STATEMENT OF DR. LOURDES MAURICE, CHIEF SCIENTIFIC AND TECHNICAL ADVISOR, OFFICE OF ENVIRONMENT AND ENERGY, FEDERAL AVIATION ADMINISTRATION, BEFORE THE HOUSE SCIENCE AND TECHNOLOGY COMMITTEE, SUBCOMMITTEE ON SPACE AND AERONAUTICS, ON AVIATION AND THE EMERGING USE OF BIOFUELS, MARCH 26, 2009

Madam Chair, Congressman Olson, and Members of the Subcommittee:

Thank you for the invitation to testify on "Aviation and the Emerging Use of Biofuels." I am the Federal Aviation Administration's (FAA) Chief Scientific and Technical Advisor for Environment and Energy. In that role I also serve as the environmental team leader for the Commercial Aviation Alternative Fuels Initiative (CAAFI). I am pleased to be able to speak to the Subcommittee today about biofuel (hereinafter referred to as "renewable jet fuel") activities of CAAFI.

Today's hearing is well timed. Aviation has made enormous progress in the last three years identifying and testing technologies for renewable jet fuels, and progressing toward broad airworthiness certification for the most mature of these technologies. As you may know, the FAA has the responsibility to make sure that any aircraft, aircraft engine or part, or fuel that is used in aviation is safe and performs to set standards. We have identified a number of alternative jet fuels (including renewable jet fuels) that can replace petroleum jet fuel without the need to modify aircraft, engines and fueling infrastructure (often referred to as "drop in" fuels). Compared to the other transportation sectors, aviation is, in fact, well positioned to adopt renewable jet fuels. Moreover, this effort is critical to achieving the environmental goals of the Next Generation Air Transportation System (NextGen).

In order to spur deployment of fuels with clear environmental benefits we are aggressively pursuing robust and reliable environmental life cycle analysis to quantify environmental impacts of renewable jet fuels, including air quality and greenhouse (GHG) impacts from direct and indirect land use change, feedstock production, fuel processing, transport and use in aircraft. We are coordinating this aviation effort with the

Environmental Protection Agency's (EPA) life cycle analysis through an interagency working group. Airlines and multiple fuel suppliers are developing a range of opportunities to deploy renewable jet fuels and are pursuing deployment options via incentives available from U.S. Department of Energy (DOE) and U.S. Department of Agriculture (USDA) programs on, for the first time, an equal basis with ground transportation users. And because safety is crucial to this effort, FAA is taking the certification process step-by-step to ensure that any fuels developed will meet or exceed the safety performance of today's jet fuels. FAA will also ensure, in collaboration with EPA, that any new fuels will meet or exceed emissions standards for aircraft engines.

While the aviation community has made significant strides, we have learned as we have worked on this effort, as is the case with most new technical initiatives. There are ongoing efforts now that we did not imagine at the outset. One example is the rapid pace of development and flight testing of hydroprocessed renewable jet fuels. However, it is clear there is no one "silver bullet" global process or feedstock solution. Rather there are multiple solutions, which we can pursue in an environmentally and economically viable and safe manner via regional development and deployment.

Founded in 2006, CAAFI[1] is a coalition of airlines, airports, aircraft and engine manufacturers, energy producers, researchers and U.S. government agencies (including FAA, EPA, USAF, NASA, DOE and USDA) that are leading efforts to develop and deploy alternative jet fuels for commercial aviation. Jointly sponsored by the FAA, the Air Transport Association of America, the Aerospace Industries Association and Airports Council International-North America, CAAFI has taken a comprehensive approach to the development, evaluation and deployment of alternative jet fuels. CAAFI focuses its stakeholder efforts in four key areas: fuel certification, research and development (R&D) needs, environmental impacts and costs and benefits, and the business and economics of commercialization. The goal is to promote the development of renewable jet fuels for use with today's aircraft fleet that offer equivalent or better cost compared to petroleum based jet fuel, with equivalent safety. Further, the goals are also to provide environmental improvement, energy supply security and economic development.

Promising renewable jet fuel feedstocks options may include biomass, corn-stover, and inedible crops such as jatropha and camellina, and algal oils.

In your invitation to testify, the Subcommittee asked me to specifically address the following five questions regarding emerging aviation renewable jet fuels:

1. What research is CAAFI sponsoring or coordinating to validate the projected benefits of using biofuel in civil aviation in terms of their ability to reduce engine emissions?

First I should clarify that CAAFI does not sponsor research per se. Rather we are a coalition of stakeholders that individually and collectively sponsor and coordinate research to meet CAAFI's goals. This ensures we strengthen each other's efforts and avoid duplication. One of the goals of CAAFI's environmental team is quantifying the potential for renewable jet fuels and renewable jet fuel blends to improve air quality and reduce life cycle GHG emissions. An improved environmental footprint is a critical objective of alternative jet fuels (including renewable jet fuels) for both the FAA and other CAAFI sponsors. Largely funded by FAA, the CAAFI environmental team's efforts in air quality include both the measurement of engine exhaust emissions such as particulate matter and sulfur oxides and calculating the cost and benefits of reducing these emissions with alternative fuels. The FAA funded efforts totaling $1 million in fiscal[2] year 2008 through the Partnership for AiR Transportation Noise and Emission Reduction (PARTNER) Center of Excellence focused on assessing select air quality emissions for alternative fuels including renewable jet fuels: *Emissions Characteristics of Alternative Aviation Fuels* and *Ultra Low Sulfur (ULS) Jet Fuel Environmental Cost Benefit Analysis*.[3]

The U.S. has National Ambient Air Quality Standards for particulate matter emissions and 44% of our 50 largest airports in terms of enplanements are in areas of non-attainment status for these emissions. Common to all alternative fuels under consideration is their potential to reduce particulate matter emissions. We have obtained direct measurements in in-service aircraft engines that clearly validate these benefits[4] .

Additionally, with CAAFI's support, the FAA-sponsored Transportation Research Board's Airport Cooperative Research Program (ACRP) will complete in May 2009 a handbook enabling possible investors, airlines and airports to quantify environmental and/or financial gains for alternative jet fuel (including renewable jet fuel) use at their specific airports.[5]

The consideration of the life cycle emissions from alternative fuel production and transportation must be considered when calculating environmental impacts and the CAAFI environmental team has also focused on measuring the potential to reduce aviation GHG emissions by using renewable jet fuels. For example, the FAA and the U.S. Air Force are jointly funding the development of a GHG life cycle analysis (LCA) framework through the FAA's PARTNER Center of Excellence.[6] We refer to the approach as "well-to-wake". The CAAFI environmental team endorsed the intent to develop a consistent framework in October 2008. The Intergovernmental Panel on Climate Change (IPCC)-endorsed global aviation emissions modeling tools anchor the framework on the aircraft exhaust end. To measure GHG emissions from the production end, CAAFI researchers are part of a working group (including FAA, U.S. Air Force, DOE, EPA, and university experts) that is developing best practice tools to capture the many variables associated with GHG life cycle calculation. At the present time a half dozen domestic and international alternative jet fuel producers are participating with CAAFI and can evaluate the outcomes of their specific projects using this framework.

Once completed, we will rigorously peer review the LCA framework to ensure it is based on the best science and accurately captures GHG life cycle emissions to inform the aviation industry and potential fuel producers.

2. What is the status of CAAFI's roadmap? How does CAAFI ensure that federal and private sector biofuel research is aligned?

CAAFI uses R&D roadmaps to align and communicate research needs that will define both process and feedstock maturity up to certification and subsequently through deployment. On January 27 CAAFI's R&D team, hosted by the U.S. Air Force in Dayton, OH, updated the R&D roadmaps. Participants contributing to this process included government technology investors such as the National Aeronautics and Space Administration (NASA), DOE's National Renewable Energy Labs and Energy Efficiency and Renewable Energy office, and USDA, as well as private sector investors. The resulting roadmaps define the work done to date, and what's planned or needed to support deployment of alternative aviation fuels. These updated roadmaps include milestones for maturing feedstock and production processes for renewable jet fuels. The roadmaps are currently available in draft form; stakeholders as well as government, and any other entities concerned about aviation alternative fuels, can use the roadmaps in their final form to guide investment decisions. CAAFI welcomes the Subcommittee's participation in both using and contributing to these roadmaps (see Appendix A).

3. Can the development readiness of various biofuels be commonly characterized and measured?

As a complement to communicating research needs, we also need a common definition of alternative fuels among all fuel investors and aviation consumers to determine the maturity of the variety of alternative options that are under considerations. Such a system helps to differentiate candidates in the research phase (such as those being pursued by NASA and the Defense Advanced Research Projects Agency (DARPA)), candidates ready for certification, and candidates in the deployment phase and worthy of support by private investors and public funding such as that by the USDA Rural Development program. On January 27, 2009, CAAFI introduced a risk management measuring system for alternative fuels named Fuel Readiness Level (FRL). The basis of FRL is the Technology Readiness Level (TRL) used by the U.S. Air Force, NASA and CAAFI's manufacturing sector to classify systems development maturity. FRL combines TRL with critical manufacturing readiness level (MRL) steps to characterize the readiness of alternative fuel candidates. As is the case with CAAFI's roadmaps, FRL protocols are available to the Subcommittee (see Appendix B).

4. What research is CAAFI sponsoring or coordinating to determine the impact that long-term and widespread biofuel use may have on aircraft safety, and engine performance/ maintainability/reliability? Is more research needed? In what areas?

The FAA (through CAAFI) collaborates with ASTM International, the industrial standards-setting organization, to perform the technical evaluation of potential alternative jet fuels leading to FAA airworthiness certification. The process adheres to strict rules and standards to ensure safety. The CAAFI certification team comprises core members of that body representing equipment manufacturer, fuel producer, and fuel consumer sectors. My colleague Mark Rumizen of the FAA's Airworthiness division chairs the CAAFI certification team. The certification team's goal is to facilitate fuel certification for alternative jet fuels by coordinating the fuel evaluation and specification development process with airworthiness authorities and industry stakeholders. The team is initially focused on, as noted above, "drop in" fuels. These fuels are essentially identical to conventional Jet A and transparent to the aircraft system and aviation fuel infrastructure. Equivalent operating performance and maintenance characteristics are inherent in the definition of "drop in" fuel.

Simply meeting top-level specification requirements for airworthiness (for example freeze point, flash point and energy content) is not sufficient for fuel approval. ASTM uses testing protocols developed by a special ASTM task force to ensure no changes in operating and maintenance characteristics. For example the "fit for purpose" testing puts bounds on lubricity requirements that will influence fuel system wear. Testing identifies a minimum aromatic content to ensure elastomer seals perform properly. Limits on electrical conductivity of the fuel ensure that there is no interference with cockpit instrumentation.[7]

Presently CAAFI's certification team and ASTM are completing a framework specification for synthetic alternatives to complement the petroleum-based specification. ASTM members are currently reviewing this new specification approach for approval. With the new specification, we expect a generic approval of the full range of fuels from

Fischer Tropsch (FT) processes[8] – including biomass to liquid fuels -- for use at a 50% blend level.[9] Similarly, we forecast approval for use by as early as the end of 2010 of hydroprocessed renewable jet (HRJ) fuel – from non-food biomass feedstocks such as corn stover, jatropha, camelina, halophytes and algae. This probable approval relies on recent data but may also require additional investment in research. The FAA's Continuous Low Emissions, Noise and Energy (CLEEN) program is one source for this investment. Flight tests sponsored by industry will also support the certification efforts.

5. In CAAFI's view, what are the main challenges facing widespread use of biofuels in civil aviation? What issues need to be resolved before CAAFI can project when widespread aviation use of biofuels may occur?

Speaking as a member of CAAFI, we view three areas as hurdles, as well as opportunities for future focus:

First and foremost is certification. We believe we have a path for achieving biofuel approvals at a 50% blend level over the next two years. However, approval of the blend and eventual approval of 100% renewable jet fuels may require full combustor rig and or engine tests under approval protocols. We can leverage U.S. Air Force investment in biofuel testing to cover the performance of in-use commercial engines such as on the C-17 aircraft. However, we will likely need additional testing to cover advanced low emissions combustors such as those on new commercial engines or advanced cycles such as those NASA is exploring. Full combustor rig and engine tests require as much as 250,000 gallons of fuel, which may be a significant challenge for some candidate alternative fuel producers, as well as requiring substantial research investment.

The next hurdle is accurately quantifying environmental impacts. Assessments of both air quality and GHG life cycle emissions impacts must continue to be timely and thorough as new fuel options emerge. For example, we, in collaboration with EPA, need to populate emissions prediction models with measured emissions data for emerging renewable jet fuels. Acquiring such data is empirical in nature and requires significant testing and investment. Reducing the uncertainties associated with land use changes, fertilizer use, and impacts on the quality and quantity of water resources, GHG inherent in-life cycle analyses from harvest to processing to transport and use of the renewable jet fuels, will also require significant effort and investment, and the collaboration of all stakeholders involved to ensure an agreeable and accurate framework.

The FAA's CLEEN program, noted above, as well as its NextGen investments in environment and energy research, are vehicles available to CAAFI sponsors and other stakeholders to address the certification and environmental issues. We appreciate the Subcommittee's support for these efforts.

The final hurdles are infrastructure and deployment. Aviation's dependence on high-density liquid hydrocarbon fuels for the foreseeable future is perhaps unique, unlike surface transportation modes which have other options such as electric power and lower-density ethanol fuel. Another unique characteristic of U.S. commercial aviation is that the fueling infrastructure can serve over 80% of all jet fuel used in about 35 locations, i.e. at our busiest airports. These realities of dependence and concentrated infrastructure should lead to aviation becoming a "first mover" in the deployment of alternative fuels. Aviation's circumstances are critical to its attractiveness to biofuel producers despite aviation's small market for transportation fuels relative to cars and trucks.

The recent economic slowdown has somewhat diminished the ability of conventional investment sources to quickly respond to the opportunities that aviation uniquely provides. However, FAA believes there is a need for investments in biofuel production infrastructure specific to aviation. With relatively modest investment at locations near airports which combine feedstock availability, existing biofuel infrastructure, need for air quality gains, and U.S. airlines eager to use renewable jet fuels, we believe successful production facilities can be built. Focusing sufficient investment on developing a number of success models, rather than a target percentage of fuel supply from renewable jet fuels, is likely the key to producers deploying these fuels for both the aviation industry and perhaps the nation as a whole.

The nation has often counted upon the skills of the aerospace industry to lead the way in technical innovation. Renewable jet fuels offer the opportunity to team the aerospace science and technology efforts with those of agriculture, energy, and sustainability to address the three challenges I outlined above.

Madam Chair and Members of the Subcommittee, thank you again for the opportunity to testify on how the aviation community is leading the way to develop and realize the potential of emerging aviation renewable jet fuels. That completes my prepared remarks and I welcome any questions that you may have.

---

[1] The CAAFI coalition includes 300 domestic and international stakeholder representatives: U.S. government agencies, aircraft and engine manufacturers, over 40 energy producers, many of the world's airlines, and numerous Universities.

[2] In fiscal year 2009, we expect to invest approximately $2 million in alternative jet fuels (including renewable jet fuels).

[3] More information about PARTNER is available at http://web.mit.edu/aeroastro/partner/projects/index.html

[4] Hileman, J, Ortiz, D., Brown, N., Maurice, L., and Rumizen, R., "The Feasibility and Potential Environmental Benefits of Alternative Fuels for Commercial Aviation," International Congress of Aeronautical Sciences, Anchorage, Alaska, September 2008.

[5] See *ACRP Project 02-07: Handbook for Analyzing the Costs and Benefits of Alternative Turbine Engine Fuels at Airports*. See http://www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=1585

[6] For work to develop alternative jet fuel life cycle analyses, see PARTNER Center of Excellence *Project 17: Alternative Jet Fuels* and *Project 28: Alternative Jet Fuel Environmental Cost Benefit Analysis* at http://web.mit.edu/aeroastro/partner/projects/index.html

[7] Much of the fit for purpose testing is being done by the U.S. Air Force and then shared with CAAFI.

[8] The Fischer Tropsch or F-T synthetic fuel production process is a catalyzed chemical reaction in which synthesis gas, a mixture of carbon monoxide and hydrogen, is converted into liquid hydrocarbons of various forms. This output produces synthetic petroleum replacements such as diesel and jet fuel from coal, natural gas or biomass.

[9] One FT fuel made by SASOL of South Africa is already approved for global aviation use at a 50% and 100% blend. However this approval is for one specific manufacturer, with one specific feedstock and one specific facility. CAAFI is targeting a generic specification that will enable approval of many different manufacturers, feedstocks and facilities that use this process.