# NASA SBIR 2019 Phase I Solicitation

## Z9.01 Small Launch Vehicle Technologies and Demonstrations

**Lead Center: MSFC**

**Participating Center(s): AFRC, KSC, LaRC, MSFC**

**Technology Area: TA2 In-Space Propulsion Technologies**

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, and by rapid miniaturization of spacecraft platform capabilities. This topic seeks innovative systems and streamlined processes that will support the development of affordable launch systems having a 5-180kg payload delivery capacity to 350 to 700km at inclinations between 28 to 98.2° 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 50kg or below $30,000/kg for payloads in excess of 50kg. 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.

Technology areas of specific interest are as follows:

- Innovative Propulsion Stages and Launch Systems
- Affordable Guidance, Navigation & Control
- Innovations for Launch Vehicle Structures
- Dual Use Hypersonic Flight Testbeds

Proposers are expected to quantify improvements over relevant SOA technologies and substantiate the performance relative to delivered payload mass and cost. Potential opportunities for technology demonstration and commercialization should be identified along with associated technology gaps. Ideally, proposed technologies would be matured between Technology Readiness Level (TRL) 4 to 6 by the end of the Phase II effort. A brief descriptive summary of desired technical objectives and goals are provided below.

**Innovative Propulsion Stages and Launch Systems**

Innovative chemical propulsion stages and integrated launch system concepts are sought that can serve as the foundational basis of an affordable, high flight rate launch system architecture. Solutions that directly address vehicle integration, mission profile sensitivities on delivered payload, and projected life cycle effects are desired. This could include main propulsion system design, novel staging concepts, and ground servicing technologies that enable rapid inspection, repair, and refurbishment of stages. Subsystem technologies that enable reusability are of particular interest. 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. Design simplicity, reliability, and reduced development and recurring costs are all important factors.

**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.

**Innovations for Launch Vehicle Structures**

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 advanced lightweight materials, including but not limited to carbon fiber composites, nanocomposites, extreme temperature materials, especially as used in combination with advanced manufacturing to enable low cost, reliable, lightweight design innovations. Of interest are systems for actively alleviating launch loads and environments. Approaches for achieving life-cycle cost reductions might also include reduced part count by substitution of multi-functional components; additive and/or combined additive-subtractive manufacturing; re-purposing launch structure for post-launch mission needs; incorporating design features that reduce operating costs. 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.

**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 4 or higher. Because small launch vehicle boosters typically undergo stage-1 to stage-2 separation in the Mach 8-10 range, it is conceivable that these vehicles could serve as low-cost boost phase systems for hypersonic flight testbeds 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.

**Relevance to NASA**

The Launch Services Program continues to seek options for small satellite orbital launch capabilities.

Sound rocket capabilities are being improved with options financed through this topic.

**References:**


- https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20160002253.pdf
- https://kscpartnerships.ksc.nasa.gov/Partnering-Opportunities/Launch-Systems/Small-Class-Launch-Vehicles