# Global Emissions Technology

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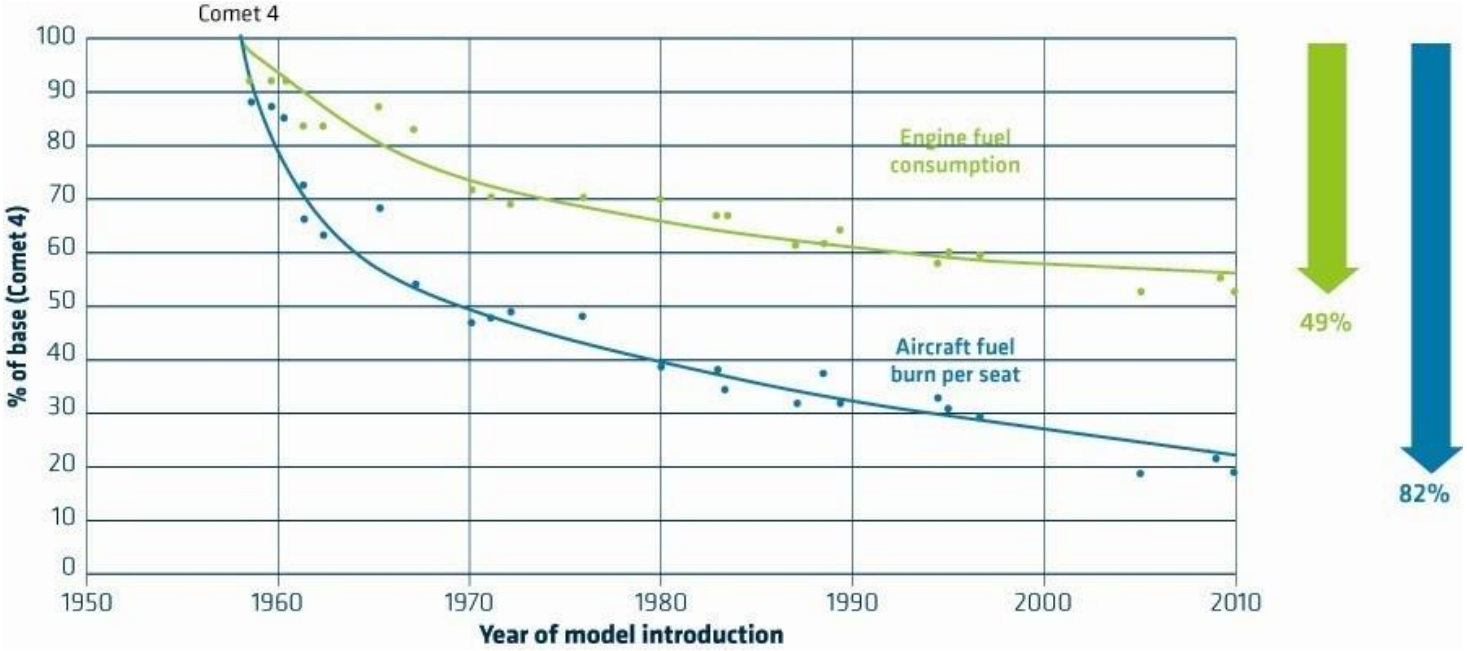
- Pushing the technology envelope
- The Independent Expert Review on Fuel Burn Technology
- The development of the ICAO $CO_2$ Standard
- Summary





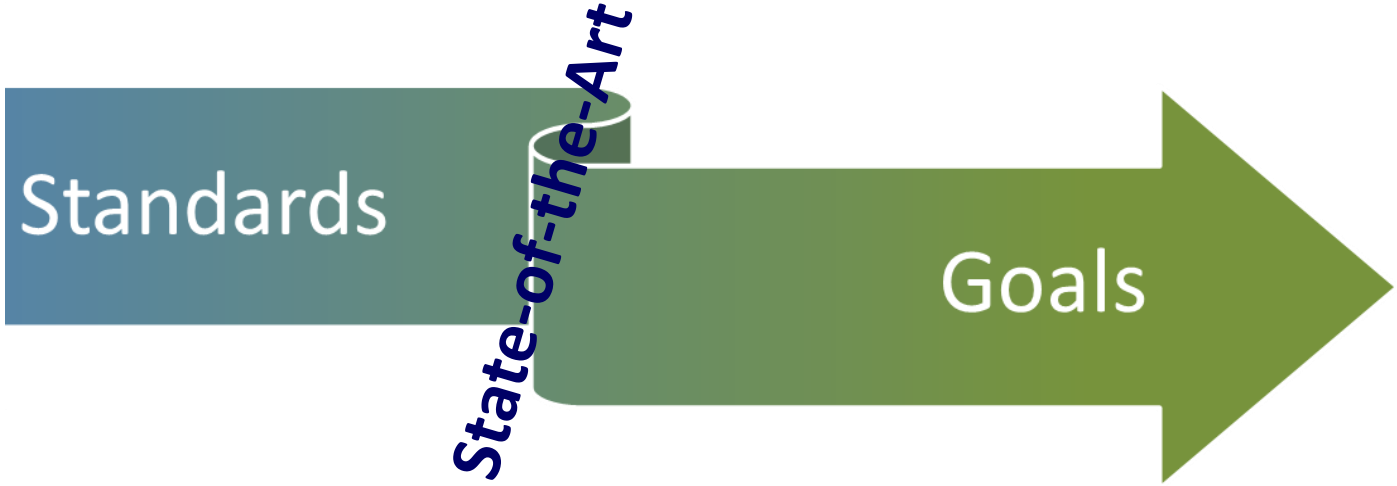
# Pushing the technology envelope

- The aerospace industry is a dynamic and advanced-technology sector.
- Historic trends show that aircraft entering today's fleet are ~80% more fuel efficient than in the 1960s.




Source: ICCAIA

# Environmental Standard Principles




## Establishing Technology Standards






# Pushing the Technology Envelope






# Pushing the technology envelope

- To improve fuel efficiency there are continuous efforts in:
  - Structures
  - Propulsion
  - Aerodynamics

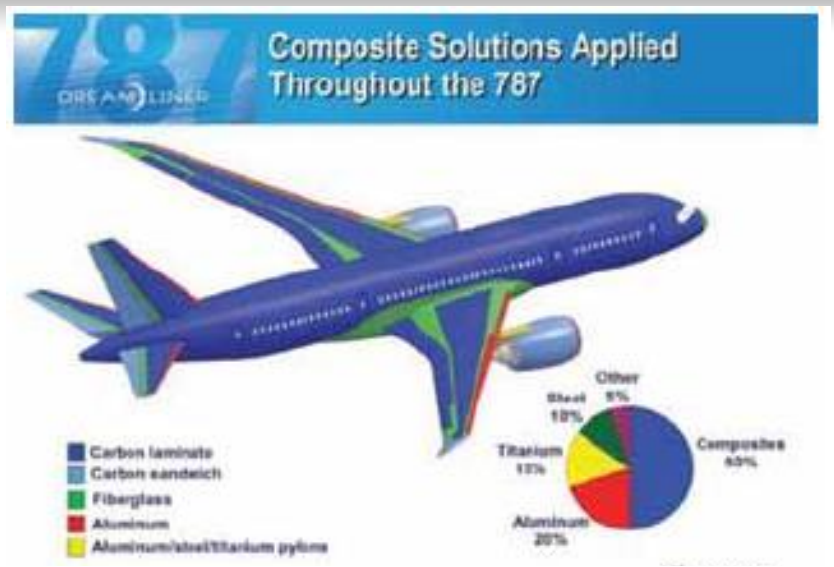
- Advanced technologies are already being incorporated into aircraft designs in order to contribute to carbon neutral growth by 2020.






# Pushing the technology envelope

- Reductions in weight are a key factor in reducing fuel burn:
  - Use of Carbon Fibre Reinforced Plastic (CFRP) and advanced alloys is increasing;
- Airbus A380 contains 25% composites.
- Boeing 787 and Airbus A350 have pushed the composite use to 50%.

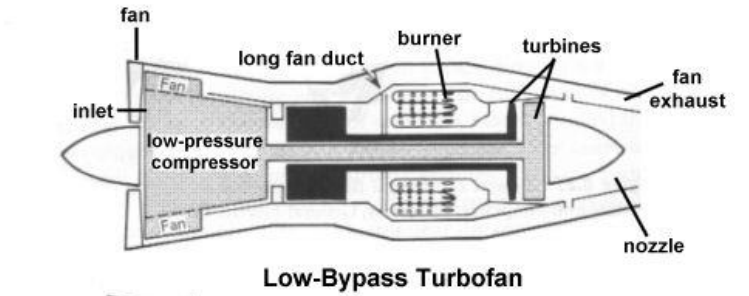




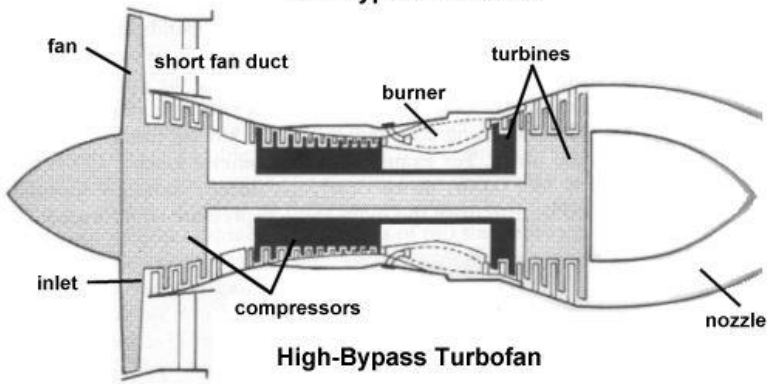
Source: ICCAIA

# Pushing the technology envelope

- Drive towards increased propulsive efficiency:
  - Higher by-pass ratio engines deliver thrust a lower fuel consumption
  - Lighter and higher temperature materials



Low-Bypass Turbofan



High-Bypass Turbofan

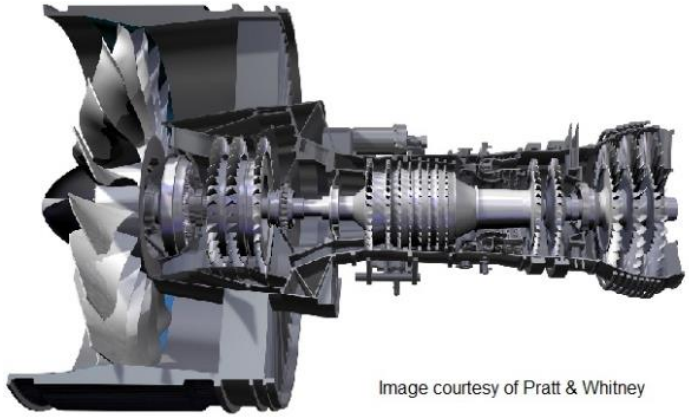


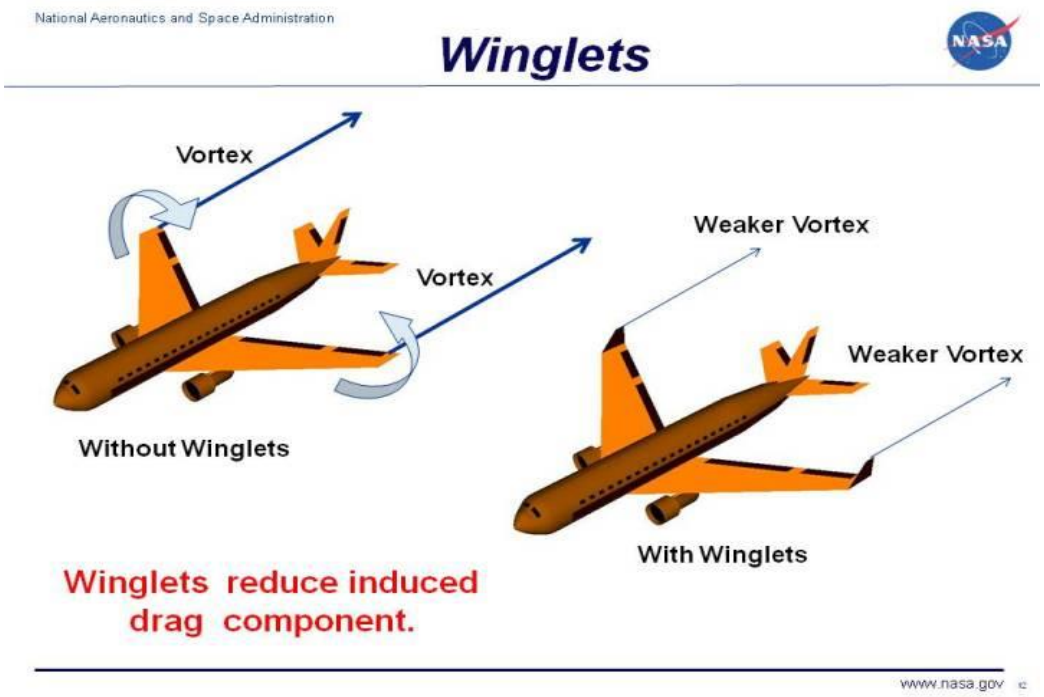
Image courtesy of Pratt & Whitney

http://www.ecomagination.com/portfolio/genx-aircraft-engine
http://machinedesign.com/archive/fewer-trips-fuel-truck




# Pushing the technology envelope

- Aerodynamics, for example:
  - Drag reduction technologies
  - Wingtip devices




http://www.airlinereporter.com/

# Independent Expert Fuel Burn Technology Review





# Independent Expert technology review

- A review of the status of aircraft technology developments for fuel burn reduction;
- An assessment of potential fuel burn reductions in the future;
- Recommended mid- and long- term aircraft fuel burn/efficiency technology goals;
- An assessment of the possibility of success in achieving the mid- and long-term fuel burn/efficiency technology goals.






# Independent Expert technology review

- The IEs concentrated on two aircraft categories, the Single Aisle (SA) and Small Twin Aisle (STA) aircraft
  - ~85% of the aviation fuel is burned in these two categories;
- The IEs also adopted three Technology Scenarios (TS) for 2020 and 2030:
  - TS1 – "*Continuation*": a continuation of the current trend of improvement;
  - TS2 – "*Increased pressure*": increased pressure to incorporate more technologies to reduce fuel burn
  - TS3 – "*Further increased pressure*": justifying more radical technology innovations






# Independent Expert technology review

| | Single Aisle (SA) | | | | | Small Twin Aisle (STA) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2020 | 2030 | 2020 | 2030 | 2030 | 2020 | 2030 | 2020 | 2030 | 2030 |
| | TS1 | TS1 | TS2 | TS2 | TS3 | TS1 | TS1 | TS2 | TS2 | TS3 |
| Propulsive efficiency | 13 | 14 | 14 | 15 | 28* | 6 | 9 | 7 | 10 | 12** |
| Thermodynamic efficiency | 3 | 4 | 4 | 5 | 3* | 2 | 3 | 3 | 4 | 5** |
| Induced non-viscous drag | 2 | 4 | 4 | 6 | 7 | 2 | 4 | 4 | 6 | 7 |
| Viscous drag | 2 | 4 | 4 | 7 | 9 | 2 | 6 | 4 | 8 | 10 |
| Structural weight | 10 | 15 | 15 | 20 | 20* | 10 | 15 | 15 | 20 | 25** |

* With Open Rotor compatible with the level of thrust of SA
** Without Open Rotor, which is judged incompatible with the high thrust requirement of twin engine STA

| | 2020 | | 2030 | |
|---|---|---|---|---|
| | SA | STA | SA | STA |
| TS1 | 23 | 19 | 29 | 26 |
| TS2 | 29 | 25 | 34 | 35 |
| TS3 | | | 41 | 41 |
| TS3 Open Rotor | | | 48 | |

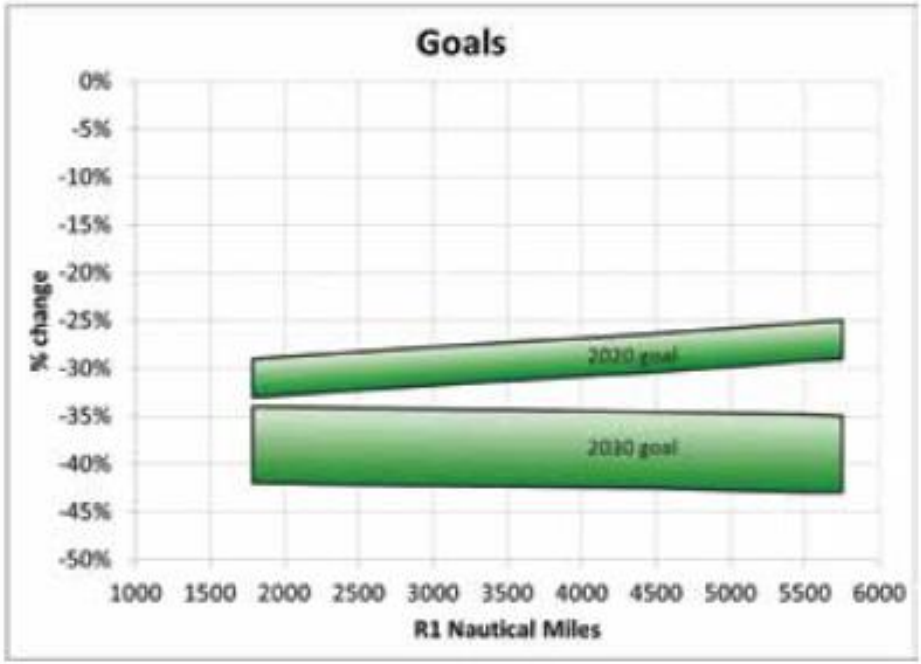




# Independent Expert technology review

- **The 2020 goal** would be met if an aircraft achieves a reduction in excess of between 29% and 25% relative to baseline aircraft of 2000.

- **The 2030 goal** would be achieved if the corresponding reduction were between 34% and 35% relative to baseline aircraft of 2000.

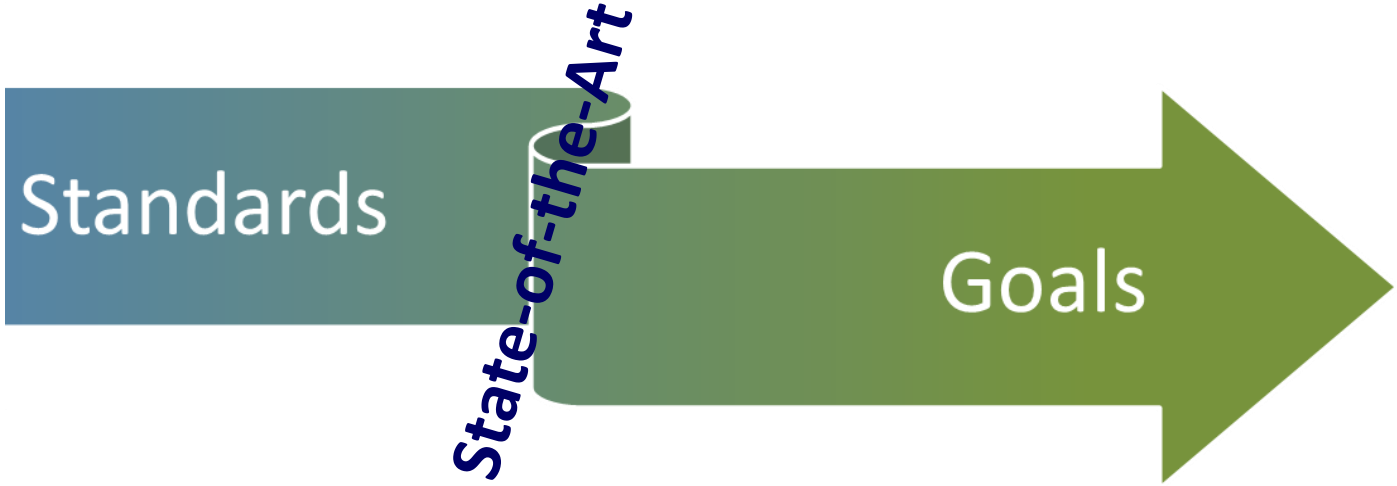



# Developing ICAO $CO_2$ Standard






# Environmental Standard Principles

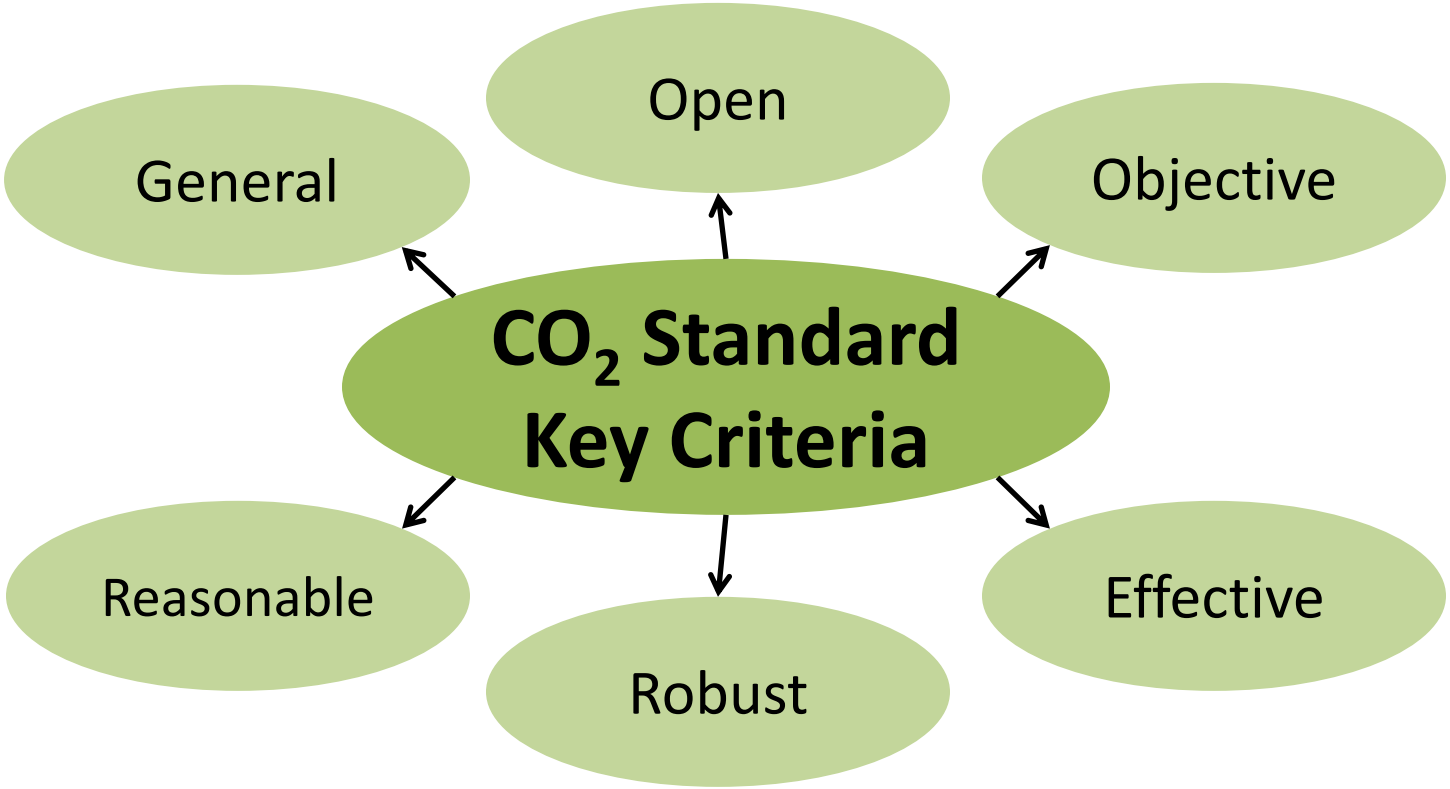



## Establishing Technology Standards






# $CO_2$ Standard Key Criteria









# Aircraft $CO_2$ Standard

**Certification requirement**

[Including: Metric system, procedures, measurement methodology, applicability]

+

**Regulatory limit**

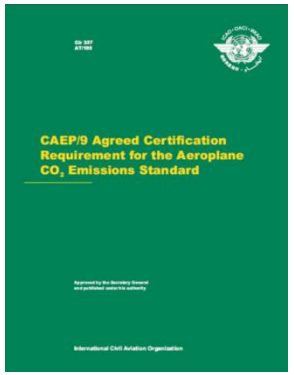
- Technology Standard similar to current Noise and Engine Emissions Standards.
- Aircraft level Standard similar to Noise Standard.






# $CO_2$ Standard Progress

- **The aircraft $CO_2$ Standard will result in a new Annex 16 Vol. III**
- **Two phases in the approach:**
  - **<u>Phase 1 (completed)</u>**
    - Development of $CO_2$ Certification Requirement (metric system, procedures);
  - **<u>Phase 2 (ongoing)</u>**
    - $CO_2$ Standard setting process (stringency levels, technology responses, cost effectiveness assessments and interdependencies).


**$CO_2$ certification requirements agreed by CAEP/9 in February 2013 and published as Circular 337 for information.**

# $CO_2$ Standard – Metric System

- The $CO_2$ Standard contains a $CO_2$ metric system, which includes:

**(A) A Metric:**

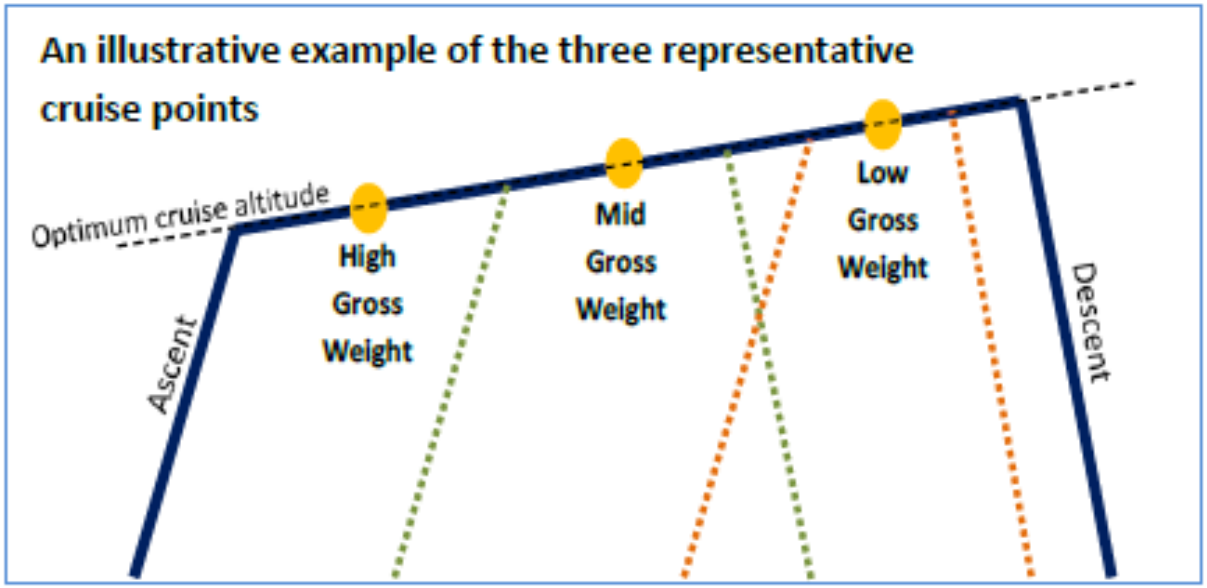
Cruise point fuel burn performance and aeroplane size.

**(B) A Correlating parameter:**

Maximum aeroplane mass.

**(C) Certification test points:**

Three certification test points, each based on aeroplane mass.




# $CO_2$ Standard – Metric System

- Using the Metric System as a basis, CAEP developed the $CO_2$ Standard certification requirement.
  - Developed using a group of certification experts from States and international organizations.
- Resulting in the certification test criteria for the implementation of the $CO_2$ metric system.
- Development of procedures to measure the elements of the $CO_2$ metric system:
  - measurement of all parameters;
  - correction of measured data to reference conditions.






# $CO_2$ Standard Applicability

- The $CO_2$ Standard will be applicable at an aeroplane level.
- The $CO_2$ Standard will be applicable to new aeroplane types.
  - Discussions continue over including in-production types.
- The $CO_2$ Standard will be applicable to subsonic jet and propeller driven aeroplanes.
- The $CO_2$ Standard will likely be applicable in 2020 or 2023.

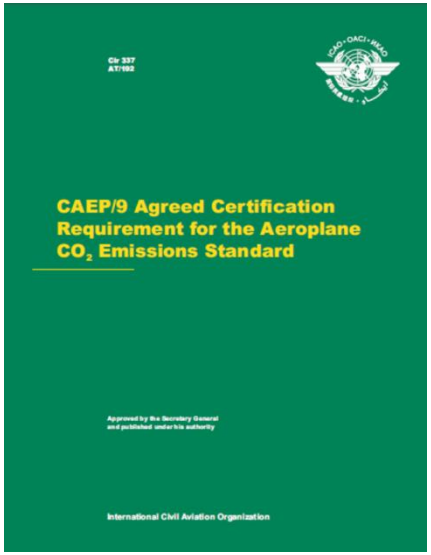





# $CO_2$ Standard – Certification Requirement

- The CAEP/9 meeting approved the mature Annex 16, Vol. III certification requirement, this includes:
  - Part I – Definitions and symbols;
  - Part II – Certification standard for aeroplane $CO_2$ emissions based on the consumption of fuel;
  - Appendix 1 – Determination of aeroplane $CO_2$ emissions evaluation metric;
  - Appendix 2 – Calculating the parameter for aeroplane size.

- Published for information as ICAO Circular 337.




# Finalising the $CO_2$ Standard

- To finalise the $CO_2$ Standard the following issues remain:
  - definition of a no-change criteria;
  - applicability requirements;
  - regulatory limit line;
  - applicability date for the limit.

- CAEP is currently working on a full cost and environmental benefits analysis.






# $CO_2$ Standard Progress

- Importance of balancing a timely delivery and robust technical product that will meet the needs of ICAO.
- Significant technical challenges in developing ICAO Annex 16 Volume III has resulted in a delay to original Assembly aim to complete a $CO_2$ Standard by the end of 2013.
- CAEP has worked on developing a comprehensive $CO_2$ Standard setting work plan:
  - CAEP has agreed to a future work schedule with a deliverable by 2016 for the full $CO_2$ Standard.


# Summary






# Global Emissions Technology

- The aerospace industry continues to push the technology envelope:
  - Aircraft entering today's fleet are ~80% more fuel efficient than in the 1960s.
- ICAO continues to review the status of fuel burn technology.
- ICAO is developing a $CO_2$ Standard which aims to encourage the use of the latest Aeroplane technologies:
  - The $CO_2$ Standard will be complete by 2016.






For more information on ICAO activities on Global Emissions Technology…

**ICAO Web Page**

*www.icao.int/*

**THANK YOU**