Federal Aviation Administration
William J. Hughes Technical Center
for Advanced Aerospace
Atlantic City International Airport
Atlantic City, NJ

BROAD AGENCY ANNOUNCEMENT AVIATION RESEARCH 2025

TOPICS OF INTEREST

Solicitation Number: 692M15-25-R-00004

December 5, 2024

The following is a list of BAA Topics of Interest of Aviation Research required by the FAA Technical Center. This BAA is an open request for white paper submittals at any time until the expiration of the BAA or until the Topic is removed. White papers and proposals will be assessed according to the instructions and criteria contained in the BAA. Offerors are invited to submit brief descriptive white papers relevant to a Topic or Topics described within the BAA. Each Topic identifies a Technical POC to whom questions relating to a particular Topic must be directed.

AVIATION RESEARCH AIRPORT PAVEMENTS (ARAP)

Topic Number: ARAP0001:

Develop Measurements, Specifications, and Guidance for Multiple Bump Events of Airport Pavement Roughness to Supplement the Existing Pavement Surface Boeing Bump Index (BBI)

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Background:
Pavement smoothness is an important consideration for airport pavement. It provides the comfort and safety of aircraft ground operations. Therefore, when pavements are put into service, the FAA recommends that airports periodically check in service roughness because the surface characteristics of a pavement affect aircraft operation cost and the riding quality. It is because of these considerations, that technical procedures and evaluation for pavement roughness is provided in Advisory Circular (AC) 150/5380-9 Guidelines and procedures for measuring airfield pavement roughness, which references the Boeing Bump Index (BBI) for evaluation. The BBI was developed solely to identify and quantify single event in-service runway pavement roughness from acceptable, excessive to unacceptable conditions.

However, the BBI does not show roughness issues caused by continuous events, which reflects the interaction between the pavement and the aircraft. Without considering it, the single bump cannot reflect the real ride quality felt by the user when the aircraft, such as when it is passing by multiple bumps caused by surface distresses, the frost heave, and runway wavelengths. The consideration of a coupled system with the runway and the aircraft in a multiple vertical bump events can reflect the real responses of the aircraft and make the airport operators correctly protect the aircraft safety and aircraft structural fatigue.

The outcome from this research effort will provide airport operators with multiple bump event surface evaluation procedures for in-service pavement roughness, as well as technical specifications to consistently conduct safe, reliable, and effective airport surface roughness inspections.

Purpose:
Develop methodologies and procedures for conducting multiple bump event based airport pavement surface roughness inspections, as well as technical criteria for acceptable, excessive, and unacceptable pavement roughness.

Requirements:
The FAA would like proposals to address the specific areas listed below; however, proposals are not limited to these requirements.

Determine if an alternative method or index for the calculation of the roughness of in-service airport pavement is possible or necessary considering both single and multiple event bumps.

- Develop processes and procedures for analyzing multiple event bumps and develop recommended technical specifications (i.e. acceptable, excessive, and unacceptable surface roughness criteria).
- Develop a software package that considers multiple event bumps and make it available for public use.

Period of Performance/ Rough Order of Magnitude: The Period of Performance (PoP)/Rough Order of Magnitude (ROM) will be determined based on the projects proposed. There are currently no set parameters for these elements.

Topic Number: ARAP0007:

Designing and Implementing an Embedded Acoustic Sensor System for Monitoring Subsurface Damage in Concrete Test Pavements at NAPTF

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Background:

The Federal Aviation Administration (FAA) will construct a full-scale test of airport concrete pavement at the NAPTF, designated Construction Cycle 10 (CC10). This five-year test aims to observe the accumulation of structural damage within the concrete pavement, starting as small cracks at the slab or joint bottom and progressing to the surface due to traffic. The primary objective is to gain knowledge into the development of internal fatigue damage before it becomes evident at the surface. Hence, it is imperative to deploy a system of embedded sensors capable of detecting and monitoring internal concrete damage. The FAA has identified coda wave interferometry (CWI), an analysis of ultrasonic wave patterns in concrete, as the technology of choice. CWI analyzes the tail end of the signal (coda) for repeatable patterns sensitive to changes in structural properties, making it suitable for monitoring structural deterioration in concrete. Although CWI has been demonstrated in laboratory settings and used for structural health monitoring in European concrete bridge structures, its application in concrete airport pavements has not been tested.

The NAPTF, established in 1999, offers a unique facility for full-scale pavement testing under heavy aircraft traffic. With a rail-based test vehicle simulating aircraft up to 1.3 million pounds and a fully automated data acquisition system, NAPTF is crucial for developing and enhancing FAA procedures for airport pavement design. Test data informs FAA Advisory Circulars (AC) 150/5320-6G and 150/5335-5D, as well as the FAARFIELD computer program. More information is available at: https://www.airporttech.tc.faa.gov/NAPTF.

Purpose:

The purpose of this Topic is to custom-design, produce, and install a system of in-pavement sensors and data collection system (DCS) at the NAPTF. The system should be capable of detecting and monitoring internal structural damage in the CC10 concrete test pavement using CWI principles.

Requirements:
The FAA would like white papers for designing, producing, installing, and analyzing a CWI-based instrumentation system for the NAPTF to address the specific research parameters listed below, however, submittals are not limited to these requirements:

- The total concrete (Portland Cement Concrete) surface area for the research and testing is 310 × 52.5 ft, divided into 3 distinct test items of 90 ft in length, separated by short transition areas. The FAA recognizes the impracticality of instrumenting the entire test area and plans to instrument one representative slab within each test item, with a possible additional slab for control purposes. The instrumented slabs are 18 ft long × 17.5 ft wide, with thicknesses ranging from 13.5 to 15.5 inches. All slabs are plain concrete (no reinforcement) with doweled joints. The system must insonify (i.e., cover) the entire slab area and must be capable of localizing cracking or other structural damage within the slab that is not visible at the surface.

- Systems should be capable of surviving the five-year life of the FAA Construction cycle as any sensors and in-pavement electronics will be inaccessible once installed.

- Systems must be designed to avoid conflicts with other in-pavement sensors (e.g., strain gages, corner displacement sensors, thermocouples, etc.).

- The DCS must be housed in a separate enclosure and function independently of the existing NAPTF DCS. DCS must be able to connect to the local NAPTF ethernet network. (The NAPTF network is an isolated system and cannot be accessed from the internet.)
- Conduct research, testing, data analysis, and required maintenance during system installation, up to two years after installation to determine the feasibility of utilizing CWI to detect structural damage in airport concrete.

Period of Performance/Rough Order of Magnitude:

Efforts up to 3 years will be considered, with continued efforts based on FAA discretion, performance, and results. Annual funding, subject to availability, is anticipated for these efforts, with a Rough Order of Magnitude not to exceed $200,000.00 per project, per fiscal year for any awards under this announcement.

Topic Number: ARAP0008:

Design Model for Reflection Cracking in Airport Asphalt Overlays of Rigid Pavements

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Background:

Existing design guidance in FAA Advisory Circular 150/5320-6G (Airport Pavement Design and Evaluation) is currently limited with respect to the control of reflective cracking in asphalt overlays. To rectify the lack of a validated design model for reflective cracking, the FAA is developing a new design procedure for hot-mix asphalt (HMA) overlays on existing concrete pavements that explicitly considers reflective cracking as a failure mode. The validated model will be included in an updated version of the standard FAA thickness design program FAARFIELD.

In previous research, the FAA developed a reflection crack prediction model that includes both repeated aircraft loads and environmental (temperature) cycles, and existing pavement conditions, as inputs to predict reflection crack growth in overlay pavements using a mixed-mode implementation of Paris' Law. This mechanistic model has been developed as pseudo- code with the intention of integrating it into the existing FAARFIELD cumulative damage factor-based design procedure. Successful integration will depend on developing transfer functions to relate the mechanistic crack growth prediction (governed by Paris' Law) to the condition of the affected pavement surface (measured in practice by pavement condition index, PCI). This effort will make maximum use of real-world airport condition data from field studies and from available airport pavement management databases such as FAA PAVEAIR.

The FAA has conducted research at the National Airport Pavement Test Facility (NAPTF). The NAPTF maintains a unique full-scale reflection cracking test rig, and to date seven (7) cycles of full-scale tests have been completed to acquire data on the formation and propagation reflection cracks under controlled cyclic loading. Data are available on the NAPTF webpage: https://www.airporttech.tc.faa.gov/Airport-Pavement/National-Airport-Pavement-Test- Facility/Reflective-Cracking-Program. In addition, two outdoor reflection cracking test lanes have been installed at the National Airport Pavement Materials Research Center (NAPMRC) to collect long-term performance data on overlays subject to (a) controlled aircraft gear traffic; and (b) natural temperature cycles without traffic. These data have been used to develop and validate the existing mechanistic models.

Purpose:

The purpose of this Topic is to find appropriate transfer functions that can relate mechanistic predictions of reflection crack growth to expected levels of reflection cracking distress on real- world airport pavements. Modifications to the existing developed models and codes may be considered if justified by new data or analysis. The result of this research will be a validated, mechanistic-empirical design model for reflection cracking in asphalt overlays, suitable for implementation in the FAA's FAARFIELD software program.

Requirements:

The FAA would like white papers for research developing transfer functions relating mathematically predicted reflection crack growth to density and severity of observed reflection cracking distress on representative airport pavements. The exact form of

transfer functions is not known at present and should be determined as part of this research. To the extent possible, representative airport pavement sections should consider a broad range of climate zones and airport categories (from large hub to general aviation), to maximize the applicability and generality of the resulting design procedures. White papers may consider the use of machine learning (ML) methods to obtain models that are neither under- determined nor over-determined based on the field data. White papers should address how the analysis will make best use of available field data including (a) FAA PAVEAIR Airport Pavement Management System (APMS) databases containing airport asphalt overlay on concrete (APC) sections; (b) other APC sections at an airport known to have reflection cracking issues, which the FAA ATRD has identified as a potential field study airport; (c) the experimental overlay sections constructed by the FAA ATRD Branch in 2019 and located at the William J. Hughes Technical Center (https://www.airporttech.tc.faa.gov/Airport-Pavement/Pavement-Design/Reflective-Cracking-Program/Reflective-Cracking-Outdoor). Sections manifesting reflection cracking distresses, as well those not currently manifesting such distress, are both of interest for calibrating the model. While the FAA will make available the above data, white papers may identify other suggested sources of field data.

The end product of the research should:

- Plan for implementation of the overlay design model in FAARFIELD (i.e., it should work with the Visual Studio.NET programming environment).
- Quantify reflection cracking density and severity using the PCI method following ASTM D5340-23 (and later versions), Standard Test Method for Airport Pavement Condition Index Surveys.
- Propose failure criteria for overlay thickness design, i.e., levels of reflection cracking density and severity that constitute a failed section in practice.

This topic combines aspects of fracture mechanics modeling (in particular fracture mechanics of viscoelastic, time-temperature dependent materials, i.e., asphalt) with the principles and practice of airport pavement design and evaluation. The results of the research will be used by FAA to develop/modify pavement design standards (Advisory Circulars) and standard design software, including the software program FAARFIELD.

Period of Performance/Rough Order of Magnitude:
Efforts lasting up to 3 years will be considered. Continued efforts at the completion of each milestone or deliverable are at the discretion of the FAA, based on performance and results. These efforts are anticipated to be funded annually, subject to availability of funds. ROM for this research is expected not to exceed $200,000.00 per project, per fiscal year for any awards made under this announcement.

Topic Number: ARAP0010:
Rational Overload Criteria for Airport Pavements in the ACR/PCR Method

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Background:

The Aircraft Classification Rating/Pavement Classification Rating (ACR/PCR) method is used throughout the world as a standard method of reporting airport pavement strength (see International Civil Aviation Organization (ICAO), Annex 14 to the Convention on International Civil Aviation, Volume I – Aerodrome Design and Operations). ICAO Doc 9157, Aerodrome Design Manual, Part 3 – Pavements, Third Edition, 2022, gives details of the method. The Pavement Classification Rating (PCR) is a number expressing the bearing strength of a pavement for "unrestricted" operations. In general, aircraft with an Aircraft Classification Rating (ACR) less than or equal to the PCR can operate on the pavement without weight restrictions, while aircraft with higher ACR are either excluded or subject to operating weight restrictions. The Federal Aviation Administration (FAA) adopted the ACR/PCR method in Advisory Circular (AC) 150/5335-5D and requires Part 139 airports to report runway PCR on Airport Master Records.

Annex 14 allows for occasional overload operations based on the published PCR. The general guidance is that occasional overload operations up to ACR 10 percent higher than PCR are allowed for both flexible and rigid pavements if they do not exceed approximately 5 percent of total annual operations (exclusive of light aircraft). However, these are "suggested" criteria; Annex 14 also provides for a detailed engineering analysis that may justify higher overloads. The existing 10 percent overload criterion does not have a strong technical or empirical justification and existing research suggests it is highly conservative.

The FAA has conducted research at the National Airport Pavement Test Facility (NAPTF) in support of the ICAO overload criteria for both rigid and flexible pavements. The full-scale tests undertaken to date are:

- Construction Cycle 7 (CC7). Flexible overload test items LFC1-6 South. This series of full-scale traffic tests located the possible overload level associated with permanent structural damage between 50-90 percent above the Pavement Classification Number (PCN). It also suggested a possible criterion based on computed subgrade strain. Data are available on the NAPTF webpage: https://www.airporttech.tc.faa.gov/Airport-Pavement/Pavement-Test-Facilities/Construction-Cycles/Construction-Cycle-7.
- Construction Cycle 8 (CC8) Phase 1. Rigid overload test item. This test represented a relatively thin rigid airport pavement on an aggregate base subject to heavy aircraft loading Data are available on the NAPTF webpage: https://www.airporttech.tc.faa.gov/Airport-Pavement/Pavement-Test-Facilities/Construction-Cycles/Construction-Cycle-8.
- Construction Cycle 9 (CC9). Flexible overload test items LFC5-N/S. This test was a follow-on to the CC7 test and represented a flexible pavement subject to a series of overloads at 75 percent above PCR. Data are available on the NAPTF webpage: https://www.airporttech.tc.faa.gov/Airport-Pavement/Pavement-Test-Facilities/Construction-Cycles/Construction-Cycle-9.

Purpose:

The purpose of this Topic is to develop rational criteria for allowable overloads of flexible and rigid airport pavements. Criteria should be consistent with the framework of the existing ACR/PCR method and does not have to include the established (10 percent) limitations. The

result of this research should be suitable for implementation in the PCR computation module of the FAA's FAARFIELD software program.

Requirements:

The FAA will entertain white papers for research ideas on developing rational engineering criteria for allowable occasional overloads on airport pavements. Overloads on airport pavements are defined in accordance with the ACR/PCR method as given in ICAO Annex 14, Vol. 1 and related documents, and FAA AC 150/5335-5D. White papers should consider how to make best use of the extensive results and data from the NAPTF full-scale overload tests described above. White papers may address overloads on flexible or rigid airport pavements, or both.

Allowable overload criteria should be based on an analysis using engineering quantities that can reasonably be measured in the field or calculated from the known properties of a given pavement. Overload criteria should be versatile enough to accommodate the range of expected failure modes that can result from overloading. Ideally, the overload criteria should reflect the actual mechanism(s) of pavement failure. However, this may not always be possible due to the simplified models adopted in the ACR/PCR method. For rigid pavements, the assumed failure mode in ACR/PCR is bottom-up slab cracking. For flexible pavements, structural failure is assumed to be related to excessive vertical strain at the top of the subgrade, and asphalt material fatigue is neglected. In the CC9 flexible full-scale test, the actual failure of both overloaded and non-overloaded flexible test items was manifested in extensive surface cracking rather than the deep rutting and surface upheaval associated with classic subgrade failure, although similar test items under similar loads in CC7 did exhibit the classic failure.

The results of the research will be used by FAA to develop/modify applicable Advisory Circulars and standard design and evaluation software, specifically the software program FAARFIELD.

Period of Performance/Rough Order of Magnitude:

Efforts lasting up to 3 years will be considered. Continued efforts at the completion of each milestone or deliverable are at the discretion of the FAA, based on performance and results. These efforts are anticipated to be funded annually, subject to availability of funds. ROM for this research is expected not to exceed $200,000.00 per project, per fiscal year for any awards made under this announcement.

Topic Number: ARAP0011:

Scale Effects in Reflective Cracking: Table-Scale versus Full-Scale Overlay Tests

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Background:

Reflection cracking occurs when cracks or joints in an existing pavement reflect through to the surface of an overlay under the influence of repeated loads (either vehicle loads or temperature

cycles, or a combination). In airport pavements, reflection cracking increases the risk of foreign object damage (FOD) and admits surface water to underlying layers, accelerating structural damage. Although reflection cracking is a significant distress for airport pavement overlays, it has not traditionally been included in standard pavement thickness design models due to its complexity and the long computational times needed to predict reflection crack growth accurately.

To remedy the lack of an appropriate design model for reflection cracking, the Federal Aviation Administration (FAA) conducts research. At the National Airport Pavement Test Facility (NAPTF), the FAA operates a full-scale reflection cracking test rig, which consists of two jointed, hydronically cooled concrete slabs, with an asphalt overlay bridging the joint. Hydraulic actuators mechanically open and close the joint, simulating the natural temperature cycles that drive reflection cracks. The NAPTF rig may be understood as a full-scale version of laboratory-scale overlay testing equipment, such as the Texas Overlay Tester (TOT). Both types of equipment are used to simulate reflection cracking failures for comparison of different materials and to derive the material constants for predictive equations (e.g., Paris' Law). The full-scale rig has the advantage that it is inherently free of size/scale effects, yet it is impractical to use for routine characterization of fracture mechanical properties such as the energy release rate (ERR).

There are multiple sources of size effects in fracture-mechanical modeling (see e.g., Bažant and Planas, *Fracture and Size Effect in Concrete and Other Quasibrittle Materials*, CRC, 1998.). These include the statistical size effect (due to randomness of material properties and the higher likelihood of capturing a flaw in a large sample), the fracture mechanics size effect, and the heat diffusion size effect. The latter is important in this case due to the temperature-dependent and viscoelastic nature of asphalt. The FAA seeks to better understand the role of size and scale effects in relating results from the NAPTF test rig to laboratory characterization tests. The FAA previously developed an analytic model in two dimensions to obtain ERR for the full-scale NAPTF reflection cracking rig (Report DOT/FAA/TC-20/17, Reflective Crack Propagation Model, 2020; Report DOT/FAA/TC-22/4, Reflective Crack Propagation Model—Part 2: Mode II, 2022).

Purpose:
Develop a dimensionless analytical model predicting ERR for a full range of dimensions from laboratory (tabletop) scale to full scale. With such a model, a separate finite element mesh for each scale will not be needed, which greatly reduces computation time.

Requirements:
White papers are needed for developing a dimensionless analytical model to predict ERR for reflection crack growth in airport asphalt overlay pavements. The model should be usable over a range of dimensions from laboratory scale (represented by the TOT) to full scale. The FAA previously developed an analytic model of reflection cracking in two dimensions. The existing model has certain limitations, described in the references above. It assumes plain strain under prescribed displacements, making it suitable for analysis of the NAPTF reflection cracking rig (which operates under displacement control). The FAA is seeking research ideas to:

- extend the model to three dimensions;
- include mixed mode and mode 3 (out-of-plane shear) fracture;
- understand and incorporate various scale effects that may not be captured in the current formulation;
- obtain ERR for various load conditions (either prescribed loading or prescribed displacement) at any scale.

White papers are not necessarily limited to the above bullets. Numerical (e.g., finite element) and mathematical closed-form modeling approaches will both be considered. Machine learning approaches are also strongly encouraged. In whatever form proposed, models should efficiently capture the viscoelastic (time- and temperature-dependent) behavior of asphalt materials.

Period of Performance/Rough Order of Magnitude:
Efforts lasting up to 3 years will be considered. Continued efforts at the completion of each milestone or deliverable are at the discretion of the FAA, based on performance and results. These efforts are anticipated to be funded annually, subject to availability of funds. ROM for this research is expected not to exceed $200,000.00 per project, per fiscal year for any awards made under this announcement.

AVIATION RESEARCH AIRPORT SAFETY (ARAS)

Topic Number: ARAS0009:

Airport Unmanned Aircraft System(s) (UAS) Detection and Mitigation Research Program

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Background:
Consistent with Section 383 of the Federal Aviation Administration (FAA) Reauthorization Act of 2018 (Public Law 115-254, Oct. 5, 2018), Airport safety and airspace hazard mitigation and enforcement, the FAA is launching an effort to test and evaluate technologies and systems that detect and/or mitigate potential aviation safety risks posed by unmanned aircraft systems (UAS)[1] operations in the airport environment.

Section 383(a) of the *FAA Reauthorization Act of 2018* created a new § 44810 in Title 49 U.S.C. Section 44810(a) requires the FAA Administrator to work with the Secretaries of Defense, Homeland Security, and the heads of other relevant federal departments and agencies to ensure that technologies or systems that are developed, tested, or deployed by federal departments and agencies to detect and mitigate potential risks posed by errant or hostile UAS operations do not adversely impact or interfere with safe airport operations, navigation, air traffic services, or the safe and efficient operation of the National Airspace System (NAS).

In addition, § 44810(b) requires the FAA to develop a plan for the certification, permitting, authorizing or allowing of UAS detection and mitigation systems in the NAS. Section 44810(b) requires the FAA to take certain actions as part of or potentially informing the plan, including convening an Aviation Rulemaking Committee. Further, § 44810(c) requires the FAA to test and evaluate technologies/systems that detect and/or mitigate risks posed by UAS at five airports and § 44810(d) directs the FAA to use detection and mitigation systems to detect and mitigate the unauthorized operation of an unmanned aircraft that poses a risk to aviation safety in the course of the required testing and evaluation.[2]

As part of this program, the FAA has issued Broad Agency Announcement (BAA) Topic Number ARAS0009 to solicit interest from manufacturers, vendors, and integrators of UAS detection and/or mitigation technologies/systems.

Purpose:
The purpose of this Topic is to identify eligible manufacturers, vendors, and integrators of UAS detection and/or mitigation technologies and/or systems in support of the FAA's Airport UAS Detection and Mitigation Research Program, which is being carried out pursuant to 49 U.S.C. § 44810(c)-(d). For purposes of this research program:

[1] *See* 49 U.S.C. § 44801(12) for definition of UAS.
[2] The FAA was expressly exempted from various federal laws that would otherwise present legal implications associated with UAS detection and mitigation activities. *See* 49 U.S.C. § 44810(g). The authority conferred in § 44810(g) is limited to the testing and evaluation of UAS detection and/or mitigation technologies/systems by the FAA at five airports. This authority cannot be delegated.

1) UAS detection system refers to a system or device capable of lawfully and safely detecting, identifying, monitoring, or tracking an unmanned aircraft or unmanned aircraft system. UAS detection systems may be integrated into or be linked to counter-UAS[3] systems, but, themselves, do not provide the capability to disable, disrupt, seize control, or otherwise directly interfere with UAS operations.
2) Mitigation refers to actions taken to deter, prevent, respond to, and minimize the immediate consequences of safety and security threats posed by certain UAS operations. Mitigation may be conducted using counter-UAS and UAS detection systems, or by using other means, including efforts not reliant on these technical systems.

Requirements:
The FAA has a requirement to test and evaluate technologies/systems that have the ability to detect and/or mitigate UAS in the airport environment. It is important to note that the FAA will not be comparing or ranking vendors, nor is it developing a list of approved vendors as part of this research program. The FAA will be collecting data on UAS detection and mitigation capabilities and the associated impacts of these systems/technologies on the safe and efficient operation of the NAS in order to inform the additional activities required under 49 U.S.C. § 44810.

The FAA is seeking the submission of white papers to address the specific areas listed below; however, submittals are not limited to these requirements:

1) UAS Detection Testing - Conduct testing and evaluation of technologies/systems to protect the air operations area (AOA)[4] of an airport and as much surrounding area as possible with a general goal of reaching approximately 5 miles out from the center point of the AOA.

2) UAS Mitigation Testing - Conduct testing and evaluation of technologies/systems that offer mitigation capabilities, either as a stand-alone system or in conjunction with a detection capability, to protect the AOA of an airport.

The FAA reserves the right to pre-test mitigation technologies/systems in a controlled setting before introducing any system/technology into any airport environment for operational testing. The selection of any offered system/technology for FAA's research program may be denied, and testing of any selected mitigation systems/technologies may be discontinued at any stage, due to the identification of unacceptable adverse impacts or interference caused by the system/technology to safe airport operations, navigation, air traffic services, or the safe and efficient operation of the NAS.

Period of Performance (PoP)/ Rough Order of Magnitude (ROM):
The PoP/ ROM will be determined based on the projects proposed. There are currently no set parameters for these elements.

[3] *See* 49 U.S.C. § 44801(5) for definition of counter-UAS.
[4] *See* 14 C.F.R. § 153.3 for definition of air operations area.

AVIATION RESEARCH SOFTWARE & SYSTEMS (ARSS)

Topic Number: ARSS0002:
Flight Controls and Mechanical Systems

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Background:
The FAA's Small Airplane Directorate has been working for a number of years to address General Aviation (GA) safety and to create a regulatory environment that uses advances in technology to enhance GA safety. In that time, the certification process study and Part 23 rewrite have indicated a need for the FAA to keep pace with technology and specifically apply it to prevent fatal GA accidents. Using a data driven approach, the FAA, along with the General Aviation Joint Steering Committee (GA-JSC), have identified the top three causes of fatal GA accidents to be: loss of control (LOC), controlled flight into terrain (CFIT), and system or component failure - power plant. Advanced Flight Controls, including augmented flight path control can help address many of these root causes of fatal GA accidents.

Purpose:
The purpose of this Topic is to solicit white papers from the aviation community to develop proposed methods of compliance for certification of advanced flight control systems and address the root causes of fatal GA accidents. The white papers can focus on any one part of these causes, multiple parts of these causes, or all the causes. Offerors are welcome to submit multiple white papers if desired.

The FAA wants to identify barriers to certification and find ways to affordably certify systems and safety enhancements. Results will be used by the FAA and/or industry to capture best design practices, create industry standards, field new designs, and develop methods of compliance for certification of advanced flight control systems. Ultimately, the expected outcome will be a significant reduction of Loss of Control, CFIT, and power plant related GA accidents.

Requirements:
The FAA would like to address the specific areas listed below; however, white papers are not limited to these requirements. Innovative ideas are welcome and encouraged.

- Aviation Safety Research focusing on new and innovative Cockpit Displays, Heads-up Displays, and/or Inceptors for General Aviation, VTOL, VSTOL, or Hybrid aircraft.
- Aviation Safety Research focusing on new and innovative Autopilot technologies, Flight Path Control Systems, Automation, and/or Collision Avoidance Systems for General Aviation, VTOL, VSTOL, or Hybrid aircraft.
- Aviation Safety Research focusing on developing Mission Task Elements, Means of Compliance/Methods of Compliance, or other research to assist in the certification of General Aviation, VTOL, VSTOL, or Hybrid aircraft.
- Aviation Safety Research focusing on how sensors, avionics, processors, actuators, etc.

could be used to enhance GA safety by safely retrofit into existing General Aviation aircraft.

- Aviation Safety Research focusing on automation in the context of safe flight path augmentation, automation for safety risk controls, aiding pilot decision making, reducing pilot workload, performing dynamic consistency checks, and providing run time assurance for complex systems.
- Aviation Safety Research focusing on ways to enhance the safety of commercial Urban Air Mobility.
- Aviation Safety Research focusing on ways to reduce the General Aviation accident rate.
- Aviation Safety Research to address design best-practices, architectures, and methods of compliance to affordably implement basic envelope protection, augmented flight path control systems, and energy management concepts.
- Aviation Safety Research to propose ways to address pilot distraction, confusion or pilot errors that have resulted in GA accidents and incidents.
- Aviation Safety Research to propose design best-practices, architectures, and methods of compliance to certify "refuse to crash" hazard avoidance systems. These systems have awareness of threats such as terrain, obstacles, weather, and other aircraft.

Period of Performance/Rough Order of Magnitude:
The Period of Performance (PoP)/Rough Order of Magnitude (ROM) will be generally determined based on the projects proposed. However, tasks lasting for more than 3 years will NOT be considered.

Continued efforts at the completion of each milestone or deliverable are at the discretion of the FAA, based on performance and results. These efforts are anticipated to be funded annually, subject to availability of funds. There are currently no set parameters for the ROM.

Topic Number: ARSS0003:
Integrated Flight and Propulsion Control for Rotorcraft

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Background:
New and novel ways of integrating propulsion and flight controls to simultaneously produce lift, thrust and control of vertical landing aircraft are being introduced. Some of the existing system requirements, airworthiness standards and associated means of compliance are not applicable, need modification or need to be drafted. Flight characteristics and thrust/control coupling of multiple propulsion and control effector vehicles (multi-rotor copters of 3 or more blades) need to be understood.

Purpose:
This Topic is part of a proactive effort by the FAA to engage with industry and collaborate on emerging technologies. Furthermore, the FAA wants to identify barriers to certification and find ways to affordably certify systems and safety enhancements on powered-lift and distributed lift rotorcraft.

The purpose of this Topic is to solicit white papers from the rotorcraft and non-rotorcraft community that offer potential solutions for multi-rotor powered-lift and rotorcraft/vehicles that will provide needed data/information to help the FAA develop guidance and airworthiness criteria and means of compliance for this type of vehicle.

Requirements:
The FAA would like white papers to address one or more of the specific areas listed below, however, proposals are not limited to these requirements. Innovative ideas are welcome and encouraged.

- Stability: Height-speed envelope, main rotor speed and pitch limits, general flight characteristics.
- Control bandwidth requirements and external disturbance rejection capability and evaluation.
- Performance: General, landing, autorotation (emergency landing), controllability and maneuverability.
- Failure modes and acceptable system degradation capabilities.
- System Integration/Flight Management: eVTOL simulation or actual test demonstration to cover takeoff, en route, and landing phase for normal and emergency procedures.
- Since certifying Emergency Auto-Land, the FAA has been looking at a new paradigm in automation integration. In some cases now, the automation is there to back up the pilot (correcting for pilot incapacitation or pilot errors) instead of the pilot stepping in when the automation fails. What types of training and aircraft certification standards should apply in this new paradigm? With new and novel automation integration (especially with fly-by-wire eVTOL aircraft and integrated envelope protections) how do the assumptions of pilot interaction with the aircraft and system change? How do these assumptions change the way aircraft are certified and the way airmen are trained and tested?

Submitted white papers should focus on solutions to one or more of the above challenges. The goal of this program is to have a system that can demonstrate a multi-rotor or powered-lift vehicle that will be tested to provide/generate data in one of the areas listed above. (Simulation and/or computer models or actual vehicle testing).

Period of Performance/Rough Order of Magnitude:
The Period of Performance (PoP)/Rough Order of Magnitude (ROM) will be generally determined based on the projects proposed. However, tasks lasting for more than 3 years will NOT be considered. There are currently no set parameters for the ROM.

Topic Number: ARSS0008:
Complex Digital Systems

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Background:
Aircraft manufacturers and modifiers are developing highly integrated and distributed system architectures with multiple aircraft functions. New methodologies, tools, and Artificial Intelligence/Machine Learning (AI/ML) applications are planned for use in airborne systems. Aircraft system element development is also evolving due to technological advancements and the desire to reduce costs and time to market. The aviation industry seeks assurance criteria and guidance to address the growing complexity introduced by new technologies in airborne systems. This includes exploring innovative assurance approaches alongside the development of new methodologies, tools, software implementations, and AI/ML applications.

Safe use of the new technologies, tools, and commercial off-the-shelf (COTS) components may not have been demonstrated in embedded aircraft equipment; which may introduce a safety risk for undetected errors with failure manifestation at the aircraft level; and may only be suitable to meet safety regulations when new, revised or additional assurance activities are also included. For example, industry is proposing to use AI where little is known about the validation and verification of AI in a safety critical environment. In addition, use of autonomous (non-piloted) aircraft are also being proposed under conditions where, currently, regulations and guidance do not exist. These methodologies, individually or in combination, could introduce unknown risk if not properly addressed early in the development process.

The Federal Aviation Administration (FAA) plans to conduct research to proactively address certification issues that may arise due to the introduction of new methodologies, tools, and techniques with a particular focus on AI/ML applications and autonomy that can potentially cause new failure conditions posed by the rapid or new and novel development processes on highly integrated and distributed systems. The research results will be used in improving the assurance standards, guidance, and training material for certification engineers.

Purpose:
The purpose of this Topic is to address the use of new methodologies and techniques particularly AI/ML applications and software assurance in safety critical airborne systems by identifying assurance concerns, validation and verification issues, and potential mitigation techniques to address risks early in the development process. Also, the FAA is studying new assurance processes that can address the safety risk that may have been introduced while implementing newer architectures, tool, and technologies. The Topic also further explores the validity of the currently-recognized development assurance standards for highly integrated and distributed systems and determine if newer development assurance approaches are needed to demonstrate compliance with the regulations in light of the rapid advances in design and development of highly integrated and distributed aircraft systems. Furthermore, to address errors originating from requirement issues and minimize the risk of single point of failure, the

research will explore novel validation approaches like diverse specifications.

The goal is to develop recommendations that assist in the certification and assurance of highly integrated, distributed, and complex digital aircraft systems, including systems development processes and architectures, requirements validation and integration; use of COTS devices, new and novel electronic hardware and software implementation techniques, tools, methods, and processes; continued operational safety; and streamlining approaches for safety assurance and aircraft certification.

Requirements:
The FAA would like white papers to address the specific areas listed below; however, submittals are not limited to these requirements. Innovative ideas are welcome and encouraged.

The research should address airborne system safety and assurance issues in the following specific areas or combination of areas, but not be limited to:

- Assurance and verification Methodologies for Automation using AI/ML in safety critical airborne systems.
- Risk mitigation methodologies and approaches to address the unknown behavior of new technologies such as AI/ML.
- Pilot studies to evaluate the use of new assurance approaches, e.g., Overarching Properties as Alternative Means of Compliance.
- Use of Formal Methods and Assurance Cases, and their use in aircraft certification.
- Explainability approaches and recommendations of AI/ML implementations for different level of autonomy and design assurance levels.
- Explore safety improvements through diverse specifications developed from multiple prospectives.
- Explore the use of Large Language Models to classify latent risks in aviation systems.

For the research areas above, the FAA aims to:

- Assess alternative assurance approaches to currently recognized standards and their effectiveness in addressing safe implementation of new technologies such as AI/ML and addressing the safe implementation of autonomy.
- Identify the issues, challenges, and gaps in the current standards/guidance in assuring new complex airborne systems and components.
- Develop criteria, mitigation approaches, recommendations, training material, or position papers.

The results of the research will be used by FAA to develop/modify standards, guidance, or training material to support the FAA's certification workforce.

Period of Performance/Rough Order of Magnitude:
The Period of Performance (PoP)/Rough Order of Magnitude (ROM) will be determined based

on the projects proposed. However, the tasks lasting for more than 3 years will NOT be considered.

Continued efforts at the completion of each milestone or deliverable are at the discretion of the FAA, based on performance and results. These efforts are anticipated to be funded annually, subject to availability of funds. ROM for this research is expected not to exceed $400,000.00 per project, per fiscal year for any awards made under this announcement.