NASA SBIR 2020 Phase I Solicitation

A2.02 Unmanned Aircraft Systems (UAS) Technologies

Lead Center: AFRC

Participating Center(s): ARC, GRC, LaRC

Technology Area: TA4 Robotics, Telerobotics and Autonomous Systems

Scope Title
Enabling Autonomy

Scope Description
Unmanned Aircraft Systems (UAS) offer significant advantages over manned aircraft for applications which are dangerous to humans, long in duration, requiring fast response and high degree of precision. Some examples include remote sensing, disaster response, delivery of goods, industrial inspection and agricultural support. Additionally, UAS may eventually be capable of safely transporting passengers, which can increase operational flexibility. The addition of autonomy to UAS enables more capability and promises greater economic and operational advantages. Some of these advantages include a higher degree of resilience to off-nominal conditions, the ability to adapt to dynamic situations and less reliance on humans during operations.

There are many barriers that are restricting greater use and application of autonomy in UAS. These barriers include, but are not limited to, the lack of methods, architectures and tools that enable:

- The verification, validation and certification of complex and/or nondeterministic systems
- Sensing, perception, cognition and decision-making
- Cost-effective, resilient and self-organizing communications
- Improved survivability in degraded or off-nominal conditions

NASA and the aviation industry are involved in research that would greatly benefit from breakthroughs in UAS capabilities that could eventually enable the new Urban Air Mobility market. A few of the areas of research and missions are listed below.

- Remote sensing missions utilizing one or more UAS would benefit from autonomous planning algorithms that can coordinate and execute a mission with minimal human oversight
- Detect and avoid algorithms, sensor fusion techniques, robust trajectory planners and contingency management systems that can enable Urban Air Mobility (UAM) and higher levels of UAS integration into the national airspace

This solicitation is intended to break through these and other barriers with innovative and high-risk research.
The Integrated Aviation Systems Program's work on UAS technology for the FY 2020 NASA SBIR solicitation is focused on tackling these barriers to enable greater use of UAS in NASA research, in civil aviation use and ultimately in the emerging UAM market. The following four research areas are the primary focus of this solicitation, but other closely related areas will also be considered for award. The primary research areas are:

- Verification, Validation and Certification - New methods of verification, validation and certification need to be developed which enable application of complex systems to be certified for use in the National Airspace System (NAS). Proposed research could include novel hardware and/or software architectures that enable alternate or expedite traditional verification and validation requirements.
- Sensing, Perception, Cognition and Decision Making - Technologies need to be developed that provide the ability of UAS to detect and extract internal and external information of the vehicle, transform the raw data into information that can be understood by machines or humans, and recognize patterns and make decisions based on the data and patterns.
- Cost-effective, Resilient and Self-organizing Communications - Methods that ensure reliable, trusted-source communications with increasingly complex and interconnected systems are needed to minimize the impact of infrastructure outages (e.g. Global Positioning System (GPS) or ground station) and that are resilient against both internal and external cyber-physical attacks. Several key areas of interest are Resilient Position Navigation and Timing (RPNT) for GPS denied/degraded environments, mesh/self-organizing networks, and quantum communication technologies, in particular, quantum repeaters and quantum key distribution methods.
- Improved survivability in degraded or off-nominal conditions - Vehicle health monitoring techniques and contingency management algorithms that will mitigate risk to people and assets on the ground or in the air.

It is important to note that some technologies such as quantum communications can be utilized in many areas and it is recommended that the scope of such proposals be tailored to unmanned aircraft.

References

Expected TRL or TRL range at completion of the project: 3 to 6

Desired Deliverables of Phase II

Prototype, Analysis, Hardware, Software, Research

Desired Deliverables Description

Phase I deliverables should include, but are not limited to:

- A final report clearly stating the technology challenge addressed, the state of the technology before the work was begun, the state of technology after the work was completed, the innovations that were made during the work period, the remaining barriers in the technology challenge, a plan to overcome the remaining barriers and a plan to infuse the technology developments into UAS application.
- A technology demonstration in a simulation environment which clearly shows the benefits of the technology developed.
- A written plan to continue the technology development and/or to infuse the technology into the UAS market. This may be part of the final report.

Phase II deliverables should include, but are not limited to:

- A final report clearly stating the technology challenge addressed, the state of the technology before the work was begun, the state of technology after the work was completed, the innovations that were made during the work period, the remaining barriers in the technology challenge, a plan to overcome the
remaining barriers, and a plan to infuse the technology developments into UAS application.

- A technology demonstration in a relevant flight environment which clearly shows the benefits of the technology developed.
- There should be evidence of infusing the technology into the UAS market or a clear written plan for near term infusion of the technology into the UAS market. This may be part of the final report.

State of the Art and Critical Gaps

Current autonomous systems have limited capabilities, poor perception of the environment, require human oversight and need special clearances to fly in the NAS. Future autonomous systems with higher degrees of autonomy will be able to freely fly in the NAS but will require certifiable software that ensure a high degree of safety assurance. Additionally, advanced sensors and more sophisticated algorithms that can plan around other UAS/UAM vehicles and obstacles will be needed. Therefore, the technology that will be required to advance the state of the art are as follows:

1. A certification process for complex non-deterministic algorithms
2. Sensors (LIDAR, GPS, etc.) and sensor fusion algorithms
3. Decision making and cooperative planning algorithms
4. Secure and robust communications

Relevance / Science Traceability

This subtopic is relevant to NASA ARMD's Strategic Thrust 5 and Strategic Thrust 6.

- https://www.nasa.gov/aeroresearch/programs/tacp
- https://www.nasa.gov/aeroresearch/programs/aosp
- https://www.nasa.gov/aeroresearch/programs/jasp