NASA SBIR 2022 Phase I Solicitation

A2.02 Enabling Aircraft Autonomy

Lead Center: AFRC

Participating Center(s): ARC, GRC, LaRC

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/or 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 greater capabilities and promise 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 multiobjective 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) mission. A few of the areas of research and missions are listed below:

- Remote missions utilizing one or more unmanned aircraft systems (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 can enable AAM and higher levels of UAS integration into the National Airspace System (NAS).
- Fault detection, diagnostics, and prognostics capabilities can inform autonomous contingency management systems.

This subtopic is intended to break through these and other barriers with innovative and high-risk research, enabling greater use of autonomy in NASA research, civil aviation, and, ultimately, the emerging AAM market. It is important...
to note that any proposals for UAS development and sensors for vehicle health/failure detection will not be considered.

The following two research areas are the primary focus, and any submissions must show a strong relevance to these areas to be considered.

- Prognostics, survivability, and fault tolerance: Techniques are required that can understand vehicle health and critical failures, 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, are also needed. Examples include, but are not limited to, new, efficient approaches and algorithms and hybrid edge/cloud approaches. Proposals for vehicle health and failure detection are covered under Subtopic A151 and will be rejected under this subtopic.
- Verification and validation technology and certification approaches: New methods of verification, validation, and certification need to be developed to enable application of complex systems to be certified for use in the NAS. Proposed research could include novel hardware and/or software architectures that expedite or enable alternates to traditional verification and validation requirements. Proposals should reference material on emerging standards for autonomy certification, including the American Society for Testing and Materials (ASTM) autonomy guidelines and emerging Federal Aviation Administration (FAA) considerations for small aircraft, UAS, and UAM. For example, proposals could reference standards coming out of ASTM AC377.

**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 technology demonstration in a simulation environment that clearly shows the benefits of the technology developed.
- 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 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 useable/workable prototype of the technology (or software program), such as toolboxes, integrated hardware prototypes, training databases, or development/testing environments, are highly desired.
- A technology demonstration in a relevant flight environment that clearly shows the benefits of the technology developed.
- 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.
- 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, have 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 technologies 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 the NASA Aeronautics Research Mission Directorate (ARMD) Strategic Thrust 5 and Strategic Thrust 6.

- Transformative Aeronautics Concepts Program (TACP): https://www.nasa.gov/aeroresearch/programs/tacp
- Integrated Aviation Systems Program (IASP): https://www.nasa.gov/aeroresearch/programs/iasp

References

- Explore Flight: We're with You When You Fly: https://nari.arc.nasa.gov/aero-autonomy