NASA SBIR 2018 Phase I Solicitation

Z9.01 Small Launch Vehicle Technologies and Demonstrations

Lead Center: AFRC

Participating Center(s): KSC, LaRC, MSFC

Technology Area: TA1 Launch Propulsion Systems

NASA is recognizing a growing demand for dedicated, responsive small spacecraft launch systems and seeks to facilitate the establishment of a robust launch service provider market sector. The movement toward small spacecraft missions is largely driven by rising development/launch costs associated with conventional spacecraft, which poses severe threats to future science/commercial mission cadence, and by rapidly evolving miniaturization innovations that are revolutionizing small spacecraft platform capabilities. This topic seeks innovative technologies, subsystems, and efficient streamlined processes that will support the development of affordable small spacecraft launch systems having a 5-180 kg payload delivery capacity to 350 to 700 km at inclinations between 28 to 98.2 degrees to support both CONUS and sun synchronous operations. Affordability objectives are focused on reducing launch costs to below $1.5M/launch for payloads ranging up to 50 kg or below $30,000/kg for payloads in excess of 50 kg. It is recognized that no single enabling technology is likely to achieve this goal and that a combination of multiple technologies and production practices are likely to be needed. Therefore, it is highly desirable that disparate but complementary technologies formulate and use standardized plug-and-play interfaces to better allow for transition and integration into small spacecraft launch systems.Â

Technology areas of specific interest are as follows:Â

- Innovative Propulsion Technologies & Prototype Stages.
- Affordable Guidance, Navigation & Control.
- Manufacturing Innovations for Launch Vehicle Structures & Components.
- Reusability Innovations.
- Dual Use Hypersonic Flight Testbeds.Â

Proposers are expected to quantify improvements over relevant SOA technologies and substantiate the basis for investment. Potential opportunities for technology demonstration and commercialization should be identified along with associated technology gaps. Ideally, proposed technologies would be matured to TRL 4Â toÂ 6 by the end of Phase II effort. Efforts leading to Phase II delivery of integrated prototype stages that could either be ground tested or flight-testing as part of a post-Phase II effort are of particular interest. A brief descriptive summary of desired technical objectives and goals are provided below.Â

Innovative Propulsion Technologies & Prototype Stages

Innovative chemical propulsion technologies/subsystem and integrated stage concepts are sought that can serve as the foundational basis of an affordable ground-launch or air-launch system architecture. The scope of interest includes main propulsion systems and novel reaction control systems based on conventional or novel propellants. Technologies or subsystems are expected to demonstrate proof-of-concept by the end of Phase II as a minimum and proposals should include a development roadmap for achieving this goal. Efforts aimed at Phase II delivery of integrated prototype stages that could either be ground tested or flight tested as part of a post Phase II effort are highly encouraged and desired. Technical approaches that address the critical challenges associated with downward scaling of launch vehicles are also highly sought. Solutions that directly address staging sensitivities on deliverable payload mass, for instance, would be of keen interest. Design simplicity, reliability, and reduced development and recurring costs are all important factors. Proposers should explain how their technology works and provide a quantitative assessment of State-of-Art (SOA) in terms of key performance and/or cost metrics. The degree to which the proposed technology or concept is new, different, and important should also be made evident.Â

Affordable Guidance, Navigation, & Control

Affordable guidance, navigation & control (GN&C) is a critical enabling capability for achieving small launch vehicle performance and cost goals. Innovative GN&C technologies and concepts are therefore sought to reduce the significant costs associated with avionics hardware, software, sensors, and actuators. The scope of interest includes embedded computing systems, sensors, actuators, algorithms, as well as modeling & design tools. Low cost commercially available components and miniaturized devices that can be repurposed as a basis for low-SWaP GN&C systems are of particular interest. Special needs include sensors that can function during prolonged periods of high-g and high-angular rate (i.e., spin-stabilized) flight, while meeting the stringent launch system environment requirements pertaining to stability and noise. A low-cost GPS receiver capable of maintaining lock, precision, and accuracy during ascent would be broadly beneficial, for example. Sensors that can withstand these conditions might be sourced from industrial and tactical applications, and performance requirements may be achievable by fusing multiple measurements, e.g., inertial and optical (sun, horizon) sensors. Modular actuator systems are also needed that can support de-spin and turn-over maneuvers during ascent. These can include cold-gas or yo-yo type mechanisms. Improved designs are needed to reduce the overall power and volume requirements of these types of actuator systems, while still providing enough physical force to achieve the desired maneuver and enable orbital insertion. Programmable sequencers are required to trigger actuators for events such as stage sequencing, yo-yo and shroud deployment. In addition to hardware, software algorithms for autonomous vehicle control are needed to support in-flight guidance and steering. Robust control laws and health management software are of interest, particularly those that address performance and reliability limitations of affordable hardware. This is especially important in the typical high dynamics (acceleration and angular velocity) conditions of proposed small launch vehicles. Algorithms that are able to merge data from redundant onboard sensors could improve reliability compared to expensive single-string sensors. Similarly, advanced ground-alignment, initialization, and state estimation routines that integrate noisy data are desired to support ascent flight. These algorithms take advantage of improved onboard computational capability in order to process observations from lower accuracy sensors to provide higher fidelity information. Implementations of state-of-the-art Unscented Kalman Filters, and Square-Root-Information Filters with robust noise and sensor models are particularly applicable. Successful technologies should eventually be tested in relevant environments and at relevant flight conditions. Potential testbeds include a variety of spacecraft and aircraft at a variety of scales. Capabilities include reduced gravity, suborbital reusable launch vehicles, high altitude balloons, subscale to ultra-high-altitude aircraft, and inflight simulation.Â

Manufacturing Innovations for Launch Vehicle Structures & Components

The development of more efficient vehicle structures and components are sought to improve small launch vehicle affordability. This may include the adoption and utilization of modern lightweight materials, advanced manufacturing inspired design innovations, or systems for actively alleviating launch loads and environments. Approaches for achieving life-cycle cost reductions might also include reduced part count by substitution of multifunctional components; additive and/or combined additive and subtractive manufacturing; repurposing launch structure for post-launch mission needs; incorporating design features that reduce operating costs; adoption of lean best practices for production and manufacturing; and shifting towards commercial practices and/or componentry. Alternatively, approaches based on the utilization of heavier materials could lead to simpler parts, fewer components, and more robust design margins. Although this could yield a larger rocket and impose performance penalties, significantly reduced life-cycle costs could be realized due to overall lower manufacturing and integration cost. Proposers should provide a quantitative assessment of State-of-Art (SOA) in terms of key performance and/or cost metrics. The degree to which the proposed technology or concept is new, different, and important should also be made evident.Â

Reusability Innovations

Reusability innovations and subsystem concepts are sought that can serve as the foundational basis of a high flight rate, gas-and-go launch system architecture. Various subsystem technologies are amenable to development and testing via the SBIR program that could then be infused into commercial RLV developments. The scope of interest includes highly reusable propulsion systems that are capable of multiple flights without significant degradation and with minimal inspection/refurbishment requirements. Reusability solutions that directly address vehicle integration, mission profile/transition sensitivities and projected life cycle effects would be of keen interest. This could include quick turnaround ground servicing technologies that enable rapid inspection, maintenance/repair, reloading, and re-flight of stages. Design simplicity, reliability, and reduced development and recurring costs are all important factors. Proposers should explain how their technology works and provide a quantitative assessment of State-of-Art (SOA) in terms of key performance and/or cost metrics. Â The degree to which the proposed technology or concept is new, different, and important should also be made evident.Â

Dual Use Hypersonic Flight Testbeds

The potential repurposing and dual use applications of small launch vehicles as hypersonic flight technology testbeds is of great interest. If low cost small launch vehicle concepts can be dual purposed as affordable hypersonic flight testing platforms with a high degree of commonality, it would open up a highly lucrative sector with significant commercial and defense market potential. The scope of interest is on launch vehicle derived concepts that could boost or gravity turn into a cruise altitude in the range of 75-100 Kft and accelerate a hypersonic testbed stage to a speed of Mach 4Â or higher. BecauseÂ smallÂ launch vehicle boostersÂ typically undergoÂ stage-1 to stage-2 separation in theÂ Mach 8-10 range, it is conceivable thatÂ these vehiclesÂ could serveÂ asÂ low-cost boost phase systems forÂ hypersonic flight testbedsÂ equal in weight to the fully loaded orbital upper stage. Testbed concepts adaptable for a wide range of hypersonic technology investigations, including air breathing propulsion systems and thermal protection systems, while also offering payload recovery and partial testbed stage reusability, are strongly encouraged.