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

Amendment 007

February 12, 2026

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: 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.

Topic Number: ARAP0012:
Engineering Analysis of Field Monitoring and Instrumentation Data

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Background:
Since 1992, Federal Aviation Administration (FAA) has had an ongoing initiative to evaluate pavement responses and monitor pavement performance of airport pavements. Data collected during this time includes responses from instrumentation in static (nontraffic-related) and dynamic (traffic-related) intervals, characterization testing of pavement layers using laboratory and field tests, and pavement condition data via Pavement Condition Index (PCI) assessments. Ultimately, the goal of this initiative is to directly support any improvements to airport pavement design, construction, and/or management practices via FAA Advisory Circulars (AC) 150/5320-6, 150/5370-10, and 150/5335-5.

ATR has conducted this research at operational airports across the United States. Some of the findings have resulted in:

- Development and validation of FAA's three-dimensional finite element software for design of rigid airport pavements.
- Load transfer in undoweled Portland Cement Concrete (PCC) pavements may be sufficient when thick pavements are used leading to more cost-effective construction strategies.
- Study of shoving mechanism in flexible pavements along high-speed exits due to delamination in asphalt overlays leading to potential considerations when designing and constructing high-speed exits.

More information on the research findings is available at:
https://www.airporttech.tc.faa.gov/Airport-Pavement.

Purpose:
The purpose of this Topic is to solicit white papers that seek to (i) improve airport pavement design, construction, or management strategies through data collected from in situ operational airports, (ii) research innovative technologies and methods that better facilitate remote monitoring of airport pavement responses, or (iii) ensures the adequacy of

engineering specifications and standards across all areas of airport systems. Offerors are welcome to submit multiple white papers if desired.

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.

- Evaluate airport pavement responses under various aircraft, environmental, and pavement structure conditions.
- Apply artificial intelligence/machine learning to advance the state-of-the-art for airport pavement construction and engineering.
- Investigate emerging areas in the fields of pavement instrumentation, signal processing, and data analysis.
- Characterize airport pavement materials using collected field samples or in situ test data
- Research innovative methods of remote data collection systems and network communications.

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.

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 the availability of funds. There are currently no set parameters for these elements.

Topic Number: ARAP0013:

Enhancement of Airport Pavement Layer Backcalculation Software (BAKFAA)

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Background:
The current version (v. 4.4.3) of the FAA's backcalculation software BAKFAA was released to the public on February 21, 2024. BAKFAA focuses on performing backcalculation of pavement material properties from Heavy Weight Deflectometer (HWD) and Falling Weight Deflectometer (FWD) data. BAKFAA uses multilayer linear elastic (LE) theory and unconstrained multidimensional simplex search to backcalculate material properties. Both the search algorithm and the static, LE response model have limitations, but with engineering judgment the results can be used to assess airport pavement structural condition and performance.

HWD and FWD both impart a highly dynamic load to the pavement, so the static analysis is necessarily an oversimplification and may not yield accurate responses. In particular, the LE static response ignores key factors such as dynamic load pulse width and time-dependent material properties. However, dynamic analysis requires much longer computation times, and the

complicated dynamic model causes difficulties in practical implementation. Moreover, the current search method in BAKFAA, which works by minimizing the global error between measured and computed deflections, has known inefficiencies.

Purpose:
Industry practitioners and research studies describe a need for updating the current FAA software BAKFAA to reflect current state-of-the practice and state-of-the-art. The purpose of this BAA topic is to explore efficient and accurate backcalculation solutions for BAKFAA that will provide a companion tool to airport owners, airport engineers, airport operators, and contractors for structural evaluation of airport pavements. The main outcome of this research will be improved BAKFAA backcalculation results, leading to better estimates of remaining airport pavement life and more reliable airport pavement designs.

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

1. Develop new models for BAKFAA to efficiently characterize the material properties of asphalt and concrete pavement from HWD/FWD data. Models must be suitable for routine use by practitioners, i.e., dynamic analyses requiring long processing times or access to specialized computers would be barriers to industry acceptance. Solutions should be available in real time or near-real time.
2. Enhance the BAKFAA software by updating its computational methods to reflect the state of the art. Consider machine learning or other advanced search techniques to improve the quality of the results.

The FAA anticipates that the above requirements will include doing a full assessment of current BAKFAA version 3.4.3 and review of related FAA Advisory Circulars, relevant literature materials, and other available backcalculation programs.

Period of Performance/Rough Order of Magnitude:
Efforts lasting up to three years will be considered. Continued efforts at the completion of each milestone or deliverable are at the discretion of the Government, based on performance and results. These efforts are anticipated to be funded annually, subject to the 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: ARAP0014:
Advancing Pavement Condition Assessment Practices for Airport Pavements

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Background:
Advisory Circular (AC) 150/5380-7 requires airports to conduct periodic inspections of airfield pavements to support the development and maintenance of an Airport Pavement Management

Program (PMP). The required frequency of pavement inspections is dependent on the inspection method used. Most airports currently follow ASTM D5340, which provides a standardized methodology for conducting foot-on-ground visual pavement condition inspections. Recently alternative innovations in pavement condition inspection technologies and methodologies have emerged that deviate from the procedures outlined in ASTM D5340. The implications of these alternative innovations on current standard practices, inspection coverage, data quality, inspection frequency, and Pavement Condition Index (PCI) determination remain unclear.

Purpose:
The purpose of this topic is to evaluate advancements in pavement condition inspection methods for airport pavements, with an emphasis on implementation considerations. Proposed research should assess how current and alternative inspection approaches compare in terms of inspection coverage, accuracy, repeatability, resource requirements, and compatibility with existing pavement management frameworks. All outcomes from this Topic are aimed at providing guidance to airport operators and regulatory agencies on the potential role of these methods in future airport pavement condition inspection programs. Offerors are welcome to submit multiple white papers if desired.

Requirements:
The purpose of this topic is to evaluate methods and considerations associated with the use of alternative innovations in pavement condition inspection approaches for airport pavements. Research that compares alternative inspection methods with current standard practices, or that evaluates variability, consistency, and limitations within both existing and emerging methods, is encouraged. This topic will not fund projects focused on the evaluation, validation, or promotion of a specific proprietary system or inspection method. Innovative, non-proprietary concepts and analytical approaches are welcome and encouraged.

Period of Performance (PoP)/Rough Order of Magnitude (ROM):
Continued efforts at the completion of each milestone or deliverable are at the discretion of the FAA, based on performance and results. The ROM will be determined based on the projects proposed but is expected to be approximately $250,000 per project, per fiscal year for any awards made under this announcement. The PoP will be determined per project and is anticipated to be between approximately twelve (12) to thirty six (36) months. These efforts are anticipated to be funded annually, subject to availability of funds.

AVIATION RESEARCH STRUCTURES AND PROPULSIONS (ARSP)

Topic Number: ARSP0001:
Nickel Anomaly Fatigue Testing

Technical POC: Daniel Cordasco, daniel.cordasco@faa.gov
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Background:
Service experience of aircraft turbine engines has demonstrated manufacturing and service-induced anomalies still occur which can degrade the structural integrity of turbine engine rotors leading to premature and abrupt failure jeopardizing passenger safety. National Transportation Safety Board (NTSB) findings from the uncontained engine failure on American Airlines (AA) Flight 383 in Chicago determined that the high-pressure turbine disk failed due to cracks consistent with low-cycle fatigue (LCF). The LCF cracks initiated from an undetected nickel material anomaly known as a dirty white spot (DWS) which formed during the processing of nickel alloy 718 used to manufacture the disk. The Federal Aviation Administration (FAA) requires a better understanding of the LCF behavior of nickel alloy in the presence of anomalies such as DWS.

Purpose:
The purpose of this Topic is to conduct research to develop fatigue crack growth (FCG) methods to address engine rotor failure mechanisms due to nickel material anomalies. Specifically, research will be performed to test wrought nickel alloy fatigue specimens with subsurface melt anomalies, such as DWS, to understand the effects on LCF life.

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

i. LCF testing of premium quality aerospace grade double-melt or triple-melt wrought nickel alloy material with a minimum ten (10) known or suspected (from inspection) subsurface melt anomalies such as DWS
ii. Determination of cycles to failure for LCF specimens containing subsurface anomalies as well as sufficient baseline pedigree testing of anomaly-free specimens
iii. Post-test fractography and metallography necessary to identify the size and type of anomaly, determine fatigue crack growth rate, and crack incubation/nucleation period
iv. Outreach and teaming plan to collaborate with subject matter experts (SME) from multiple commercial aircraft engine manufacturers on fatigue of aerospace grade wrought nickel alloy. SME input can include, but is not limited to, defining the specific LCF test conditions and review of the test results necessary to facilitate industry-wide adoption.

Period of Performance (PoP)/Rough Order of Magnitude (ROM):

The PoP is anticipated to be twenty-four (24) months. The ROM for this research is estimated to be approximately $350,000.

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.

Topic Number: ARSS0009:
Future of Oversight

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Background:
The Federal Aviation Administration (FAA) continuously improves the effectiveness of its oversight to ensure the aviation system meets public expectations. Oversight activities encompass the breadth of FAA actions, such as regulation, safety promotion, approvals, surveillance, and the compliance program. The scope and method of these activities have largely been developed over decades of experience and in response to in-service events. Modern concepts for safety systems and data capture/analysis, and system modeling provide an opportunity to transform how oversight can be used effectively to assure the public's expectations for safety. Industry and the FAA are embracing Safety Management Systems (SMS). In 2024, the FAA expanded the regulatory applicability of SMS requirements for certain industry segments. FAA continues to encourage other industry segments to voluntarily implement SMS. FAA is also evolving its State Safety Program[1]. New data sources and methods have become available, and new tools are being developed using technologies such as AI/ML (Artificial Intelligence/Machine Learning). To support the aviation system's adoption of these opportunities while meeting safety expectations, the FAA must explore new methods for developing, monitoring, and informing changes to its oversight.

The FAA expects the foundation of a future oversight system will use performance-based regulations, systems, measures, tools, and procedures that proactively monitor the performance of compliance and safety promotion actions and be capable of making timely adjustments to ensure the rigor of oversight achieves a level of safety that satisfies expectations. A mature company SMS, delivering on a commitment to compliance and safety, enables the FAA to change its engagement to focus on areas of highest risk and to monitor the effectiveness of the

[1] U.S. State Safety Program document:
https://www.faa.gov/sites/faa.gov/files/about/initiatives/sms/reference_library/AVS-210503-001-Supporting-US_State_Safety_Program.pdf

company's safety systems to recognize when intervention is needed.

Purpose:
The purpose of this BAA research topic is to explore new concepts for oversight that would modernize the FAA's procedures and systems and enable the FAA to evaluate the effectiveness of oversight activities. This will require methods to evaluate the performance of oversight systems as well as to identify comprehensive and transparent performance indicators for continuous improvement. The research will explore oversight performance and compare the effectiveness and cost-efficiency among oversight systems across various aviation segments. The analysis will identify the characteristics that lead to effective oversight. Considerations include:

- How to evaluate the effectiveness of oversight systems and define the success of oversight?
- How to estimate safety expectations for and of aviation operations?
- How to effectively communicate safety intentions and objectives between the FAA, industry, and the public.
- How to match oversight results with safety expectations, intentions, and objectives?
- How to transform FAA oversight to leverage effective Safety Management Systems?
- How can oversight evaluate the effectiveness of a Safety Management System?
- How to integrate the oversight functions across FAA services and offices to achieve safety goals and objectives.
- Other proposals to modernize how the FAA conducts oversight.

Requirements:
The FAA seeks white papers to address the areas listed below. However, white papers are not limited to these areas:

- **Traditional Oversight and SMS-based Oversight**: The performance-based intentions of safety management systems offer flexibility and scalability benefits to industry while also challenging regulators to develop oversight approaches that support these industry benefits. The FAA has an interest in comparing traditional, prescriptive-based oversight and SMS-based oversight approaches regarding identified findings, resources applied, and other pertinent conclusions in a real-world setting, to gain insight into the lessons learned in implementing these two approaches.

- **Safety workforce of the future:** The transition from traditional compliance-based oversight to performance-based oversight warrants changes in the FAA oversight workforce. The FAA is interested in identifying the characteristics of a future safety oversight workforce and recruiting and developing pathways to transform it into such a workforce.

- **Measures of effectiveness of FAA involvement in the oversight actions of certification and surveillance:** As a regulator, the FAA is involved in every stage of certification and surveillance processes and takes oversight actions as warranted and is seeking to identify new and novel measurements of the effectiveness of the FAA's roles in certification and surveillance.

- **Comparison of aviation oversight to alternate industries:** Many industries, besides aviation, require SMS or similar management system-based oversight, such as the financial sector, possibly the health sector, maritime, transit, etc. The FAA is interested in lessons learned from those industries, comparing effectiveness and efficiency, and normalizing for differences in those industries.

- **Aviation safety risk management cooperation, where the FAA promotes safety and enables industry**: Safety information sharing and safety risk management cooperation are critical to the safety in the aviation industry but are often restricted due to information privacy and trust issues among companies. The FAA is interested in identifying the challenges and receiving recommendations on promoting or enabling data/information sharing and protection, and safety risk management cooperation among entities who are required to comply with 14 CFR Part 5 (SMS) and among entities who maintain an SMS yet may not be required to comply with 14 CFR Part 5 (SMS).

The results from this study will be used to improve the FAA's integrated oversight practice.

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 the availability of funds. There are currently no set parameters for the ROM.