FAA REDAC Subcommittee on Environment & Energy

Federal Aviation Administration

International Aircraft CO_2 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 CO_2 Standard

- **International aircraft-level CO_2 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 CO_2 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

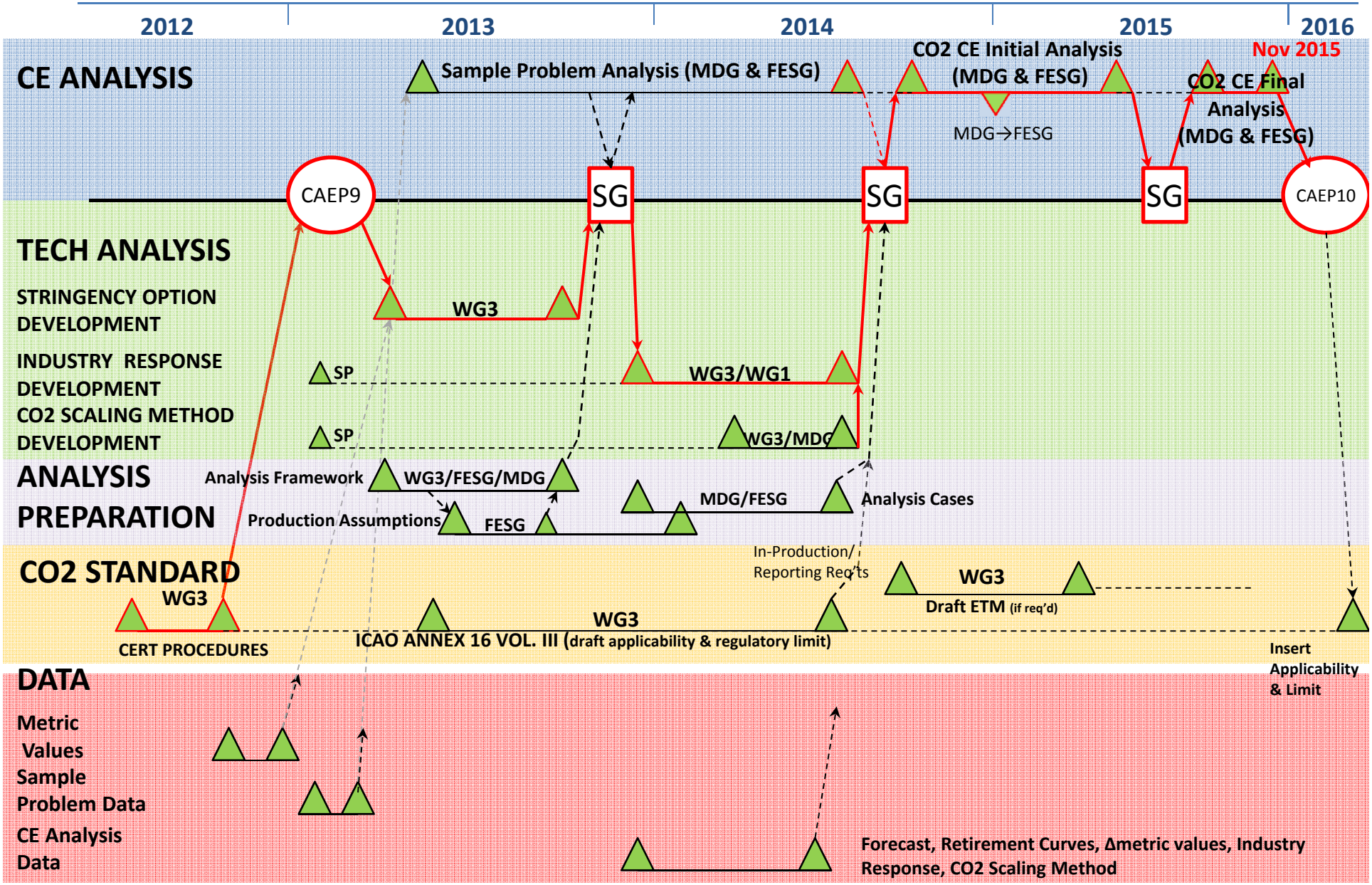
- **Agreed CO_2 Metric System in May 2012, supported by CAEP Steering Group (SG) in July 2012 and CAEP/9 meeting in February 2013**

- **Agreed on draft ICAO Annex 16 Vol. 3 (i.e. CO_2 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**

Overall CO_2 Schedule

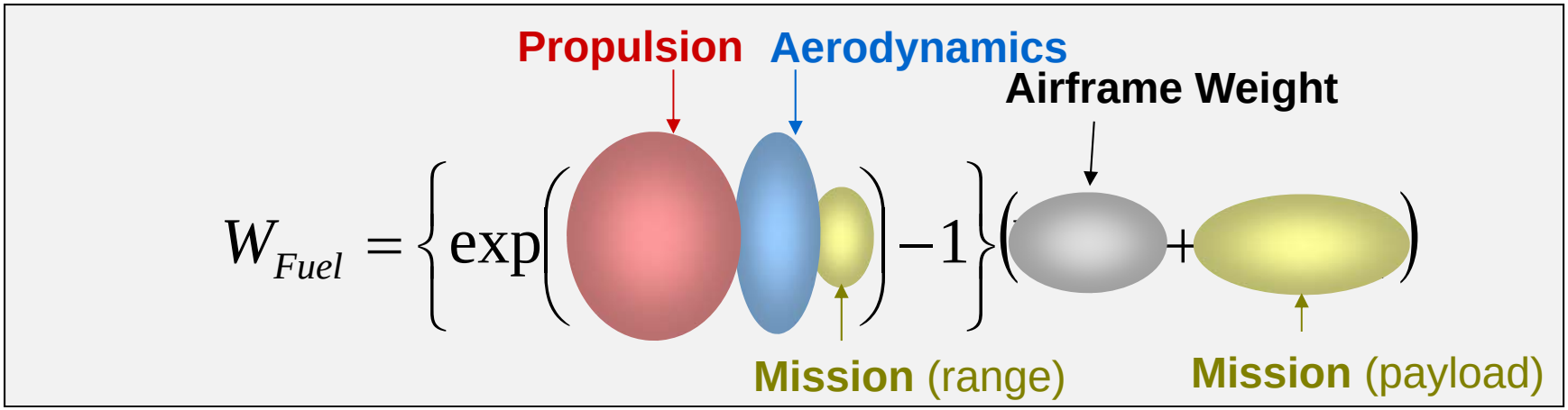


ICAO Draft Annex 16 Vol. 3

- Certification requirement that describes the technical procedures for the measurement of the CO_2 metric
- Reviewed best practices among certification authorities and manufacturers to ensure fairness and minimal burden
- Includes details on the CO_2 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

CO_2 Metric: CO_2 emissions & Fuel Burn

- **Primary environmental issue is the emission of CO_2**
- **CO_2 emissions are directly proportional to fuel burn**
- **Drivers of CO_2 can be determined at aircraft-level**



Fuel burn is driven by:

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

❖ Mission:
- Payload
- Range

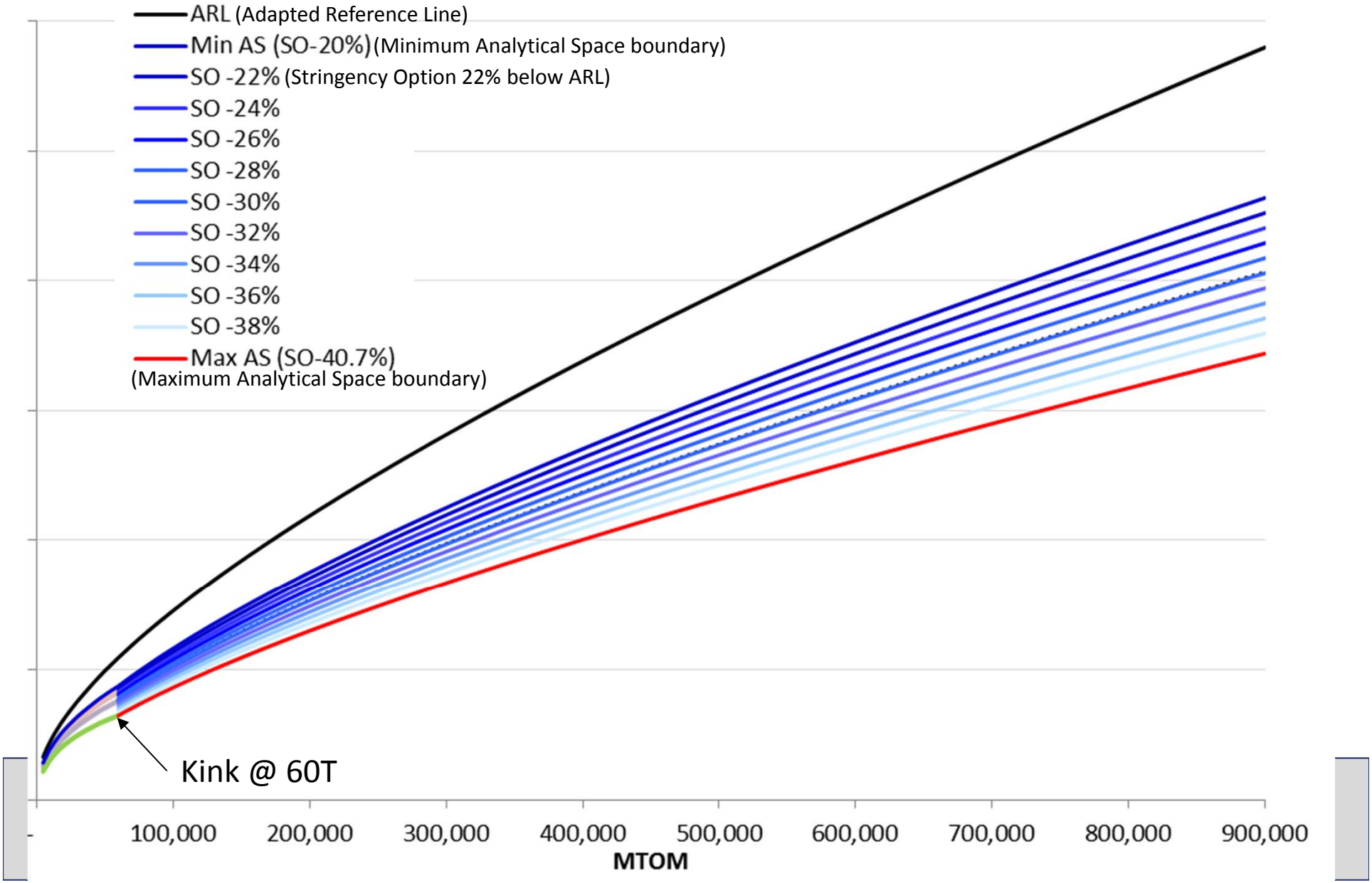
ICAO CO_2 Metric System

- **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 CO_2 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 CO_2 analysis framework
- The shape of the curves and stringency options were agreed in 2013, which are to be used as the basis for the CO_2 main cost effectiveness analysis

Stringency Options Visually (example)



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 CO_2 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?