NASA SBIR 2021 Phase I Solicitation

S3.04 Guidance, Navigation, and Control

Lead Center: GSFC

Participating Center(s): JPL, MSFC

Scope Title:

Guidance, Navigation, and Control

Scope Description:

NASA seeks innovative, groundbreaking, and high-impact developments in spacecraft guidance, navigation, and control technologies in support of future science and exploration mission requirements. This subtopic covers mission-enabling technologies that have significant size, weight and power, cost, and performance (SWaP-CP) improvements over the state-of-the-art commercial off-the-shelf (COTS) capabilities in the areas of S, Absolute and Relative Navigation Systems, and Pointing Control Systems, and Radiation-Hardened Guidance, Navigation, and Control (GNC) Hardware.

Component technology developments are sought for the range of flight sensors, actuators, and associated algorithms and software required to provide these improved capabilities. Technologies that apply to most spacecraft platform sizes will be considered.

Advances in the following areas are sought:

- Spacecraft Attitude Determination and Control Systems: Sensors and actuators that enable <0.1 arcsecond-level pointing knowledge and arcsecond-level control capabilities for large space telescopes, with improvements in size, weight, and power requirements.
- Absolute and Relative Navigation Systems: Autonomous onboard flight navigation sensors and algorithms incorporating both spaceborne and ground-based absolute and relative measurements. For relative navigation, machine vision technologies apply. Special considerations will be given to relative navigation sensors enabling precision formation flying, astrometric alignment of a formation of vehicles, robotic servicing and sample return capabilities, and other GNC techniques for enabling

the collection of distributed science measurements.Â In addition, flight sensors and algorithms that support onboard terrain relative navigation are of interest.
- Pointing Control Systems: Mechanisms that enable milliarcsecond-class pointing performance on any spaceborne pointing platforms. Active and passive vibration isolation systems, innovative actuation feedback, or any such technology that can be used to enable other areas within this subtopic applies.
- Radiation-Hardened Hardware: GNC sensors that could operate in a high radiation environment, such as the Jovian environment.

- Increasing the fundamental precision of gyroscopes and accelerometers that utilize optical cavities could benefit autonomous navigation and open up new science possibilities. Two strategies may be pursued to increase the precision. First, can the scale factor be increased without a concomitant increase in the quantum noise? Possible approaches include but are not limited to: (a) the use of fiber optics to increase cavity length without increasing SWaPÂ and (b) exploitation of the degeneracies known as exceptional points (EPs) that occur in non-Hermitian systems. Prominent examples of such systems include parity-time symmetric systems and cavities containing a fast-light medium. It remains to be seen, however, whether the boost in scale factor near an EP can result in increased precision or is entirely counteracted by additional quantum noise. Proposals are sought that seek to answer this question through theoretical or experimental means in passive and active systems, including continuous-waveÂ and pulsed lasers. Second, can the quantum noise be reduced without a concomitant reduction in scale factor? The frequency measurement in a laser gyro or accelerometer only involves the uncertainty in phase. Therefore, the relevant quantum noise might be reduced by squeezing. Proposals are sought that investigate and utilize squeezing, for exampleÂ via the propagation of quantum solitons, for the improvement of inertial sensors.

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

This subtopic is for all mission-enabling GNC technology in support of Science Mission Directorate (SMD) missions and future mission concepts. Proposals for the development of hardware, software, and/or algorithms are all welcome. The specific applications could range from CubeSats/SmallSats, to ISS payloads, to flagship missions.

Expected TRL or TRL Range at completion of the Project:Â 4 to 6Â
Primary Technology Taxonomy:Â
Level 1: TX 17 Guidance, Navigation, and Control (GN&C)Â
Level 2: TX 17.X Other Guidance, Navigation, and ControlÂ
Desired Deliverables of Phase I and Phase II:

- Prototype
- Hardware
- Software

Desired Deliverables Description:

Prototype hardware/software, documented evidence of delivered TRL (test report, data, etc.), summary analysis, supporting documentation.

- Phase I research should be conducted to demonstrate technical feasibility as well as show a plan towards Phase II integration and component/prototype testing in a relevant environment as described in a final report.
- Phase II technology development efforts shall deliver aÂ component/prototype at the TRL 5 to 6 level consistent with NASA SBIR/STTR Technology Readiness Level (TRL) Descriptions. Delivery of final documentation, test plans, and test results are required. Delivery of a hardware component/prototype under the Phase II contract is preferred.

State of the Art and Critical Gaps:

Capability area gaps:

- Spacecraft GNC Sensorsâ€”highly integrated, low-power, low-weight, radiation-hard component sensor technologies, and multifunctional components.
- Spacecraft GNC Estimation and Control Algorithmsâ€”sensor fusion, autonomous proximity operations algorithm, robust distributed vehicle formation sensing and control algorithms.

Relevance / Science Traceability:

Science areas: Heliophysics, Earth Science, Astrophysics, and Planetary missionsâ€™ capability requirement areas:

- Spacecraft GNC Sensorsâ€”optical, radio-frequency (RF), inertial, and advanced concepts for onboard sensing of spacecraft attitude and orbit states
- Spacecraft GNC Estimation and Control Algorithmsâ€”innovative concepts for onboard algorithms for attitude/orbit determination and control for single spacecraft, spacecraft rendezvous and docking, and spacecraft formations.

References:

- 2020 NASA Technology Taxonomy:Â https://go.nasa.gov/3hGhFJf
- 2017 NASA Strategic Technology Investment Plan:Â https://go.usa.gov/xU7sEÂ

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