This focus area includes technologies addressing both the Airspace Operations and Safety Program (AOSP), and NASA’s ARMD Strategic Thrusts 1, 5, and 6. AOSP is targeting system-wide operational benefits of high impact for NextGen and beyond, both in the areas of airspace operations and safety management. The SBIR Airspace Operations and Safety Topic is focused on research and technology development for enabling a modernized air transportation system that will achieve much greater capacity and operational efficiency while maintaining or improving safety and other performance measures. This will include the integration of new types of vehicles such as unmanned vehicles, advanced subsonic aircraft, supersonic or commercial space vehicles; new types of business models or operations (i.e., urban air mobility); and new architectures or services for enabling these operations within the NAS.

Subtopics

A3.01 Advanced Air Traffic Management System Concepts

Scope Title:

Advanced Air Traffic Management System Concepts

Scope Description:

This subtopic addresses contributions towards Air Traffic Management (ATM) systems and concepts with potential application in the near-future (2025-2030) National Airspace System (NAS). The subtopic seeks proposals that can apply novel and innovative technologies and concepts towards addressing established ATM challenges of improving efficiency, capacity, and throughput while minimizing negative environmental impact, maintaining or improving safety, and/or accelerating the implementation of NASA technologies in the current and future NAS.

Given the recent coronavirus pandemic, and the dramatic impact to the airlines and U.S. aviation industry as a whole, this solicitation also seeks proposals that can apply novel and innovative concepts, technologies, and capabilities towards enabling the U.S. air transportation system to recover from the recent negative impacts of reduced traffic demand.
The NASA technologies that are being researched and developed for the future NAS include, but are not limited to: Integrated Arrival, Departure, and Surface (IADS) capabilities, routing and rerouting around weather from ground-based and cockpit-based systems, tools enabling trajectory-based operations (TBO), and capabilities that can be integrated with a fully-realized Unmanned Aircraft Systems Traffic Management (UTM) system for a wide range of commercial and public use.

Technologies, concepts, models, algorithms, architectures and tools are sought in this solicitation to bridge the gap from NASA’s research and development (R&D) to operational implementation, and should address such nearer-term ATM challenges as:

- Safe, end-to-end TBO.
- Enabling and integrating existing independent systems and domains, and increasingly diverse and unconventional operations (gradually enabling the future integration of large unmanned vehicles, unconventional commercial airline business models, space traffic management, and subsonic and supersonic vehicles).
- Applying elements of the service-based architecture concept being pioneered in the UTM domain.

Expected TRL or TRL Range at completion of the Project: 1 to 4

Primary Technology Taxonomy:
Level 1: TX 16 Air Traffic Management and Range Tracking Systems
Level 2: TX 16.3 Traffic Management Concepts

Desired Deliverables of Phase I and Phase II:

- Research
- Analysis
- Prototype
- Software

Desired Deliverables Description:

Technologies that can advance safe and efficient growth in global operations [Aeronautics Research Mission Directorate (ARMD) Thrust 1 Goal] that can be incorporated into existing and future NASA concepts.

Phase I deliverables may take the form of a prototype/proof-of-concept decision support tool, automation and/or service, a proof-of-concept demonstration of the underlying architecture, and/or validation of the approach taken, which shows focus on a particular aspect or use case of the R&D challenge being investigated. Phase II deliverables would presumably take the form of higher TRL tools/decision support services that convincingly demonstrate a solution to the proposed R&D challenge.

State of the Art and Critical Gaps:

State of the Art: NASA has been researching advanced air transportation concepts and technologies to improve commercial operations in the NAS.
Critical Gaps: Significant challenges remain in integrating air transportation technologies across different domains and operators (e.g., airport surface and terminal area; airport authority and air navigation service providers; etc.), providing comprehensive, strategic scheduling and traffic management technologies, enabling concepts that will allow for increased demand and complexity of operations, and enabling recovery from the global pandemic-induced air transportation system impacts.

Relevance / Science Traceability:

Airspace Operations and Safety Program (AOSP) within ARMD.

Successful technologies in this subtopic have helped to advance the air traffic management/airspace operations objectives of the Program, and enable successful technology transfer to external stakeholders (including the Federal Aviation Administration and the air transportation industry).

References:

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

A3.02 Increasing Autonomy in the National Airspace System (NAS)

Lead Center: ARC
Participating Center(s): LaRC
Scope Title:

Increasing Autonomy in the National Airspace System (NAS)

Scope Description:

NASA’s future concepts for air transportation (2030 and beyond) will significantly expand the capabilities of airspace and vehicle management and are anticipated to increasingly rely on autonomy and artificial intelligence and machine learning to ensure safe, secure, and equitable operations. Such future concepts propose a seamless, integrated, flexible, and robust set of systems that are anticipated to include traditional as well as nontraditional vehicle types and operations, diverse airspace domains and mission types, and a service-based architecture to provide user services as those demonstrated within NASA’s Unmanned Aircraft Systems Traffic Management (UTM) Project, as appropriate. Future concepts will require resilient, cyber-attack-resistant systems to ensure safe and robust operations that maintain expected levels of safety, as well as accommodate changes to environmental and operational conditions.

Human operators currently perform the most significant roles in decision making in the National Airspace System (NAS). The appropriate allocation of functions as humans team with autonomy (and even current automation) is a critical research question as more autonomous systems are introduced. To address these research challenges, this subtopic seeks proposals that will apply novel and innovative techniques, methods, and approaches to developing tools and/or technologies that will enable successful human-autonomy teaming in the future NAS.

This subtopic is focused on the human-autonomy teaming of the airspace operations in the future NAS. Proposals that do not address the human operator interaction with future NAS technologies will be rejected.

Expected TRL or TRL Range at completion of the Project: 1 to 4
Primary Technology Taxonomy:
Level 1: TX 16 Air Traffic Management and Range Tracking Systems
Level 2: TX 16.3 Traffic Management Concepts

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

- Research
- Analysis
- Prototype
- Software

**Desired Deliverables Description:**

Technologies that can advance safe and efficient growth in global operations [Aeronautics Research Mission Directorate (ARMD) Thrust 1 Goal] as well as developing autonomy applications for aviation (as under ARMD Thrust 6).

Phase I deliverables may take the form of a prototype/proof-of-concept decision support tool, automation and/or service, a proof-of-concept demonstration of the underlying architecture, and/or validation of the approach taken, which shows focus on a particular aspect or use case of the research and development (R&D) challenge being investigated. Phase II deliverables would presumably take the form of higher TRL tools/decision support services that convincingly demonstrate a solution to the proposed R&D challenge.

**State of the Art and Critical Gaps:**

*State of the Art:* NASA has been researching advanced air transportation concepts and technologies to improve commercial operations in the NAS. Autonomy is the focus of increased ARMD interest as evidenced in Thrust 6, Assured Autonomy for Aviation Transformation. Airspace Operations and Safety Program (AOSP) research is increasingly applying autonomous technologies and capabilities towards air transportation challenges. These technologies and capabilities may address limited solutions to targeted problems.

*Critical Gaps:* The growth of data sciences and autonomy/artificial intelligence technologies continue to have great potential to benefit the development of a more autonomous air transportation system. This is needed to accommodate the increasing demand and diversity of air transportation missions and operations. The interpretation and use of data science-based information by human operators and decision makers, continues to be of interest.

This subtopic is focused on the human-autonomy teaming of the airspace operations in the future NAS. Proposals that do not address the human operator interaction with future NAS technologies will be rejected.

**Relevance / Science Traceability:**

Airspace Operations and Safety Program (AOSP).

Successful technologies in this subtopic have helped to advance the air traffic management/airspace operations objectives of the Program. The technologies also introduce new autonomy/artificial intelligence/data science methods and approaches to air transportation problems for current and near-future application, and show where such approaches are/are not appropriate to advance airspace operations.

**References:**

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

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A3.03 Future Aviation Systems Safety

*Lead Center:* ARC

*Participating Center(s):* LaRC
Scope Title:

Future Aviation Systems Safety

Scope Description:

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 include: increased use of automation and autonomy to enhance system capabilities, airspace systems with tightly coupled air and ground functions, cloud computing-based technologies used to perform functions or services, other widely distributed functions across ground, air, and space environments, increasingly integrated aircraft systems, and novel vehicles and mission types, such as Unmanned Aircraft Systems (UAS) and Advanced Air Mobility (AAM). These revolutionary changes are leading to greater system complexity, and current methods of ensuring that airspace and vehicle 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). 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. Thus, a proactive approach to managing system safety requires that once a new system, technology, procedure, or training is introduced, that operators have: (1) the ability to monitor the system continuously and to extract and fuse information from diverse data sources to identify emergent anomalous behaviors through health monitoring of system-wide functions; and (2) the ability to reliably predict probabilities of the occurrence of hazardous events and of their safety risks. Specifically, AOSP’s System-Wide Safety (SWS) Project is developing an In-Time Aviation Safety Management System (IASMS), to address aviation system safety needs. Based on ISSA building blocks, its functional capabilities are architecturally structured to “Monitor—Assess—Mitigate” operational safety risks. One application area of high interest is monitoring, assessing, and mitigating cybersecurity vulnerabilities and attacks. Innovative approaches and methods are sought that monitor/assess/mitigate vulnerabilities before they can be exploited by malicious actors. Proposed innovations are sought that can be easily incorporated into the IASMS. Proposals that lack a technology/function that can be integrated into IASMS will be rejected.

Specifically, this subtopic seeks the following types of proposals, whose technologies can be integrated into IASMS:

1. Proposals to address the safety-critical risks identified in beyond visual-line-of-sight (BVLOS) operations in small and large UAS, including but not limited to risks such as:
   - Flight outside of approved airspace.
   - Unsafe proximity to people/property.
   - Critical system failure [including loss of command and control (C2) link, loss or degraded Global Positioning System (GPS), loss of power, and engine failure].
   - Loss-of-control (i.e., outside the envelope or flight control system failure).
   - Any potential cybersecurity or cyber-physical attack affecting any or all operations within the UAS airspace system.

2. Proposals supporting the research and development of ISSA objectives:
   - To detect and identify system-wide safety anomalies, precursors, and margins.
   - To develop the safety-data-focused architecture, data exchange model, and data collection mechanisms.
   - To enable simulations to investigate flight risk in attitude and energy aircraft state awareness.

3. Proposals supporting safety prognostic decision support tools, automation, techniques, strategies, and protocols:
   - To support real-time safety assurance (including in-time monitoring of safety requirements).
   - That consider operational context, as well as operator state, traits, and intent.
   - For integrated prevention, mitigation, and recovery plans with information uncertainty and system dynamics.
in a UAS and trajectory-based operations (TBO) environment.

- To enable transition from a dedicated pilot in command or operator for each aircraft (as required per current regulations) to single pilot operations.
- To enable efficient management of multiple unmanned and AAM aircraft in civil operations.
- To assure safety of air traffic applications through verification and validation (V&V) tools and techniques used during certification and throughout the product lifecycle.

4. Cybersecurity resiliency requiring availability and integrity of critical functions including:

- Rapid detection of incidents to enable remediation.
- Automatic remediation actions to restore sufficient network or application services to support mission essential functions.
- Information resilience for shared airspace status.
- Reliable delivery and authentication of important messages.
- Security management systems, security management frameworks or information security management systems.
- Resilient voice, data, and precision navigation and timing.

**Expected TRL or TRL Range at completion of the Project:** 1 to 3

**Primary Technology Taxonomy:**
- Level 1: TX 16 Air Traffic Management and Range Tracking Systems
- Level 2: TX 16.1 Safe All Vehicle Access

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

- Research
- Analysis
- Prototype
- Software

**Desired Deliverables Description:**

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

Desired deliverables for Phase I include development of multiple concepts/approaches, tradeoffs analyses, and proof-of-concept demonstrations.

Desired deliverables for Phase II include development of functional prototypes, integration of prototypes into existing and future NASA concepts, and demonstration of the prototype in a realistic environment.

**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 Urban Air Mobility (UAM)/AAM concepts, and increasing development of UAS Traffic Management (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 proactively 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.

References:

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

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

A3.04 Nontraditional Airspace Operations

Lead Center: ARC
Participating Center(s): LaRC

Scope Title:

Nontraditional Airspace Operations

Scope Description:

NASA is exploring airspace operations incorporating unmanned vehicles and novel operations occurring in all airspaces (controlled and uncontrolled), with a goal to safely and efficiently integrate with existing operations and mission types. NASA’s research to enable unmanned vehicles to be safely and fully integrated into existing airspace structures (or lack thereof) has already demonstrated the potential benefits and capabilities of a service-based architecture [such as developed for the Unmanned Aircraft Systems Traffic Management (UTM) Research and Development (R&D) evaluations], and has led to new procedures, equipage and operating requirements, and policy recommendations, to enable widespread, harmonized, and equitable execution of diverse unmanned missions.

This subtopic seeks proposals to continue to adapt the UTM concept elements for application to Urban Air Mobility (UAM)/Advanced Air Mobility (AAM), including:

- Service-based architecture designs that enable dense and/or increasingly complex UAM operations.
- Dynamic route planning that considers changing environmental conditions, vehicle performance and endurance, and airspace congestion and traffic avoidance.
- Dynamic scheduling for on-demand access to constrained resources and interaction between vehicles with starkly different performance and control characteristics.
- Integration of emergent users with legacy users, large commercial transport, including pass-through to and from ultrahigh altitudes and interactions around major airports.
Operational concepts for fleet and network management, market need and growth potential for future operations, and airspace integration. Identification of potential certification approaches for new vehicles operations (such as electric vertical takeoff and landing).

Future service-based architectures also require resiliency to cyberattacks to ensure safe and robust operations that maintain expected levels of safety, as well as accommodating changes to environmental and operational conditions. Therefore, proposals incorporating cyber-resiliency methods, tools, or capabilities, or address cyber-resiliency as part of the proposed effort are also being solicited.

New this year, this solicitation is focused on UAM/AAM airspace operations only, and is not accepting proposals specific to other nontraditional operations. In addition, proposals that focus only on cyber-resiliency solutions without proposing specific UAM/AAM services, will be rejected.

**Expected TRL or TRL Range at completion of the Project:** 1 to 4

**Primary Technology Taxonomy:**
Level 1: TX 16 Air Traffic Management and Range Tracking Systems
Level 2: TX 16.3 Traffic Management Concepts

**Desired Deliverables of Phase I and Phase II:**
- Research
- Analysis
- Prototype
- Software

**Desired Deliverables Description:**
Technologies that can advance safe and efficient growth in global operations [Aeronautics Research Mission Directorate (ARMD) Thrust 1 Goal] as well as developing autonomy applications for aviation (as under ARMD Thrust 6), that are specifically applicable to UAM operations, and address post-pandemic recovery, as appropriate.

Phase I deliverables may take the form of a prototype/proof-of-concept decision support tool, automation and/or service, a proof-of-concept demonstration of the underlying architecture, and/or validation of the approach taken, which shows focus on a particular aspect or use case of the R&D challenge being investigated. Phase II deliverables would presumably take the form of higher TRL tools/decision support services that convincingly demonstrate a solution to the proposed R&D challenge.

**State of the Art and Critical Gaps:**
Current state of the art: NASA has been researching advanced air transportation concepts and technologies to improve commercial operations in the National Airspace System and has been applying this expertise, as well as a service-based architecture and concepts pioneered for UTM towards UAM/AAM.

Critical gaps: Significant challenges remain to fully develop the UAM/AAM airspace concept of operations, including integrating air transportation technologies across different domains and operators, providing comprehensive, strategic scheduling and traffic management technologies, and enabling concepts that will allow for scaling demand and complexity of operations.

This subtopic is focused on the Airspace Operations of the UAM/AAM concept only. Proposals must have clear application to UAM/AAM airspace operations. Proposals that focus on UAM/AAM vehicle capabilities, or onboard vehicle technologies or systems, will be rejected. Proposals that are specific to other nontraditional operations (such as, but not limited to, space traffic management, automated air cargo, UTM, and ultrahigh altitude), without clear application to UAM/AAM, will be rejected.

**Relevance / Science Traceability:**
Airspace Operations and Safety Program (AOSP).

Air Traffic Management-eXploration (ATM-X) Project.

Successful technologies in this subtopic will help NASA pioneer UAM concepts and technologies. The technologies also incorporate new autonomy/artificial intelligence/data science methods and approaches to air transportation problems for current and near-future application.

References:

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

https://www.aviationsystemsdivision.arc.nasa.gov/publications/index.shtml
https://www.aviationsystemsdivision.arc.nasa.gov/index.shtml

https://www.nasa.gov/aeroresearch/strategy