Alternative Jet Fuel Supply Chain Analysis –P1
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Alternative Jet Fuel Supply Chain Analysis
University: University of Hawaii
Amount: $100,000

University: Massachusetts Institute of Technology
Amount: $450,000

University: Purdue University
Amount: $350,000

University: University of Tennessee
Amount: $100,000

University: Washington State University
Amount: $412,313

TASK DESCRIPTION

The goal of this effort is to provide scientific data and analyses to evaluate sustainable aviation fuel (SAF) supply chains, with the potential to support rural economic development and job growth through development of economically valuable feedstock crops and fuel processing facilities. The overall effort consists of a series of activities spread across a six-university team. This funding request will support work for one year at three of those six universities.

The University of Hawaii will continue evaluating the use of urban wood waste from construction and demolition (C&D) as a reliable, low-cost source of renewable material for the production of SAF. This project will assess gasification systems to produce SAF and/or hydrogen in combination with technology options for contaminant removal or conversion to benign forms. Additionally, the University of Hawaii is developing a model for tropical oil supply chains for SAF and associated coproducts. The work is being done in a collaborative manner with university researchers from the Canary Islands of Spain to ensure the effort is applicable to other areas with similar ecosystems around the world.

The Massachusetts Institute of Technology task includes efforts to calculate the lifecycle greenhouse gas emissions benefits from the use of SAF, evaluate fuel production costs for SAF, and examine production potential for SAF. The work is considering a wide range of fuel pathways, including the co-production of SAF in existing petroleum refineries. The resulting scientific data will inform private sector decision making and support the accurate crediting of SAF within the International Civil Aviation Organization (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Additionally, the team will continue a multi-year effort to examine the potential production of SAF that will result from CORSIA, and extend the analysis to 2050.

The Purdue University effort is advancing our understanding of the induced land use change impacts of SAF on greenhouse gas emissions to inform decision making by government and the private sector.. The tools will be expanded to facilitate the analysis of the emissions from different global regions to inform how SAF are credited within CORSIA.

The University of Tennessee will continue multiple efforts. They will finish their work to examine the potential production of SAF from lipids on a national basis, including the use of cover crops that are grown across the United States. The team will also continue their effort to support the development of an industry to produce SAF and other coproducts using woody biomass feedstock in the Central Appalachian Region (CAR), which consists primarily of Kentucky, Tennessee, North Carolina, and West Virginia.

The Washington State University work, which is being done in collaboration with efforts of the U.S. Department of Agriculture, will examine the potential for retrofitting existing pulp and paper mills, sugarcane mills, dry corn ethanol plants, and petroleum refineries to enable jet fuel production from forest harvests, waste materials, and various crops. In collaboration with the Department of Energy, the team will also examine the potential for producing liquid fuels through electricity. The team will focus on the potential for fuel production in the Inland Pacific Northwest, but will extend the tools being developed to examine the entirety of the U.S. The research team will also continue to use techno-economic analysis to understand how costs could be reduced across a wide range of SAF pathways. These supply chains will be evaluated for their ability to create jobs and add resiliency to the national liquid fuel supply. The overall goal of the work is to identify potential supply chains that could aid U.S. industry and inform decision making at the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP).

IMPACT STATEMENT

The development of economically viable SAF supply chains in the United States has the potential to provide substantial reductions in greenhouse gas emissions and provide a source of rural economic development, with the potential to lead to hundreds of thousands of jobs in rural America with tens of billions in economic growth. These projects foster private industry involvement by generating strategic information and educating stakeholders on production pathways that can reduce greenhouse gas emissions, increase economic efficiency, leverage economies of scope and scale, and reduce fuel production costs. The projects are key to informing international decision making by the FAA on fuels within multiple working groups of ICAO CAEP, including how fuels will be credited under CORSIA.

Hydrogen Production Alternatives for Sustainable Aviation Fuel (SAF) Production – P80

Grant Request Information (New Project)

GENERAL INFORMATION

Title: Hydrogen production alternatives for sustainable aviation fuel (SAF) production
University: Massachusetts Institute of Technology
Amount: $150,000

University: Washington State University
Amount: $450,000

TASK DESCRIPTION

The aviation industry is under considerable pressure to reduce its greenhouse gas (GHG) emissions. Sustainable aviation fuels (SAF) are considered the most promising approach to reduce the sector's GHG emissions. To date, no comprehensive assessment exists which analyzes how different carbon, hydrogen and energy sources and conversion processes can be combined to produce SAF with a maximum of GHG emission reductions at the lowest possible costs. Washington State University and MIT, in collaboration with the DOE Pacific Northwest National Lab (PNNL) will conduct research with the goals to: (1) evaluate the strengths and weaknesses of hydrogen production and Power-to-Liquid (PtL) concepts; (2) assess the state-of-the-art on how hydrogen production and PtL production can be integrated with existing infrastructure (SAF production and industries); (3) analyze the cost and environmental impacts of these production pathways; and (4) synthesize the information and obtain rules on how to best combine the C, H, and energy sources with different conversion technologies to improve environmental impacts and costs.

IMPACT STATEMENT

The outcomes of this project will outline new pathways to optimize SAF production. Besides process designs, the outcomes will guide optimization of SAF production through providing quantitative data, which can support informed decision-making on the choice of SAF production pathways. This data directs stakeholders such as airlines or fuel producers in their efforts to identify the SAF production pathway designs with the most efficient use of limited input resources such as biomass, renewable electricity, or renewable hydrogen in the short and long term. As such, the outcomes of this project are expected to help maximize SAF availability and SAF environmental benefits, while minimizing SAF costs. This systematic analysis of novel pathways to optimize SAF production will also help the entire U.S. Government identify new opportunities towards increasing environmental emission reductions, lowering costs, and maximizing production. The resulting road map will help the entire aviation industry identify new research and development opportunities.

Alternative Jet Fuel Test and Evaluation to Support the ASTM International Approval Process – P31
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Alternative Jet Fuel Test and Evaluation to Support the ASTM International Approval Process
University: University of Dayton
Amount: $499,784

TASK DESCRIPTION

In coordination with industry and other government agencies, this project is providing a cost effective and coordinated performance testing capability to support the evaluation of promising alternative jet fuels to ensure they are safe for use. This effort is critical to ensure the continued approval of new jet fuels by ASTM International following the ASTM D4054 process. This project provides the FAA with a capability to conduct the necessary work to support alternative jet fuel evaluations. Combustion testing and evaluations of alternative fuels are used to evaluate fuel operability, performance, and emissions. Cold start and altitude relight performance of alternative fuels and fuel blends relative to petroleum fuel are also conducted. This task would fund fuel testing for a novel cycloparrafinic fuel composition being developed by Shell using the Integrated Hydropyrolysis & Hydroconversion (IH2) process. The project will continue to evaluate seal performance with the use of these fuels, which will be important to finding means to go beyond the current 50% blend limit. Additionally, the project is improving the fuel certification process, including for conventional and alternative fuels, by conducting validation testing of potential methods to quantify hydrocarbon composition of jet fuels. This work will lead to faster, more cost-effective jet fuel certification requirements thus ensuring a safe and reliable supply of aircraft fuel across the country.

IMPACT STATEMENT

This research effort would facilitate innovations by industry in making low cost jet fuels from a wide variety of sources. Thus far, ASTM International approvals have been for fuels with a single composition. This research will provide a database that can be used to evaluate jet fuels that instead have a cycloparaffinic composition. This information does not currently exist. This work will enable the accurate prediction of the behavior of these fuels in real jet engines thus ensuring the safety of operations as well as potentially opening up future design innovations in terms of fuel composition and combustor design. This research will ultimately aid the work of the government and industry members of ASTM International to certify novel fuels for their safe use in gas turbine engines.

Alternative Fuels Test Database Library – P33
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Alternative Fuels Test Database Library
University: University of Illinois
Amount: $150,000

TASK DESCRIPTION

This project will continue the development of the 'FAA Jet Fuel Test Database,' a comprehensive, publically available, repository of conventional and alternative jet fuel test data for the commercial aviation sector. The current version of the database is available online at https://altjetfuels.illinois.edu/. The research team is currently working toward three advances to the database. First, they are extending the database architecture towards an international framework capable of linking various aviation fuel systems data across the globe. Preliminary efforts will integrate the database with the European JETSCREEN program, from which an international standard can be established. Second, they are working to capture fuel data in real time from airports around the country to understand the properties of fuel actually being used. Third, they are working to facilitate a deeper understanding of jet fuel by implementing flexible and advanced analysis methods based on Big Data techniques. With prolific diversification of new jet fuels, an effort to integrate information and facilitate real time analysis is critical in providing the FAA with the ability to track the latest jet fuel developments around the world and support advanced research, increase sustainability, and safety monitoring in the future.

IMPACT STATEMENT

The aim of this study is to establish an internationally connected database on jet fuel, which can serve as a resource for the U.S. in the global aviation arena. As other countries initiate efforts to integrate alternative jet fuels into their current infrastructure, international airlines will be directly impacted by these changes as planes inevitably refuel at international locations. The long-term vision of this effort is to institute a database that supports the monitoring and analysis of current jet fuels not only in the U.S., but across the globe. The benefits will be to (1) increase our understanding of the global fuel infrastructure and variability, (2) increase sustainability by supporting the certification and integration of new fuels via scientific analysis, and (3) safeguard U.S. airlines by monitoring the fuel consumed across the complex global aviation landscape as new types of fuels are integrated into the system.

Fuel Testing Approaches for Rapid Jet Fuel Prescreening – P65
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Fuel Testing Approaches for Rapid Jet Fuel Pre-Screening
University: University of Illinois
Amount: $150,000

TASK DESCRIPTION

This study seeks to establish a formal prescreening process for novel jet fuels that can complement the ASTM D4054 evaluation and qualification guidelines by reducing the uncertainty and cost that propagates from the multi-tiered testing. The efforts outlined here is to introduce a new compact test rig, developed by previous ASCENT research with OEM support that can screen fundamental combustor behavior with much reduced fuel volume (~gallons) prior to testing in actual gas turbines. In previous work, an OEM defined referee rig at the Air Force Research Laboratory was utilized as a foundational test rig for this goal. The new compact test rig being developed through this project may have the potential to carry out these tasks at significantly reduced fuel volumes (on the order of a few gallons vs. a hundred gallons of fuel) in a simplified and open architecture that can be readily shared and operated at different locations at a fraction of the cost.

IMPACT STATEMENT

Currently, more than a dozen US-based companies are in the process of developing domestic alternative energy sources for aviation transportation. One of the bottlenecks for these products is the approval and evaluation process to ensure that fuels are safe for use. The high volume requirement and approval ready criteria mean many companies fail before approval submission and have few opportunities to interact with engine operability experts to better position fuels for approval. In this project, the research team is working to develop tools with minimal volume requirements to identify potential approval pitfalls for the industry. These tools will enable low-cost expert evaluations of fuel performance, potentially alleviating challenges with the approval process.

Chemical Kinetics Combustion Experiments – P25
(Ongoing Project)

GENERAL INFORMATION

Title: Chemical Kinetics Combustion Experiments
University: Stanford University
Amount: $200,000

TASK DESCRIPTION

The goal of this ongoing project is to develop, validate and apply a rapid fuel screening method using small volume fuel samples. This will provide a practical, economical analysis strategy to support ASTM D4054 fuel qualification for novel jet fuels including those produced from domestic feedstocks such as waste streams. This effort could reduce the cost requirements to ensure that novel fuels are safe for use. This method, InfraRed (IR) Analysis for Fuel Screening (IRAFS), employs Fourier-transformed infrared (FTIR) spectroscopy to determine jet fuel properties. This strategy collects high resolution spectral data that the research team have previously demonstrated can be used to develop strong correlations between fuel spectra and fourteen key physical and chemical properties, such as density, initial boiling point, surface tension, kinematic viscosity, average chemical formula, and derived cetane number. In this work, the research team will extend this analysis strategy to: a) include identification of bond structures and their relationship to physical and chemical properties for existing and new jet fuels; b) expand the spectral range to further strengthen spectra-property correlations; and c) use this fuel characterization to advance kinetics mechanisms for jet fuels used in performance assessments, which we can then experimentally validate with shock tube measurements.

IMPACT STATEMENT

This research will enable the development of state-of-the-art jet fuel screening that is accurate, rapid and needs only a small sample of fuel. The proposed method requires a single fuel measurement and can generally be carried out with samples of ~1 mL. This represents a reduction by a factor of ~1000 in the amount of fuel required based on typical requirements of two U.S. gallons for initial fuel specification testing. Novel fuels can be rapidly screened without requiring large-scale production, facilitating early stage screening for more fuel producers into the ASTM D4054 qualification process. This research supports the FAA's aim to enable the market uptake of sustainable aviation fuels (SAF) by ensuring viable jet fuels are quickly and easily identified early in the approval process. This can potentially minimize the level of later stage testing required, further reducing the time and costs for fuel approval.

Evaluation of High Thermal Stability Fuels – P66
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Evaluation of High Thermal Stability Fuels
University: University of Dayton
Amount: $100,000

TASK DESCRIPTION

Jet fuel is subjected to high temperatures in regular aircraft operations as fuel is used as a coolant within the engine system to absorb heat from various components, reducing thermal material stresses in the engine and ensuring material durability and component life. This study will examine the role changes in fuel composition could play in improving fuel efficiency through improvements in fuel thermal stability and to quantify the system level improvement from using fuels with high thermal stability. Aromatics, a common chemical class in conventional jet fuel, have recently been identified as a limiting factor with respect to providing thermal stability. This project will investigate fuel composition and associated thermal stability limits of aromatic free fuels, fuels with selected aromatic content, and blends with conventional jet fuel. The outcomes of this work will facilitate the understanding of fuel composition to support the development of novel fuels with enhanced performance capabilities. These fuels could reduce fuel burn and improve aircraft operations through optimization of key fuel compositional features including minimization of identified molecular structures that limit thermal stability. This funding would support continued efforts in three distinct research areas: (1) exploration of the thermal stability of jet fuels that are mixtures of petroleum-derived fuel with SAF, (2) thermal management trade studies, wherein the aircraft, engine, and fuel are treated holistically as a system, and (3) identification of high-performance fuels though optimization of specific energy and viscosity, while maintaining acceptable fit-for-purpose properties in ASTM D7566.

IMPACT STATEMENT

The utilization of high thermal stability fuels has the potential to lead to significant fuel burn and emissions reductions owing to system weight reductions from thermal equipment simplification. Fuels with high thermal stability have higher heat-sink capability, and therefore, are good coolant candidates. This study is expected to produce clear results on the effects of fuel composition, namely, aromatics on the thermal stability of fuels. Unlike other research trajectories towards these goals, improved thermal stability of fuels with respect to aromatic content is not well characterized. Thermal management of a jet engine is a vital aspect that ensures proper functioning and structural resistance for several engine components. Utilization of higher thermal stability fuels could reveal redundancy in various engine components used in thermal management today, leading to engine weight reduction, and in turn, fuel burn benefits. Moreover, higher thermal stability fuels may enable certain hybrid electric concepts where thermal management is a challenge.

Impact of Fuel Heating on Combustion and Emissions – P67
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Impact of Fuel Heating on Combustion and Emissions
University: Purdue University
Amount: $250,000

TASK DESCRIPTION

Fuel heating has been identified as a means to increase the cycle efficiency of advanced gas turbines operating at high pressure ratios. However, heating the fuel will affect the performance of the combustor, principally by changing the penetration, atomization, and vaporization characteristics of the fuel spray. These effects may also vary with fuel composition. Stored fuel is a working fluid on aviation platforms, where stringent weight and system reliability requirements drive innovation in the design of ancillary airframe and engine systems. When fuel is used as a heat sink, the enthalpy transferred to the fuel from the heat exchange process still contributes to thrust generation, rather than being dissipated (and lost) by other means. The temperature of the air entering an engine core increases as a function of the flight Mach number squared and rapidly increases the cooling requirements throughout the propulsion system at supersonic flight speeds. Fuel can be used to support the increased thermal management load, enabling higher flight speeds. However, small changes in the fuel supply temperature can have strong effects on the structure and dynamics of fuel-air injection, mixing, and ignition in high-pressure, swirl flames. The performance of modern, low-emissions combustors is particularly sensitive to these changes due to the tight coupling of physical and chemical processes within the heat release zone. The goal of this task is to investigate the effects of using hot fuel on combustion performance and the level of emissions for a lean burn combustor. Laser-based measurements of these physical and chemical processes performed at engine flow conditions will provide key insight to the effects of fuel temperature on gas turbine combustors.

IMPACT STATEMENT

This project will characterize the global and local impact of hot fuel injection on the performance of combustion systems in modern aircraft engines. Extractive exhaust sampling will provide valuable information on global metrics such as combustion efficiency and pollutant emission production. Advanced diagnostics will provide crucial insight into the physics of hot fuel injection and mixing within the flow as well as the coupled chemical processes that manifest the global trends. The impact of this project will be to advance lean-burn, low emissions gas turbines to the next level of cycle efficiency by providing the key insights needed to design combustion devices for operation with hot fuels.

Fuel Composition Impact on Combustor Durability– P37
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Fuel Composition Impact on Combustor Durability
University: University of Dayton
Amount: $199,865

TASK DESCRIPTION

In this study, the effect of fuel chemical composition on radiative heat transfer and the resulting combustor liner lifetime will be evaluated. Alternative jet fuels contain hydrocarbon types that differ from familiar petroleum-based fuels. For petroleum-based fuels, it is known that higher aromatics levels contribute to greater radiative heat transfer and reduced combustor liner lifetime. As a result, aromatics are limited to 25 volume percent in the ASTM D1655 jet fuel specification. Some candidate alternative jet fuels contain synthetically-produced aromatics and cycloparaffins, which need to be evaluated for their radiative heat transfer characteristics. The measurements will provide insight into the effect of fuel type on liner lifetime. Several fuel types will be investigated including a Synthetic Aromatic Kerosene, a baseline jet fuel, and a fuel that is high in cycloparaffins. Diagnostic methods to be used in the investigation include the measurement of wall and gas temperatures, infrared (IR) cameras, and radiometers.

IMPACT STATEMENT

This study will quantify the potential benefits of changes in fuel composition to engine life. It will also ensure that future candidate fuels do not negatively impact combustor liner lifetime of jet engines. As such, the study will ensure that candidate drop-in fuels will perform satisfactorily in jet engines and not increase engine maintenance nor decrease flight safety. A secondary benefit is that the measurements will be useful for the development of advanced, higher fidelity combustion models.

Contrail Avoidance Decision Support and Evaluation – P78
Grant Request Information (New Project)

GENERAL INFORMATION

Title: Contrail Avoidance Decision Support and Evaluation
University: Massachusetts Institute of Technology
Amount: $550,000

TASK DESCRIPTION

Contrails are the white, line-shaped ice clouds that form behind aircraft. These contrails and subsequent contrail cirrus are thought by some in the research community to contribute around half of the climate warming attributable to aviation. Contrail avoidance through vertical and horizontal flight path changes is estimated to cause fuel burn penalties at the few percent level. As such, it is a potentially cost-effective way to mitigate aviation's climate impacts. However, contrail avoidance has not been demonstrated at scale, and a comprehensive toolset to support the approach has not been developed. The goal of this project is to create a contrail avoidance decision support and evaluation tool that can be trialed to optimize and evaluate the benefits, costs, and practicality of contrail avoidance. The project will focus on four specific objectives: (1) develop the capabilities necessary to predict the formation and impacts of contrails from a given flight; (2) evaluate the financial costs and environmental benefits of deviating from that path to avoid a contrail, including uncertainty; (3) integrate these capabilities into an operational tool which can provide near-real-time estimate of the costs and benefits of a contrail avoidance action, informed by automated, coordinated observational analysis and modeling; and (4) evaluate the effectiveness of these tools in a safe, scientifically-sound real-world experiment. Subject to agreement with industry partners, the team will also seek to test contrail avoidance in a way that has no implications for air traffic control or safety.

IMPACT STATEMENT

Because contrails result in around half of the warming from aviation it is important for the industry to develop approaches to reduce or eliminate this warming, in addition to reducing CO2 emissions. Contrail avoidance through vertical and horizontal flight path changes has been shown to be an effective instrument for reducing these impacts at low costs. This project will be the first to provide the tools and data to show that this approach is indeed an effective and efficient approach for contrail avoidance under real-world operating conditions.

Ambient Conditions Corrections for Non-volatile PM Emissions Measurements– P2
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Ambient Conditions Corrections for Non-volatile PM Emissions Measurements
University: Missouri University of Science and Technology
Amount: $521,246

TASK DESCRIPTION

The goal of this ongoing project is to quantify the effects of ambient atmospheric conditions and fuel composition on the formation of non-volatile particulate matter (nvPM) in aircraft engine exhaust. This work will lead to a better understanding of aircraft engine exhaust emissions and facilitate aircraft engine certification in line with existing requirements as well as lead to further innovations in combustor design to reduce the emissions that are produced by gas turbine engines. To carry out this project, a series of emission measurement tests will be conducted using a gas turbine engine that will be operating within a wind tunnel facility that can mimic the conditions an aircraft engine experiences on the ground as well as at cruise altitudes. In addition to requiring precision facilities, these tests will also require the use of thousands of gallons of jet fuel with precise controls on the fuel composition. As a result, there is considerable expense with this project. The work is being done with Honeywell and EMPA, the Swiss Federal Laboratories for Material Science and Technology.

IMPACT STATEMENT

This project will enhance and inform the regulatory airworthiness certification process by providing up-to-date and accurate measurement protocols for emissions monitoring. Specifically, the measurement data will inform the development of ambient atmospheric conditions so that certifiable nvPM emissions can be standardized to International Standard Day conditions, a regulatory requirement for airworthiness certification. The results will also provide invaluable data to industry to help understand how particulate matter is produced in their engines at both ground conditions and during cruise. This knowledge will enable further innovations in combustor design as well as potentially enabling the development of jet fuels that result in reduced particulate matter emissions.

Transitioning a Research nvPM Mass Calibration Procedure to Operations – P12

Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Transitioning a Research nvPM Mass Calibration Procedure to Operations
University: Missouri University of Science and Technology
Amount: $100,853

TASK DESCRIPTION

The non-volatile Particulate Matter (nvPM) standardized measurement system that is used to ensure compliance with the ICAO nvPM standard relies on state-of-the-art instruments to measure nvPM mass from the engine exhaust. Unlike gas measurements, the nvPM measurements lack a standardized source to calibrate these instruments. Research has been completed on a nvPM calibration method using a Centrifugal Particle Mass Analyzer (CPMA). A recent test demonstrated that this method can be used to calibrate and verify the performance of the nvPM mass instrument before, during and after an engine test. This new approach has potential to reduce calibration costs and eliminate constraints on certification test schedules posed by the calibration of the nvPM mass instruments. However, the robustness of the CPMA mass calibration approach needs to be demonstrated before this method could be implemented in the ICAO Annex 16 Volume II and transitioned to certification practice. This project will continue to investigate the validity of the CPMA mass calibration research approach across all nvPM mass ranges encountered during certification tests to successfully transition the methodology to operations. The work will be done using a dedicated small engine test facility at the USAF Arnold Engineering Development Complex using the North American Reference nvPM Measurement System with the current instruments along with the CPMA and other needed instruments. In addition, measurements will also be made during an already scheduled rig test at Honeywell Aerospace. The funds requested in this proposal are for annual calibration needs for the North American Reference System for nvPM measurements and for additional performance assessment tests to be undertaken in the MS&T laboratories.

IMPACT STATEMENT

This project will validate an advanced calibration method that reduces the time needed for nvPM mass instrument calibration and also reduces measurement uncertainty during certification. Once successfully demonstrated, the method can be implemented in ICAO Annex 16 Vol. II. Noting that each engine emissions certification test costs approximately $500,000, the implementation of this new method will greatly reduce instrument calibration costs (by more than 50%) and test schedule constraints imposed by the annual calibration of the nvPM mass instrument. In addition, this approach will provide instant checks on the performance of the nvPM mass instrument during a test, improving confidence on the measurements.

Analysis to Support the Development of an Engine nvPM Emissions Standard – P48
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Analysis to Support the Development of an Engine nvPM Emissions Standard
University: Massachusetts Institute of Technology
Amount: $200,000

TASK DESCRIPTION

The goal of this ongoing project is to provide scientific data and analyses to support decision making on the implementation of a non-volatile particulate matter (nvPM) emissions standard for aircraft engines. The project includes analyses which are important in understanding the costs and benefits of both the current standard and the policies which may be proposed in the future. By providing a rational, scientific basis for decision making on the implementation of the nvPM standard, this project will contribute to an efficient implementation process and provide industry with regulatory certainty. The analyses provided in this project will allow the FAA to identify policy proposals which serve the national interest and advocate for those policies within ICAO. In the coming year, the project will (1) develop and assess improved methods for evaluating the impact of fuel composition on nvPM emissions; (2) develop a modeling-based approach to estimating nvPM emissions at cruise; and (3) evaluate the relationship between cruise emissions and Landing-and-TakeOff (LTO) emissions for all species covered by LTO standards.

IMPACT STATEMENT

This project will support the FAA decision-making process regarding the implementation of an engine nvPM emissions certification standard. The project includes analyses which are important in understanding the costs and benefits of both the current standard and the policies which may be proposed in the future. By providing a rational, scientific basis for decisions on the implementation of the nvPM standard, this project contributes to an efficient implementation process and provides industry with regulatory certainty. The analyses provided in this project will allow the FAA to identify policy proposals which serve the national interest and advocate for those policies within ICAO.

Reduction of nvPM emissions from aero-engine fuel injectors – P70
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Reduction of nvPM emissions from aero-engine fuel injectors
University: Georgia Institute of Technology
Amount: $500,000

TASK DESCRIPTION

Fuel atomization and the mixedness of fuel and air at the fuel injector both have a significant effect on non-volatile particulate matter emission (nvPM) formation. These factors are especially important for Rich-Quench-Lean combustion technologies used in many smaller, modern combustors, where NOx and nvPM trade-offs must be managed through improved mixedness. The goal of this project is to investigate how jet fuel atomization affects the formation and oxidation of nvPM in engine-relevant conditions (pressure, temperature, flow) and develop validated numerical models for the design of novel fuel injector to reduce nvPM formation in aero-engines. To achieve this goal, the research team will measure the velocity field, and fuel droplet size and spatial distraction inside the combustor to understand the fuel/air mixing process, intermediate combustion product distributions, nvPM volume fraction and size distribution, and exhaust gas composition to understand the kinetic formation and oxidation process of nvPM. The proposed comprehensive diagnostics are being conducted for a set of current (for baselining) and proposed new fuel injectors provided by Honeywell Aerospace, which is a research collaborator on the work. The comprehensive experimental data will be used to validate a computational model that can be used to design novel fuel injectors with breakthrough reductions nvPM formation.

IMPACT STATEMENT

The intended purpose of this project is to provide breakthrough reductions in nvPM emissions through novel design of the injector at relevant conditions. This project will do this by developing knowledge and analytical tools to enable industry to design fuel injectors that have improved fuel atomization and reduced nvPM formation. The aviation industry lacks data on the relationship between nvPM mass and number with fuel atomization, especially in relevant geometries and conditions, which this project seeks to improve. The project will provide a vital experimental dataset to not only demonstrate reductions in nvPM from a given set of injectors but also to provide important data for numerical models to further calibrate nvPM predictions and thereby lead to further insights and aero engine performance improvements.

Predictive Simulation of nvPM Emissions in Aircraft Combustors – P71
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Predictive Simulation of nvPM Emissions in Aircraft Combustors
University: Georgia Institute of Technology
Amount: $500,000

TASK DESCRIPTION

This project sets out to develop improved knowledge on non-volatile particulate matter (nvPM) emissions to enable the development of soot-reduction technologies. In this project, a multi-scale hierarchical simulation strategy is being developed as a predictive tool for soot emissions from gas turbine engines. As soot particles are generated in gas turbine combustors, they can either oxidize completely or escape oxidation in the form of solid particles. A new multiscale approach is being established by this work to predict soot formation in aircraft engines by integrating "first principle" simulations (used to account for the multi-scale physics of soot formation and transport) with large-eddy simulation (LES) that can be used to simulate turbulent flames in realistic engine combustors. The research will explicitly target and isolate the layers of empiricisms that currently exist for example in particle inception models, in the role of precursor species in nucleation, in the sensitivity of predictions to particle shape and size distribution and in the ad hoc coagulation/coalescence mechanisms. All of the tools that will be used already exist within the research team but a systematic coupling of these tools in a multi-scale, LES strategy has yet to be accomplished by anyone. This study will establish a new predictive capability by integrating these capabilities. The work is being done in collaboration with Raytheon Technology Research Center (RTRC).

IMPACT STATEMENT

This project will advance the state-of-art in modeling soot formation and emission processes for aircraft engine combustors to enable innovative means to reduce these emissions. Use of real jet fuel chemistry will highlight the impact of fuel components and their reaction pathways on soot formation, and hence would be of direct relevance to legacy and next generation aircraft engines. Integrating these sub-models in LES will enable study of realistic gas turbine configurations. The proposed work addresses knowledge gaps, leveraging and building upon a long history of fundamental and modeling strategies at Georgia Institute of Technology, University of Michigan, and UTRC.

Low Emission Premixed Combustion Technology for Supersonic Civil Transport – P74

Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Low Emission Premixed Combustion Technology for Supersonic Civil Transport
University: Georgia Institute of Technology
Amount: $999,995

TASK DESCRIPTION

Combustor conditions in supersonic engines exceed the pressure-temperature range of existing subsonic engines. New combustor technologies are needed to reduce emissions of nitrogen oxides (NO_X), carbon monoxide (CO), unburnt hydrocarbon (UHC), and non-volatile particulate matter (nvPM) across the flight mission, while achieving the necessary durability and stability. Fuel-lean premixed combustion is viewed as a key enabling technology; however, the ability of current design methodologies to predict the operability and emissions of these combustors at the relevant conditions is unproven. Hence, there is a critical need to generate high-quality experimental data at relevant conditions, coupled to the development and validation of computational fluid dynamics (CFD) simulations and reduced order models. This project, which is being done in collaboration with General Electric Aviation, will fill this need through a combination of experiments and simulations, all applied in a novel lean-premixed combustor that is specifically designed for supersonic civilian transport.

IMPACT STATEMENT

This program will generate critical data and validated design methods that are needed to predict the behavior of novel premixed combustion technology at conditions encountered during supersonic flight. This, in turn, will guide design decisions that ultimately enable low-emission, robust, and stable combustion for supersonic civilian transport. Expected long-term benefits include reduced CO, UHC, NO_X, and nvPM emissions across the supersonic flight mission, with simultaneous reductions in engine development times and costs. Additionally, the program will support workforce development and training of students in state-of-the-art methods for combustor measurement and simulation, while building strong and synergistic connections between industry and academia.

Combustor Wall Cooling Concepts for Dirt Mitigation – P68
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Combustor Wall Cooling Concepts for Dirt Mitigation
University: Pennsylvania State University
Amount: $150,000

TASK DESCRIPTION

A critical issue related to the operation of a gas turbine in today's world is the ingestion of dirt, sand, and other fine particles that are in the ambient air. These common air pollutants can lead to blockages of cooling holes and passages required for effectively cooling the walls of the combustion chamber. Dirt is one of the primary sources of durability issues in the combustor and turbine. The effect that dirt has is to build a contamination layer that can lead to blockages of cooling passages. As these blockages occur, the metal temperatures rise dramatically. As double-wall cooling designs for combustors continue to evolve, thus enabling continued improvements in fuel efficiency, it is important to assess the likelihood of dirt deposition. Because aircraft need to fly in dirty environments, especially in the Middle East and Southeast Asia, the criticality of operations in dirty environments is paramount. Modern gas turbine engines typically employ a double-walled combustor liner with impingement and effusion cooling plates whereby impingement cooling enhances the backside internal cooling and effusion cooling creates a protective film of coolant along the external liner walls. Dirt accumulation on the internal and external surfaces severely diminish the heat transfer capability of these cooling designs. This study will continue the investigation of practical designs for reduced dirt accumulation at representative temperature conditions. This will enable the detailed exploration of dirt-tolerant designs through detailed flow and heat transfer measurements on a scaled geometry. The work is being done in collaboration with Pratt and Whitney.

IMPACT STATEMENT

The major expected benefit from this study is a cooling design for combustor walls that is insensitive to dirt accumulation, as well as an improved understanding of why it is insensitive. Cooling performance of combustor walls is critical to aircraft engine durability and a strong function of the environment in which turbines operate. The goal of this research is to drive towards a cooling design that is as effective at existing or lower coolant flowrates as state-of-the-art designs, while being insensitive to dirty cooling air from the operational environments of the turbine. The resulting outcome will ensure that engine designs achieve fuel burn reductions over a longer time period, as well as allowing continued turbine operations while reducing turbine maintenance.

Community Measurements of Aviation Emissions Contributions to Ambient Air Quality – P18
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Community Measurements of Aviation Emissions Contributions to Ambient Air Quality
University: Boston University
Amount: $599,371

TASK DESCRIPTION

The goal of this ongoing project is to improve available information regarding the contribution of aircraft emissions to ambient air quality, which could lead to more precise estimates of the relative contribution of aircraft compared with other sources. Previously published emissions measurements have suggested that aviation has a higher contribution to ambient air quality than is expected based on detailed calculations and previously conducted measurement campaigns. This research project will monitor and analyze community air quality measurements to determine the contributions of inflight arrival and departure aircraft to ground based concentrations with the aim of providing more realistic and accurate measurements. The research team will use state-of-the-art fixed air quality monitoring stations in combination with electric vehicles outfitted with the same monitoring equipment. The team will measure at fixed locations and throughout an airport's communities to better characterize geographic variation in air quality. Statistical analyses will compare the stationary and mobile measurements with flight activity data to determine aircraft contributions to the ground measured air pollution.

IMPACT STATEMENT

Recent studies have concluded that airports are significant contributors to local air quality pollution, but they have not had sufficient data to quantify how much of what was measured came from aircraft versus other sources. This research effort will collect measurements at sites specifically chosen to evaluate aviation contributions to air quality pollution, use both stationary sites and mobile measurements to get a better understanding of air quality patterns over space and time, and compare these measurements with real-time arrivals and departures to better explain how much of measured ground-level air pollution comes from aircraft in flight. This work will provide a more accurate understanding of the relative contribution of aircraft to the air quality in communities near airports. It is often assumed that much of what is measured near airports is associated with inflight aircraft, which may or may not be correct. Ground-based monitoring with appropriate statistical analyses is critical to quantify how much of what is measured comes from aircraft, as well as to building and validating air quality models that could be applied at airports across the country.

Development of Aviation Air Quality Tools for Airport Specific Impact Assessment – P19
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Development of Aviation Air Quality Tools for Airport Specific Impact Assessment
University: University of North Carolina
Amount: $650,000

TASK DESCRIPTION

This project will result in improved aviation emissions dispersion capabilities that are suitable for use in the Aviation Environmental Design Tool (AEDT). AEDT is currently coupled with the U.S. EPA's AERMOD dispersion model for modeling aircraft sources, as this is the required regulatory model in the U.S. for modeling airport-level aircraft operations during landing and takeoff (LTO) cycles. Several recent studies have shown multiple limitations in the use of AERMOD for modeling aircraft sources. As part of this continuing research, the team will expand the new state-of-the-art dispersion model based on current science. The team will continue with the phased approach to develop a model that will engage with all stakeholders and use data from field studies for model validation, before final integration with AEDT. In the coming year, the research team will focus on: expanded and refined treatment of the various physical and chemical processes related to local-scale air quality around airports, and model evaluation using multiple new datasets.

IMPACT STATEMENT

This study will provide the FAA with an alternate approach to modeling local-scale air quality that specifically addresses known limitations in the AERMOD model and improves model performance in assessing air quality impacts of aircraft emissions during landing and takeoff cycles. If funding is not provided and further research is not performed, aircraft emissions impacts on local scale air quality will not be adequately characterized, especially in terms of the short term NO_X emissions concentrations, and over predictions in National Environmental Policy Act (NEPA) studies and/or other case studies will continue to occur, causing concerns for airport operators. Without funding, aircraft emissions impacts on local air quality will likely be mischaracterized.

Improving Policy Analysis Tools to Evaluate Higher-Altitude Aircraft Operations – P58
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Improving Policy Analysis Tools to Evaluate Higher-Altitude Aircraft Operations
University: Massachusetts Institute of Technology
Amount: $150,000

TASK DESCRIPTION

Companies are proposing, developing, and testing aircraft operating at higher altitudes such as commercial supersonic aircraft and high-altitude, long-endurance (HALE) unmanned aerial vehicles, which offer the potential to become enablers for new use cases and business models in the aviation sector. However, the combustion emissions of these vehicles will have atmospheric impacts that differ from conventional subsonic aviation due to the higher altitudes of emission. Emissions at higher altitudes are associated with a different chemical environment, longer emission lifetimes, and greater distances over which the emissions will be transported. Furthermore, new developments in emissions impact estimation have enabled a more nuanced view of the environmental consequences of conventional aircraft activity. This includes recognition that both climate and air quality impacts vary depending on prevailing conditions and time horizon of the assessment. In this project, the research team will quantify the environmental consequences of aviation emissions, incorporating information about altitude, location, and timing. The results will be leveraged to: (i) evaluate the climate (radiative forcing) effects of aircraft emissions by region and location; and (ii) to estimate the sensitivity of global ozone column and surface air quality to these emissions. As a result, the climate, air quality, and ozone impacts for aircraft designs with different target altitudes and performance characteristics will be quantified. We will also perform a historical assessment of the impacts of aviation emissions, quantifying how factors such as changing emissions indices and an evolving chemical background have affected – and will affect – the total impacts. Using the data from these simulations, a flexible, rapid assessment approach for assessing the impacts of sub- and supersonic aircraft will be presented.

IMPACT STATEMENT

The research proposed under this project will inform FAA decision making on the costs and benefits of aircraft operations at all altitudes, including supersonic aviation and high-altitude, long endurance, unmanned aerial vehicles (HALE UAVs). Currently, no state-of-the-art tool exists which could support such investigations. There is also no rapid assessment tool that incorporates the latest understanding of contrail impacts, or the influence of an evolving atmospheric background on aviation's broader environmental impacts. This project will enable FAA to co-lead national and international efforts aiming to analyze potential regulations of aircraft operating at high altitudes, including future supersonic aircraft.

Evaluation of FAA Climate Tools – P22
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Evaluation of FAA Climate Tools
University: University of Illinois
Amount: $150,000

TASK DESCRIPTION

To quantify the costs and benefits of using advanced aircraft and engine technologies, FAA uses tools that are underpinned by state-of-the-art technical knowledge. These tools are used to inform decision-making by providing the benefits and costs of various options that could enable technology development. The overall objective of this project is to enhance our understanding of the relationships between subsonic and proposed supersonic aircraft, the state of the atmosphere and the development and evaluation of the capabilities, limitations, and uncertainties of the metrics and simple models used to assist decision-makers. The goal of this ongoing project is to use state-of-the-art geophysical models of the earth system that fully represent tropospheric and stratospheric processes to evaluate the impacts of emissions from supersonic aircraft on the global climate and ozone layer. Specific project goals include: (1) Science-based evaluation of analytical tools used by the FAA; (2) development of ideas and concepts for the next generation modeling of aviation effects on the earth system; (3) updated evaluation and analyses of the science of aviation effects on atmospheric composition; and (4) the evaluation of potential environmental impacts from assumed fleets of supersonic commercial, and business jet aircraft.

IMPACT STATEMENT

This project will utilize state-of-the-art technical knowledge to evaluate the analytical tools that are being developed to assess the costs and benefits of technology development. The work relies on models of the earth system that can provide useful scientific input for considerations by decision-makers. The analyses in the project will aid decision-making by translating complex models into simpler tools for use in cost-benefit analyses. With the upcoming advanced technologies and revolutionary concepts such as modern supersonic aircraft, timely decision-making is critical such that technology-enabling international standards are developed based on the best scientific and technical information.

Improved Engine Fan Broadband Noise Prediction Capabilities – P75
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Improved Engine Fan Broadband Noise Prediction Capabilities
University: Boston University
Amount: $300,000

TASK DESCRIPTION

The noise signature of contemporary turbofan engines is dominated by fan noise, both tonal and broadband. Accepted methods for predicting tonal noise have existed for many years, and engine designers have methods for reducing tonal noise that are used in their design process. This is not the case for broadband noise. The ability of engine manufacturers to reduce the noise from aircraft engines is limited by the lack of accurate prediction methods for broadband noise from the engine fan. Noise created by the interaction of the turbulence in the fan wake with the fan exit guide vanes (FEGVs) is a dominant broadband mechanism in modern high bypass engines. This project will leverage prior development of low-order models for the prediction of fan broadband interaction noise. Gaps in the low-order approach will be addressed based on knowledge gained from computation and experimentation leading to techniques that can be used by engine manufacturers to create lower noise designs.

IMPACT STATEMENT

Fan broadband noise, particularly in the aft direction, is a dominant source of noise in modern engines and is expected to become more so with current trends in aircraft engine design. Current fan broadband models rely on a multitude of simplifying assumptions that make them unable to simulate some realistic cases. Also, they require accurate representation of the fan-wake turbulence rendering them reliant on long runtime computations. The proposed research will address these shortcomings and deliver a faster, more applicable, fan broadband prediction method thus enabling industry to design quieter aircraft.

Novel Noise Liner Development Enabled by Advanced Manufacturing – P79
Grant Request Information (New Project)

GENERAL INFORMATION

Title: Novel Noise Liner Development Enabled by Advanced Manufacturing
University: Pennsylvania State University
Amount: $299,867

TASK DESCRIPTION

The Pennsylvania State University (PSU) and its Applied Research Laboratory (ARL) in collaboration with its industrial partner, Raytheon Technologies Research Center (RTRC), and government collaborator, NASA Langley Research Center (LaRC) will help the FAA develop and advance innovative engine acoustic liner technology to meet the demands of low noise for future aircraft. The team will develop and demonstrate a methodology to design and manufacture novel lattice structures that enhance noise attenuation in aircraft engines. Analysis and experimental testing will be used to understand the effect of geometry and feature size of the lattices to control noise while ensuring the manufacturability of these complex structures in different materials. Advanced manufacturing technologies will be used to enable rapid design-build-test cycles for design development, including assessment of structural integrity and acoustic performance. Promising engine liner designs and their performance will be documented and archived for the FAA to aid future advancements in aircraft engine noise reduction.

IMPACT STATEMENT

With aircraft engines trending toward more compacts designs with ultra-high bypass ratios, lower fan pressure ratios, and lower blade pass frequency, engine acoustic liners have to be more effective to maintain current noise levels, let alone support additional reductions in noise. To be effective, engine liners of the future will need to reduce noise at lower frequencies, over a broader frequency range, and do so with less space in the nacelle (axial extent and thickness). This project will develop novel engine acoustic liner technology targeted to meet these new engine requirements. This program will seek to develop and evaluate the performance of novel acoustic liners based on complex lattice structures that are enabled by advanced manufacturing technologies. A methodology will be established to account for critical design parameters and accompanied by experimental test data to advance the next generation of acoustic liners that address these noise and fuel burn technical challenges of future aircraft.

Jet Noise Modeling and Measurements to Support Low Noise Supersonic Aircraft Technology Development – P59
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Jet Noise Modeling and Measurements to Support Low Noise Supersonic Aircraft Technology Development
University: University of Illinois
Amount: $199,999

University: Stanford University
Amount: $200,000

University: Pennsylvania State University
Amount: $100,000

University: Georgia Institute of Technology
Amount: $100,000 (analytical modeling)
Amount: $250,000 (experimental measurement)

TASK DESCRIPTION

The goal of this new project is to work in close collaboration with industry, NASA, Department of Defense, and ASCENT researchers to develop improved jet noise prediction methods to enable industry to design supersonic transport engines with reduced noise. Gas turbines for supersonic aircraft need to have a relatively small engine diameter to avoid large fuel burn penalties during supersonic cruise. To have sufficient thrust, the jet exit velocity needs to be relatively large (as compared to subsonic jet engines) resulting in substantial noise from the jet exhaust. Research is needed to reduce the uncertainty in predicting jet noise from realistic engine designs such that engine makers can make informed design choices that reduce noise. The research team will work with industry partners, NASA and other ASCENT researchers to develop an open engine model that can be examined by the full research team. The team (analytical researchers from each of the four universities) will conduct computational aeroacoustic analyses on the model and Georgia Institute of Technology's testing team will take measurements in an experimental facility to support the validation of the results. This work will be closely coordinated with engine design efforts being conducted by NASA as well as Georgia Institute of Technology and Massachusetts Institute of Technology through ASCENT Projects 10 and 47 that are developing standards for civil supersonic transport noise.

IMPACT STATEMENT

This project is supporting innovation in aircraft technology by developing improved computational models that will enable industry to reduce jet noise from future supersonic aircraft. It will be done in close collaboration with industry, NASA, Department of Defense, and other ASCENT researchers thus also providing technical data on how choices in supersonic aircraft engine design affect vehicle fuel burn, noise, and emissions, as well as their interdependencies. The work will also help improve our understanding of noise generation is other low bypass ratio gas turbines, such as those used on business jets and regional jets, thus providing further benefits. The analysis will inform decision makers on what is in the realm of possibility to reduce noise from supersonic

aircraft operations.

Improved Open Rotor Noise Prediction Capabilities – P76
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Improved Open Rotor Noise Prediction Capabilities
University: Georgia Institute of Technology
Amount: $300,000

TASK DESCRIPTION

The Contra-Rotating Open Rotor (CROR) system has promising environmental benefits due to its ultra-high bypass ratio and high propulsive efficiency thus reducing fuel burn and emissions compared to an equivalent thrust turbofan; making it a viable economic and environmentally friendly propulsion alternative to the traditional ducted systems. However, in the absence of a noise-conditioning duct, aerodynamic interactions within the CROR system as well as between the system and surrounding installation components like the engine pylon may result in additional noise generation. If such a system is not optimized, the added effect of flow asymmetry to the aerodynamic interactions could potentially result in severe noise penalties, making the CROR system infeasible for the use in the aircraft industry. The proposed work will perform a sensitivity study on the design parameters of a CROR-pylon configuration. This study, which is being done with industry partner General Electric Aviation, will build on past efforts by leveraging previous knowledge in this type of configurations so that the space of design parameters is narrowed down to a select set of parameters. Based on this previous knowledge, key CROR system design parameters have been chosen to perform the parametric study to understand noise sensitivity. The analysis will identify the trends that can aid further research and provide the engine manufacturers an ability to perform the design tradeoffs. Then high-fidelity computational aeroacoustics analyses will be carried out in order to generate the accurate data necessary to analyze the effect of each of the chosen parameter on noise generation.

IMPACT STATEMENT

The acoustic environment of a CROR is particularly challenging to understand as there are two high speed fans creating wakes that interact with one another and stationary pylons. Industry needs improved tools to understand the design space to reduce noise from CROR systems. The outcomes of this work should provide the aviation industry with key insights on how to design CROR that provide a step change reduction in fuel efficiency while also being quieter than modern aircraft engines.

Alternative Design Configurations to Meet Future Demand - P64
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Alternative Design Configurations to Meet Future Demand
University: Georgia Institute of Technology
Amount: $1,199,999

TASK DESCRIPTION

The work is supporting FAA engagement and decision-making at the International Civil Aviation Organization (ICAO), in particular relating to the effort to assess the feasibility of a Long Term Aspirational Goal for CO_2 emissions from international aviation. This project is investigating how trends in innovative aircraft technology and design will impact fuel burn and CO_2 emissions with a focus on international aviation. Mature, in development, and foreseen technologies and aircraft design concepts will be considered, and technology readiness, feasibility, effects on aircraft configurations, designs and performance will be assessed. The goal of the work is to forecast impacts of new technologies that could enter the fleet through 2050 on fuel burn and CO_2 emissions from international aviation through to 2070 under a variety of scenarios related to technology, market factors, and constraints. The work is being done in collaboration with the US DOT Volpe Center as well as ASCENT researchers who are considering the use of different kinds of fuel in aviation.

IMPACT STATEMENT

The impact of this project will be an improved understanding of the impacts of potential alternative design and technology choices by the aircraft manufacturers on potential CO2 reduction goals of the future. This project will identify the appropriate design requirements and technologies for new conventional and alternative aircraft with available technologies of the future and assess the environmental impact. By assessing the potential CO2 reduction of the future fleet, the FAA will be informed by a data driven process on the potential long term CO2 reduction goals.

Aircraft Technology Modeling and Assessment – P10
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Aircraft Technology Modeling and Assessment
University: Georgia Institute of Technology
Amount: $700,000

TASK DESCRIPTION

The goal of this task is to improve FAA's ability to assess the fleet-wide benefits of the introduction of new aircraft and technologies, including supersonic aircraft. The focus of the work is the evaluation of new technologies and the assessment of how these will reduce aircraft fuel burn, noise, and emissions to enable aviation growth. The research project is also modelling and assessing the potential evolution of the commercial airline fleet, including the introduction of future supersonic aircraft. In addition to evaluating how technology and aircraft introduction will reduce the environmental footprint of the fleet, this work will evaluate interdependencies among fuel burn, emissions, and noise for both subsonic and supersonic aircraft. In the coming year, the project will focus on supporting the conclusion of an exploratory analysis of supersonic aircraft that is being done within the International Civil Aviation Organization's Committee on Aviation Environmental Protection (ICAO CAEP) which will be used to support the creation of a landing and takeoff noise standard to enable the reintroduction of commercial supersonic aircraft into the global fleet. Georgia Tech will use their experience in vehicle system design to work with industry to develop generic models that can be used within ICAO CAEP to examine tradeoffs among noise, fuel burn, and emissions. The Georgia Tech team will also work with the DOT Volpe National Transportation Systems Center (Volpe) to modify the Aviation Environmental Design Tool (AEDT) to model supersonic vehicle operations, and share results with other researchers in ASCENT who are evaluating the environmental impacts of the potential introduction of supersonic aircraft into the fleet.

IMPACT STATEMENT

This project is providing a detailed technical evaluation of how supersonic aircraft could result in changes in fuel burn, emissions, and noise from the civil fleet, and how technological advancements could result in reductions in these environmental factors. It is also providing technical data on how choices in supersonic aircraft design affect vehicle fuel burn, noise, and emissions; their interdependencies; and the resulting impact on the fleet. The work is being used by FAA to inform decision-making at ICAO CAEP on potential new noise and emissions standards.

Clean Sheet Supersonic Aircraft Engine Design and Performance – P47
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Clean Sheet Supersonic Aircraft Engine Design and Performance
University: Massachusetts Institute of Technology
Amount: $200,000

TASK DESCRIPTION

Supersonic aircraft present unique challenges in terms of their fuel consumption, noise, and emissions impacts in comparison to subsonic aircraft. This project aims to evaluate the design space of "clean sheet" engines designed specifically for use on civil supersonic aircraft, and to determine the resulting environmental performance of such engines. This project will quantify the benefits for a range of engine designs relevant to currently proposed civil supersonic aircraft. This project will do this by developing frameworks for quantifying the noise and emissions footprints of propulsion systems employed on supersonic civil aircraft, integrating models of aircraft performance, engine thermodynamic cycles, and gas turbine combustors. These tools will be used to quantify the performance of a range of engine designs relevant to currently proposed civil supersonic aircraft, and create a roadmap for technology development, prioritizing mitigation of the environmental challenges associated with supersonic aircraft engines. This includes an examination of potential methods for reducing nitrogen oxides (NO_X) and particulate matter emissions from the supersonic engine. The project will also support the development of an exploratory analysis of supersonic aircraft that is being done within International Civil Aviation Organization's Committee on Aviation Environmental Protection (ICAO CAEP) to inform the creation of a landing and takeoff noise standard to enable the reintroduction of commercial supersonic aircraft into the global fleet.

IMPACT STATEMENT

This project is supporting innovation in aircraft technology by providing a detailed technical evaluation of how the use of a clean-sheet engine design could reduce the fuel burn and noise produced by future supersonic aircraft thus enabling continued aviation growth. It is also providing technical data on how choices in supersonic aircraft engine design affect vehicle fuel burn, noise, and emissions, as well as their interdependencies. The analysis will inform decision makers on what is in the realm of the possible with the use of new technologies and accounting for the unique environment in which supersonic aircraft operate. The work will also demonstrate the limited relevance of information about supersonic aircraft that are no longer in service. This research will show the potential that can be achieved in terms of fuel burn, noise and emissions reductions through the use of technological innovations in modern supersonic aircraft.

Rotorcraft Noise Abatement Procedures Development – P38
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Rotorcraft Noise Abatement Procedures Development
University: Pennsylvania State University
Amount: $150,000

TASK DESCRIPTION

Pennsylvania State University and its industrial partner, Continuum Dynamics, Inc., will continue to support the FAA in the development of rotorcraft noise abatement procedures through computational and analytical modeling in various phases of flight. The team will use the recently developed rotorcraft noise prediction system comprised of PSU-HeloSim rotorcraft flight simulation modeling tool coupled with the Comprehensive Hierarchical Aeromechanics Rotorcraft Model (CHARM) analysis module and the PSU-WOPWOP noise prediction code. This tool will be used to develop and analyze noise abatement procedures for several categories of helicopters and to demonstrate the noise benefits of the flight abatement procedures. This project has been using noise data from ongoing FAA and NASA rotorcraft flight tests to assess and improve the accuracy of the modeling approach being used. The proposed funding would support the team in using these flight measurement data to provide detailed analysis of the noise components generated while flying the noise abatement procedures and validate the noise prediction system for heavier rotorcraft.

IMPACT STATEMENT

The proposed extension to this research will reduce the need for flight testing of each rotorcraft of interest when developing low noise operating procedures. Current guidelines provided to pilots and operators in the Fly Neighborly Guide are based on recommendations from manufacturers, but this guidance is not required and often is not provided. Other methods used by the FAA and NASA for developing noise abatement procedures are empirical, and hence based on previous flight measurements of specific aircraft. The proposed funding will enable analysis of new flight procedures and noise analysis strategies through computations alone. The proposed funding will also assist in the detailed analysis and understanding from recently conducted FAA/NASA noise abatement flight tests.

Modeling of Urban Air Mobility Noise to Enable Innovative Means of Noise Reduction – P49

Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Urban Air Mobility Noise Reduction Modeling
University: Pennsylvania State University
Amount: $280,000

TASK DESCRIPTION

Under this task, Penn State University and its industrial partner, Continuum Dynamics, Inc., will support the FAA in the development of an acoustic modeling approach for future Urban Air Mobility (UAM) and electric Vertical Take-Off and Landing (eVTOL) aircraft that will enable assessment of the wide variety of proposed concepts in this vehicle space, and address configuration and operation of such vehicles for low noise impact near vertiports and enroute. This noise prediction tool will be an extension of the noise prediction system developed in ASCENT Project 6 (Rotorcraft Noise Abatement Operating Conditions Modeling) and the low noise operations part of the task will build substantially upon Project 38 (Rotorcraft Noise Abatement Procedures Development). In particular, the extensions of the noise prediction system must efficiently account for multiple rotors and propellers with many unsteady aerodynamic and acoustic interactions. Furthermore, low noise operations will require optimization of the vehicle trim – from hover, through transition, and in winged flight. The noise prediction tool will be used to provide baseline noise profiles for notional UAM and eVTOL aircraft. Flight profiles and operating procedures will be simulated to demonstrate the potential of low noise design and operations. This is a continuation of the current ASCENT Project 49 during which the UAM/eVTOL noise prediction system coupling will be completed, validation of the noise prediction system will be performed, and evaluation of computational algorithm efficiency for many rotor UAM and eVTOL aircraft will be initiated.

IMPACT STATEMENT

The noise of UAM and eVTOL vehicles is expected to be one of the determining factors for community and passenger acceptance. A wide variety of unconventional configurations with many electrically driven propellers and lifting rotors have been proposed and are currently under development by industry. This project is expected to provide the initial capability to analyze the noise from these vehicles, and enable the FAA, manufacturers, and related entities to investigate how this new class of vehicles – and their noise – might be integrated into the national airspace. In addition, the tools developed in this project may ultimately provide guidance on how to fly these vehicles in a quiet manner through flight operations. Because the analysis and computations are based on fundamental physics, noise abatement procedures for novel new vehicles can be developed, and unique features of specific UAM and eVTOL designs can be studied as well.

Measurements to Support Noise Certification for UAS/UAM Vehicles and Identify Noise Reduction Opportunities – P77
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Measurements to Support Noise Certification for UAS/UAM Vehicles and Identify Noise Reduction Opportunities
University: Pennsylvania State University
Amount: $500,000

TASK DESCRIPTION

The Pennsylvania State University and its industrial partner, BETA Technologies, are supporting the FAA in determining noise measurement and analysis methods that will allow the external noise radiation of a variety of Unmanned Aircraft System (UAS) and Urban Air Mobility (UAM) vehicles to be accurately characterized. The noise of these vehicles is not well understood due to a lack of available acoustic data. These vehicles often feature a number of electrically driven rotors or propellers, which vary rotor speed independently for control or in response to disturbances, resulting in variability in the radiated noise. This project aims to develop a measurement and data processing approach tailored to characterize the noise of these vehicles. This approach will then be applied to a range of vehicles across different flight conditions. It will provide: FAA and the research community with a better understanding of the noise radiation characteristics of these vehicles; industry with new experimental approaches to tailoring vehicle designs for low noise; and operators with low noise flight control systems and operational guidance. In this work, noise measurements will be collected for a wide range of UAS and UAM configurations across different operating modes, flight speeds, and altitudes. A reconfigurable multirotor UAS will be developed and tested in order to assess the effects of rotor number, blade design, and position on the radiated noise and the measurement and analysis process. The data analysis process developed through this project will allow the contributions of the individual rotor or propeller noise sources to be separated and modeled independently, allowing the variability in noise generation to be correlated to the variability in the vehicle flight state..

IMPACT STATEMENT

This project will provide FAA with timely information that can be used to inform the development of practical noise certification standards for UAS and UAM vehicles of varied configurations. The data processing methods developed under this project will enable accurate empirical noise models to be developed such that acoustic impacts can be quantified. This project will also inform the development of low noise UAS and UAM configurations and flight operations, leading to low noise designs and “acoustically aware” flight control laws for these vehicles. The data collected under this project will also enable the validation of the UAM noise prediction system currently being developed at Penn State under a separate ASCENT Project.

Noise Certification Streamlining – P61
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Noise Certification Streamlining
University: Georgia Institute of Technology
Amount: $250,000

TASK DESCRIPTION

Noise certification procedures were developed in the 1960s and many parts of the regulations reference processes and equipment that are obsolete. Consequently, many original equipment manufacturers (OEMs) utilize equivalent procedures and technology not explicitly addressed in the regulations. The objective of this research is to examine current noise certification procedures and identify opportunities to streamline the noise certification process while recommending process updates for building the needed flexibility to accommodate all air vehicle types. In order to perform the proposed research, Georgia Institute of Technology has teamed with several industrial partners with extensive experience in noise certification, and each industrial partner also represents different classes of vehicles, such as large subsonic transports, propeller-driven small aircraft, and rotorcraft. OEMs strongly adhere to practices mandated and recommended by the FAA, thus ensuring compliance with noise certification regulatory frameworks. The Georgia Tech team is working with industry and FAA to identify practices that could lead to a more streamlined noise certification process. The current focus of the work is on addressing technical challenges in the flight testing phases for certification. Through process modeling and experimentation, it is expected that process bottlenecks and risks can be identified, and technology alternatives could be rapidly tested and evaluated against process requirements directly linked to Part 36 regulations. Model-based systems engineering-driven, scenario-based testing and evaluation of process alternatives are being used to develop a set of recommended practices for certification flight testing that will reduce cost and time while adding flexibility for noise certification of air vehicles that do not fit within existing vehicle types.

IMPACT STATEMENT

This project will contribute towards the generation of an improved noise certification process. This new certification process will be designed such that it can be performed with greater efficiency than the current process, yielding reductions in the time and cost to certify. Furthermore, this new process will consider new air vehicle categories thereby producing a process that is flexible enough to be used for the certification of both new and existing air vehicle categories.

Geospatially Driven Noise Estimation Module – P9
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Geospatially Driven Noise Estimation Module
University: Georgia Institute of Technology
Amount: $249,999

TASK DESCRIPTION

The goal of this task is to develop a novel geospatially driven noise estimation module to support computation of noise resulting from the operation of Unmanned Aircraft Systems (UAS) and other upcoming vehicle concepts. The development of the module will leverage emerging computational technologies in order to achieve fast and efficient modeling of a potentially large number of vehicles and operations. The module will be designed to be integrated as a component module or plug-in to other applications relying on a Geographic Information System (GIS) interface. The noise estimation approach will be based on the concept of precomputed noise grid tiles addition. The module's design phase will identify what emerging open source geospatial and data processing technologies would be best suited to serve as the module's computational infrastructure and assess if they can provide innovative, maintainable, and affordable solutions.

IMPACT STATEMENT

This research effort will produce a GIS driven noise estimation module that can evaluate the noise exposure that could result from the introduction of large numbers of UAS vehicles into commercial and private use. This module will be able to quickly compute and return noise levels to be overlaid on maps by the hosting application. The resulting visualizations will provide decision-makers insight on where the noise would be distributed or concentrated. This method could also help identify innovative operational concepts to promote sustainable growth of UAS operations by minimizing noise generation over sensitive areas. Additionally because of its modular design and inherently flexible noise grid-based computational approach, the module will support integration in any tool and the modeling of any other emerging vehicle concepts such as advanced air mobility vehicles.

Noise Model Validation for AEDT – P62
Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Noise Model Validation for AEDT
University: Georgia Institute of Technology
Amount: $235,000

University: Pennsylvania State University
Amount: $140,000

TASK DESCRIPTION

The focus of this project is to assess the accuracy of the Aviation Environmental Design Tool (AEDT) in estimating noise in both the vicinity of airports as well as further afield. The foundation of AEDT noise modeling is based on the Integrated Noise Modeling (INM) tool, which has undergone a number of validation and verification efforts in the past, specifically at Denver International Airport (DIA) and showed continually improving agreement of modeling with measurement data. During the development of AEDT, multiple algorithm updates have occurred and this project seeks to quantify the new noise modeling capabilities based on comparison to field measurement data from DIA and other airport monitoring systems. The research team is gathering aircraft flight data from airline partners and comparing it to noise measurements from an airport partner. These data are then compared to calculations of the noise from specific flights using AEDT. The research team is also investigating the importance of atmospheric conditions on noise propagation assumptions and examining the use of higher fidelity weather data to improve modeling accuracy.

IMPACT STATEMENT

The research, once completed, will provide a noise model validation benchmark with respect to real world measurement data that can be used to respond to questions on AEDT noise prediction accuracy. The work will also result in recommendations to the AEDT development team on modeling features and enhancements that could further improve noise prediction accuracy. These will be done both in the vicinity of the airport and further afield.

Analytical Methods for Expanding the AEDT Aircraft Fleet Database – P60

Grant Request Information (Ongoing Project)

GENERAL INFORMATION

Title: Analytical Methods for Expanding the AEDT Aircraft Fleet Database
University: Georgia Institute of Technology
Amount: $150,001

TASK DESCRIPTION

The goal of this research is to improve the accuracy of Aviation Environmental Design Tool (AEDT) noise and emissions modeling of aircraft not currently in the Aircraft Noise and Performance (ANP) database. Georgia Institute of Technology will identify and review the aircraft not currently modeled in AEDT and collect information and necessary data to better understand the characteristics of the aircraft. Various statistical analysis methods will be utilized to classify the aircraft into different aircraft types in terms of size, age, technologies, and other engine/airframe parameters. Quantitative and qualitative analytical methods will be identified and evaluated for each aircraft type to develop the ANP and noise data for the aircraft. Validation data from real world flight and physics-based modeling will be gathered to validate the methods. The Environmental Design Space (EDS) will be employed to generate Noise Power Distance (NPD) curves for the aircraft using physics based modeling and simulation of new and existing aircraft designs and technologies that can support the method validation analysis. After the methods are validated, they will be applied to develop ANP and noise data for the aircraft. Finally, recommendations and guidelines will be developed for how to implement the developed data in AEDT to expand the AEDT database to include noise and performance data for the aircraft currently not in ANP database.

IMPACT STATEMENT

This research will use analytical methods to expand the AEDT database to include noise and performance data of aircraft types, which are not currently in AEDT. This will improve the noise and emissions modeling of these aircraft and eventually enhance AEDT's environmental modeling capability. The enhanced modeling capability will improve the accuracy of AEDT to better reflect the environmental assessment of the aircraft operations. The outcomes of this research also include recommendations and guidance on implementation of the methods and data into AEDT.