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Statement of
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Before the

Subcommittee on Space and Aviation
Committee on Science and Technology
U.S. House of Representatives

Mr. Chairman and members of the subcommittee, I am Alan Epstein, Vice President of Technology and Environment at Pratt & Whitney, this country's foremost manufacturer of aircraft and rocket engines with over 70,000 engines in the field. Pratt & Whitney is part of United Technologies Corporation, a global technology corporation with a long history of pioneering innovation in aviation, space, climate control, elevators, and fuel cells. Because we power many of the world's airplanes and rockets, control climate in and move people around buildings in every corner of the globe, we are dedicated to reducing mankind's impact on climate change.

I am here to speak on sustainable aviation biojet fuels from the point of view of a manufacturer and maintainer of aircraft engines. I appreciate the opportunity to participate in this hearing which addresses one of the most promising avenues for aviation to reduce its impact on climate change.

This January was the 50th anniversary of the first commercial jet flight in the United States, a Boeing 707 powered by Pratt & Whitney engines. Since then, our jet engines have improved dramatically. The most modern engines, such as the new P&W PurePower Geared Turbo Fan engine family consumes only half as much fuel as those on the B707. However, no progress has been made on civil aviation fuels over these 50 years; today we still use the same fuel as we did in 1959.

Introduction to Biojet Fuels for Aviation

I am here to discuss how concerted action can move civil aviation toward new fuels; fuels which are benign to the environment and promote energy independence for the nation. The reason why this is an important topic is that civil aviation is both a generator of national wealth and a reflection of it. Aerospace is this nation's largest manufacturing export and provides over half a million jobs in the US. We expect the world's commercial aviation to grow at an annual rate of 4-5% averaged over the next 40 years, reflecting an increase in global wealth. The CO_2 emissions from aviation are simply proportional to amount of fuel burned, so unless we take action, they will increase as well. We anticipate that a public - private partnership in aeronautical research can continue the 2-2½% per year improvement in fuel economy we have worked so hard to achieve over the last 50 years. Replacement of old airplanes with new, much more fuel efficient models is the mechanism by which this new technology reduces environmental impact. Of course, airlines need cash and credit to purchase new aircraft. Therefore, care must be taken that proposed economic measures such as carbon trading or taxes do not drain funds from aviation that are needed to renew airline fleets with fuel efficient, climate friendly new aircraft.

Even if all new aircraft and engines were introduced into the world's fleets, it would still result in a 2-3% average annual growth in aviation CO_2. To stem this CO_2 growth over the next 40 years the world must move to a new aviation fuel. It is important to note that all of the biofuels under consideration result in the same amount of CO_2 exiting a jet engine's tailpipe, an amount no different than that of today's petroleum based fuel. The difference important to the climate is the source of the carbon in the exhaust. In the case of petroleum, natural gas, and coal based fuels, this is fossil carbon, which was removed from the atmosphere eons before the advent of humankind. The large scale release of this fossil carbon is a major factor in the current climate change concerns. In the case of biofuels, the carbon has been recently extracted by plants and is then returned to the atmosphere by the engine. This extraction-addition cycle can be repeated indefinitely without disturbing our climate. The energy for the process comes, of course, from the sun. Thus in a very real sense, biojet fuels let us convert our aircraft to solar power. The biojet fuel simply serves as a chemical battery charged by the sun.

However, there is carbon release overhead in the process. Currently, fossil fuels are used in the cultivation, transport, and processing of the bio material. This is an area ripe for improvement and innovation, so I expect this carbon overhead will decrease dramatically as, for example, we learn to increase the efficiency of sustainable biojet fuel cultivation and processing. Even at its current state, biojet fuels add much less total carbon to the atmosphere than do petroleum based jet fuels.

There are many practical considerations of capital requirements, manufacturing capacity, and logistics, which when combined with the imperative for relatively near term action on climate change mean that any new fuel should be a drop-in fuel. By drop-in we mean a fuel we can distribute and use without modification either to fuel distribution channels such as the pipelines and the tank farms or to airplanes and engines. For many of the same reasons, the biojet fuels must also be mixable with current jet fuels in arbitrary ratios. We now know that all these requirements are technically feasible. My following comments are offered in the context of drop-in biojet fuels.

With this as background, I will discuss what we have learned about biojet fuels for aviation and where we hope to go. Specifically I will touch on lessons learned in our research, ground, and flight testing.

What We Have Learned From Recent Flight Tests

While laboratory testing is very useful, since safety is our primary concern in aviation, I cannot overemphasize the importance of full scale ground and flight testing. Pratt & Whitney has tested biofuel blends in a variety of engine sizes ranging from those powering small business jets up to the Boeing 747. These tests revealed no negative effects on engine operations or their performance characteristics. Indeed, emissions measurements with pure biojet fuels showed that emissions of regulated particulates in the exhaust were reduced compared to those from conventional fuels. However, those gains were largely eliminated when we diluted biojet fuel with appreciable amounts of conventional fuel.

Preliminary results from the recent January 2009 flight tests on a Pratt & Whitney powered Japan Airlines Boeing 747 are that the mix of 2nd generation biojet fuel and conventional fuel performed as expected, with no impact on performance and nothing of note observed in the post flight engine inspection. This result is another encouraging step toward approving biojet fuels for aviation applications. This flight test is particularly noteworthy because of the heterogeneous composition of the biojet fuel feedstock used - including camelina, jatropha, and algae. This shows that that biojet fuel can be processed properly from a variety of feedstocks; that such fuels can be mixed with each other and conventional fuel; and that aviation need not bet on a single source of fuel. Together this implies that biojet fuels can be a robust technical and commercial solution to aviation's CO_2 challenge.

Pratt & Whitney is working closely with the engine/airframe/equipment/fuel supplier community to harness the lessons learned in recent flight and ground tests of commercial aircraft and engines to establish the understanding and data base necessary to support the certification of biojet fuels for civil and military operations. We are sharing this information as needed under the auspices of DoD and the American Society of Testing and Materials (ASTM), which define the specifications for aviation fuels in this country. The community is benefiting greatly by the experience gained in recent years from the USAF sponsored efforts to certify alternative fuels made with the decades-old Fischer-Tropsch process. The primary motivation was DoD's desire for diversification of the US energy supply to foster energy independence. Last year, Pratt and Whitney approved the use of these fuels in all non-afterburning P&W military engines (some of which are variants of commercial engines) and we expect to approve them for afterburning fighter aircraft by the end of this year. The climatic impact of these fuels can be significantly reduced if carbon sequestration or biomass is used in their production. Fischer-Tropsch fuels made with only biomass feedstock is one class of biojet fuel. The experience of certifying these fuels, the first all new fuel in decades, has taught the aviation community how to streamline the approval process such that it is now feasible to certify a biojet fuel within the next 2-3 years.

The next flight test demonstration with P&W involvement is the Jet Blue/Airbus/IAE (International Aero Engines)[1] flight test scheduled for next year using a

[1] International Aero Engines (IAE) is a collaboration of Pratt & Whitney/Rolls-Royce/MTU/Japan Aerospace Corp which supplies the V2500 series of engines for Airbus A320 family aircraft

blend of 3rd generation biojet fuel feedstocks. To our knowledge this will be the first flight test using only 3rd generation feedstock. In addition to generating data on an advanced type of biojet fuel, this demonstration will add value by broadening the experience base to include aircraft-engine types which have yet to fly with biojet fuels. This helps the industry to evaluate if there are less obvious or overlooked elements in the complex fuel systems of modern airplanes which might be affected. Also, the total flight time on biojet fuels is quite limited at the moment, so that each additional test flight helps to build confidence. Since safety is the predominate concern for aviation, the value of test data and flight experience cannot be underestimated.

Other activities

Pratt &Whitney is leading an international consortium which includes universities, government researchers, and biojet fuel suppliers looking at sustainable biofuels, specifically as applied to small gas turbine engines that power general aviation, business, and commuter aircraft.

One result of research at Pratt & Whitney is the realization that an advanced engine can be designed for improved performance if we could be assured that all aircraft fuel consisted in large measure of biojet fuel. By improved performance, we mean better fuel efficiency and lower engine weight. For example, the improved heat capacity of the bio fuel lets us reduce or eliminate radiators and their attendant weight and drag penalties. (The irony of increasingly efficient aircraft engines is that it becomes more difficult to reject waste heat.) There are two major constraints on realizing such improved performance. First, the engine must be expressly designed for biojet fuel or a biojet-conventional fuel mix. There is no performance gain from biofuels burned in current engines. Second, biofuel must be a substantial fraction of the fuel in the airplane, 25% or more. However, it may be several decades before biojet fuels are available in the tens of billions of gallons per year this implies, so that we are a ways off from being able to exploit some superior biofuel properties in our engine designs.

Our confidence as an industry in defining appropriate, formal standards for a drop-in biojet fuel is quite high and tests to date indicate that biofuels can be produced to meet appropriate standards. While we do not expect such fuels to affect engines' economic life, additional testing would be wise. Endurance tests are part of the normal development process for new engines and materials and would be recommended in this process. Also, once biojet fuels are deployed into commercial service, it would be prudent to institute in-service evaluations which periodically examine engines as they age. This is typically done when designs are changed or new materials are introduced. Funding for such tests and evaluations has yet to be identified.

It is important to note that the activities outlined above are not what we regard as research. The research required to introduce biofuels to civil aviation has been done, there are no unanswered scientific questions. What is required is a modest amount of straightforward engineering development. From the propulsion provider's point of view, all that is needed to move biojet fuel into civil service are a few more tests, documentation, and action by the approving bodies. Of course, you also need commercial quantities of certified, sustainable biojet fuel.

What Else Is Needed

Given concerted action, approval and certification of biojet fuels for civil aviation can be completed with the next 2-3 years. Then, biofuels meeting the approved specifications can be legally used in civil aviation. At that point, all you need is commercial quantities of biofuel. Therefore, the challenges remaining are not in the realm of the aeronautical or propulsion engineer. Once the aviation supplier community completes its approval of biojet fuel, the remaining questions and challenges belong to the business community, to bio and chemical engineers, to ecologists, and to lawmakers. The growth of the civil aviation biofuel market will depend on such factors as:

- The cost of the biojet fuel must reflect the value it brings to the purchaser, the airlines in the case of commercial aviation. In other words, biojet fuel must be cost competitive with petroleum based fuels, all things considered. Passing on increased airlines costs to consumers has not worked well in the past.
- Capital must be invested in the biojet fuel production chain. At the moment capital is in short supply, but we all hope that this is only a short term challenge. The near term formal certification of a biojet fuel standard should help to encourage investment.
- Authoritative, peer-reviewed quantitative research is needed to establish the carbon footprint of various biofuels and document their sustainable nature. This will be an ongoing process and should be supported by governments in independent organizations such as universities.

Innovation has been a mainstay of the long term increase in US productivity. Aviation biojet fuel is an area ripe for innovation, in technology and in business. We see significant opportunities for technical advancements in such areas as feedstock production to increase crop yields and decrease freshwater requirements in order to reduce cost and improve sustainability. Also, there is synergy with military fuel requirements and markets to foster US energy independence.

All things considered, it is reasonable to anticipate that several percent of the world’s civil aviation fuel may be supplied by biological sources by the end of the next decade.

Pratt & Whitney is bullish on biojet fuel for aviation. Simply put, drop-in, sustainable aviation biojet fuels are an excellent idea. They will reduce aviation’s CO_2, while diversifying our fuel supply and promoting energy independence. Combined with continuing technical innovation in aircraft and engines, we see sustainable biojet fuels as enabling the growth in civil aviation that is critical to the nation’s and the world’s economic growth.

Thank you for permitting me to address this important topic.

Alan H. Epstein

Vice President
Technology & Environment

Alan Epstein is responsible for Pratt & Whitney's long-term technology and environmental strategy. Alan joined the company in August 2007, after a distinguished 30-year career with Massachusetts Institute of Technology (MIT), where he was R.C. Maclaurin Professor of Aeronautics and Astronautics, and Director of the Gas Turbine Laboratory.

Alan is leading Pratt & Whitney's efforts to identify and evaluate new methods to improve engine fuel efficiency and reduce noise and combustion emissions for all new Pratt & Whitney engines. Alan will also provide strategic leadership in the investment, development and incorporation of technologies that reduce the environmental impact of Pratt & Whitney products and services. In addition, Alan will also be responsible for validating Pratt & Whitney's technology and environmental strategy with customers, industry representatives and government agencies.

For more than 30 years, Alan has served on numerous government advisory committees and was an active consultant and advisor to industry and government on topics ranging from gas turbine engineering, power and energy, to strategic planning.

He was an author of the Intergovernmental Panel on Climate Change (IPCC) report on aviation and the environment, has been published in more than 120 technical publications, and has given more than 90 plenary, keynote and invited lectures around the world. He is a member of the US National Academy of Engineering and a fellow of the American Institute of Aeronautics and Astronautics and of the American Society of Mechanical Engineers.

Alan received his Ph.D., M.S. and B.S. degrees from the Massachusetts Institute of Technology in Aeronautics and Astronautics.