Safety is in the forefront of all airport operators. Since the crash of US Airways Flight 1549 in the Hudson River, avian radar systems have been in the spotlight as a means to monitor and manage bird movements in the airport environment. Researchers at the FAA Center of Excellence for Airport Technology (CEAT) and its Airport Safety Management Program are leading the efforts of a new advanced bird tracking system using avian radars. This technology could not be possible without the partnerships that CEAT has formed with airports, radar equipment companies, government agencies and many more.

With the help of its partners, CEAT completed a 15-month long independent evaluation program of avian radar systems. The study assessed the systems’ ability to detect and track avian targets and considered environmental clutter caused by buildings, topography, and vegetation. Avian targets present challenges to radar systems due their size, body composition, changing reflectivity due to flight and unpredictable movements. The study included field observations of bird movements and specific bird targets in varying weather conditions, changing bird populations due to migration and varying clutter conditions. The validation work was performed at Naval Air Station Whidbey Island (NASWI), Washington, in cooperation with the US Navy BASH program, due to the large resident bird population and seasonally changing bird populations along the Pacific Flyway.

CEAT is now conducting a study at SEA-TAC International Airport. The system is live and provides wildlife managers with real time displays of bird activity on and around an airport, presented as overlays on a Google Earth™ map of the area. Industrial and Government Partners, such as the wildlife biologist at the Port of Seattle and equipment from Accipiter radar, provides wildlife managers with real time data.

A list of CEAT's Airport Safety Management Program's collaborating organizations can be found at: http://ceatasmp.cee.illinois.edu/asmp/collaborating organizations.

(CEAT Partnerships continued on page 7)
OCTANE ENHANCERS FROM CROP OILS

University Lead:
University of North Dakota

Challenge:
The main objective of this project was to produce a replacement for lead additives to increase octane in aviation gasoline without hindering the performance, efficiency, and safety of aircraft engines. In this study, crop oil (soybean oil) was the target feed stock to produce the replacement octane enhancers needed for a lead-free 100-octane rated AvGas. These octane enhancers, which were aromatic-rich organic liquid product (OLP), maintained the required high octane rating for AvGas without a lower environmental/health impact than that from the emission of TEL.

Research and Development:
Experiments were conducted to maximize the aromatics content and yield using undoped commercially available HZSM-5 zeolite catalyst. A detailed study was conducted to determine the reaction conditions that produced the highest amount of aromatics in a single step reaction in a batch reactor. In the study, products were analyzed and a statistical analysis was used to determine the reaction conditions that results in the highest production of aromatics. Reactions conditions determined from the statistical analysis were used in the production of aromatics used further in the study.

Results:
These octane enhancers, which were aromatic-rich organic liquid product (OLP), maintained the required high octane rating for AvGas without a lower environmental/health impact than that from the emission of TEL.

ENHANCED JET EXHAUST PROJECT

University Lead:
Wichita State University

Challenge:
The objective was to increase the mixing rate so that jet exhaust noise could be reduced. The proposed study investigated different stream wise vortex generation techniques in laboratory experiments and computational simulations. Flow conditions to be modeled were those appropriate for moderate bypass ratio turbofans.

Research & Development:
The study investigated these techniques in the laboratory through experiments as well as through computational simulations.

Results:
The goal in these experiments and simulations was to create stream wise vorticity in order to enhance mixing in the jet exhaust flow, which in turn reduced the jet exhaust noise. Flow conditions modeled were those appropriate for moderate bypass ratio turbofans. Thus, the velocity ratio between the simulated core and fan exhausts were relatively close to unity rather than the relatively large velocity ratios which were more common in high bypass ratio turbofans.

JOINT TRAINING STANDARDS DEVELOPMENT

University Team:
University of North Dakota
Embry-Riddle Aeronautical University
Middle Tennessee State University

Challenge:
The purpose of this project was to develop the methodology to create and deploy joint training standards under the FAA/Industry Training Standards (FITS) program for a new generation of technologically sophisticated and extremely capable aircraft entering the General Aviation fleet.

(CGAR - FITS Program continued on page 9)
COLLABORATIVE DECISION MAKING (CDM) AND FREE FLIGHT PHASE 2

COE Principal Investigators:
Prof. Michael Ball, Ph.D., University of Maryland, College Park
Prof. John-Paul Clarke, Ph.D., Massachusetts Institute of Technology
Prof. Mark Hansen, Ph.D., University of California
Prof. Lance Sherry, Ph.D., George Mason University
Prof. Antonio Trani, Ph.D., Virginia Polytechnic Institute

Industry Partner:
Metron Aviation

Objectives:
Collaborative Decision Making is a joint FAA/Industry initiative aimed at improving Traffic Flow Management through real-time access to weather, equipment and delay data.

In general, CDM seeks to improve traffic flow management through enhancement of communications between the FAA and airspace users and through better distribution of decision-making responsibility and emphasizes that decisions with a potential economic impact on air carriers should be decentralized and made in collaboration with the air carriers whenever possible.

Methods:
NEXTOR research employed a combination of techniques from both operations research and economics. This research used stochastic models to represent the high degree of uncertainty associated with air traffic management systems, and drew upon methods and theory from multi-objective optimization, fair resource allocation and non-monetary resource exchanges.

Results:
NEXTOR developed several enhancements to the ground delay program (GDP) models and procedures. NEXTOR analysis has shown that the exemption procedures used in GDP’s have an inherent systematic bias against airlines that tend to operate shorter haul flights.

NEXTOR developed modifications to the CDM slot allocation procedures that substantially reduce this bias. In addition, models that substantially improved the ability of FAA specialists to optimize GDP parameters were developed.

An important component of GDP planning is the compression algorithm, which implements a certain type of inter-airline slot exchange. By viewing this process as a general exchange mechanism, NEXTOR was able to develop an enhanced exchange capability that substantially improves the types of worthwhile exchanges possible among airlines.

Impact:
NEXTOR research has shown that there is substantial economic benefit is associated with the new procedures.

CONGESTION MANAGEMENT OPTIONS FOR LGA AIRPORT

COE Principal Investigators:
Prof. Michael Ball, Ph.D., University of Maryland, College Park
Prof. Cynthia Barnhart., Massachusetts Institute of Technology
Prof. Mark Hansen, Ph.D., University of California, Berkeley
Prof. Karla Hoffman, Ph.D., George Mason University

Affiliate University: Harvard University.

(NEXTOR - Congestion Management continued on page 10)
AGING OF COMPOSITE AIRCRAFT STRUCTURES

University Team:
Wichita State University
National Institute for Aviation Research

Industry Partners:
The Boeing Company
Raytheon Aircraft Company

Challenge:
As more commercial and military airplanes are being used beyond their original design life, it has become necessary to answer the questions of their continued airworthiness and structural integrity. Most of the aging aircraft studies conducted so far have focused on metallic structures; however, with the increasing use of composites in primary aircraft structures, it is crucial to address these aging concerns for composite components as well.

Research & Development:
The primary objective of this project is to evaluate effects of aging on composite aircraft structures. It involves the investigation of two aircraft structures, a decommissioned Boeing 737 stabilizer that had a commercial service history of 18 years and a Beechcraft Starship, after 12 years of service corresponding to 1827 hours. Data generated from the project will be used by FAA to assess the structural health of composite structures currently in service, evaluate the efficiency of field NDI methods to detect flaws, understand the aging mechanisms of composite structures by conducting thermal, mechanical and physical tests and validate the OEM (original equipment manufacturer) design and repair philosophies.

Results:
During the visual inspection process, the first observation made after disassembly is that the stabilizer, after 18 years of service, appeared to be in exceptional condition with no evidence of typical pitting and corrosion as would be observed in most metal structures after a comparable service life. Non-destructive evaluation was also performed on the the B-737 stabilizer using a hand-held probe to detect skin/stringer delaminations, disbonds, and porosity with a pulse echo at a frequency of 3.5 Mhz.

The teardown of the B-737 stabilizer has revealed a composite structure that held up well in service and did not exhibit any obvious signs of aging such as pitting and corrosion, as would a metal structure with a similar service history. It also provides closure to the NASA ACEE program undertaken almost 30 years ago and affirms the viability of composite materials as substitutes for metals. The composite materials used today versus 25 years ago have undergone durability improvements and are better able to handle environmental and aging attack. The physical and mechanical evaluation will provide additional evidence of composite materials capabilities over the expected service life of commercial aircraft structures.
ments were made on 40 flights and limited measurements were made on 200 flights to characterize aircraft air quality. Commercially available sensing technology was assessed for potential installation on aircraft. The cabin air filters were assessed as a potential source of air sampling during actual events. Specimens from 200 filters, removed during routine maintenance, were analyzed to provide a baseline of information of chemical species and elements present. A bleed air simulator which can generate temperatures and pressures representative of bleed air conditions and provide controlled contamination was used to expose filters to determine measurement sensitivity.

Results:
Filters from aircraft with air quality incidents are now being assessed using the methods developed to determine the nature and source of contamination. This information can then be used to identify the problem source and develop corrective action to prevent reoccurrence. Without such information, corrective action is often a trial and error process. This ability to assess an incident after-the-fact is very useful. However, the ultimate goal is to develop practical, reliable sensing systems that provide real time warnings of incipient contamination events and provide sufficient information to the crew during an incident so actions can be taken to minimize exposure, safety hazards, and disruptions to flight operations.

AIRCRAFT CABIN AIR QUALITY

University Team:
Auburn University
Boise State University
Harvard University
Kansas State University
Purdue University
University of Medicine and Dentistry of NJ
with participating Airlines and Manufacturers

Challenge:
The RITE-ACER COE has addressed a variety of cabin air quality topics including ozone, pesticides, cabin altitude, and air quality incidents, the latter which is described here. The air supply for aircraft is bleed air extracted from the propulsion engine compressors or APU. Under some circumstances, the bleed air may be contaminated with lubricating oil or hydraulic fluid, creating contamination in the cabin and cockpit air that may sicken passengers and crew members and impair crew functioning. Serious air quality incidents occur on a very small fraction of flights but, when the whole commercial aircraft fleet is considered, they occur with some regularity. They are sporadic and unpredictable, making it very difficult to analyze the air during an incident and to determine its cause and resulting exposure. There is no onboard sensing that can provide information to the crew during an incident.

Research and Development:
RITE-ACER has addressed the challenge through the Incidents, In-flight, and Sensors projects. Detailed measure-
Air transportation benefits and environmental impacts are interwoven products of a complex interaction of interdependent technological and operational systems, operating within policy constraints and evolving with market conditions. Today, environmental policy design, and research and development activities, are largely compartmentalized - focusing for example solely on noise, air quality, or climate change. This arrangement is incompatible with the engineering and organizational realities of the air transportation system. Decisions in one domain can produce 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. Project 3 will enable better communication and decision-making in addressing the interdependent environmental effects of aviation by offering an ability to fully assess benefits and costs of interdependent policies, technologies, operational procedures, and market conditions.

Anticipated outcome: Supporting the International Civil Aviation Organization/Committee on Aviation Environmental Protection, the Joint Planning and Development Office, and FAA decision-making and research need identification by creating an integrated modeling tool aviation’s environmental impact assessment.
Efficiency is a critical factor for the O’Hare Modernization Program (OMP) during its ten billion dollar project to modernize the runways of one of the busiest international airports in the U. S.

CEAT’s partnership with OMP began in October 2004 and emphasizes research through CEAT which targets technical issues related to the construction of new and extended runways at O’Hare International Airport.

The objective of the OMP is to create a modern and efficient air traffic system based on parallel East-West runways. The CEAT research program illuminates many of the technical issues faced by OMP engineers, providing improved and cost-effective solutions. CEAT research for the OMP is focused on airport pavement materials and issues, wildlife safety hazards, and anti-icing. CEAT hosts monthly seminars at the OMP to address areas of interest of the engineers.

CEAT’s partnership with Rensselaer Polytechnic Institute (RPI) provides the FAA with expertise in airport lighting technology. The Lighting Research Center (LRC) located at RPI works in a synergistic way to combine the LRC’s expertise in lighting technologies, applications and human factors research. The LRC’s lighting research is a part of the CEAT research program, conducting research on new LED and tungsten halogen technologies for airport visual guidance. The research includes field evaluation of commercial products, studies of color balance, human perception, and durability of LED lighting equipment.

North Carolina A&T State University partners with CEAT’s Minority Internship Program to bring undergraduate students to UIUC for the summer to work in a Civil Engineering Laboratory on CEAT research projects. The students gain valuable research experience and a look at graduate studies/research in the civil engineering transportation and aviation.

The Center of Excellence for Airport Technology is a research center with its home in the Department of Civil and Environmental Engineering at the University of Illinois at Urbana-Champaign. CEAT was founded in 1995 as a Federal Aviation Administration Center of Excellence focusing on airport pavement improvement and safety issues, including wildlife, anti-icing and lighting.

### LED AVIATION SIGNAL - LIGHT BRIGHTNESS

**University Lead:**
Rensselaer Polytechnic Institute, Lighting Research Center

As light-emitting diode (LED) technologies continue to advance, signal lights using LEDs are increasingly used to replace incandescent signals. Generally, LED signal lights have narrower spectral distributions than incandescent (filtered and unfiltered) signals, resulting in more saturated colors. Since color saturation increases the perception of brightness, the Federal Aviation Administration (FAA) asked the LRC to develop a set of “brightness correction factors” for white, green, and blue signal lights.

**Experiment:**
The LRC conducted a study to identify the brightness /luminous intensity (B/L) ratio values for white, green, and blue LED signals (and in different LED color bins) relative to incandescent signals of the same nominal color. In a dark laboratory, subjects viewed pairs of signal lights: one LED and one incandescent (filtered and unfiltered) signals, adjusting the intensity of the LED to randomly selected values.
Additional experiments determined if the following factors affected B/L values:

- Arrays of signal lights (rather than single lights)
- Dim (rather than dark) conditions
- Simulated fog conditions

**Results:**

- Generally, LED signals were judged brighter than incandescent signals of the same nominal color
- Only the simulated fog had reliable effects on B/L values, reducing the relative brightness differences between LED and incandescent signal lights.
- The results were used to develop a general model with which signal lights of any chromaticity within the FAA color boundaries could be assessed for their B/L characteristics.

**Design Criteria:**

Nearly all commercial LED-based elevated taxiway luminaires mimic the designs of incandescent models with top-mounted glass domes. Yet there is no requirement for this design. All taxiway luminaires must meet FAA performance specifications in ambient temperatures ranging from –40°C to +55°C. LRC researchers investigated different luminaire assemblies to determine the one that could transfer heat to the optics most efficiently. They concluded that the most efficient design produced the lowest ratio of LED pin temperature (a good indicator of junction temperature, which correlates to LED life) over optics surface temperature.

**Design Solution:**

LRC researchers produced a novel prototype design that used several blue LEDs distributed around an aluminum heat sink. This design reduced the size of the optics surface as well as the path length for the heat to travel from the LED junction to the optics for melting ice and snow. Laboratory tests at room temperature showed that the prototype met FAA photometry requirements. At 10 watts, the prototype was projected to produce enough heat to melt ice and snow at –40°C.
Conclusion:

- LED junction heat can be used to raise the optics surface temperature to a level similar to that found in taxiway luminaires employing incandescent lamps.
- At a maximum 10-watt load, an LED solution can be achieved using metal components and no heater.
- If needed, during the summer the LED current can be reduced to save energy further and reduce the junction temperature to extend life.

Results:

In partnership with the FAA and selected "launch" customers (under the FITS program), CGAR developed, prototyped, and implemented appropriate training curriculum and syllabus as "launch" products for a more streamlined and effective flight training system that prepared pilots for more "real world" operation of advanced general aviation aircraft and systems in a modernized NAS.

Initial results indicated that the pilots completing this course had the same or better level of aeronautical competency over traditionally trained pilots and a higher level of skills in the 4 key areas: aeronautical decision making, risk management, situational awareness, and single pilot resource management.

The FAA has established this type of training as the standard. Consequently, the entire training system (training and checking) needs to be available to the general aviation community. This includes training tools (syllabi), PTS changes that support FITS training, FAA inspector and designated pilot examiner guidance, support materials, and training.

REMOTE AIRPORT LIGHTING SYSTEMS (RALS)

University Team:
University of Alaska Anchorage
University of North Dakota
Embry-Riddle Aeronautical University
Rensselaer Polytechnic Institute, Lighting Research Center

Challenge:

The Remote Airfield Lighting System (RALS) project was a multi-year project to complete several objectives over several phases:

(CGAR - RALS Systems continued on page 10)
• Investigated available airfield lighting technologies for a possible remote airfield application including portable and passive systems (non-powered-use A/C landing light). The team designed a prototype which gave the pilot the visual cues necessary for night landing and reduce power costs.

• Developed specifications for remote airport lighting systems that optimized performance and minimized cost/power consumption. Factors of importance included visual effectiveness, minimal energy use, low maintenance, reliable/durable.

• Completed visual studies to establish intensity, spectral, temporal, and spatial requirements for remote airfield lighting to allow pilots to locate the field, determine the orientation of the field, maintain situational awareness throughout the maneuvering to touchdown.

• Investigated the possible technologies: Lighting, to ensure that the application of lighting technology (incandescent, LED, electroluminescent, etc.) met desired performance;

• Determined power for meeting specified operational requirements; environment and the range of operating conditions, temperature, humidity, weather.

Research & Development:
The working group developed a description of the type of airfield operations in remote areas of the United States and the geographical comparisons of remote airfields that influence the lighting technologies available for implementation. The project included a description of the capabilities of current airfield lighting, and the shortcomings of current portable and permanent lighting systems and their power needs. This description limited the scope of effort to remote airfield lighting systems. The project examined the adequacy of existing systems, in terms of both navigational capabilities provided, shortfalls, and expected remaining useful life of the system to support the proposed concept of operations. Additionally, the FAA/DOT requirements and industry working group recommendations, specifications for remote airfields, and metrics for evaluating lighting technologies were examined. The focus of the lighting technology study was to ascertain the shortcomings and advantages of current portable and permanent lighting system technology and their power needs.

Results:
A final report on the long term field testing of the RALS included: ease of system installation in a more permanent location; maintenance and maintenance issues; reliability of components and system in typical weather conditions; reported system failures, reasons, and solutions; and overall impact of the system on the community.

NEXTOR - Congestion Management (continued)

Objectives:
In January, 2007, the legislation governing the High Density Rule (HDR) for regulating access to New York’s LaGuardia Airport (LGA) will expire. The Federal Government and the Port Authority of New York and New Jersey are considering a wide range of options to manage LGA congestion in the absence of the HDR. The goal of this project was to define and analyze a variety of market-based and administrative measures for managing LGA access. Special emphasis was given to investigating the use of auctions for allocating of arrival and departure slots. Focus on auctions was necessary since auctions historically have never been used for this purpose and the amount of existing research into slot auctions is relatively limited.

Methods:
The NEXTOR team included experts in economics, operations research and transportation systems. The body of knowledge on auction design, which is based on game theory and mathematical economics, was used extensively. Practical experience and experiments from other industries, e.g. telecommunications spectrum auctions, was carefully considered. The team also made extensive use of computer-based and strategic simulations and optimization models were developed for certain supporting resource allocation decisions.
Results:
The NEXTOR team recommended that some action be taken in the absence of the HDR to avoid the strong likelihood of extreme congestion at LGA. Since capacity expansion at LGA is impractical, the three general classes of approaches to mitigating congestion considered were: administrative measures, congestion pricing and auctions. NEXTOR found that market mechanisms, properly implemented, foster a vibrant air transportation business environment by encouraging new entrants, expansion into unserved markets, price competition, strengthening of smaller carriers and other characteristics of a well operating market. NEXTOR analysis compared two market-based approaches and found that a slot/auction approach has the advantage of providing a high level of control over congestion and delays. NEXTOR provided a detailed auction design and also guidelines for implementing congestion pricing.

Impact:
The aviation policy office of the FAA is preparing a Notice of Proposed Rule Making (NPRM) for LGA congestion management policies after January 1, 2007. The NEXTOR analysis is a key input into this activity. In addition, members of the NEXTOR team are carrying out a regulation evaluation for this NPRM activity.

Anticipated outcome:
Spatially-resolved characterization of the exposure and health implications of aviation-related emissions.
METRICS FOR AN AVIATION CO2 STANDARD

University Team:
Massachusetts Institute of Technology
Georgia Institute of Technology

Lead investigators:
Prof. Ian Waïtz, MIT and Prof. Dimitri Mavris, GaTech

Aircraft certification standards are among the means that can be used to incentivize commercial aviation CO2 emissions. Setting such standards requires the definition and identification of a metric (e.g., gCO2/km.kg, gCO2/pas-senger.km) and its scope of applicability (i.e., type of aircraft, reference missions, fuel mix). The use of poorly defined metrics to establish policies can create equity issues amongst stakeholders that may result in unintended reactions or behaviors. This has the potential to decrease policy effectiveness and drive the system to a different operating point than the one originally intended. Project 30’s objective is to identify robust metrics that will accurately and objectively evaluate emissions over time. First, a broad range of candidate metrics for aircraft CO2 emissions will be systematically generated. Second, the relationship of these candidate metrics to the current fleet, and the possible impacts on the future evolution of the fleet and aircraft development will be assessed. Third, potential equity issues and gaming dynamics resulting from the implementation of each of the metrics will be evaluated. Finally, interdependencies of the proposed CO2 emission metrics with other environmental objectives (i.e., NOx, noise) will be assessed.

Anticipated outcome:
Identification of a metric, or set of metrics, for potential use in the certification of aircraft and for monitoring fleet performance. Also, development of recommendations on the scope of applicability of these metrics.