U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON SPACE AND AERONAUTICS

HEARING CHARTER

Aviation and the Emerging Use of Biofuels

Thursday, March 26, 2009
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

I. Purpose

The House Committee on Science and Technology's Subcommittee on Space and Aeronautics is convening a hearing to review the status of federal and industry research and development (R&D) efforts to develop and demonstrate the safe and cost-effective use of biofuels in civil aviation. The hearing will focus on the following questions and issues:

- What research is needed to determine the optimal characteristics of both aircraft engine technologies and biofuels to minimize harmful emissions while maintaining aircraft safety and reliability and maximizing performance?
- What are the most realistic aviation biofuel options over the long term, and what will be required to achieve widespread use of biofuels in aviation?
- What steps, if any, is the federal government taking to assess the viability of biofuels for aviation or to facilitate their widespread use in aviation?
- What are the results of the recently completed aviation biofuels demonstrations?

II. Witnesses

Dr. Jaiwon Shin
Associate Administrator
Aeronautics Research Mission Directorate
National Aeronautics and Space Administration

Dr. Lourdes Maurice
Chief Scientist
Federal Aviation Administration
Environmental Lead for the
Commercial Aviation Alternative Fuels Initiative (CAAFI)

Dr. Alan H. Epstein
Vice President, Technology and Environment
Pratt & Whitney
United Technologies Corporation

Mr. Bill Glover
Managing Director, Environmental Strategy
Boeing Commercial Airplane Company

Mr. Holden Shannon
Senior Vice President of Global Real Estate and Security
Continental Airlines

III. Overview

The convergence of high fuel prices with possible caps on harmful aircraft engine emissions has encouraged the aviation community to investigate alternatives to petroleum-based jet fuels that would be safe and cost-effective—both to use and produce. In 2006, for the first time in history, fuel became the single largest component of U.S. airline operating cost. According to the Air Transport Association (ATA), while consumption by commercial aircraft has stayed steady over a seven year period at about 20 billion gallons per year, jet fuel expenses have more than doubled over that same period. The aviation industry has achieved substantial improvements in fuel efficiency since the introduction of commercial jet aircraft in the 1960s through fleet modernization, air traffic management improvements and operational changes. However, despite such improvements, expectations of increased fuel consumption from projected growth in air travel and the possibility of higher fuel prices are forcing the aviation industry to try to reduce its reliance on fossil fuels and find alternative sources of supply.

So far, alternative fuels being considered for aviation include synthetic fuels, such as those produced using a process called Fischer-Tropsch, and a number of biofuels. While synthetic fuels made from coal, natural gas and other hydrocarbon feedstock are attractive because they can be easily integrated into existing aircraft systems, such fuels do not help address climate issues and as such are viewed by some as only near-term alternatives. In contrast, biofuels produced from a wide variety of plant material are characterized as “carbon neutral” and thus may help mitigate the impact of aviation on the environment. First-generation biofuels, commonly made from fermented sugars from wheat or corn, soy beans and sunflower seeds, are generally unsuitable for aviation fuel. In addition, they compete with food crops for land and consume valuable resources, such as water and fertilized soil. If biofuels are to become successful in aviation use, they will need to avoid such competition. In addition to needing to be high in energy, safe to use and capable of working well in sub-zero

temperatures at high altitudes, biofuels for aviation must also be cost-efficient to make, suitable for production in large quantities, and burn cleanly.

Of late, there has been significant activity in the development and testing of biofuels for aviation. U.S. research in the application of biofuels for aviation is being conducted by the National Aeronautics and Space Administration (NASA); the Department of Defense (DOD); a consortium of the Federal Aviation Administration (FAA), airlines and aircraft manufacturers; and other partnerships. The airline industry views the primary benefit of using biofuels as being the enhancement of the industry's ability to reduce greenhouse gases throughout the fuels' entire life cycle.

Recent tests using various biofuel blends, including well-publicized demonstrations by several commercial partnerships, have created high expectations, both in this country and abroad. Testimony at this hearing should provide the Subcommittee with an assessment of what research and tests are being done, who is doing it, what further research is needed, and whether a timeframe for the widespread availability of biofuel for aviation can be projected.

IV. Potential Hearing Issues

The following are some of the potential issues that may be raised at the hearing:

- *What research is being conducted to validate the projected benefits of using biofuels in aviation with regards to their ability to reduce aircraft engine emissions?*
- *Is there an overall "roadmap" for conducting aviation biofuel research? Is the research performed by the federal government aligned with that conducted by the private sector? Are research results available to all?*
- *Can the development readiness of emerging biofuels be commonly characterized and measured using standard metrics?*
- *What has been learned so far from partnership demonstrations using biofuels? Are additional demonstrations planned?*
- *What research is being planned or conducted to determine the impact long-term and widespread biofuel use may have on aircraft safety, and engine performance/ maintainability/reliability? Is more research needed? In what areas?*
- *Has the recent downturn in fuel prices and in the nation's economy lessened the urgency of developing biofuels for civil aviation use?*
- *What key challenges need to be resolved before widespread use of biofuels in civil aviation can occur and what role should the federal government play?*

V. Background

Issues Associated with Biofuels in Aviation

Before biofuels can be used in civil aviation, a number of issues will need to be addressed. While not exhaustive, the following list of R&D tasks identified by NASA is illustrative of the scope of research that may be needed before widespread use of biofuels in the aviation sector can occur:

- Understanding combustion behavior for the new fuels and demonstrating long-term engine combustor performance and developing predictive models for combustor performance to enable low emission combustor design using biofuels.
- Understanding the emission characteristics of biofuels, in particular understanding the effect of biofuel constituents on the emission characteristics so that the biofuel can be optimized for reducing emissions in gas turbine engines.
- Demonstrating the biofuels' desired thermal stability under a range of temperatures encompassing high temperatures to freezing, lubricity, and no seal leakage.
- Demonstrating long-term performance of engines.
- Demonstrating long-term durability of engine components.

The setting of fuel specifications is another significant issue recognized by the aviation industry. As indicated in an Alternative Aviation Fuels Q&A by the Air Transport Association (ATA) on their website, all aircraft and engines in the United States must be approved (technically, "certificated") by the Federal Aviation Administration (FAA) for use. To quote the ATA website's Q&A:

"FAA approval is specific to the fuel that is used and the particular aircraft and/or engine type. Any deviation from the FAA approval certificate requires extensive FAA re-evaluation and approval."

FAA's role is in certifying aircraft, not in the fuel. However, FAA's certification has a tie-in to the type of fuel utilized. As stated in ATA's Q&A:

"The FAA certifies aircraft and engines. An element of this certification is a listing of the operational requirements and limitations for the specific equipment that is being certified, which includes identification of the type of jet fuel approved for use in that equipment. Therefore, the FAA specifies what type of fuel is to be used but does not certify the jet fuel itself. Separately, airline fueling manuals, with which airlines must comply by law, are based upon the jet fuel recognized by the FAA. Before FAA identifies the fuel appropriate for specific equipment, and before airlines can include the fuel requirements in fueling manuals, the fuel already has been determined to meet the specifications necessary to be safely used in the relevant equipment. In the case of jet fuel, the applicable standard

(also referred to as a "specification") is controlled by ASTM International, an organization devoted to the development and management of standards for a wide range of industrial products and processes. It is this specification that is included in FAA product approvals and required air carrier manuals. Periodically, through ASTM's established procedures, the specification is updated and revised by a specialized committee of experts. Proposed changes to the specification are carefully considered, and a formal balloting process is conducted to secure consensus before any revision is accepted. Fuels produced from alternative sources must complete this rigorous vetting process to establish that they meet the specification requirements to be safely used as jet fuel."

Alternative fuels such as biofuels will need to go through this vetting process before they can be used in civil aviation. The ATA website's Q&A further states:

"*In light of this regulatory arrangement and the fact that the specification for Jet A and Jet A-1 fuel is identified in the FAA approval certificate, no other type of fuel can be utilized at this time in the United States. Much work needs to be done before alternative fuels can safely be used in commercial aircraft operations with approval from the FAA."*

The importance of establishing alternative fuel specifications was recently highlighted in the Technical Appendix to the National Plan for Aeronautics Research and Development and Related Infrastructure. In this document, released in December 2008 by the Executive Office of the President's National Science and Technology Council, opportunities were listed where additional R&D focus may be warranted. One such opportunity relates to alternative fuels. Specifically, the document states:

"Certification in a timely manner could help enable alternative fuels for the civil aviation sector. An area of opportunity identified for potential increased emphasis is R&D efforts appropriate to promote the development of private sector capabilities to produce alternative fuel (including renewable fuels) in the large quantities necessary to conduct tests essential for the certification process. These tests include evaluation of fuel specification and fit for purpose properties, turbine hot section tests, combustor rig tests, and engine and auxiliary power unit endurance tests."

A representative of the Commercial Aviation Alternative Fuels Initiative (CAAFI), a coalition drawn from all elements of the commercial aviation industry, fuel suppliers, universities, and U.S. government agencies, recently highlighted the need for an ASTM specification for alternative fuels at a workshop held by the International Civil Aviation Organization. Dr. Lourdes Maurice, a witness at the hearing who also serves as one of FAA's representatives on CAAFI, will be able to provide further details on the challenges associated with the setting of alternative fuel specifications for aviation.

Recent Activities of Key Aviation-focused Alternative Fuels Stakeholders

There are a number of stakeholders whose views have helped shape the discussion of the technical, operational, and economic issues associated with the use of alternative fuels in aviation. Many of these stakeholders are involved in research initiatives associated with the use of alternative fuels in the aviation sector. They represent federal, industry, and global interests.

National Aeronautics and Space Administration

NASA's Fundamental Aeronautics Program has been conducting a range of research activities related to alternate aviation fuels. For example, NASA is:

- Conducting fundamental reaction studies on the Fischer-Tropsch process. Although the process is well-established, NASA believes that there is significant potential for process improvement that will increase process yield and reduce cost and reduce energy consumption during the Fischer-Tropsch process which should translate to a decrease in carbon dioxide emissions. As a result, NASA research is focusing on investigating Fischer-Tropsch reaction kinetics and developing a nanotechnology based catalyst. The process improvements resulting from NASA laboratory reactor studies will be implemented in the Air Force Research Laboratory's Fischer-Tropsch pilot plant. Scientists and researchers from NASA's Glenn Research Center are conducting this research in the Alternative Fuel Research Laboratory. Partners in this effort include the FAA, DOD, the Department of Energy (DOE), General Electric, Pratt and Whitney, Boeing and the University of Kentucky's Center for Applied Research.
- Generating a database of properties for the use of alternate fuels in aviation. The database of key properties such as thermal stability and freezing point is being generated to evaluate various alternate fuels for application to aviation uses and provides an independent assessment of these fuels.
- Modeling growth processes for biofuel feedstock. Under a non-reimbursable Space Act Agreement, NASA is partnering with Seambiotic, Inc. on a project aimed at biomass process cost reduction. The goal of the Space Act Agreement is to make use of NASA's expertise in large scale computational modeling and combine it with Seambiotic's biological process modeling to make significant advances.
- Performing engine and flight testing with alternate fuels in collaboration with Pratt & Whitney, the Air Force Research Laboratory, Aerodyne Research, FAA, and the Environmental Protection Agency (EPA). For example, NASA's DC-8 at the Dryden Flight Research Center was recently used to evaluate aircraft performance and emissions using alternate fuels. Fuels used for the ground tests were 100% synthetic fuels and 50/50 blends of synthetics and regular jet fuel. NASA believes that synthetic fuels may have fewer particulates and other harmful emissions than standard jet fuel and is attempting to validate that hypothesis. The tests used sampling probes placed

downstream from the DC-8's right inboard engine. Researchers are examining the plume chemistry and particle evolution to compare it to that of standard jet fuel.

Federal Aviation Administration

In addition to its involvement in the Commercial Aviation Alternative Fuels Initiative described later in this section, FAA may have some legislative direction related to alternative fuels in pending legislation. The agency was directed in the House-passed FAA Reauthorization Act of 2007 [H.R. 2881, Sec 914] to "*establish a research program related to developing jet fuel from alternative sources (such as coal, natural gas, biomass, ethanol, butanol, and hydrogen) through grants or other measures authorized under section 106(l)(6) of such title, including reimbursable agreements with other Federal agencies."* The bill further directed that in conducting the program, the Secretary "*provide for participation by educational and research institutions that have existing facilities and experience in the development and deployment of technology for alternative jet fuels".*

The bill also directed, within the section describing the Continuous Lower Energy, Emissions, and Noise (CLEEN) program [Sec. 505] that the FAA Administrator, in coordination with the NASA Administrator, "*enter into a cooperative agreement, using a competitive process, with an institution, entity, or consortium to carry out a program for the development, maturing, and certification of CLEEN engine and airframe technology for aircraft over the next 10 year*s." Performance objectives for the program, to be achieved by September 30, 2015 included the "*determination of the feasibility of the use of alternative fuels in aircraft systems, including successful demonstration and quantification of the benefits of such fuels."*

Legislation [H.R. 915] to authorize appropriations for FAA for fiscal years 2009 through 2012 was recently marked up by the House Committee on Transportation and Infrastructure. The direction to FAA on alternative fuels and CLEEN program is maintained [Sections 505 and 913] in that bill.

Department of Defense

Knowledge gained from research on alternative fuels being conducted by DOD, the Air Force and the Defense Advanced Research Projects Agency (DARPA) in particular, is beneficial to the aviation community since test results can be extended to commercial aircraft.

The Air Force has been investigating synthetic fuels produced using the Fischer-Tropsch process, even though it recognizes that synthetic fuels will not lead to fewer emissions of carbon dioxide, the greenhouse gas primarily responsible for global climate change. According to a recent article in Flight International, the Air

Force "*is uninterested in fuels made from feedstocks that compete with food supply or require huge amounts of land for production".* In that same article, the Air Force's Alternative Fuels Certification Office director was reported as having said that the service is planning to apply lessons learned from its Fischer-Tropsch initiative to an expanded alternative fuel development program that includes biofuels. The Air Force's involvement in alternative fuels is understandable: It has been reported that the service uses more aviation fuel than all other branches of the U.S. military combined. In 2007, this amounted to 2.5 billion gallons—about 10 percent of the total used by the entire U.S. domestic aviation-fuel market. The Air Force has set a goal of running half of its domestic operations on a 50/50 blend of synthetic and conventional jet fuel by 2016.

DARPA has also shown a growing interest in biofuels. Biodiesel Magazine has reported that DARPA's BioFuels program recently awarded two research contracts aimed at developing a scalable process for the cost-effective and large-scale production of algae oil to be processed into an alternative to JP-8 jet fuel. In one contract valued at $43 million, General Atomics will lead a team of 18 university and industrial partners in a three-year project. The contract will conclude with a pre-pilot-scale demonstration. In the second contract, Science Applications International Corp. (SAIC), along with industrial and academic organizations from Georgia, Florida, Hawaii and Texas will investigate all phases of an algae development program. It has been reported that during the first 18 months of the project, the two teams will try to get costs of algae-based oil down to $2 a gallon. It was also reported that, in the following 18 months, they will attempt to drop it to $1 a gallon and build a 30-to 50-acre demonstration facility.

Commercial Aviation Alternative Fuels Initiative

The Commercial Aviation Alternative Fuels Initiative (CAAFI) is a coalition drawn from all elements of the commercial aviation industry, fuel suppliers, universities, and U.S. government agencies, including FAA, DOE, NASA, the Air Transport Association of America (ATA), the Aerospace Industries Association (AIA), and the Airports Council International-North America (ACI-NA). CAAFI staff come from its members. For example, Dr. Lourdes Maurice, a witness at this hearing, is from FAA and serves as CAAFI's Environmental Lead. The coalition's stated goal is to enhance energy security and environmental sustainability for aviation by exploring the potential use of alternative fuels. CAAFI provides a forum for the U.S. commercial aviation community to engage the emerging alternative fuels industry and to work together, share and collect needed data, and motivate and direct research on aviation alternative fuels.

CAAFI participants meet annually to give updates on the state of alternative fuel developments, identify gaps and hurdles, and decide on next steps required in the research, development and deployment process. Work to date has included the creation of roadmaps to communicate aviation needs and solutions; disseminating flight-test information on synthetic fuels and bio-fuels; supporting

R&D on low carbon fuels sourced from plant oils, algae and biomass; understanding life-cycle environmental impacts of production and use of alternative fuels; and planning for certification in 2009 of a 50% synthetic fuel, 2010 for 100% synthetic fuel, and 2013 for bio-fuels. CAAFI's Executive Director told Subcommittee staff that the coalition is presently executing a major update to its roadmaps as a result of the Dayton workshop discussed below and projected that they would be available in the near future.

Two CAAFI initiatives relevant to the focus of this hearing are worth noting:

- At CAAFI's request, the Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER), a university, industry, and government collaborative that researches solutions for existing and anticipated aviation-related noise and emissions problems, is conducting a study on alternative fuels for commercial aviation. The study, conducted by MIT and the RAND Corporation, compares a set of potential alternative jet fuels on the basis of compatibility with existing aircraft and infrastructure, near-term production potential, near-term production costs, life-cycle greenhouse gas emissions, emissions impacting air quality, and relative merit of using the fuel in aviation versus ground transportation. The focus is on alternative jet fuels that could be commercially available in the next decade using North American resources. According to CAAFI, the report documenting PARTNER's research is under internal review and is scheduled to be released in May of this year. PARTNER is an FAA/NASA/Transport Canada-sponsored Center of Excellence.
- Last January, CAAFI held a Research & Development Team workshop in Dayton, OH. The workshop's goals were to update ongoing R&D activities and needs; develop an overall R&D roadmap and a renewable fuel feedstock roadmap; and align aviation efforts with broader government and private sector energy initiatives. The workshop was an opportunity for makers of biofuel feedstocks to meet with funding sources. Federal attendees included representatives of the Air Force; Departments of Agriculture and Energy; the National Science Foundation; EPA; FAA; and NASA. In commenting on the progress that the alternative fuels effort had made in a short time, Boeing's representative and R&D team co-lead said:

  "*We've made great strides in making aviation a central focus of alternative fuels research including 4 successful flight programs* [These flight programs are described later in this section]. *Our efforts today will help focus industry and government - suppliers and users on how to move forward to deployment on those fuels that have been tested and how to mature additional technologies*."

  One of the participants at the workshop introduced a new Fuel Readiness Level (FRL) scale to allow a common understanding of fuel development steps from R&D to fuel certification to business development. The new scale

incorporates civilian and military Technology Readiness Level (TRL) scales and was advanced as a useful tool and common language for tracking the fuel development, approval and commercialization process.

Departments of Energy and Agriculture

The U.S. Departments of Energy (DOE) and Agriculture (USDA) announced in January 2009 that they were providing up to $25 million in funding for research and development of technologies and processes to produce biofuels, bioenergy, and high-value biobased products. USDA and DOE issued a joint funding opportunity announcement (FOA) for several types of projects aimed at increasing the availability of alternative renewable fuels and biobased products. The projects, DOE and USDA said, will aim to create a diverse group of economically and environmentally sustainable sources of renewable biomass.

In commenting on the announcement, the Air Transport Association said that it was the first step in implementing provisions found in the 2008 Farm Bill that provide grants for commercial-scale biofuel demonstration projects, including those that could ultimately produce clean, homegrown, renewable jet fuel.

ATA's President and CEO added: *"This commitment to the research and development of advanced renewable fuels will allow for commercial-scale demonstration projects and other important activities that will move us closer to commercially viable, environmentally friendly alternative jet fuel. ATA and its member airlines look forward to working with the federal government to further promote the rapid development of these exciting new fuel sources."*

European Commission

In February 2009, the Office National d'Etudes et de Recherches Aerospatiales (ONERA) was chosen by the European Commission's Directorate-General for Energy and Transport as prime contractor to conduct a strategic feasibility and impact study on alternative fuels for aviation called Sustainable Way for Alternative Fuel and Energy in Aviation (SWAFEA). ONERA is leading a consortium of 19 industry and research partners representing aircraft manufacturing, air transport, oil industry, research and consulting sectors. ONERA is the French national aerospace research center and was originally created by the French government in 1946.

By providing a clearer view of the feasibility of different alternative fuel options, the SWAFEA study will also help determine research paths to prepare future European programs as well as providing a foundation for potential international partnerships extending beyond Europe, including the United States.

According to the ONERA press release announcing the program, the SWAFEA study will be carried out over a 26-month period, "*synthesizing our current*

knowledge of the different alternatives to conventional jet fuel, and issuing recommendations and a road map for their deployment in the medium term." Furthermore, the press release stated that the study "*will call on a multidisciplinary approach to integrate all issues involved, spanning technical, organizational, economic, society, environmental and geopolitical aspects. This inventory of the "state of the art" will be backed by experimentation*."

International Air Transport Association

The International Air Transport Association (IATA), representing 230 airlines that account for 93 per cent of scheduled international air traffic, released a report in December 2008 entitled "IATA 2008 Report on Alternative Fuels".

The report's findings were listed as:

- "*The potential for biomass as feedstock supply is high, even though the differences in sources and locations require multiple technologies for conversion.*
- *The oil price will stay low as long as deep recession causes more demand destruction. However, projects to develop new reserves are being stopped. Once recession ends supply-demand pressures are widely expected to take oil prices back up to the $100 a barrel level.*
- *"Peak oil" is not reached yet; the current oil reserves are high enough to supply the world for the next 42 years of oil, calculated with current consumption.*
- *The impact of the European Union emissions trading scheme is estimated to add around 5% to jet kerosene fuel costs for flights in and out of the EU from 2012.*
- *The current certification process of aviation fuels can take up to 4 phases in testing: testing on specification properties, fit-for-purpose properties, component testing and engine testing. When all the testing steps have to be performed the amount of fuel is about 1000 m3 (250.000 gallon).*
- *Some of the technologies, both in biochemical and thermo chemical conversion, are well established and have produced renewable jet fuel for testing."*

The report's recommendations were stated as:

- *"Applying biomass as a feedstock requires further analysis in sustainability criteria in order to ensure that negative nature changes from historic actions, like deforestation, are not repeated.*
- *The uncertainty in calculated greenhouse gas emissions needs to be reduced. This can be done by increasing the quality of models and performing measurements at production plants.*

- *Most of the technologies that are able to produce jet fuel from the currently available feedstock need more research and development to become commercial.*
- *The technologies that are in the end of the innovation phase require actions that reduce the risk of commercialisation.*
- *Industry stakeholders are taking various diversified actions to promote sustainable alternative fuels for aviation. It is recommended to the industry to collaborate in directly non-competitive issues to reduce the accessibility hurdles of innovators."*

International Civil Aviation Organization

The search for alternative fuels for aviation is not limited to the U.S. The International Civil Aviation Organization (ICAO), an agency of the United Nations, held a workshop in Montreal, Canada on Aviation and Alternative Fuels in February 2009 The main goals of the workshop were identified by ICAO as stimulating a dynamic exchange of views and initiating work on a global roadmap for the effective and responsible contribution of aviation alternative fuels to protecting the environment. The event, ICAO noted, was designed as a preparatory event to a world conference in November 2009 that will showcase progress and establish a road map for the implementation of alternative fuels for aviation.

In his opening remarks, ICAO's Secretary General said:

"Alternative fuels on their own are not, and never will be, the solution. They should, however, be part of a comprehensive energy strategy. There are very few low-carbon energy options for reducing aviation emissions, and alternative fuels may be the only option for large scale use in the short term. Nevertheless, the decision to develop and use alternative fuels must be an informed and responsible one, taking into account total life-cycle costs and carbon footprints."

In summarizing the workshop in his closing remarks, ICAO's Director of the Air Transport Bureau said:

"As we heard over the last three days, much progress has been achieved to date and there are high expectations for the use of more environmentally friendly drop-in alternative fuels for aviation in the short term. At the same time, research is underway with potential for a globally-available alternative fuel in the mid to long-term. However, concerted international action will be necessary to translate this possibility into a reality."

"It is clear from this workshop that aviation alternative fuels could be a win win solution in that they will reduce aviation's dependence on climate changing fossil fuels while stabilizing the economic volatility associated with conventional fossil fuels. Now, let us take another look at these alternatives.

While synthetic fuels are already or soon to be available, their environmental benefit over conventional fuels is unclear. They do however address the issue of energy security and also diversify energy sources. Biofuels, on the other hand, seem to offer environmental benefits but the production scalability issues need to be resolved. Regardless of these challenges, the importance of alternative fuels in the development of balanced and robust strategies to mitigate the impact of aviation on the environment is unquestionable."

"As is so often the case in recent industrial undertakings where the supplier and consumer base is not limited to any one country or region, global cooperation will be essential in ensuring the consistent and standardized use of alternative fuels. This is especially true of aviation which relies on a standard and consistent infrastructure across the world for its efficient operation. However, at present, the international aviation community has not achieved an integrated approach to alternative fuels. While regional and national efforts by airlines, manufacturers, and fuel producers have done an excellent job of bringing together the expertise to consider technical issues, the subject has been addressed in a fragmented way. ICAO can help with better coordination since it is the only globally recognized forum to deal with aviation."

Partnerships between Major Carriers and Airframe/Engine Vendors and Fuel Providers

Several partnerships have conducted flight demonstrations using biofuels in the past year:

- In February 2008, a Virgin Atlantic Boeing 747-400 flew from London's Heathrow Airport to Amsterdam's Schiphol Airport partially fueled by a 20-percent mix of biofuel derived from coconut and babassu oil with conventional jet fuel. Other test participants were Boeing, General Electric and Imperium Renewables. Mr. Bill Glover, a witness at the hearing representing the Boeing Commercial Airplane Company, will provide further details about this and other demonstrations involving Boeing aircraft.
- In May 2008, Jet Blue teamed with Airbus, International Aero Engines (IAE) and Honeywell Aerospace to pursue the development of sustainable biofuels derived from algae and other non-food vegetable oils for use in commercial aircraft. In addition to investigating the environmental benefits of biofuels, the partnership plans to conduct research into whether biofuels could potentially be developed that would expand payload-range aircraft performance, reduce fuel burn, and increase engine reliability and durability.
- In July 2008, Rolls-Royce and British Airways announced that they were starting a test program to research alternative fuels for the aviation industry. The companies invited suppliers to offer alternative fuel samples for testing on an engine taken from a British Airways Boeing 747. The tests will be carried out on an indoor engine test bed. After a selection of up to four alternative fuels, these fuels will undergo laboratory testing before being

delivered to Rolls-Royce for further testing. It was recently reported that the partnership encountered difficulty in securing alternative fuel samples in the desired quantities

- In December 2008, an Air New Zealand Boeing 747-400 powered by Rolls-Royce RB211 engines flew a 2-hr demonstration flight using a 50-50 jatropha and conventional jet fuel mix. The jatropha-derived fuel was supplied by Terasol Energy, which is based in India. Other test participants were Boeing, Rolls-Royce, and Honeywell subsidiary UOP.
- In January 2009, a Continental Boeing 737-800 powered by two CFM56-7B engines made a 2-hour demonstration flight at Bush International Airport in Houston using a biofuel mixture of jatropha and algae that was provided by Honeywell UOP. The test included powering the right engine with the biofuel mix, turning it off and on as well as rapidly accelerating and slowing down the plane. A borescope inspection was done on the engine using the biofuel mixture; no change in engine condition was found. This followed a November 2008 ground test of the biofuel mixture at which time fuel consumption at different power settings was measured. Among Continental's reasons for conducting a flight demonstration were helping collect needed data to support fuel qualification/certification for use by the aviation industry; showing the public that biofuel is safe and that it works; and stimulating research and development on biofuel use in aviation. Other test participants were Boeing and the engine's manufacturer, CFM. Mr. Shannon Holden, a witness at the hearing representing Continental Airlines, will provide further details on Continental's test and interest in biofuels.
- In January 2009, a Japan Air Lines Boeing 747-300 outfitted with Pratt & Whitney JT9D engines made a one hour flight at Tokyo's Haneda Airport using a mixture of camelina, jatropha, and algae. Camelina was sourced from Sustainable Oils, a U.S. based provider. Terasol provided the jatropha oil. Other test participants were Boeing, Pratt & Whitney, and Honeywell UOP. Dr. Alan Epstein, a witness at the hearing representing Pratt & Whitney, will provide further details on the test.

Sustainable Aviation Fuel Users Group

Formed in September 2008, the Sustainable Aviation Fuel Users Group brings together major airlines, Boeing, and biofuel provider Honeywell UOP with the goal of accelerating the development and commercialization of sustainable new aviation fuels. The group's charter is to enable the commercial use of renewable fuel sources that can reduce greenhouse gas emissions, while lessening commercial aviation's exposure to oil price volatility and dependence on fossil fuels. The group receives support and advice from two environmental organizations, the World Wildlife Fund and the Natural Resources Defense Council (NRDC). Airline members are Air France, Air New Zealand, All Nippon Airways, Cargolux, Continental Airlines, Gulf Air, Japan Airlines, KLM, Scandinavian Airlines System (SAS), and Virgin Atlantic. Collectively, these carriers account for over 15% of annual commercial use of jet fuel.

According to Honeywell UOP, the group has announced two initial sustainability research projects. An Assistant Professor at Yale University's School of Forestry & Environmental Studies, through funding provided by Boeing, will conduct the first peer-reviewed, comprehensive sustainability assessment of jatropha curcas, to include lifecycle CO2 emissions and the socioeconomic impacts to farmers in developing nations. Similarly, NRDC will conduct an assessment of algae to ensure it meets the group's sustainability criteria.

Algal Biomass Organization

The Algal Biomass Organization (ABO) is a trade association dedicated to the advancement of the algal biomass industry. Formed in May 2008 out of the 2007 Algae Biomass Summit, ABO's goal is to promote the development of viable commercial markets for renewable and sustainable commodities derived from algae. The organization is composed of companies, some aviation-related such as Boeing, air carriers such as Air New Zealand, Virgin Atlantic, and FedEx; along with researchers, entrepreneurs, harvesters, processors and end users of algae. Among the primary purposes of the organization, ABO cites:

- Facilitating commercialization and market development of microalgae biomass specifically for biofuels production and greenhouse gas abatement.
- Establishing cutting edge research and commercialization summits and other meeting opportunities.
- Developing quality and measurement best practices for algal biomass, products, systems technology, and econometrics.