Scope Title:

Enabling Aircraft Autonomy

Scope Description:

The increased use of automation on aircraft offers significant advantages over traditional manned aircraft for applications that are dangerous to humans, long in duration, and require a fast response and high degree of precision. Some examples include remote sensing, disaster response, delivery of goods, industrial inspection, and agricultural support. Advanced autonomous functions in aircraft can enable 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 air vehicles. These barriers include, but are not limited to, the lack of methods, architectures, and tools that enable:

- Cognition and multi-objective decision making.
- Cost-effective, resilient, and self-organizing communications.
- Prognostics, survivability, and fault tolerance.
- Verification and validation technology and certification approaches.

NASA and the aviation industry are involved in research that would greatly benefit from breakthroughs in autonomous capabilities that could eventually enable the Advanced Air Mobility (AAM). A few of the areas of research and missions are listed below:

- Remote missions utilizing one or more unmanned aircraft system (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 AAM and higher levels of
UAS integration into the national airspace

- Fault detection, diagnostics, and prognostics capabilities to inform autonomous contingency management systems.

This solicitation is intended to break through these and other barriers with innovative and high-risk research.

The Integrated Aviation Systems Program's FY2021 SBIR solicitation is focused on tackling these barriers to enable greater use of autonomy in NASA research, in civil aviation use, and, ultimately, in the emerging AAM market. The following four research areas are the primary focus of this solicitation, and any submissions must show a strong relevance to these areas to be considered. The primary research areas are:

- Cognition and multi-objective decision making—Technologies need to be developed that transform the raw data into actionable information and make decisions based on this information. Detect and avoid in the national airspace utilizing multiple sensors is an example of one challenge this particular research is attempting to address. Artificial intelligence-based methods such as machine learning will be considered if it provides a novel approach.

- 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 cyberphysical attacks. Several key areas of interest are:
  - Resilient wireless communications in the presence of jamming, terrain, or weather caused interference.
  - Quantum communication technologies, in particular, quantum repeaters and quantum key distribution methods.

- Prognostics, survivability, and fault tolerance—Techniques that can understand vehicle health, critical failures, can anticipate failures, and autonomously replan or execute emergency landings safely. Prognostics technologies capable of providing accurate predictions in a computationally constrained environment, such as that expected for small vehicles. Examples include, but are not limited to, new, efficient approaches and algorithms and hybrid edge/cloud approaches.

- Verification and validation technology and certification approaches—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. Proposals should reference material on emerging standards for
autonomy certification, including ASTM autonomy guidelines and emerging Federal Aviation Administration (FAA) considerations for small aircraft, UAS, and Urban Air Mobility (UAM).

It is important to note that any proposals for UAS development will not be considered unless it can demonstrate strong relevance to aforementioned research interests.

**Expected TRL or TRL Range at completion of the Project:** 3 to 6

**Primary Technology Taxonomy:**
Level 1: TX 10 Autonomous Systems
Level 2: TX 10.X Other Autonomous Systems

**Desired Deliverables of Phase I and Phase II:**

- Research
- Analysis
- Prototype
- Hardware
- Software

**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.
- A technology demonstration in a simulation environment that clearly shows the benefits of the technology developed.
- A written plan to continue the technology development and/or to infuse the technology. 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.
- A technology demonstration in a relevant flight environment that clearly shows the benefits of the technology developed.
- There should be evidence of infusing the technology or a clear written plan for near term infusion of the technology. 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/AAM 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 nondeterministic algorithms.
2. Prognostics, vehicle health, 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/tacp)
- [https://www.nasa.gov/aeroresearch/programs/aosp](https://www.nasa.gov/aeroresearch/programs/aosp)
- [https://www.nasa.gov/aeroresearch/programs/iasp](https://www.nasa.gov/aeroresearch/programs/iasp)

References:
