FAA REDAC Subcommittee on Environment & Energy

International Aircraft CO₂ Standard

Presented to: FAA REDAC Subcommittee
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Background

• Growing concern over aviation’s impact on climate change
  – Commercial aircraft contribution to domestic greenhouse gas emissions is relatively small compared to other sectors
  – Air transportation demand and therefore contribution to climate change expected to increase over the upcoming decades

• Ambitious goals have been established (e.g. carbon neutral growth by 2020 w/ 2005 baseline)

• Achievable via various solutions that could help mitigate aviation’s environmental impacts:
  – Aircraft Technologies
  – Operational Improvements
  – Alternative Fuels
  – Policies
Objective of CO₂ Standard

• International aircraft-level CO₂ standard is being developed under the International Civil Aviation Organization (ICAO)/Committee on Aviation Environmental Protection (CAEP)
  – Technical development conducted by the CO₂ Task Group (CO2TG) of CAEP’s Emissions Technical Working Group 3 (WG3)

• Incentivize the reduction of CO₂ emissions beyond what could be achieved by expected market forces

• Standard should incentivize only the introduction of fuel burn reduction technologies

• Standard should not cause unintended consequences on how aircraft are operated
PARTNER Research Team

PARTNER research team has been supporting development of CO2 standard since 2009

Team members:

• Georgia Tech
• MIT
• Booz Allen Hamilton
Major Milestones to-date

• Agreed CO₂ Metric System in May 2012, supported by CAEP Steering Group (SG) in July 2012 and CAEP/9 meeting in February 2013

• Agreed on draft ICAO Annex 16 Vol. 3 (i.e. CO₂ certification requirement) in February 2013
  – Functional in terms of flight test procedures and measurement conditions, but missing a regulatory limit and final applicability

• Agreed on a schedule aiming for standard setting to occur in 2016 at CAEP/10 meeting

• Agreed on Stringency Options in September 2013, supported by CAEP in November 2013
ICAO Draft Annex 16 Vol. 3

- Certification requirement that describes the technical procedures for the measurement of the CO₂ metric
- Reviewed best practices among certification authorities and manufacturers to ensure fairness and minimal burden
- Includes details on the CO₂ metric, procedures, instrumentation and measurement methodology, and compliance requirements (i.e. tolerances)
- To become basis of the standard upon agreement of a regulatory level and final applicability rules
- Draft was supported in February 2013
- Work is ongoing to update and finalize by February 2016
CO₂ Metric: CO₂ emissions & Fuel Burn

- Primary environmental issue is the emission of CO₂
- CO₂ emissions are directly proportional to fuel burn
- Drivers of CO₂ can be determined at aircraft-level

\[
W_{Fuel} = \left\{ \exp\left(\frac{\text{Mission (range)}}{\text{Payload}}\right) - 1 \right\} \left(1 + \frac{\text{Mission (payload)}}{\text{Payload}}\right)
\]

Fuel burn is driven by:

- **Technology:**
  - Propulsion,
  - Aerodynamics, and
  - Airframe Weight (i.e. Structural Efficiency)

- **Mission:**
  - Payload
  - Range
ICA0 CO₂ Metric System

• Many metric and correlating parameter combinations were assessed, which can be generalized in two categories:
  – Instantaneous Performance Measurement
  – Mission Performance Measurement

• Technical analyses resulted in the former being chosen in 2012, which was an instantaneous metric based on:
  – Specific Air Range (e.g. distance / fuel mass)
  – Correlated with Maximum Take-Off Mass (i.e. normalize for fairness)
  – Corrected by a floor area factor
  – Evaluated at 3 weights
  – Considered key criteria to extent possible (e.g. fairness, ease of certification, account for fundamental aircraft performance, and limiting unintended consequences)
Stringency Options Development

- Assessed different stringency line curve methodologies and shapes for small and large aircraft
- Defined analytical space boundaries in the CO₂ metric and MTOM framework
- Conducted analyses on a broad sweep of stringency options within the defined space
- Identified a range of meaningful stringency options for the CO₂ analysis framework
- The shape of the curves and stringency options were agreed in 2013, which are to be used as the basis for the CO₂ main cost effectiveness analysis
Stringency Options Visually (example)

- ARL (Adapted Reference Line)
- Min AS (SO-20%) (Minimum Analytical Space boundary)
- SO -22% (Stringency Option 22% below ARL)
- SO -24%
- SO -26%
- SO -28%
- SO -30%
- SO -32%
- SO -34%
- SO -36%
- SO -38%
- Max AS (SO-40.7%) (Maximum Analytical Space boundary)

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Technology Responses

• Technology responses to meet the agreed stringency options are under development at this time

• Assumptions relevant to technology responses are being defined, some of which include:
  – Technical feasibility
  – Additional margin to a stringency option
  – NOx, PM and noise trade-offs
  – Non-recurring costs
  – Airplane transition pairs
  – Airplane families
  – Project airplanes

• Technology responses expected to be agreed by July 2013
Applicability to In-Production Airplanes

- Many ways to potentially apply the CO$_2$ standard to in-production airplane types, for instance:
  - Reporting Process
  - Full CO$_2$ emissions Type Certification

- Considerations of options also include, but limited to:
  - Timing
  - Regulatory level
  - Data requirements

- The definition, advantages, disadvantages, costs and benefits of each potential option can vary significantly

- Draft document detailing possible in-production applicability options expected to be available by July 2013
Summary of CO₂ Standard Next Steps

• Complete sample problem analysis by mid 2014
• Finalize technology responses by mid 2014
• Draft in-production applicability options by mid 2014
• Finalize scenarios cases and data for main cost effectiveness analysis by mid 2014
• Complete main cost effectiveness analysis round 1 by mid 2015, round 2 by end of 2015
• Decision on applicability and regulatory limit by February 2016
• Insert applicability and regulatory level into final Annex 16 Vol. 3 by February 2016
Questions?