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**COMMITTEE ON AVIATION ENVIRONMENTAL PROTECTION (CAEP)**

**SEVENTH MEETING**

**Montréal, 5 to 16 February 2007**

**Agenda Item 1: Review of proposals relating to aircraft engine emissions, including the amendment of Annex 16, Volume II**

**Agenda Item 3: Review of proposals relating to aircraft noise, including the amendment of Annex 16, Volume I**

**Agenda Item 4: Future work**

**PARTNERSHIP FOR AIR TRANSPORTATION NOISE AND  
EMISSIONS REDUCTION (PARTNER) CENTER OF EXCELLENCE  
RESEARCH ACTIVITIES AND INTERNATIONAL COLLABORATION**

(Presented by the Canadian and U.S. Representatives)

**SUMMARY**

This paper provides a summary of research conducted by the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) Center of Excellence. The Center, jointly sponsored by Canada and the United States, seeks to enhance the understanding of aerospace environmental issues and foster breakthrough technical, operational, and workforce capabilities enabling a quieter and cleaner aviation sector. The consortium conducts basic research and engineering development to reduce uncertainties associated with aviation's environmental impact and prototype solutions to mitigate these impacts. The paper also provides information on PARTNER's efforts to expand its international collaborative research efforts and its student paper competition. The knowledge and capability gained from PARTNER will provide critical information to government, industry and community decision-makers to tackle environmental impacts, which may represent the single greatest challenge to the continued growth and prosperity of civil aerospace. This paper provides CAEP with an update of PARTNER's activities.

## 1. INTRODUCTION

1.1 In December 2003, the United States established the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) Center of Excellence (COE). In the spring of 2004, Transport Canada joined the U.S. Federal Aviation Administration (FAA) and the U.S. National Aeronautics and Space Administration (NASA) as a sponsor. PARTNER is a long-term partnership of academia, industry, and government established to create a world-class consortium, closely aligned with national and international needs to foster breakthrough technological, operational, policy, and workforce advances for the betterment of mobility, the economy, and the environment. The group conducts basic research and engineering development to reduce uncertainties associated with aviation's environmental impact and prototype solutions to mitigate these impacts. The knowledge and capability gained from this research will provide critical information to government, industry, and community decision-makers to tackle environmental impacts, which may represent the single greatest challenge to the continued growth and prosperity of civil aerospace. The Massachusetts Institute of Technology leads the COE. An extensive network of industrial affiliates also participates in the activities of the Center.

1.2 PARTNER's research projects continue to contribute toward achieving the environmental goals adopted by ICAO's 35<sup>th</sup> Assembly to limit or reduce: (1) noise exposure; (2) local air quality emissions; and (3) greenhouse gas emissions, and bring about a more environmentally compatible aviation sector. The governments of Canada and the United States have thus far invested 12.6 million U.S. dollars in PARTNER research projects. Industrial partners have matched 11 million of this investment. Research highlights are discussed in Section 2.

1.3 The broader aviation community will benefit from enhanced research collaboration between PARTNER and international research establishments. To provide the best scientific and technical input and foster consensus to inform policy decisions, PARTNER and its sponsors have adopted a vision of commonality and interconnectivity in research plans, which would be separately funded by home agencies. One of PARTNER's key strategic goals is continued expansion of its international activities. SNECMA, Airbus, Bombardier, and Rolls-Royce are PARTNER international industrial affiliates. PARTNER has research relationships with the Environmentally Compatible Air Transport System (ECATS) Network of Excellence, EUROCONTROL, and the Opportunities for Meeting the Environmental Challenge of Growth in Aviation (OMEGA) project. PARTNER is also exploring collaboration with entities in China, Japan, and Singapore, and has expanded its student paper competition to participants of all nationalities. Further details of PARTNER's international outreach activities are also discussed in Section 2.

## 2. PARTNER RESEARCH RESULTS AND COLLABORATIVE ACTIVITIES

2.1 PARTNER's research portfolio comprises three detailed research plans:

2.1.1 Noise: Provide quantitative predictions and qualitative assessments of aviation noise and its impacts, and contribute to mitigation strategies considering all interrelationships.

2.1.2 Emissions: Provide quantitative predictions of aviation emissions and their impacts that contribute to mitigation strategies considering all inter-relationships.

2.1.3 Interdependencies: Enable better communication and decision-making in addressing the interdependent environmental effects of aviation through the ability to fully assess the benefits and costs of interdependent policies, technologies, operational procedures, and market conditions.

2.2 The tangible outcomes of PARTNER research are growing. These include the public release of the *Report to Congress: Aviation and the Environment*, and the first PARTNER reports: *Development, Design, and Flight Test Evaluation of a Continuous Descent Approach Procedure for Night-time Operation at Louisville International Airport*; *Assessment of the Effects of Operational Procedures and Derated Thrust on American Airlines B777 Emissions From London's Heathrow and Gatwick Airports*; *Advancing the Understanding of Aviation's Global Impact*; *Workshop on the Impacts of Aviation on Climate Change: A report on findings and recommendations, June 7-9, 2006, Cambridge, MA.*; *Requirements Document for the Aviation Environmental Portfolio Management Tool*; *Architecture Study for the Aviation Environmental Portfolio Management Tool*; *Architecture Study for the Aviation Environmental Portfolio Management Tool*; *Prototype Work Plan for the Aviation Environmental Portfolio Management Tool*; and several papers and theses, which are, or will shortly be, available at PARTNER's website, <http://partner.aero>. Perhaps most importantly, the first PARTNER students are graduating and entering the workforce.

2.3 PARTNER is nearing completion of a substantial effort to study low frequency noise. The final report is anticipated by mid 2007. This research may have implications on airport operations and future regulations. It may eventually result in a set of recommended acceptance metrics for low frequency noise. The findings could inform regulatory action and technology development to mitigate the impacts of low frequency noise. PARTNER is now turning its attention to examining other noise metrics and health impacts.

2.4 PARTNER conducted its third aviation emissions measurement campaign, which took place at Cleveland Hopkins International Airport in November 2005. Researchers continue reducing the extensive data sets collected during this, and two other aviation emissions measurement campaigns at two North American Airports (September 2004 and August 2005). Results have helped refine the First Order Approximation (FOA), a methodology developed to correlate the smoke number reported in the certification process with mass emission rates of non-volatile particulate matter (PM) emissions to also quantify the volatile fraction of PM. The results have also supported similar measurement campaigns in the UK. Research efforts will continue to gain understanding of particle formation, composition, and growth and transport mechanisms for assessing aviation's particulate emissions, and understanding their impact on human health and the environment. Researchers are also starting to tackle the impact of hazardous air pollutants (HAPs), commonly referred to as "air toxics."

2.5 PARTNER progresses with development of and implementation of continuous descent arrival (CDA) procedures and its implementation at select airports. Research is currently focused on implementation of CDA, or other procedures, in higher density traffic. PARTNER has also started a research effort to optimize en route operations in order to minimize fuel burn.

2.6 In the past year, PARTNER's most significant area of growth has been in developing analytical tools that provide rigorous guidance to policy-makers who must decide among alternatives for addressing the environmental impacts of aviation. PARTNER is collaborating with an international team to develop aircraft-level and aviation system-level tools to assess the costs and benefits of different policies and R&D investment strategies. A critical area of research is an effort to monetize the health and welfare impacts of aviation noise, local air quality, and climate effects to enable a robust cost-benefit analysis of policy alternatives.

2.7 Other ongoing PARTNER research projects include an effort to assess potential acceptability of shaped sonic booms from a new class of supersonic business aircraft being investigated by industry; studies to better understand the dynamics of land-use, aircraft noise, and local development around airports; and various activities to address aviation's impact on climate. The latter includes an

effort by Stanford University to advance our understanding of the climate impact of aircraft contrails, and a recent award by Transport Canada to York University to model ozone in the upper troposphere and lower stratosphere.

2.8 PARTNER collaborated with the Environmental Integrated Product Team (EIPT) of the Joint Planning and Development Office (JPDO) charged with developing the U.S Next Generation Air Transportation System (NextGen) to convene a workshop on the Impacts of Aviation on Climate Change on June 5-7, 2006. This workshop brought together approximately 30 selected international science experts to assess and document the present state of knowledge of climatic impacts of aviation and the underlying uncertainties. Participants identified the gaps in scientific knowledge and prioritized them; identified ongoing or further research needs; and explored the development of metrics for environmental trade-off issues. The workshop helped to focus the scientific community on the climate change research needs of aviation. All findings of this workshop are summarized in a report available on PARTNER's website and discussed in CAEP/7-IP/26.

2.9 PARTNER's sponsors are increasingly relying on its expertise to inform key decisions. The FAA has identified seven PARTNER research efforts as "highly influential," a moniker that is applied to research whose dissemination could have a potential impact of more than 500 million U.S. dollars in any one year on either the public or private sector, or the work is novel, controversial, or precedent setting. This means that after a formal peer review process, the research will be used to help inform U.S. policy decisions. However, an international approach in formulating the regulatory framework on aircraft noise and emissions issues encourages harmony in rulemaking. An international approach is also critical to reducing scientific uncertainties to levels that enable appropriate actions to be undertaken. The Canada-United States collaboration in PARTNER has served to enrich perspectives and better focus research on issues that impact all global stakeholders. A major focus for PARTNER during the past year has been on expanding its international activities.

2.9.1 The collaboration with the Environmentally Compatible Air Transport System (ECATS), <http://www.pa.op.dlr.de/ecats>, Network of Excellence established by the European Commission has rapidly and significantly matured. A small team comprising PARTNER researchers and sponsors from the United States and Canada and ECATS sponsors and members, met in Europe in December 2005 to explore and formalize collaborative activities. A number of tasks for collaboration were agreed upon: (1) quantifying socio-economic effects of aviation emissions; (2) assessment of technological and operational options for reducing impacts; (3) characterizing global and local atmospheric impacts of aviation emissions; and (4) educating practitioners and the public on aviation emission issues. The agreement was formally signed at the Transport, Atmosphere, and Climate Conference in Oxford, England, June 26-29, 2006, and collaborations are ongoing. Several PARTNER universities are also collaborating with Manchester Metropolitan University and other UK institutions on the recently awarded Opportunities for Meeting the Environmental challenge of Growth in Aviation – OMEGA project. This collaboration is an outgrowth of the ECATS-PARTNER relationship.

2.9.2 ECATS remit is strictly aviation emissions. PARTNER also seeks to expand collaborative activities in the noise and interdependencies elements of its research portfolio. The team of PARTNER researchers and sponsors charged with expanding and formalizing collaborative research with European partners also met with representatives from EUROCONTROL and defined specific areas for collaboration. Collaboration between PARTNER and EUROCONTROL is included in the research work program between the FAA and EUROCONTROL.

2.9.3 Although the initial efforts to expand PARTNER's international collaborations are focused on Europe, PARTNER's long-range plans include establishing collaborative activities with other

world regions. A team of PARTNER sponsors recently visited several Asia-Pacific research establishments with the aim of fostering collaborative activities. Several potential collaborations are being explored.

2.9.4 PARTNER sponsors a student award contest: the Joseph A. Hartman Student Paper Competition. This contest, which bestows cash awards ranging from \$200 to \$5,000 on winning graduate and undergraduate entries, was conceived by the late Joseph Hartman, one of the original PARTNER researchers, who passed away prior to the first competition in December of 2004. Named in Hartman's memory, the competition was previously limited to U.S. entries. However, in 2007, the contest accepted international entries in keeping with PARTNER's increasingly global outlook.

2.9.5 Given concerns about rising fuel prices and the security outlook of energy supplies, PARTNER has initiated a project to assess the feasibility of alternative aviation fuels. This includes exploring all environmental aspects, from well to wing, of the use of these fuels.

### 3. CONCLUSION

3.1 The Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER) Center of Excellence (COE) has completed three years of operation. Researchers have made substantial progress in several areas and its research portfolio continues to grow. PARTNER, Canada, and the United States are continuing to expand international collaborations with the goal of providing decision-makers with robust and integrated scientific and technical input. We invite CAEP to consider research results from the PARTNER COE in its future work programs, and encourage member states to collaborate in COE research projects.

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