

# Partnership for AiR Transportation Noise and Emissions Reduction

## RESEARCH PROJECTS

**PARTNER** — the Partnership for AiR Transportation Noise and Emissions Reduction — is a leading aviation cooperative research organization, and an FAA/NASA/Transport Canada-sponsored Center of Excellence. PARTNER fosters breakthrough technological, operational, policy, and workforce advances for the betterment of mobility, economy, national security, and the environment. The organization's operational headquarters is at the Massachusetts Institute of Technology.

The knowledge and capability gained from PARTNER research provides government decision-makers and industry senior executives with the critical information necessary to address environmental impacts, which may represent the single greatest challenge to the continued growth and prosperity of civil aerospace.

More information is available on the PARTNER Web site, <http://www.partner.aero>, or by emailing [info@partner.aero](mailto:info@partner.aero)

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### PROJECT

- 1 | Low Frequency Noise Study (**completed**)
- 2 | Quantifying and Mitigating the Impact of Noise on People
- 3 | Valuation and Trade-offs of Policy Options
- 4 | Continuous Descent Arrival
- 5 | En Route Traffic Optimization to Reduce Environmental Impact
- 6 | Land Use Management and Airport Controls (**completed**)
- 8 | Sonic Boom Mitigation
- 9 | Measurement of Emissions
- 10 | NoiseQuest
- 11 | Health Impacts of Aviation-Related Air Pollutants
- 12 | Emissions Atmospheric Impacts
- 13 | Lateral Alignment in Complex Systems (**completed**)
- 14 | Environmental Design Space
- 15 | Energy Policy Act Study
- 16 | Investigation of Aviation Emissions Air Quality Impacts
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## **PROJECT 1 | LOW FREQUENCY NOISE STUDY (completed)**

The Low Frequency Noise Study evaluated the perceptual impact of low frequency aircraft noise. It encompassed many factors, including the source level and its spectrum; atmospheric propagation; the impact on homes in the form of noise, vibration and rattle; subjective perception and annoyance; and the ability of metric calculations to predict the physical and perceived impact. Its goal was to enhance metrics currently used in the FAA's Integrated Noise Model, and to identify alternative algorithms that predict the impact of low frequency noise and its perceived annoyance.

Reasons for focusing on aircraft noise low-frequency components were:

- as low-frequency sound encounters less absorption as it travels through the air than higher frequency sound, it persists for longer distances
- the amount of sound transmitted from the outside to the inside of buildings is greater at low than at high frequencies
- A-weighting metrics, commonly used in aircraft noise impact assessment, deemphasize low frequencies
- standard airport noise assessment models neglect source noise below 50 Hz
- prior research indicates that frequencies in the 20-80 Hz range influence perception of low-frequency noise

Major Project 1 findings were:

- Start-of-takeoff-roll, runway acceleration, and thrust reversal generate high LFN levels (below 200 Hz) at critical distances from runways (around 3000 ft in the study), which can be annoying to people living around airports.
- The Hubbard exterior sound pressure level threshold criteria should be used as a first assessment of the potential for low-frequency noise impact.
- Assessment of impact should include both single and multiple events in areas where noise from multiple runways can impact a neighborhood simultaneously.
- A-weighted Sound Pressure Level (LA<sub>max</sub>) and C-weighted Sound Pressure Level (LC<sub>max</sub>) metrics correlate well with laboratory based subjective response to indoor aircraft noise when LFN levels are low to moderate. Because these metrics are simple to implement, they should be used to predict subjective response to indoor aircraft noise when the levels are appropriate for A- and C-weightings and there are not high levels of low-frequency noise.
- When high levels of LFN are present, Tokita & Nakamura thresholds can be used as indicators of the potential for annoyance due to LFN. C-Weighted Sound Exposure Level (LCE) metric should be used as a single-number metric for assessing the potential for annoyance. Data lower than 50 Hz is needed to assess vibration/rattle annoyance.
- Overall the findings suggest that people are responding to the broad spectral content and any predictive metric should quantify the full broadband noise. Loudness algorithms should include frequency content below 50 Hz to optimally correlate with the perception of low frequency noise.

- The risk of window rattle is lowered with preload and avoiding resonance response in the design. Outdoor–Indoor Transmission Class is a better rating for rattle prone applications than Sound Transmission Class commonly used in rating windows for transmission loss.

The results of this research will offer much-needed guidance for authorities in addressing noise-related issues at local airports.

### Participating universities

Pennsylvania State University, Purdue University, University of Central Florida

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## PROJECT 2 | QUANTIFYING AND MITIGATING THE IMPACT OF NOISE ON PEOPLE

The objectives for Project 2 are to develop metrics that can be used to evaluate the impact of airport and other noise sources on a community, and to understand the relationship between noise annoyance, physiological responses, cognitive performance, and sleep quality.

To achieve these objectives, we will (1) develop a method to predict airport noise in a community based on individual aircraft landing and takeoff noise time histories; (2) determine the level-based metric that best predicts community response to noise; (3) determine whether sound characteristics, other than Loudness, play a role in annoyance due to airport noise, and whether the sound metrics (Sharpness, Roughness, Fluctuation Strength, Tonality) are useful for measuring these characteristics; (4) determine the influence of room panel/window/floor vibration on low frequency sound perception and annoyance, and develop a method of modifying noise annoyance models to account for vibration; (5) develop a data collection system that can be used to create health-effects and annoyance maps of the community that could then be compared with community noise maps; (6) develop tools that relate land usage and the impact of noise on communities; and (7) to develop an understanding of response to noise in National Parks and other special low-level noise environments.

Successful completion of these tasks will: (a) facilitate generation of a sound time history database that can be used by researchers to develop and improve community noise metrics, and in software that predicts community noise as a result of airport operations; (b) provide metrics that can be used by the airports and the FAA to evaluate airport and aircraft noise and noise mitigation strategies; (c) provide an understanding of how the time-of-day and desired activity factor into annoyance, providing tools to plan land usage to minimize annoyance; (d) provide an understanding of how vibration affects noise annoyance; and (e) facilitate study of airport noise long-term impact.

The research effort is currently focused on items (2), (3), and (4), above, and follow-on work arising from Project 1|Low frequency noise has been recently incorporated into the Project 2 research effort, specifically issues related to high levels of low frequency noise potentially giving rise to vibration and rattle. Working in collaboration with research engineers at NASA, Wyle, Harris Miller Miller and Hanson, UTRC, and Bombardier, we are also looking at how to create a database of subjective response data and noise measurements/predictions to help researchers validate proposed metrics. To complement this effort we are studying how to modify existing noise prediction (mapping) software to incorporate calculation of more recent models that predict perceived loudness. We are also gathering information and perspectives on the use of supplemental metrics.

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## PROJECT 3 | VALUATION AND TRADE-OFFS OF POLICY OPTIONS

The benefits and environmental impacts of air transportation are highly interwoven, each products of a complex interaction of interdependent technological and operational systems, acting within policy constraints and evolving with market conditions. Today, environmental policy design, and research and development activities, are largely compartmentalized — focusing for example on only noise, only local air quality, or only climate change. Further, the full costs and benefits are often not considered when evaluating policies and prioritizing research investments. This arrangement is incompatible with the engineering and organizational realities of the air transportation system. Decisions in one domain may produce unintended negative consequences in another. Restructuring the decision-making process to integrate consideration of all environmental impacts simultaneously, and to provide a full assessment of costs and benefits, can increase economic efficiency, reduce the potential for unintended consequences, establish new understanding of the interdependencies among effects, and improve stakeholder understanding to better interpret future issues.

Fostering these changes is the principal aim of Project 3. The overall objective of Project 3 is to enable better communication and decision-making in addressing the interdependent environmental effects of aviation by being able to fully assess the benefits and costs of interdependent policies, technologies, operational procedures, and market conditions.

## REPORT TO CONGRESS: AVIATION AND THE ENVIRONMENT

In December 2003, as part of HR 2115 Vision 100-Century of Aviation Reauthorization Act, Congress required the Secretary of Transportation, in consultation with NASA, to study reducing aircraft noise and emissions, and increase fuel efficiency. PARTNER, the Partnership for AiR Transportation Noise and Emission Reduction, conducted the study.

Presented to Congress in March 2006, the report recommends that the United

States should adopt a national aviation and environmental goal of reducing the significant impacts of aircraft noise and emissions on local communities by the year 2025, notwithstanding anticipated growth in movement of people and goods. The report says that by that date, uncertainties regarding both the contribution of aviation to climate change and the impacts of aviation particulate matter and hazardous air pollutants, will be reduced to levels that enable appropriate action. This action would mitigate restraints on air travel, commerce, and national security. Emphasizing the diversity of the reports' contributors, the report "vision" says that "Through broad inclusion and sustained commitment among all stakeholders, the U.S. aerospace enterprise will be the global leader in researching, developing, and implementing technological, operational and policy initiatives that jointly address mobility and environmental needs."

#### **AVIATION ENVIRONMENTAL PORTFOLIO MANAGEMENT TOOL PROTOTYPE**

The Aviation Environmental Portfolio Management Tool is a comprehensive suite of software tools that will allow for thorough assessment of the environmental effects of aviation. The main goal of the APMT effort is to develop a new capability to assess the interdependencies between aviation-related noise and emissions effects, and to provide comprehensive cost and benefit estimates of aviation environmental impacts for a range of assumptions and stakeholder viewpoints. The new APMT tool suite will help users to better address complex aviation environmental issues in a comprehensive, consistent, and more efficient manner.

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#### **PROJECT 4 | CONTINUOUS DESCENT ARRIVAL**

The Continuous Descent Arrival, also referred to as the Continuous Descent Approach, has proven, through both simulation and flight demonstration tests, to be highly advantageous over conventional "dive-and-drive" arrival and approach procedures. These advantages provide ample motivation for research efforts to further develop CDA for implementation in low-density through high-density traffic. PARTNER researchers in flight tests at Louisville International Airport demonstrated the environmental and economic benefits of CDA in 2002 and 2004. CDA was implemented at LAX in 2007, and will be implemented in Atlanta in 2008. From the environmental perspective, there are significant reductions in noise (due to reductions in thrust and a higher average altitude) and emissions (due to reductions in thrust and a higher average speed). From the economic viewpoint, there are significant fuel and flight time savings (due to reductions in thrust and a higher average speed) as well as the potential to meet or exceed current runway throughput without the need to vector aircraft.

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## PROJECT 5 | EN ROUTE TRAFFIC OPTIMIZATION TO REDUCE ENVIRONMENTAL IMPACT

Results of previous analyses indicate that the throughput of en route airspace can be increased by optimizing the cruise altitude and speed of aircraft based on the distance between their origin and destination. The increase in throughput, and the corresponding reductions in fuel burn and emissions, result from aircraft ability to fly closer to the optimum altitude for their performance characteristics, and from a reduction in situations where one aircraft "gets stuck" behind another with a lower optimal cruise speed.

We are investigating and quantifying potential benefits of an optimization tool that en route air traffic controllers could use to assign aircraft to cruise altitude and speed by: a) developing a mathematical model of the air routes through Cleveland Air Route Traffic Control Center, one of the most congested US airspaces; b) developing a prototype optimization algorithm by enhancing an existing Mixed–Integer Linear Program within an A\* Search–based Branch & Bound framework; and c) conducting simulation studies based on existing and potential future traffic levels.

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## PROJECT 6 | LAND USE MANAGEMENT AND AIRPORT CONTROLS (completed)

Project 6 research examines population encroachment on airport operating areas. Currently, the focus is on assessment of the dynamics of how airports become encroached upon, and how these encroachments potentially fuel noise concerns and complaints. During this phase of the study, Purdue's research team will continue to work closely with airport administrators, civic leaders, and aviation organizations to identify and collect salient data concerning the most prominent issues precipitated by the encroachment of their airports. Personal interviews and focus groups will be used to gather the richest possible data. The research seeks to provide a balanced view of the noise complaint data and will hopefully help researchers understand the dynamics of why some individuals complain about airport noise while others do not. Florida International University will continue to examine population encroachment near selected airports and provide trends and a list of indicators that, when considered collectively, can predict where and why

population encroachment occurs. Once these indicators are identified, it will be possible to provide suggestions for preventing future population encroachment near airports. Aerial photographs and demographic data for different years will be obtained and analyzed. A comparative analysis of the images will provide a direct indication of the extent of population encroachment throughout the years surrounding the study airports. Population encroachment data will be correlated with local factors, such as land cost, job availability, and other demographics, to determine common indicators that act as drivers for population encroachment.

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## PROJECT 8 | SONIC BOOM MITIGATION

As demand for long range business travel increases and technologies for efficient supersonic flight mature, a market for small supersonic civil aircraft appears to be forming. Results of recent studies indicate that such aircraft are feasible. However, a major remaining impediment to the operation of such aircraft is the cruise noise signature. Sonic boom noise issues are different from many other aspects of aircraft noise in that the potential annoyance occurs en route, along the flight path rather than just near airports. Maximum utility will require supersonic flight over land, currently prohibited by regulation promulgated at a time before the purposeful shaping of the sonic boom waveform was achievable. The aim of the proposed work is to determine if sufficient new data exists to warrant a reevaluation of the FAA's regulation prohibiting supersonic flight over land. Recent research on shaped sonic booms has indicated low boom designs are possible and result in significantly less objectionable signatures than classic booms of the 1960s - 1980s. Several recent studies have investigated designs with initial overpressures of no more than 0.3 lb/ft<sup>2</sup>, in contrast to Concorde's typical 2 lb/ft<sup>2</sup> N-wave signature — a dramatic reduction in noise levels. Due to this technological progress and resulting potential commercial and military application for the United States, supersonic aircraft operation and sonic boom signatures should be investigated for low boom designs, and this is the overarching goal of Project 8. This research is expected to lead to the re-evaluation of existing regulations and, possibly, to the development of new regulations to permit operation of commercial supersonic aircraft over both land and water in the United States and worldwide, for the specific case of shaped boom aircraft designs.

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## PROJECT 9 | MEASUREMENT OF EMISSIONS

Project 9's objectives are to characterize the emissions (both small particles and condensable gaseous species) from aircraft and airports through measurements, understand and model the microphysical processes associated with particle formation, and determine the health effects of emissions.

### Participating universities

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## PROJECT 10 | NOISEQUEST

NoiseQuest's goal is to develop and maintain a Web site as a resource for both airports and communities, and that provides educational information on aviation noise. NoiseQuest will facilitate the outreach programs that currently exist, and provide an outreach forum for airports too small to have an established community program. NoiseQuest will help to bridge the gap between airports and their communities. The site will address the real concerns of citizens. The site may include ways to contact authorities to assist with the public's noise-related issues problems. It will capture the user 's attention with pictures, graphs, and interactive tools. It will offer information in an understandable manner. It has been noted that users require and desire different amounts and levels of information. Therefore, the site should be "layered" so information is available to people with differing need levels. This will allow all users to access the amount of information they wish, so that a page of text does not overwhelm some users, and others are not disappointed that the information is sparse.

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## PROJECT 11 | HEALTH IMPACTS OF AVIATION-RELATED AIR POLLUTANTS

The demand for aviation transport is expected to increase 2-3 times over the next two decades, and that may lead to an increase in some emissions. The FAA recognizes the growing public health concern associated with aviation emissions.

In order to quantify the health and human exposure risks with reduced uncertainties, the FAA has initiated this research project through PARTNER. The main science objective of this project is to understand and evaluate the potential incremental health risks due to direct (or primary) and indirect (secondary) aviation emitted air pollutants such as hazardous air pollutants (HAPs or toxics), ozone and particulate matter. Once sufficiently well developed, the research carried out under this project with strong interactions with PARTNER projects 9 and 16, will greatly help airport operators in preparing Environmental Assessment and Environmental Impact Statements in support of National Environmental Policy Act requirements. Additionally, this research project will help to consider potential tradeoffs amongst emissions, and to inform comprehensive policy analyses for aviation management that are being pursued under other PARTNER research projects.

### Participating university

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## PROJECT 12 | EMISSIONS ATMOSPHERIC IMPACTS

The direct impact of aviation on climate via the emission of greenhouse gases is small relative to other anthropogenic sources. However, the potential impact of aviation on climate is unique because aviation associated sources occur at high altitudes where other anthropogenic sources are absent. The climatic impact of aviation on stratospheric ozone for a supersonic airplane fleet, and the impact on radiative forcing via carbon dioxide, oxides of nitrogen, persistent contrails, and contrail-induced cirrus clouds, may be significant. There are large uncertainties in relating aviation emissions to changes in radiative forcing or surface temperature, especially for contrail-associated pathways. This project is led by researchers from Stanford University. It seeks to find robust relationships between aircraft parameters (i.e., controllable inputs) and the properties of contrails generated by the aircraft under a variety of atmospheric conditions using high-fidelity numerical simulations. This effort is linked to regional and global scale study designed to assess methods for system-level estimation of fuel burn, emissions, and contrail formation. MIT is conducting this system-level work using the FAA System for assessing Aviation's Global Emissions.

### Participating universities

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## PROJECT 13 | LATERAL ALIGNMENT IN COMPLEX SYSTEMS (completed)

The overall project consists of three-phases of action-research designed to further understanding and to address the challenge of lateral alignment within and across stakeholders in complex, engineered systems. The initial focus is on aircraft noise and emissions, with a longer-term focus across a broad range of air transport and aerospace systems.

Under the auspices of the Joint Planning and Development Office (JPDO), a series of Integrated Product Teams have been established in order to ensure a proactive approach to the anticipated tripling of demand for air travel and transport by the year 2025. To prepare for the projected 2025 system requirements, the JPDO initiative brings together FAA, NASA, EPA, DoD, DOT, DOC, and DOI – with oversight by the Secretaries and Administrators of these respective agencies. Pressing social and technical challenges face such an organization. These challenges require an integrated systems approach spanning traditional organizational and institutional boundaries.

As a result of this research, the following outcomes or benefits are anticipated:

- The Aircraft Noise and Emissions IPT will have a clear charter and shared vision, with documentation of lessons learned in the chartering and visioning process.
- The impact of alignment efforts on specific outcomes (such as recommendations to Congress on Aircraft Noise and Emissions) will be documented and analyzed.
- Selected case examples of lateral alignment and additional lessons on communication and coordination will be documented in the form of at least one to two case studies, which can be used for educational purposes.
- Systematic documentation of patterns of interaction has the potential to yield deep insights in the alignment process, as well as demonstrating relevant tools and methods.

Overall lessons will be documented with respect to improved effectiveness within and across government agencies, as well as among public and private stakeholders.

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## PROJECT 14 | ENVIRONMENTAL DESIGN SPACE

The Federal Aviation Administration's Office of Environment and Energy, in collaboration with the NASA, is developing a comprehensive suite of software tools that will allow for thorough assessment of the environmental effects of aviation. Of

particular significance is the ability to assess the interdependencies between aviation-related noise, emissions, and cost valuations. This comprehensive suite of software tools includes the Aviation Environmental Portfolio Management Tool, Aviation Environmental Design Tool, and the Environmental Design Space. The three tools combined provide a capability to perform aviation noise and environmental policy analysis, including interdependencies.

EDS is a numerical simulation tool capable of estimating source noise, exhaust emissions, performance, and economic parameters for aircraft designs under different technological scenarios. Once EDS is connected to AEDT and APMT, the combined tool suit will also be able to assess operational, policy, and market scenarios. EDS will be designed to explore tradeoffs within currently available technology capabilities, and explore the impacts of potential future technological capabilities. The project benefits from a close collaboration with many industry counterparts, represented on a technical advisory board, including the Aerospace Industries Association, Airbus Industries, The Boeing Company, Bombardier, General Electric Aircraft Engines, SNECMA and United Technologies Pratt & Whitney.

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### PROJECT 15 | ENERGY POLICY ACT STUDY

The Energy Policy Act of 2005 requires the FAA and EPA to initiate a study to identify:

1. The impact of aircraft emissions on air quality in nonattainment areas;
2. Ways to promote fuel conservation measures for aviation to enhance fuel efficiency and reduce emissions; and
3. Opportunities to reduce air traffic inefficiencies that increase fuel burn and emissions.

The Massachusetts Institute of Technology is assisting the FAA and the EPA in meeting their obligations under the EPACT in each of the above areas. This project requires coordination and partnership with CSSI Inc. and Metron Aviation, as some of the deliverables are interdependent with deliverables being fulfilled by CSSI and Metron under separate FAA agreements.

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## PROJECT 16 | INVESTIGATION OF AVIATION EMISSIONS AIR QUALITY IMPACTS

Aircraft emissions that impact local air quality represent a relatively small contribution to overall regional emissions. With a projected 2–3 times growth in aviation transport sector over the next two decades, some aviation emissions are expected to increase. The National Vision for Aviation and Environment, which forms the basis for the environmental strategy of the Next Generation Air Transportation System, states that the significant environmental and health impacts of local air quality caused by aviation emissions will be reduced in absolute terms notwithstanding the anticipated growth in aviation. In order to understand and evaluate the potential role of aviation emissions in local and regional air quality, the FAA has initiated this research project through PARTNER. The main science objective of this project is to quantify the potential incremental contribution of aviation emissions to local and regional air quality through their interaction with the background air. The research carried out under this project will exchange information with PARTNER projects 9 and 11. The lessons learned under this project will help to develop methodology for air quality analysis to aid airport operators in preparing Environmental Assessment and Environmental Impact Statements in support of National Environmental Policy Act requirements. Additionally, this research project will help to consider potential tradeoffs amongst emissions, and to inform comprehensive policy analyses for aviation management that are being pursued under other PARTNER research projects.

### Participating university

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## PROJECT 17 | ALTERNATIVE FUELS

Project 17 is exploring the potential to reduce aviation environmental impacts via alternative fuels while taking into account the full lifecycle of these fuels. The study will be conducted by MIT researchers from the Department of Aeronautics and Astronautics, the MIT Engineering Systems Division, and the MIT Laboratory for Energy and the Environment, in collaboration with Pratt & Whitney, The Boeing

Company, General Electric Aircraft Engines, Airports Council International – North America, and the Aerospace Industries Association.

The project objective is to evaluate the relative environmental impacts of potential alternative aviation fuels. Consideration will be given to kerosene fuels and other hydrocarbon fuels derived from fossil fuels, synthetic liquid fuels manufactured from coal, biomass or natural gas, bio-fuels made from agricultural crops, and hydrogen. The evaluation will include the full chain of use from initial energy harvesting/resource extraction, to production and transportation, to use by the aviation industry, to any end-of-use/disposal issues. We will consider the full range of health, welfare and ecological impacts including effects related to changes in non-renewable resource use, local air quality, community noise, water quality, exposure to hazardous materials, and global climate change.

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## PROJECT 18 | REDUCED VERTICAL SEPARATION MINIMUMS (completed)

The term Reduced Vertical Separation Minimum describes a reduction from 2,000 feet to 1,000 feet of the standard vertical separation required between aircraft flying at levels from FL290 (29,000 ft.) and FL410 (41,000 ft.). RVSM reportedly enhances aircraft operating efficiency by making more fuel/time efficient flight levels available, enhancing air traffic control flexibility, and providing the potential for enhanced enroute airspace capacity.

The FAA developed the System for assessing Aviation’s Global Emissions (SAGE) to estimate aircraft fuel burn and emissions for variable-year emissions inventories, and for operational, policy, and technology-related scenarios. One element of this effort is the ability to model air traffic movement in 4-D flight trajectories (latitude, longitude, altitude, and time) using as much measured data as possible.

The FAA has developed the System for assessing Aviation’s Global Emissions (SAGE) to estimate aircraft fuel burn and emissions for variable-year emissions inventories and for operational, policy, and technology-related scenarios. One element of this effort is the ability to model air traffic movement in 4-D flight trajectories (latitude, longitude, altitude and time) using as much measured data as possible.

To examine more fully the environmental benefits of RVSM, PARTNER Project 18 will:

- Assess the accuracy of the fuel burn and emissions modeling within SAGE as a function of weather source, resolution of weather data, and modeling methodologies, through comparison to CFDR data
- Utilize ETMS data from one month of representative days, just prior to and shortly after, the implementation of RVSM to quantify the effects of this transition

- Report on the results of the RVSM study, including reference to the previous EUROCONTROL and FAA studies

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## PROJECT 19 | HEALTH EFFECTS OF AIRCRAFT NOISE

Health related consequences of community noise may include: cardiovascular effects as a consequence of stress caused by noise, sleep disturbance where sleep patterns are disturbed and conscious and premature awakenings may occur, and noise related annoyance that can cause negative emotions. Noise can also cause cognitive impairment in children.

It is important to be able to quantify the impact of noise accurately so that a realistic cost-benefit analysis of proposed airport development can be performed. In many cases, hedonistic measures of noise impact, such as differences in house prices in noise exposed vs. non-exposed communities, are used. But, by using such an approach, is the true cost of the noise being determined, or are there more serious health effects caused by environmental noise exposure, perhaps not fully understood by people living in communities, that ultimately lead to a shortened life span and/or reduced quality of life? If so, at what noise level do these effects begin to occur and how do they grow with increasing noise levels?

Initial Project 19 research involves a review of the health effects of noise literature, particularly that portion related to aircraft noise, and to examine in detail the basis for the findings reported in these recent meta-analysis studies. We will use the research findings to determine whether a different approach to measuring the cost of noise should be adopted in PARTNER Project 3: Valuation and trade-off of policy options, and also to identify gaps in knowledge that need to be explored to help develop more realistic health effects of aircraft noise models.

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## PROJECT 20 | EMISSIONS CHARACTERISTICS OF ALTERNATIVE AVIATION FUELS

In an information paper from the International Civil Aviation Organization's Committee on Aviation Environmental Protection February 2007 Meeting, "The Potential use of Alternate Fuels for Aviation," it is stated that, "Interest in alternative fuels for commercial aviation has grown in tandem with concerns about rising fuel costs, energy supply security and the environmental effects of aviation. At the moment, the largest single driver for industry adoption of alternative fuels is the high cost of petroleum. If oil prices remain high, alternatives will remain attractive. However, energy security and possible environmental benefits are also powerful drivers. And, if oil demand outpaces supplies, jet fuel availability could become a constraint to growth. The United States has determined that it is prudent to explore now the potential move toward alternative fuels."

The objectives of Project 20 are to work with the aviation community to gather accurate data on emissions from candidate alternative fuels and to compare these emission characteristics with those of conventional aviation fuel types being gathered in PARTNER Project 9 - Measurement of Emissions. These data will provide the essential information for PARTNER Project 17 - Alternate Fuels and to the aviation community at large as it charts a course for environmental sustainability in an uncertain energy future.

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## PROJECT 21 | AIRPORT SURFACE MOVEMENT OPTIMIZATION

Taxiing aircraft contribute significantly to fuel burn and emissions at airports. The quantities of fuel burned as well as different pollutants, such as carbon dioxide, hydrocarbons, nitrogen oxides, sulfur oxides and particulate matter, are functions of aircraft taxi duration (along with throttle setting, number of running engines, and pilot and airline decisions regarding engine shutdowns during delays). The reduction of taxi times through improved planning of surface movements has the potential to reduce these emissions.

Project 21 focuses on opportunities to reduce surface emissions through departure planning and surface movement optimization. The research will include a detailed plan for implementing these techniques in a pilot study at an airport, with an overall goal of initiating wider adoption of the methods throughout the United States. This project will investigate approaches, such as gate-holds and taxi-route planning, to decrease taxi times. In addition, environmental factors will be incorporated into the objective functions of the optimization through the use of aircraft-specific delay costs, which will reflect the fact that the emissions characteristics of various aircraft may differ. Project 21 will also address the development of approaches to surface movement optimization that will balance both airport throughput and emissions objectives, while simultaneously ensuring fairness in the delays incurred by the different airlines.

Barriers to the practical adoption of these approaches, such as gate usage and ownership issues, as well as surface infrastructure considerations such as taxiway layouts, the availability of tugs, and the presence and location of holding areas, will be identified, and possible approaches to overcome these barriers will be developed. Airline competition, tradeoffs between airline and air traffic control objectives, traffic flow management initiatives in the airspace and the presence of uncertainty in airport processes (which result in uncertain estimates of pushback times and taxi times) also pose significant challenges to surface movement optimization, and will be addressed.

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**PROJECT 23 | NETWORK RESTRUCTURING SCENARIOS FOR ATO FORECASTS**

To plan for future capacity needs and mitigate environmental impacts, the FAA’s Air Traffic Organization requires detailed projections of where traffic growth will occur. These network forecasts are produced and used to project future performance, identify operational shortfalls, determine workforce requirements, and estimate the benefits of future investments. Each network forecast is a projected schedule, which can be used to estimate future air traffic to the sector and to the minute. The projected schedules are based upon the assumption that the future air transportation system network structure will be the same as the current network structure. That is, no new direct flights are added (or subtracted) between cities, and it is assumed that the existing airline hubs will continue to operate without any additions or subtractions.

However, the future network structure is likely to differ from the current structure. Historically, the competitive nature of the airline industry is such that new direct routes are routinely added between cities with significant passenger demand. In addition, the location and number of airline hubs are not fixed (e.g., eliminated hub operations in St. Louis and Pittsburgh) and hubs that persist can be substantially restructured.

The Project 23 objective is to analyze airline network topology dynamics and identify likely alternative network structures, including especially the ability to forecast creation of service for new city pairs. Such an analysis capability should reduce risks associated with present FAA forecasts and thus enable improved assessments of solutions for capacity and environmental challenges.

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