads are anticipated to be "plug-and-play", where the interface between hardware elements is transparent across the interface. This implies that and allows the software to be reusable from mission to mission. An analogy would be a reusable core executive operating system that controls central satellite functions. Each payload or special hardware element will have subservient applications, written by the element developed that provides special needs. In order to be most economical, the subservient applications should be capable of utilizing an extensive library of modules.

This subtopic calls for the definition and development of a common core executive software and library modules that can be utilized repeatedly for many small satellite missions. The software shall be portable between several types of core processors. The executive and libraries shall provide robust functionality, based on open standards that can be utilized by specialized payload and component developers. In this manner, a minimum amount of custom software, limited to basic functional control of certain hardware elements, will be required. Library functions within the reusable core executive shall be capable of performing computation intense work. The intent is to not modify the reusable core executive except as experience dictates from previous missions.

The Reusable Flight Software subtopic encourages offerors to utilize open source software and hardware solutions to be utilized for other actors, including entrepreneurial and university teams, for reusability.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration, and when possible, deliver a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

Phase 2 emphasis should be placed on developing and demonstrating the software technology under relevant test conditions. Additionally, a path should be outlined that shows how the technology could be commercialized or further developed into space-worthy systems.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.