NASA SBIR 2008 Phase I Solicitation

O4 Navigation

NASA is seeking innovative research in the areas of positioning, navigation, and timing (PNT) that have relevance to Space Communications and Navigation programs and goals, as described at http://www.spacecomm.nasa.gov. NASAâ€™s Space Communication and Navigation Office considers the three elements of PNT to represent distinct, constituent capabilities: (1) positioning, by which we mean accurate and precise determination of an assetâ€™s location and orientation referenced to a coordinate system; (2) navigation, by which we mean determining an assetâ€™s current and/or desired absolute or relative position and velocity state, and applying corrections to course, orientation, and velocity to attain achieve the desired state; and (3) timing, by which we mean an assetâ€™s acquiring from a standard, maintaining within user-defined parameters, and transferring where required, an accurate and precise representation of time. NASA has divided its PNT interests into six focus areas: (1) Global Positioning System (GPS) (2) Distress Alerting Satellite System (DASS) (3) Flight Dynamics (4) Tracking and Data Relay Satellite System (TDRSS) (5) TDRSS Augmentation Service for Satellites (TASS) (6) Geodesy This year, NASA seeks technology in focus areas (1), (3), (4), and (5), and related areas that provides PNT support and services for NASAâ€™s current tracking and communications networks and systemsâ€”including tracking during launch and landing operations, and research and technology relevant to the planning and development of PNT support and services for NASAâ€™s Project Constellation, including lunar surface operations, and other Exploration and Science Programs that NASA may undertake over the next two decades. Some of the subtopics in this topic could result in products that may be included in a future small satellite flight opportunity. Please see the Science MD Topic S4 for more details as to the requirements for flight opportunities.Â

Subtopics

O4.01 Metric Tracking of Launch Vehicles

Lead Center: KSC

Participating Center(s): GSFC, MSFC

Range Safety requires accurate and reliable tracking data for launch vehicles. Onboard GPS receivers must maintain lock, reacquire very quickly and operate securely in a highly-dynamic environment. GPS Course Acquisition Code (CA) does not require classified decryption codes and has an accuracy of better than 30 m and 1 m/s. Although this accuracy is good enough for most Range Safety needs, better accuracy is needed for antenna pointing, docking maneuvers and attitude determination. CA code also offers little protection against deliberately transmitted false signals or â€œspoofingâ€.

This solicitation seeks proposals in the following areas:

- Innovative technologies to increase the accuracy of the L1 C/A navigation solution by combining the pseudoranges and phases of the L1 C/A signals. Factors that degrade the GPS signal can be obtained by differencing the available carrier phase and pseudorange measurements and then removing this difference from the navigation solution.
- Technologies that combine spatial processing of signals from multiple antennas with temporal processing techniques to mitigate interference signals received by the GPS receiver. The coordinated response of adaptive pattern control (beam and null steering) and digital excision of certain interfering signal components minimizes strong jamming signals. Adaptive nulling minimizes interfering signals by the optimal control of the GPS antenna pattern (null steering).

These technologies should be independent of any particular GPS receiver design.

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

O4.02 Precision Spacecraft Navigation and Tracking

Lead Center: GSFC

Participating Center(s): ARC, GRC, JPL

This solicitation seeks proposals that will serve NASAâ€™s ever-evolving set of near-Earth and interplanetary missions that require precise determination of spacecraft position and velocity in order to achieve mission success. While the definition of â€œpreciseâ€ depends upon the mission context, typical scenarios have required meter-level or better position accuracies, and sub-millimeter-level or better velocity accuracies.

Research should be conducted to demonstrate technical feasibility during Phase 1, and show a path toward a Phase 2 hardware and/or software demonstration of a demonstration unit or software package that will be delivered to NASA for testing at the completion of the Phase 2 contract. The Small Spacecraft Build effort highlighted in Topic S4 (Low-cost Small Spacecraft and Technologies) of the solicitation participates in this subtopic. Offerors are encouraged to take this in consideration as a possible flight opportunity when proposing work to this subtopic.

Purpose: NASA Needs vs. Current State of the Art

This solicitation is primarily focused on NASAâ€™s needs in three focused areas: onboard near-Earth navigation systems; onboard deep-space navigation systems; technologies supporting improved TDRSS-based navigation. Proposals that leverage state-of-the-art capabilities already developed by NASA such as GEONS (http://techtransfer.gsfc.nasa.gov/ft-tech-GEONS.html), Navigator (http://techtransfer.gsfc.nasa.gov/ft-tech-GPS-NAVIGATOR.html), GIPSY, Electra, and Blackjack are especially encouraged. NASA is not interested in funding efforts that seek to â€œre-invent the wheelâ€ by duplicating the many investments that NASA and others have already made in establishing the current state-of-the-art.

General Operational Specifications and Requirements:

Core Capabilities:

Onboard Near-Earth Navigation System

NASA seeks proposals that would develop a commercially viable transceiver with embedded orbit determination software that would provide enhanced accuracy and integrity for autonomous onboard GPS- and TDRSS-based navigation and time-transfer in near-Earth space via augmentation messages broadcast by TDRSS. The augmentation message should include information on the TDRS orbits, status, and health that could be provided by future TDRS, and should provide information on the GPS constellation that is based on NASAâ€™s TDRSS Augmentation for Satellites Signal (TASS). Proposers are advised that NASAâ€™s GEONS and GIPSY orbit determination software packages already support the capability to ingest TASS messages.

Onboard Deep-Space Navigation System

NASA seeks proposals that would develop an onboard autonomous navigation and time-transfer system that can reduce DSN tracking requirements. Such systems should provide accuracy comparable to delta differenced one-way ranging (DDOR) solutions anywhere in the inner solar system, and exceed DDOR solution accuracy beyond the orbit of Jupiter. Proposers are advised that NASAâ€™s GEONS and DS-1 navigation software packages already support the capability to ingest many one-way forward Doppler, optical sensor observation, and accelerometer data types.

Technologies Supporting Improved TDRSS-based Navigation

NASA seeks proposals that would provide improvements in TDRS orbit knowledge, TDRSS radiometric tracking, ground-based orbit determination, and Ground Terminal improvements that improve navigation accuracy for TDRS users. Methods for improving TDRS orbit knowledge should exploit the possible future availability of accelerometer data collected onboard future TDRS.

Optional Capabilities:

NASA may consider other proposals relevant to NASAâ€™s needs for precise spacecraft navigation and tracking that demonstrably advance the state-of-the-art.

Development Timeline Associated with NASA Needs:

Phase 1 deliverables should include documentation of technical feasibility, which should at minimum show a path toward hardware and/or software demonstration of a demonstration unit or software package in Phase 2.

Phase 2 deliverables should include a demonstration unit or software.

The proposer to this subtopic is advised that the products proposed may be included in a future small satellite flight opportunity. Please see the SMD Topic S4 on Small Satellites for details regarding those opportunities. If the proposer would like to have their proposal considered for flight in the small satellite program, the proposal should state such and recommend a pathway for that possibility.

O4.03 Lunar Surface Navigation

Lead Center: GRC

Participating Center(s): JSC

In order to provide location awareness, precision position fixing, best heading and traverse path planning for planetary EVA, manned rovers and lunar surface mobility units NASA has established requirements for organic navigation capabilities for surface-mobile elements of lunar missions. This topic will develop systems, technologies and analysis in support of the required capabilities of lunar surface mobility elements. Contemplated navigation systems could employ celestial references, passive or active optical information such as optical flow or range to local terrain features, inertial sensor information or other location-specific sensed data or combinations thereof. However, radiometric measurements are considered to be concomitant to the lunar communications network and the lunar network will likely be used to communicate state information between lunar mission elements. As such, the main emphasis of this topic is on systems that exploit radiometric measurements such as range, Doppler or Angle of Arrival. Radiometric measurements can be considered between lunar mission elements such as surface mobility units, elements of a lunar surface architecture (such as surface landers or habitation units or other surface mobility units) or elements of the lunar communications and navigation infrastructure such as surface communications towers or lunar communication/navigation orbiters. Earth-based nodes are not excluded from consideration, nor are two-way radiometric measurements, nor are non-NASA-standard (e.g. UWB) modulation schemes. Traverse-path planning systems and navigation-specific displays are also of interest.

Emphasis of the development is on navigation accuracy, Size Weight and Power (SWaP), systems that operate effectively with minimal communications/navigation infrastructure (such as towers or orbiters) or with complete autonomy, with minimal crew involvement or completely automatically. Unified concepts and systems that provide a range of hardware capabilities (possibly trading accuracy with SWaP) are of interest. Mature system concepts and technologies including system demonstration with TRL 6 components and internalized (by NASA) standards are required at the end of a Phase 2.

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

O4.04 Timing

Lead Center: JSC

Participating Center(s): GRC, GSFC, JPL

One of the most critical components of robust relative navigation is accurate and reliable timing across the entire sensor suite. Clock errors, drift, and drift rates must be estimated and corrected. During extended duration operations small clock errors propagated from measurement to measurement can contribute to continued growth in positional errors. Improved timing estimation and reliability within a general navigation clocking system will improve navigational accuracy.

Purpose:Â This solicitation aims to develop two unique timing systems. The first timing system (TS) is for a relative navigation sensor suite to be utilized during lunar surface navigation that will utilize multiple sensors at different times. The sensor suite may include a star tracker, inertial measurement unit, vision-based feature recognition sensor, and RFID tag ranging devices. The TS will take an accurate time input from the primary base station at irregular intervals and a less accurate clock at periodic intervals from a software defined communications radio. The TS should, in an FPGA only, produce a clock signal suitable for time stamping and a clock pulse for four navigation sensors. This generated clock should be accurate to within 1ms of the base station input clock over a period of five minutes between primary clock inputs. Additionally, clock error, drift, and drift rates of the two input clocks and four output timing streams (time stamp and clock pulse) should be made available for analysis.

The second timing system is for proposals that improve timing standards. NASA seeks proposals that would improve accuracy for both ground-based tracking networks and onboard navigation systems by providing time and frequency standards that exceed the long-term performance of the GPS Block IIR Rb clocks (for ground-based applications) and current flight USO performance and also for tracking networks at ground-based locations. Timing accuracy is of the utmost importance for this TS; however, size, weight, and power consumption are still considerations. The goal of this TS is to improve the timing and frequency standards and, if possible, exceed the long-term performance of the GPS Block IIR Rb clocks in the ground-based application.

Core capabilities:Â Provide an accurate and self correcting time source suitable for use in a navigation system suite consisting of multiple sensors. The TS clock and time stamp output should be independently adjustable to the needs of the sensors.

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

Phase 1 Deliverables:

- A trade study on industry standard timing systems with a focus on overall accuracy and drift performance;
- Report on the tools and systems currently available;
- Recommendations on furthering the state-of-the-art in timing performance.

Phase 2 Deliverables:

- Demonstration of implemented timing system given the necessary inputs;
- Written report and presentation detailing the system performance including electrical and electronic characteristics;
- Delivery of the timing system and the environment used during development;
- Delivery of timing system math models for real-time simulation.