Statement of

R. John Hansman, Jr.
T. Wilson Professor of Aeronautics & Astronautics and Engineering Systems
Director, MIT International Center for Air Transportation
Massachusetts Institute of Technology

before the

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

March 24, 2021

Chairman Beyer and Members of the Committee:

Thank you for the opportunity to comment on *R&D Pathways to Sustainable Aviation*. I am a Professor of Aeronautics and Astronautics at the Massachusetts Institute of Technology. I Chair of the FAA Research and Development Advisory Committee (REDAC) and am also Co-Director of the FAA Center of Excellence for Alternate Jet Fuels and the Environment (ASCENT). I should note that while my testimony is informed by my participation in the REDAC and ASCENT, due to time constraints my comments have not been coordinated with my colleagues so I am speaking as an individual today.

The impact of aviation on climate change is an increasing concern for the air transportation community. While aviation represents only 2-3% of anthropogenic Green House Gas (GHG) emissions they occur higher in the atmosphere where they have a stronger impact than ground based emissions. Aircraft can also influence atmospheric warming through contrails from water vapor emissions. In addition to climate level impacts, aviation sustainably also includes considerations of the impact on local communities near airports in terms of noise, and emissions of small particles, nitrous oxides (NOX) and other landing and takeoff.

Addressing and improving the sustainability of aviation is a critically important to the nation and requires investment in Research and Development. Aviation is important both in terms of its direct, indirect, induced and catalytic economic effects but also through enabling international collaboration which will be critical to addressing global level climate change phenomena. Improving the environmental performance of our aircraft and operations are also an important competitive factor as the rest of the world increases its focus on environmental performance.

There is growing interest in from airlines, other operators and manufacturers in improving the sustainability of their operations in response to public perception and growing market pressure.

I will briefly discuss some of the important R&D needs below and frame the discussion in terms of the likely timeframe that this R&D would have impact.

Understanding and Modeling Environmental Impacts of Aviation

In order to inform policy and prioritize R&D in environmental mitigations it is important to understand the full systems level and life cycle impact of adverse aviation mechanisms. This requires research on aviation environmental impact mechanisms as well as modeling at a systems level. There are models such as the FAA Aviation Environment Design Tool that do a good job at representing well established mechanisms of fuel burn, emissions and noise but these should be enhanced and expanded to include mechanisms such as aviation induced cloudiness as well as full life cycle impacts and system level effects.

Aviation also provides a platform to monitor and forecast key climate change risks. The global aviation system continuously probes the global atmosphere and operational flight data can be used to identify change signatures. Focused airborne monitoring systems such as the stratospheric solar electric observing platform being developed by Harvard and MIT can be used to monitor key risks such as Antarctic and Greenland ice breakup, tropical storm evolution, wildfire risk and convective storm driven ozone depletion over the US.

Near Term Mitigations (0-5 years)

Sustainable Aviation Fuels (SAF) and environmentally focused operations represent the most significant opportunities for near term mitigation as they can be implemented in the existing fleet of aircraft. There has been significant interest in “drop-in” SAFs which can be used in current aircraft engines as a direct replacement for fossil fuels. Currently SAF must be blended with traditional fuels to a maximum of 50% SAF due to concerns about low aromatic content and fuel system seals. There is general consensus in the SAF community that research should be done to enable 100% SAF as a near term mitigation. Research is also required to scale up and enable new SAF pathways including “electro” fuels and “bio” fuels considering the full life cycle impacts.

R&D to support more environmentally efficient operations is also a near term mitigation opportunity. Most environmental impacts scale with fuel burn so efforts to improve fuel efficiency have compounding GHG and emissions benefits. Since most fuel is burned during the cruise phase of flight, efforts to allow with more flexible ATC routing in high altitude sectors and oceanic airspace and better flight planning including contrail avoidance will have the greatest impact. At lower altitudes environmentally focused operations have the potential to reduce noise impacts and local air quality impacts during approach and departure.

Mid Term Mitigations (5-20 years)

New aircraft and propulsion systems with significantly lower environmental footprints will play an important role in sustainable aviation. The long time to develop and certify these aircraft and the even longer time to replace the active fleet make this a mid-term or later strategy. As the NASA N+3 program demonstrated, game changing reductions in fuel burn, NOx emissions and noise are possible with innovative transport aircraft and propulsion system configurations. Federal R&D will be critical to accelerating and enabling the transition from the current from current tube and wing aircraft configuration.

The R&D goal should be to enable and de-risk innovation and the transition to significantly cleaner aircraft. This should be focused at both the fundamental research level and at providing the processes and basis for certification and operational approval of fundamentally new aircraft. There is a role for demonstrator aircraft programs if they enable broad innovation and risk reduction but they need to be more than simple demonstrations of a single concept.

Electrification may also play a role as a mid-term mitigation but full electric aircraft will be limited in range and payload to levels similar to automobiles due to the limitations on battery specific energy (energy per unit weight) which are particularly important for aircraft. Development of ultra-high specific energy batteries focused on aviation would enable a broader range of electrification but need to satisfy safety concerns and have a sustainable life cycle including battery disposal.

Hybrid-electric propulsion (fueled with SAF) may be have a role in some aircraft if the hybrid-electric system can “buy its way onto the airplane” through increased performance or fuel efficiency.

Sustainable Aviation Fuel will continue to be important in the mid-term and research to assure the ability to scale SAF production will be important as aviation will be competing with other energy users for sustainable fuels. This will likely include increased use of “electro” fuels and development of scalable bio feedstock pathways that do not compete for food or water resources.

Far Term Mitigations (20+ years)

The ultimate objective of sustainable aviation should be a fully decarbonized aviation system. This implies that the future aviation system will need to source all its energy from sustainable electric energy. This energy will be carried on future aircraft either in batteries or advanced “electro” SAFs. One attractive fuel is hydrogen as it is simpler to generate from electricity than “drop in” electro SAF which requires adding carbon into the fuel.

Hydrogen has long been considered as an aviation fuel due to its very high specific energy but has not been practical due to a number of challenges including safety, aircraft design challenges due to fuel volume or pressure, and lack of a hydrogen distribution infrastructure which is why this would be a far term mitigation. If hydrogen fueled aircraft become practical, they will have the highest impact on long haul flights which consume a large fraction of aviation fuel and have a limited set of airports which would require a hydrogen refueling infrastructure. Enabling R&D for hydrogen would consider both combustion and fuel cell approaches and would address safety concerns like fuel inerting to prevent explosions from lighting strikes or electrical shorts. In addition the potential impact of hydrogen fuel on other climate change mechanisms need to be investigated. For example hydrogen based propulsion will generate water vapor and the contrail behavior of hydrogen based propulsion aircraft are unknown.

I have only scratched the surface of what needs to be done. I am encouraged that the Committee is addressing this important issue which will become a dominant issue driving air transportation. I am happy to answer any questions you might have.

R. John Hansman is the T. Wilson Professor of Aeronautics & Astronautics MIT, where he is the Director of the MIT International Center for Air Transportation. He conducts research in the application of information technology in operational aerospace systems. Dr. Hansman holds 6 patents and has authored over 250 technical publications. He has over 5800 hours of pilot in-command time in airplanes, helicopters and sailplanes including meteorological, production and engineering flight test experience. Professor Hansman chairs the US Federal Aviation Administration Research Engineering & Development Advisory Committee (REDAC) as well as other national and international advisory committees. He is a member of the US National Academy of Engineering (NAE), is a Fellow of the AIAA and has received numerous awards including the AIAA Dryden Lectureship in Aeronautics Research, the ATCA Kriske Air Traffic Award, a Laurel from Aviation Week & Space Technology, and the FAA Excellence in Aviation Award.