



NASA SBIR 2019 Phase I Solicitation

A1.09 Vehicle Safety - Internal Situational Awareness and Response

Lead Center: GRC

Participating Center(s): AFRC, ARC, LaRC

Technology Area: TA15 Aeronautics

Achieving a vision for a safer and more efficient National Airspace (NAS) with increasing traffic and the introduction of new vehicle types requires increasingly intelligent vehicle systems able to respond to complex and changing environments in a resilient and trustworthy manner. Future air vehicles, especially autonomous vehicles and those that support Urban Air Mobility (UAM), must operate with a high degree of awareness of their own well-being, and possess the internal intelligence to provide warning and potentially take action in response to off-nominal states. A vehicle's capability to independently assure safety may be the only recourse in some situations and addresses the recurring issue of inappropriate crew response. Further, early warning of impending maintenance conditions reduces maintenance cost and vehicle down-time through improved vehicle availability and throughput. Understanding the vehicle state also has impact on vehicle performance, efficiency, and environmental impact.

It is predominately left to pilots (not the vehicle) to interpret current state and infer future states based on experience and expertise. Commercial Aviation Safety Team (CAST), FAA, NTSB, and the NRC have called for research on systems that can predict the state of the aircraft, including the state of autonomous systems, to provide notifications of trending to unsafe states. In order for there to be trust in autonomy, vehicle situational awareness and response needs to be tailored for independent autonomous systems without human intervention. There has been development in component health management technology with some adoption; integrated subsystem/vehicle system full-field health management is limited. Significant new capabilities are needed to enable safe vehicle operation in the NAS independent of human intervention.

This subtopic seeks technologies to enable intelligent vehicle systems, including subsystems such as airframes, propulsion, and avionics, with an internal situational awareness and ability to respond to off-nominal conditions for piloted vehicles augmented with autonomous capabilities, as well as increasingly autonomous vehicle systems (including On Demand Mobility/Urban Air Mobility and vertical lift vehicles). Specific areas of interest include:

- Networked sensors and algorithms to provide necessary vehicle full-field state information ranging from the component level to the subsystem and system level.
- On-board hardware and software systems that are modular, scalable, redundant, high reliability, and secure with minimal vehicle impact.
- Information fusion technologies to integrate information from multiple, disparate sources and evaluate that information to determine health and operational state.
- Diagnostic and prognostic technologies that inform decision-making functions with critical markers trending to unsafe state.
- Decision-making algorithms and approaches to enable trustworthy real-time operations, take preventive actions as needed in complex uncertain environments, and appropriately communicate status to other

components of the NAS.

- Integrated systems technologies that enable the mitigation of multiple hazards, while effectively dealing with uncertainties and unexpected conditions.
- Approaches that combine improved in-flight vehicle state safety awareness with adaptive methods to achieve improved efficiency, performance, and reduced environmental impact.
- Methods that significantly enhance the fidelity and relevance of information provided to ground systems by the vehicle in-flight for use in on-demand maintenance.

The expected Technology Readiness Level (TRL) range at completion of the project is 3 to 6.

This technology development is directly relevant to NASA's Aeronautics Research Mission Directorate (ARMD) Thrust 6 Autonomy Roadmap in order to allow more intelligent vehicle systems and has strong relevance to NASA's autonomy activities. NASA also plans to have an increasing role in the expanding market of ODM/UAM. In these fields, technologies that enable vehicle situational awareness and response will be enabling for NASA to carry out its future missions across a range of ARMD projects. This includes operations not only at the vehicle level, but at the subsystem and component level as well. The approach is to mature technology through this subtopic for ongoing implementation into NASA missions.

References:

- ARMD Strategic Thrust 6: Assured Autonomy for Aviation Transformation, Vision and Roadmap, M. Ballin, June 2016, <https://nari.arc.nasa.gov/sites/default/files/attachments/ARMD%20ST%206%20Roadmap%20Webinar%20Briefingv2.pdf>
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- M. D. Moore, K. Goodrich, J. Viken, J. Smith, B. Fredericks, T. Trani, J. Barraclough, B. German, and M. Patterson, "High-Speed Mobility through On-Demand Aviation," 2013 Aviation Technology, Integration, and Operations Conference, AIAA AVIATION Forum, AIAA013-4373, Aug. 2013. 10.2514/6.2013-4373
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