Public benefits derived from continued growth in the transport of passengers and cargo are dependent on the improvement of the intrinsic safety attributes of the Nation’s and the world’s current and future air transportation system. Recent developments to address increasing demand are leading to greater system complexity, including airspace systems with tightly coupled air and ground functions as well as widely distributed and integrated aircraft systems. Current methods of ensuring that designs meet desired safety levels will likely not scale to these levels of complexity (Aeronautics R&D Plan, p. 30). The Airspace Operations and Safety Program (AOSP) is addressing this challenge with a major area of focus on In-Time System-wide Safety Assurance (ISSA). A proactive approach to managing system safety requires (1) the ability to monitor the system continuously and to extract and fuse information from diverse data sources to identify emergent anomalous behaviors after new technologies, procedures, and training are introduced; and (2) the ability to reliably predict probabilities of the occurrence of hazardous events and of their safety risks.

Understanding and predicting system-wide safety concerns of the airspace system and the vehicles flying in it, as envisioned in future aviation systems is paramount. Such systems would include the emergent effects of increased use of automation and autonomy to enhance system capabilities, efficiency and performance beyond current, human-based systems, through health monitoring of system-wide functions that are integrated across distributed ground, air, and space systems. Emerging highly automated and even autonomous operations, such as those envisioned for unmanned aircraft systems (UAS) and urban air mobility (UAM) will play a major role in future airspace systems. In particular, operating beyond the operator’s visual line-of-sight (BVLOS) and near or over populated areas are topics of concern. Safety-critical risks include (1) flight outside of approved airspace, (2) unsafe proximity to people/property, (3) critical system failure (including loss of command and control (C2) link, loss or degraded GPS, loss of power, and engine failure); (4) loss-of-control (i.e., outside the envelope or flight control system failure).

Tools are being sought for use in creating prototypes of ISSA capabilities. The ultimate vision for ISSA is the delivery of a progression of capabilities that accelerate the detection, prognosis and resolution of system-wide threats.

Proposals under this subtopic are sought, but are not limited to, development and/or demonstration in the following areas (with an emphasis on safety applications):

- Data collection architecture, data exchange model and data collection mechanism (for example via UTM
TCL-4).
- Data mining tools and techniques to detect and identify anomalies and precursors to safety threats system-wide.
- Tools and techniques to assess and predict safety margins system-wide to assure airspace safety.
- Prognostic decision support tools and techniques capable of supporting real-time safety assurance.
- Verification and validation (V&V) tools and techniques for assuring the safety of air traffic applications during certification and throughout their lifecycles, and techniques for supporting the in-time monitoring of safety requirements during operation.
- Products to address technologies, simulation capabilities and procedures for reducing flight risk in areas of attitude and energy aircraft state awareness.
- Decision support tools and automation that will reduce safety risks on the airport surface for normal operations and during severe weather events.
- Alerting strategies/protocols/techniques that consider operational context, as well as operator state, traits and intent.
- Methodologies and tools for integrated prevention, mitigation and recovery plans with information uncertainty and system dynamics in a UAS and in a trajectory-based operations (TBO) environment.
- Strategies for optimal human-machine coordination for real-time hazard mitigation.
- Methods and technologies enabling transition from a dedicated pilot-in-command or operator for each aircraft (as required per current regulations) to single operators safely and efficiently managing multiple unmanned and UAM aircraft in civil operations.
- Measurement methods and metrics for human-machine team performance and mitigation resolution.
- System-level performance models and metrics that include interdependencies and relationships among human and machine system elements.

References

https://www.nasa.gov/aeroresearch/programs/aosp

https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/aero-rdplan-2010.pdf

Expected TRL or TRL range at completion of the project: 1 to 3

Desired Deliverables of Phase II

Prototype, Analysis, Software, Research

Desired Deliverables Description

Technologies that can advance the goals of safe air transportation operations which can be incorporated into existing and future NASA concepts.

State of the Art and Critical Gaps

State of the Art: Recent developments to address increasing air transportation demand are leading to greater system complexity, including airspace systems with tightly coupled air and ground functions as well as widely distributed and integrated aircraft systems. Current methods of ensuring that designs meet desired safety levels will likely not scale to these levels of complexity (Aeronautics R&D Plan, p. 30). AOSP is addressing this challenge with a major area of focus on ISSA.

Critical Gaps: A proactive approach to managing system safety requires (1) the ability to monitor the system continuously and to extract and fuse information from diverse data sources to identify emergent anomalous behaviors after new technologies, procedures, and training are introduced; and (2) the ability to reliably predict probabilities of the occurrence of hazardous events and of their safety risks. Also, with the addition of UAM concepts, and increasing development of UTM, the safety research needs to expand to include these various missions and vehicles.

Relevance / Science Traceability

Successful technologies in this subtopic will advance the safety of the air transportation system. The AOSP safety
effort focuses on pro-actively managing safety through continuous monitoring and extracting relevant information from diverse data sources and identifying anomalous behaviors to help predict hazardous events and evaluate safety risk. This subtopic contributes technologies towards those objectives.