COMMITTEE ON AVIATION ENVIRONMENTAL PROTECTION (CAEP)

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Agenda Item 5: Future work

UPDATE ON U.S. AVIATION ENVIRONMENTAL RESEARCH AND DEVELOPMENT EFFORTS

(Presented by the United States)

SUMMARY

Under the auspices of the Next Generation Air Transportation System (NextGen), the U.S. has adopted a five-pillar strategy to effectively address aviation environmental impacts. This strategy is designed to characterize issues and problems, develop well informed solutions and manage their effectiveness to meet environmental targets in a verifiable manner. The elements of this five-pillar strategy are: (1) advance scientific understanding and improve integrated noise, emissions, and fuel efficiency analyses capability; (2) advance and accelerate maturation of clean, quiet, and energy efficient aircraft technologies; (3) develop and qualify aviation alternative fuels; (4) develop and implement clean, quiet, and energy efficient operational procedures; and finally (5) policy, environmental standards and market-based options. These efforts, though focused on domestic issues, also support the work program of CAEP. This paper provides CAEP Members and Observers a summary of the progress being made in the various areas.

1. INTRODUCTION

1.1 Aviation must have a reliable, affordable, and environmentally-efficient energy supply as well as an effective and balanced approach to simultaneously address aviation environmental issues related to noise, air quality, and climate change impacts in a cost-beneficial manner and considering potential tradeoffs in order to support continued growth. Despite the recent volatility, the commercial aviation market is expected to recover and continue to grow. Therefore, aviation environmental impacts could increase in the future in the absence of effective mitigation measures. Particularly for air quality and climate change human health and welfare impacts, aviation's contribution may also increase relative to other sources if emissions of air pollutants from non-aviation sources decrease at a faster rate. Independent of its growth, aviation-related environmental impacts, particularly for noise and air quality, are expected to increase as well due to an increase in human exposure caused by projected growth in population and urbanization.

1.2 Addressing aviation environmental concerns is also important given more stringent environmental standards and policies. For example, the U.S. national ambient standard for an 8-hour average ozone concentration has been reduced from 80 ppb (parts per billion) to 75 ppb and more stringent standards are being considered for ambient levels of nitrogen and sulfur oxides.

1.3 There are not only potential environmental tradeoffs and interdependencies but also economic consequences associated with each solution designed to mitigate environmental impacts. Also, there is a range of time horizons associated with aviation noise, air quality and climate impacts. For example, similar to those from other sources, CO_2 emissions from aircraft have an average lifetime more than 100 years whereas lifetime of aircraft non-CO_2 emissions and their byproducts, including contrails, range from minutes to years. Therefore, there is a need for a multi-faceted approach as there will not be one solution that can uniquely address all aviation environmental concerns. Also, there are different levels of benefits that can be realized from various solution sets despite similar dedicated levels of effort and resources.

1.4 Under the auspices of the Next Generation Air Transportation System (NextGen), the U.S. has adopted a five-pillar strategy to effectively address aviation environmental impacts. This strategy is designed to characterize issues and problems, develop well informed solutions and manage their effectiveness to meet environmental targets in a verifiable manner. The elements of this five-pillar strategy are: (1) advance scientific understanding and improve integrated noise, emissions, and fuel efficiency analyses capability; (2) advance and accelerate maturation of clean, quiet, and energy efficient aircraft technologies; (3) develop and qualify aviation alternative fuels; (4) develop and implement clean, quiet, and energy efficient operational procedures; and finally (5) policy, environmental standards and market-based options.

2. ADVANCE SCIENTIFIC UNDERSTANDING AND IMPROVE INTEGRATED ENVIRONMENTAL ANALYSIS CAPABILITY

2.1 Characterization of the problem and comprehensive understanding of tradeoffs and interdependencies of aviation as an integrated system is critical so that appropriate targets for environmental goals and well informed cost-beneficial solutions can be developed and implemented.

2.2 Even though noise and emissions originate from the same aircraft source, their related environmental and human welfare impacts are distinctly different. There are also various levels of uncertainties associated with each impact. Therefore, it is important to characterize these impacts and develop corresponding metrics, including approaches to interrelate the various impacts, so that their reduction targets can be developed.

2.3 Aviation air quality and climate impacts are related to direct engine emissions and their atmospheric evolution. Therefore, it is important to characterize the inventory of direct emissions, including speciation profiles, particularly for hydrocarbons, at the engine exit plane. Atmospheric evolution of direct emissions of air pollutants lead to the additional formation of air pollutants such as particulate matter and ozone, both of which contribute to air quality and climate impacts. Therefore, environmental impacts of these additional pollutants also need to be considered while developing overall strategies for reducing aviation emissions and their associated impacts.

2.4 Efforts to better characterize aviation emissions are coordinated through an Aviation Emissions Characterization (AEC) Roadmap, with participation from national and international stakeholders. This approach has been instrumental in coordinating and advancing scientific research activities. The AEC Roadmap brings researchers and stakeholders together to plan, conduct and share the latest developments in the field and coordinate research activities towards the common objective.

2.5 To date, research conducted by the Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER) (an FAA, Transport Canada and National Aeronautics and Space Administration (NASA)-sponsored Center of Excellence) has clearly demonstrated that aviation emissions-related air quality changes and health impacts are mainly due to volatile particulate matter formed due to physical and/or chemical transformations of gaseous precursor (NOx, HC, and SOx) emissions at temperatures lower than the exit plane temperature, followed by non-volatile particulate matter emissions that exist at gas turbine engine exit plane temperature and pressure conditions. Health impacts of ozone, a secondary pollutant formed from gaseous nitrogen oxides and hydrocarbon precursors, are relatively very low as compared to health impacts due to incremental change in particulate matter.[1] These findings are consistent with the recommendations of the 2007 CAEP workshop on 'Assessing Current Scientific Knowledge, Uncertainties and Gaps in Quantifying Climate Change, Noise and Air Quality Aviation Impacts'.[2]

2.6 Recent research also shows that air quality impacts of aviation emissions are not just 'local' in nature. Associated health impacts due to aviation emissions are regional and potentially extend globally if non-LTO (landing and takeoff cycle) aircraft emissions are also included in air quality and health impacts analysis. Presently, PARTNER research is investigating the extent to which aircraft cruise emissions impact surface air quality.

2.7 Given the role of aircraft sulfur oxides emissions on surface air quality and the potential of lowering overall sulfur oxides emissions of aircraft by the use of inherently low sulfur alternative aviation fuels, research efforts are seeking to quantify environmental benefits of lower fuel sulfur content. PARTNER is undertaking a study to assess the costs and benefits of lower sulfur fuels. An information paper (CAEP/8-IP/32) provides an update on the status of this effort.

2.8 Ongoing PARTNER air quality research has shown that future health impacts due to aviation emissions could be even higher if future emissions and population levels are held at the corresponding present levels. This is primarily due to changes in background air quality condition that increase the relative contribution of aviation emissions to air quality.

2.9 Noise impacts continue to be a major aviation environmental concern to communities in the vicinity of airports. The FAA, with input from domestic and international stakeholders, is in the process of developing a systematic Aviation Noise Research Framework (ANRF) similar to the AEC described above to better characterize noise and related impact pathways in order to better inform mitigation options. This framework will be based on the latest state of knowledge on aircraft noise,

[1] Ratliff, G. et al., Aircraft Impacts on Local and Regional Air Quality in the United States. Final report of PARTNER Project 15. October 2009. Report No. PARTNER-COE-2009-002 (http://web.mit.edu/aeroastro/partner/reports/proj15/proj15finalreport.pdf)

[2] Assessing Current Scientific Knowledge, Uncertainties and Gaps in Quantifying Climate Change, Noise and Air Quality Aviation Impacts Workshop - Final Report of the ICAO CAEP Workshop, 29 October to 2 November 2007 (http://web.mit.edu/aeroastro/partner/reports/caepimpactreport.pdf)

impacts and metrics. It will identify gaps in current capabilities to develop and implement a research agenda.

2.10 The ANRF will focus on six research areas: (1) quantification of potential noise impact on health and welfare in noise compatible areas; (2) investigation of the basis for establishing significant noise impacts for airport communities in terms of the Day-Night Average Sound Level (DNL) metric; (3) analysis of noise impacts on national park and wilderness areas; (4) characterization of noise propagation in all regimes of aircraft operations and their impacts on the surface; (5) development of acceptability standards and noise impacts of supersonic and future unconventional aircraft; and (6) definition of the social cost of aircraft noise impacts relative to other aviation environmental impacts.

2.11 To develop the ANRF, the FAA has convened several international workshops focused on specific areas such as sleep disturbance, annoyance, and effects on children's ability to learn. Initial research activities under this ANRF are expected to be implemented later this year. These activities will build upon ongoing noise-related studies on sleep disturbance, noise health impacts, and trends in noise exposure and acoustics factors that contribute to annoyance being conducted by PARTNER.

2.12 Aviation climate impacts are the area of most growing concern and largest uncertainties. The FAA, with support from the U.S. Climate Change Science Program and its participating federal agencies (NASA, National Oceanic and Atmospheric Administration, Environmental Protection Agency and Department of Energy) has developed the Aviation Climate Change Research Initiative (ACCRI) with a goal to advance scientific understanding for well-informed decision-making. The ACCRI program is designed to understand and quantify climate impacts of aircraft emissions and to develop improved estimates of regional and global climate impacts with quantified uncertainties for current and projected aviation scenarios under changing atmospheric and climate conditions. Another key focus of ACCRI activities will be on development and evaluation of metrics to interrelate various non-CO_2 climate impacts with each other as well as with those of CO_2.

2.13 With scientific input from national and international aviation climate change research experts, as compiled in the ACCRI report on the Way Forward and subject-specific white papers[3], the ACCRI program has embarked on the next step of its activities. Under a multi-year program, eight teams of international researchers were recently selected through a competitive process to support solution-focused research projects, with the responsibility to deliver realistic outcomes to inform decision-making. The thrust of the ACCRI program is distinctly different from those of other aviation climate impact research efforts. The research teams will apply multi-models, multi-sets of observation data and various teams. The ACCRI program will assess the aviation climate impacts within the interactive atmospheric modeling system framework considering dynamical, radiative, chemical and microphysical feedbacks. These feedbacks modify not only the magnitude of aviation climate impacts but also those due to background atmosphere.

2.14 To evaluate existing and expected future advanced aircraft technologies, develop reliable estimates of full flight fuel burn, develop inventories of aviation noise and emissions at the source level, and perform integrated analysis of aviation environmental impacts guided by the above listed extensive portfolio of scientific research, the FAA continues to develop a comprehensive suite of models, comprising of the Environmental Design Space (EDS), the Aviation Environmental Design Tool (AEDT) and the Aviation Portfolio Management Tool (APMT).

[3]Aviation Climate Change Research Activities (http://www.faa.gov/about/office_org/headquarters_offices/aep/aviation_climate/)

2.15 These tools are being used to assess aviation environmental impacts and providing guidance on actions needed for and benefits derived from the implementation of mitigation measures. For the first time, the AEDT is being utilized to develop an integrated inventory of noise and emissions at the source level. In addition, these aviation environmental analysis tools are presently being used for CAEP and U.S. NextGen environmental analysis and to support research on emerging aircraft technologies. Two information papers (CAEP/8-IP/29 and CAEP/8-IP/30) provide results from application of APMT for CAEP NO_x stringency analysis. Also, CAEP/8-IP/35 provides an update on how the EDS tool is being used for assessment of aircraft technologies that are being pursued under the FAA and NASA's research programs.

2.16 Comprehensive assessment is an integral part of the development of these tools not only for transparency but also to establish confidence in performance, credibility, and operational efficiency. Once fully mature, the integrated suite of these tools will be capable of characterizing and quantifying the interdependencies among aviation-related noise and emissions, impacts on health and welfare, and industry and consumer costs with associated environmental benefits under different policy, technology, operational, environmental standards and market-based scenarios.

2.17 Implementation, management, and verification of environmental mitigation solutions are all critical to ensure that their intended outcomes are realized to meet environmental goals and targets. Therefore, the FAA is developing and implementing a NextGen Aviation Environmental Management System (EMS). NextGen EMS is necessary to quantify impacts, measure progress towards meeting the aviation environmental goals and targets and to enable mitigation solutions and ensure their effectiveness.

3. ADVANCE AND ACCELERATE CLEAN, QUIET, AND ENERGY EFFICIENT AIRCRAFT TECHNOLOGIES

3.1 Advances in engine and airframe technologies have been traditionally instrumental in reducing the aircraft noise and emissions at the source level and increasing aircraft fuel consumption efficiency. To accelerate maturation of promising clean, quiet, and energy efficient aircraft technologies from Technology Readiness Levels (TRL) 3-4 to TRL 6-7 and to advance sustainable alternative fuels, the FAA has recently launched the multi-year Continuous Lower Energy, Emissions, and Noise (CLEEN) technology program.

3.2 The CLEEN program is a federally-funded effort with equal investment from the industry. The CLEEN program has selected proposals on the competitive basis and contracts are being awarded. The goals of the CLEEN program are consistent with the near–term (less than five years) U.S. National Aeronautics research and development goals for environment and energy.[4] The effort is complemented by efforts by NASA's efforts, most notably the recently launched Environmentally Responsible Aviation (ERA) efforts.

[4]National Plan for Aeronautics Research and Development and Related Infrastructure (2007), published by Aeronautics Science and Technology Subcommittee, National Science and Technology Council, (http://ostp.gov/galleries/default-file/Final%20National%20Aero%20RD%20Plan%20HIGH%20RES.pdf).

4. DEVELOP AND QUALIFY SUSTAINABLE AVIATION ALTERNATIVE FUELS

4.1 High fuel prices, ensuring sustained supply, and the need to mitigate aviation emissions environmental impacts are motivating factors for speedy exploration and fusion of sustainable alternative jet fuels.

4.2 The FAA, the Aerospace Industries Association (AIA), the Air Transport Association (ATA), and the Airport Council International-North America (ACI-NA) have jointly formed the Commercial Aviation Alternative Fuels Initiative (CAAFI, www.caafi.org). CAAFI seeks energy security and environmental sustainability for aviation by promoting the development of alternative fuel options that offer equivalent levels of safety and compare favorably with petroleum-based jet fuel on cost and environmental basis, with the specific goal of enhancing the security of energy supply. CAAFI, as a coordination forum for aviation alternative fuels activities, represents a global public/private coalition of all leading stakeholders in the field of aviation – to build relationships, share and collect data, identify resources, and direct research, development and deployment of alternative jet fuels.

4.3 CAAFI comprises four panels on (1) research and development (to accelerate research and development efforts on advanced feedstock and conversion processes to increase the range of fuel options, reduce cost, and increase quality); (2) environment (to ensure environmental sustainability of alternative jet fuels via quantification of "well to wake" greenhouse gas lifecycle and air quality impacts); business and economics (to enable aviation as a "first mover" use of alternative fuels by supporting production and deployment of new fuels); and (4) certification and qualification (to enable supply of alternative jet fuels by expediting new fuel certification). CAAFI and all its four panels meet annually to address critical needs essential to the development and deployment of alternative fuels in aviation using discipline specific roadmaps which serve as a means of communication among stakeholders.

4.4 The FAA is presently funding a number of projects through PARTNER to investigate life-cycle analysis for a range of alternative fuels and to explore options for "drop-in" and "renewable" aviation alternative fuels and their production outlook. An information paper (CAEP/8-IP/34) provides a status update of Alternative Fuels Emissions Life Cycle Analysis. As noted above, the CLEEN program also comprises a component focused on advancing alternative aviation fuels including efforts to support certification, environmental analysis, and operational demonstrations.

4.5 The CAAFI Certification and Qualification team is focused on quantifying and certifying aviation alternative fuels, particularly "drop in" candidates that can replace existing petroleum derived jet fuels with no equipment modification. CAAFI leadership helped facilitate the recent ASTM International synthetic fuel standard, D7566, "Aviation Turbine Fuel Containing Synthesized Hydrocarbons". The initial issue of the specification will enable use of fuels from the Fischer-Tropsch (FT) process up to 50 percent blend with conventional Jet A. FT fuels can be generated from a variety of feedstocks, including biomass (biomass to liquid) and natural gas to liquid, in addition to coal to liquid and combinations thereof. We expect that the FT approval will be followed by the approvals of hydrotreated renewable Jet (HRJ) and other sustainable alternatives as data from technical evaluations is obtained. CAAFI partner The Boeing Company delivered an ASTM required research report on the HRJ fuels in December 2009. This will support incorporation of HRJ fuels into the new specification by 2011.

4.6 CAAFI and the European initiative SWAFEA (Sustainable Ways for Alternative Fuels and Energy in Aviation) are coordinating their respective efforts on developing the potential for alternative jet fuels. Participants from both efforts are sharing analyses on environmental impacts and particularly on greenhouse gas lifecycle analysis. In addition, the CAAFI Executive Director is serving as a consultant to the SWAFEA team as it begins an alternative fuels scoping study.

5. DEVELOP AND IMPLEMENT CLEAN, QUIET, AND ENERGY EFFICIENT OPERATIONAL PROCEDURES

5.1 Improvements in aviation operational procedures may offer near term ways to meet aviation environmental and energy efficiency goals. The development and integration of clean and quiet operational procedures will foster a more efficient air space system and reduce fuel use.

5.2 The FAA is working with national and international stakeholders to coordinate and advance aviation environmental and energy efficient operational procedures and initiatives. The scope of the effort is gate-to-gate (surface optimization, departure/arrival, en-route, and oceanic), and the goal is a more systematic approach to address critical environmental operations research needs and development of a research plan. To date, the FAA has sponsored research and demonstrations in each of the flight segments identified above. The Operations Research Roadmap will focus on near-term exploration and significant demonstration of clean and quiet operational procedures.

5.3 The FAA continues to support efforts to implement CDA/OPD (Continuous Descent Arrival/ Optimal Profile Descent) procedures at both high and low density airports beyond LAX, ATL, MIA, Louisville, Phoenix and Salt Lake City airports. In particular, CDA procedure has been implemented at the Charleston (CHS) International Airport.

5.4 Efficiencies beyond terminal operations are also being pursued to include surface traffic movements and en route operations management. For example, under the International Air Traffic Interoperability (IATI) program comprising of Atlantic Interoperability Initiative for Reduced Emissions (AIRE) and the Asia and South Pacific Initiative to Reduce Emissions (ASPIRE), demonstrations are being expanded to investigate and demonstrate potential efficiency enhancements. Additional investments will further explore and demonstrate new capabilities. Coordinated decision-making through comprehensive automated systems communication/data networking of surface movement/en route/terminal domains will be vital for total “gate-to-gate” fuel efficiency. Additional international partners and participants are being added to realize the environmental and performance benefits under both AIRE and ASPIRE initiatives.

6. MARKET-BASED MEASURES, ENVIRONMENTAL STANDARDS AND REGULATORY POLICIES OPTIONS

6.1 Penetration of advanced technologies and sustainable alternative fuels and better management of the air space system along with implementation of improved environmentally efficient procedures provide an effective basket of measures to meet aviation environmental goals and a secure energy future. However, market-based measures, noise and emissions specific environmental standards and regulatory policies are also important measures.

6.2 As the fifth and final pillar of its environmental strategy, the FAA is currently engaged in analyzing the effectiveness of various market and regulatory-based policy options. For example, the FAA is supporting a project through PARTNER to investigate options for possible metrics for aircraft CO_2 standards. An information paper (CAEP/8-IP/31) provides an update on this study.

6.3 The FAA is also supporting research through PARTNER to investigate various aspects of Cap and Trade as a market and regulatory option to limit aviation related greenhouse emissions within the context of the greenhouse emissions from all other anthropogenic sources. This project will develop methods to examine policies designed to limit greenhouse gas emissions and to estimate their effects on aviation economics and on emissions from aircraft. This study applies APMT and EPPA (Emissions Predictions and Policy Analysis) model for underlying analyses. The EPPA model was developed by Massachusetts Institute of Technology to provide projections of world economic development and emissions along with analysis of proposed emissions control measures.

6.4 The FAA is also planning a study that will inform the sampling and testing techniques needed for a certification requirement of aircraft non-volatile particulate matter emissions.

7. INTEGRATED ANALYSIS OF NEXTGEN AVIATION ENVIRONMENTAL GOALS AND TARGETS

7.1 Different options that will be developed under the above stated five-pillar solution sets will provide a range of contributions towards meeting the ambitious NextGen environmental goals. Implementation and rate of infusion will also vary among various mitigation options. Therefore, the FAA is sponsoring a study to develop scenarios and analyze how factors such as implementation time and rate of infusion, applied to various mitigation measures, impact progress in achieving NextGen environmental goals and interim targets. Interdependencies among noise, air quality, climate change, and energy efficiency will be emphasized. A range of interim target metrics options will be investigated. This analysis should reveal gaps in meeting the goals and targets, which will help focus research, and will also inform guidance for producing optimally balanced, cost-beneficial solutions. Preliminary results from this study are expected by the end of this year. This analytical framework could also inform CAEP as it strives to meet its environmental and energy efficiency goals.

8. SUMMARY

8.1 Given the complexity of aviation as an integrated system with associated tradeoffs and interdependencies among environmental impacts, there is a need to fully characterize the problem and issues. Moreover, no singular solution will mitigate aviation noise and emissions impacts while simultaneously improving energy efficiency. Therefore, a basket of solutions including advanced quiet, clean, and energy efficient aircraft technologies, sustainable alternative jet fuels, and improved operational procedures aligned with market-based options, environmental standards, and policy measures are needed to mitigate aviation environmental impacts. The U.S., under the auspices of the Next Generation Air Transportation System (NextGen), is sponsoring a robust five-pillar research and development program to better characterize and model environmental impacts and energy efficiency, and develop solutions to mitigate impacts and enhance fuel efficiency. These collective efforts will also support the CAEP work program.

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