CONFERENCE ON AVIATION AND ALTERNATIVE FUELS

Rio de Janeiro, Brazil, 16 to 18 November 2009

Agenda Item 1: Environmental sustainability and interdependencies

CONTINUOUS IMPROVEMENT IN AIRCRAFT FUEL EFFICIENCY

(Presented by the International Coordinating Council
of Aerospace Industries Associations)

SUMMARY

Aircraft and engine manufacturers, in collaboration with research organisations and other stakeholders, continuously strive to develop innovative technology and design highly performing products to provide the air transport sector with vehicles that can achieve their mission in the safest, most cost-effective and environmentally friendly manner. This is supported by extensive, continuous and consistent research programmes and collaborative partnerships that deliver significant technical improvement steps that contribute to the remarkable past records in terms of aircraft efficiency and will keep delivering comparable results in the future. This continuous efficiency improvement path, particularly in terms of fuel burn, provides proportional reductions in terms of CO_2 emissions. Sustainable alternative fuels can now be envisaged as an additional potential solution to further reduce the emissions from aviation.

1. INTRODUCTION

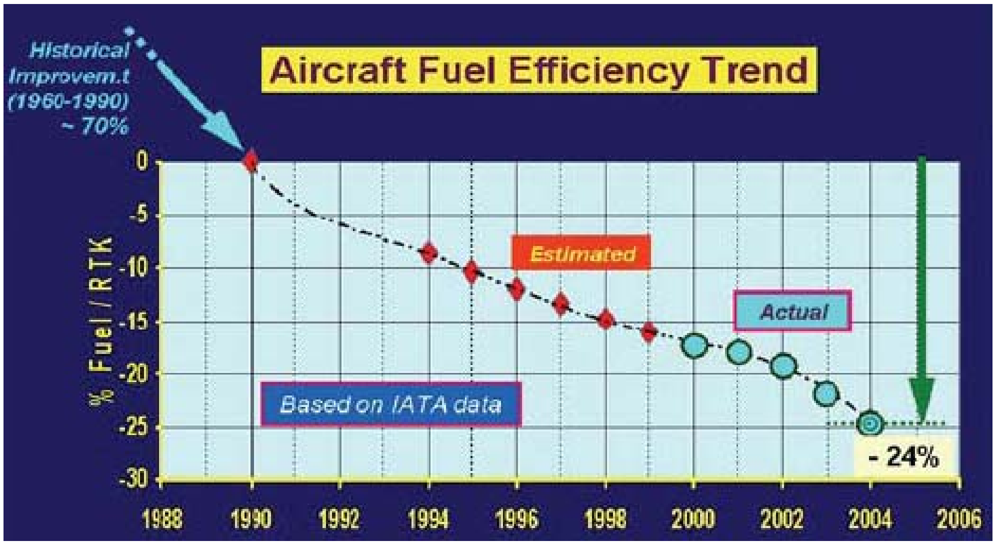
1.1 Aircraft and engine manufacturers, in collaboration with research organisations and other stakeholders, continuously strive to develop innovative technology and design highly performing products to provide the air transport sector with vehicles that can achieve their mission in the safest, most cost-effective and environmentally friendly manner.

1.2 This is supported by extensive, continuous and consistent research programmes and collaborative partnerships that deliver regular technical improvement steps that contribute to the remarkable past records in terms of aircraft efficiency and will keep delivering comparable results in the future.

1.3 This continuous efficiency improvement path, particularly in terms of fuel burn, provides proportional reductions in terms of CO_2 emissions. This paper gives a detailed overview of the path of continuous improvement in fuel efficiency in which the manufacturing industry is engaged: it summarizes the record achievement made over the past decades and gives an overview of the ambitious commitments and goals that the industry has taken for the future.

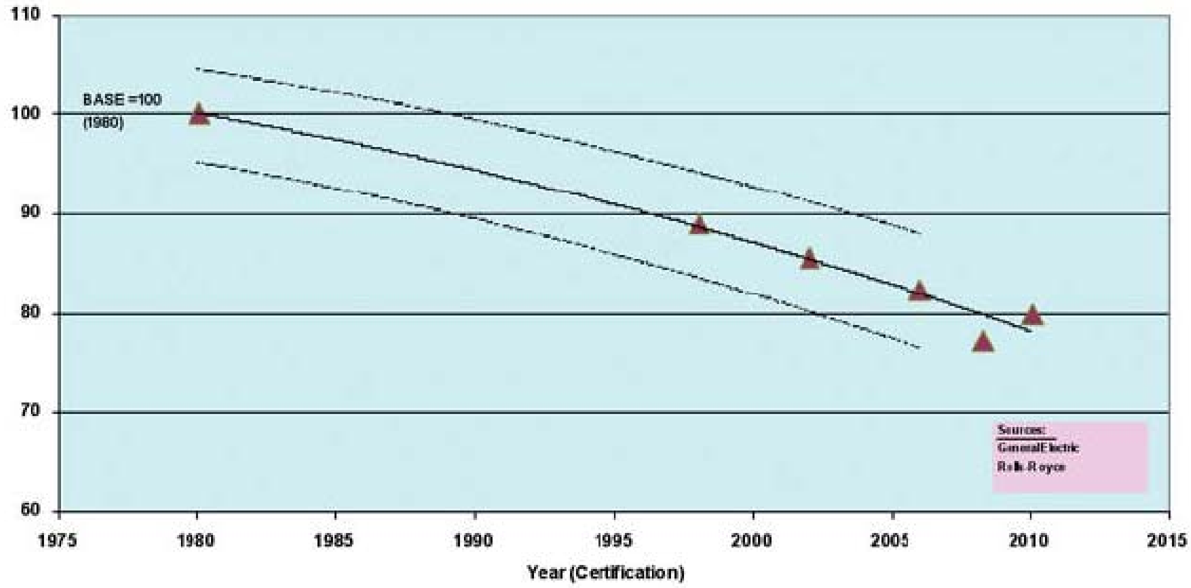
2. A HIGHLY EFFICIENT INDUSTRY

2.1 Over the past decades, market forces have always ensured that fuel burn (and associated CO_2 emissions) have been kept to a minimum for efficiency reasons. As a result of permanent fleet modernization, with new aircraft achieving unmatched efficiency performance, fuel burn has been reduced by about 70% over the last 40 years, from 1960 to the 1990s. From 1990 to 2004, that trend continued to the point where it is estimated that fuel efficiency in the commercial aviation fleet quadrupled from 1960 to 2004.



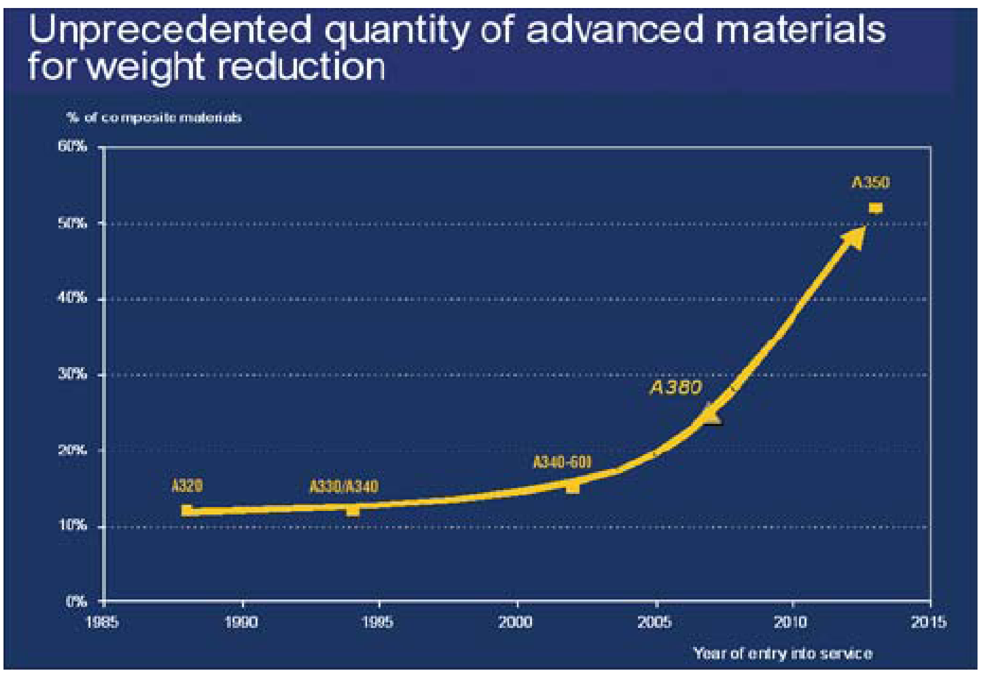
Source: ICAO Environmental Report (P130) – ICCAIA contribution

2.2 Improvements in aircraft fuel efficiency are inextricably linked to how engine, aircraft and systems manufacturers design their products. The figure below illustrates progress of actual and projected specific fuel consumption (SFC) improvement trends form 1980 to 2010. The concepts, the design criteria, the design optimization and the technology transition processes are all tightly interconnected, and the interactions usually increase as a product is developed.



Typical SFC Trend Line Over time
Source: General Electric and Rolls-Royce, published in ICAO Environmental Report (P131)

2.3 Generation after generation, aircraft have shown impressive weight reductions, aerodynamics improvement and engine performance increase, thus reducing drastically the amount of fuel burn (and of CO_2 emitted) to perform the same or further improved operational mission.



Source: Airbus – published in ICAO Environmental report (P132)

2.4 Simultaneously, product innovations are permanently introduced through design, simulation, modelling, testing and validation tools. The optimization process and the challenging tradeoffs involve iterative loops at the technology, design and product levels. A detailed description of six key technical elements that contributed to the past record achievements is given below.

2.5 These key elements explain how past technological achievements were accomplished and also cover some of the potential areas for future improvements. The six key elements are:

1) Propulsion Systems;

2) Materials;

3) Structure, Aero & Systems Design & Methods;

4) Manufacturing Processes;

5) Aircraft Systems; and

6) Operational Procedures

2.6 Table 1 describes each of these elements and shows how they interact with corresponding factors such as weight reductions, aerodynamic and engine performance improvements, and operations – all towards achieving reductions in aircraft emissions.

	Weight Reductions	Aerodynamic & Engine Performance Improvts.	Operations
1. Propulsion System	- Engine, Nacelle & Propulsion System • Advanced lightweight materials • Weight optimized Configuration	-Engine turbomachinery efficiency - Cycle optimized (intercooler, HBPR, UHBPR, geared turbofan, contra-fan) -"Intelligent"systems/more integrated engine -Innovative/active engine systems (heat management, cooling, power transmission,...) - Enhanced modelling capabilities (numerical) - low emissions combustor	- FADEC - Enhanced Controls & Sensors - Optimized Engine Operating Procedures
2. Materials	- Composites - Advanced light Alloys (Ti, Al-Li, Mg), Hybrid alloys (glare) - Innovative, smart materials	*NOTE: Information provided in this table is very general, non-exhaustive*	
3. Structure, Aero & Systems Design & Methods	- Aero-elasticity (load alleviation & control) - Structural optimization, integration & new concepts - Smart, morphing structures, nanotechnologies (future) - Wing, fuselage, empennage, landing gear, pylon innovative features	- Wing, HLD, HTP, Winglets, Fuselage - Engine/nacelle/pylon integration - Flow control - New unconventional configurations & concepts (future) - Multi-disciplinary design methods - Virtual Engineering	- Systems Modelling - Systems Simulation & Virtual Testing - Adaptive flight path to reduce emissions (future)
4. Manufact. Processes	- Welding processes (EBW, LBW, FSW) - Innovative structures & processes	- Welding Processes (drag reduction)	
5. Aircraft Systems	- Fly by Wire - Optimized, integrated & simpler electrical & mechanical systems, less components - IMA - Fuel transfer/load alleviation	- Advanced flight controls, more electronic systems: optimized control surface deflections, level & trajectory control	- Advanced Cockpit, Flight Management & Navigation - Optimized Energy & Electric Power managt (generation/distribution)
6. Operational Procedures	*Some procedures are linked with minimizing TOW*	*Some procedures optimize operations based on Aircraft aerodynamic characteristics*	- Optimized ground & flight, Maintenance procedures - ATM

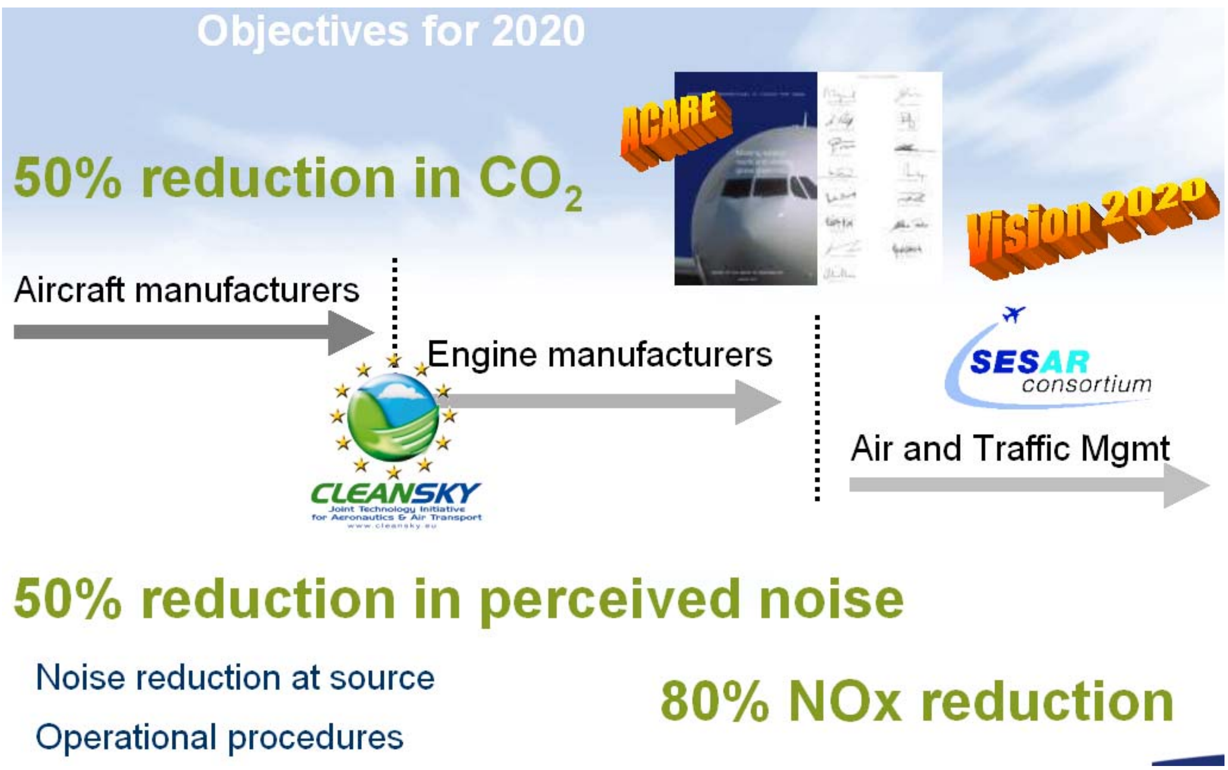
Six Strands of Technological Progress – Published in ICAO Environmental Report

2.7 These elements illustrate the multiple paths and opportunities often adopted by manufacturers to reduce emissions (e.g. propulsion system, materials, systems design, etc.).

2.8 As a consequence, it takes approximately a decade to design and develop an aircraft. The choice made and the technical decisions adopted have to be done in anticipation with regards to the current end future regulatory contexts and societal acceptability.

2.9 In order to make the appropriate decisions, when investing in future technologies, aircraft engine and airframe manufacturers need a stable regulatory framework, based on dependable scientific knowledge, and consistent funding to sustain the current and future extensive research programmes.

2.10 Some commitments have been taken by the manufacturing industry to keep that improvement trend: in Europe, the goals set by the Advisory Council for Aeronautics Research in Europe (ACARE) are targeting an additional 50% improvement in fuel burn and associated CO2 emissions in 2020, compared to 2000 performance. This should be done while reducing the perceived noise levels by 50% and the emissions of NOx by 80% over the same period. Comparable objectives are set in the US, through the different programmes running with the NASA for instance



ACARE objectives

2.11 Associated research programmes, development clusters to foster synergies through appropriate partnerships, have been set up, thus enabling to better take in consideration the challenges associated to the interdependencies between environmental improvement and other parameters (performance, economics…) and within the environmental criteria themselves between noise, local air quality and climate change-related issues. Some choices for future technology engine and aircraft configuration will be based on the decisions the society will make relative to these challenges.

2.12 In addition to the traditional embedded technological improvement pattern that aircraft engine and airframe manufacturers are continuously supporting, some further opportunities to further reduce the emissions from aviation may arise. They are related to the design, development, validation and production of sustainable alternative fuels. This new avenue must be further explored to identify the environmental benefit it can generate, on top of the expected technological improvements.

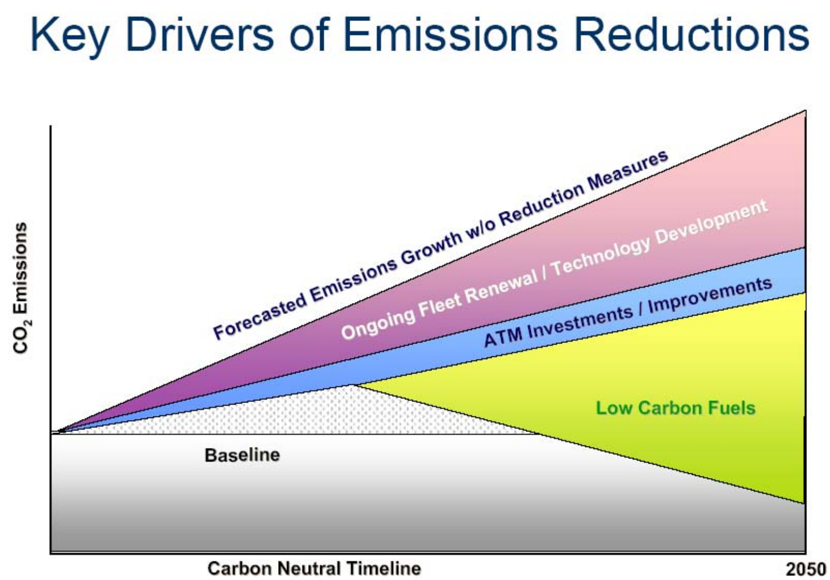


Figure 1—Conceptual Forecast of Industry CO2 emissions and reduction opportunities
(Source: ATAG – Air Transport Action Group)

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