Written Submission of the International Civil Aviation Organization (ICAO)
to the Workshop on Cooperation on Research and Development
in the Fourth Session of the AWG-LCA

(Poznan, Poland, 1-10 December 2008)

Technology Progress

Executive Summary

ICAO is very conscious of its responsibility for pursuing limitation or reduction of GHGs from international aviation. At the same time, ICAO believes that cooperation with other UN bodies and in particular with the UNFCCC process is paramount to achieving a sound and effective solution for addressing aviation emissions. ICAO has made previous submissions summarizing its efforts on reducing GHG emissions using various measures such as promulgating Standards, publishing guidance documents, encouraging technology improvements, and pursuing market-based measures. This submission is to apprise AWG-LCA of trends and progress in the aviation sector related to the Bali Action Plan paragraph 1(d)(iii) "cooperation on research and development of current, new and innovative technology, including win-win solutions".

ICAO and aviation stakeholders fully understand that technological research is essential for development in aviation. Although technology alone cannot resolve the aviation's emissions of CO_2, it has been and will continue to be a key element of the solution in improving efficiencies in the air transport system. The industry together with the research organizations are dedicated to intensive research aimed at developing new technologies to improve air transport efficiencies. Significant research and development efforts are underway to further reduce aviation's impact on the environment.

A new and very promising area for research and development is aviation alternative fuels. This could be a win-win solution in that it will reduce aviation's dependence on climate changing fossil fuels while stabilizing the economic volatility associated with conventional fuels. Much progress has been achieved to date and there are high expectations for the use of more environmentally friendly drop-in alternative fuels for aviation in the short term. At the same time, research is underway with potential for alternative fuels, that are available on a global basis, in the mid to long-term. However, concerted international action will be necessary to translate this possibility into a reality. ICAO is at the forefront of this international coordination and is leading the way to a internationally agreed road map that will identify the roles and responsibilities of the main stake-holders as well as provide a timeline of actions.

ICAO realizes the urgency to implement solutions that reduce aviation's environmental footprint while allowing economic growth, especially in developing countries and islands that greatly depend on aviation for travel and trade. Research and development in aviation technologies, such as advanced materials, improved aerodynamics, and use of alternative fuels, offers great promise. These are win-win technologies and, once developed for aviation, will also trickle down to other sectors for an overall better environmental performance.

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1. Introduction

In December 2004, the ICAO Council approved six Strategic Objectives for the period 2005-2010, Safety, Security and Environmental Protection being the core ones. Specifically for Environmental Protection three goals have been adopted as set forth in Assembly Resolution A36-22:

a) limit or reduce the number of people affected by significant aircraft noise;
b) limit or reduce the impact of aviation emissions on local air quality; and
c) limit or reduce the impact of aviation greenhouse gas emissions on the global climate.

Annex 16 to the Convention on International Civil Aviation (Chicago Convention) sets the Standards and Recommended Practices relating to aviation environmental protection – Volume I for aircraft noise and Volume II for aircraft engine emissions. The Committee on Aviation Environmental Protection (CAEP), a technical committee of the ICAO Council, addresses aviation environmental aspects, updating and developing ICAO's Standards and Recommended Practices as well as related guidance material for both aircraft noise and aircraft engine emissions. In light of the heightened climate change concerns, ICAO has formed an ad hoc high level group, consisting of 15 senior government officials from States that are geographically representative of developed and developing countries. The Group on International Aviation and Climate Change (GIACC) is to develop the ICAO Programme of Action, a comprehensive framework for addressing the global impact of aircraft emissions. It must be emphasized that the development of the Programme of Action by ICAO is aligned with the Bali Action Plan and supports UNFCCC efforts. The Programme of Action will be reviewed at a high-level meeting of ICAO and it is intended to ultimately reflect the shared vision and strong will of all Contracting States of ICAO to address emissions from international aviation. It is important to note that the Contracting States of ICAO represent a virtually identical constituency as the States that are parties to the UNFCCC.

ICAO has developed studies, guidance and policies to reduce aviation emissions based on three approaches: reduction of emissions at source through technological innovation (cleaner and more efficient engines and airframes); reduction of emissions through operational measures (e.g. more efficient air traffic management); and through market based measures. One of the most challenging tasks for ICAO consists of assessing aviation environmental progress against its high level goals as described above. In this task, several sub-groups are reviewing the contributions from technology and also looking at current and future research and development programs to assess what improvements are possible in the mid and long terms. There have been periodic reviews of technology progress and promise under the ICAO umbrella since its inception. Most recently, the process has been formalized to be led by impartial panels of independent experts. In this respect, an IE review of NOx reduction technologies was requested in 2004. Based on the success of this event, ICAO initiated IE Reviews for Noise, Operations, and Fuel Burn, respectively and requested a review of the NOx results. ICAO is also leading the way in establishing a global roadmap for the use of alternative fuels in aviation. The present submission provides a summary of the progress in improving air transport system efficiencies through technology and also highlight areas of current research and development efforts.

2. Aviation and Climate Change

The Kyoto Protocol includes binding emission reduction targets for developed countries (Annex I parties), for the period 2008-2012. Emissions from domestic aviation are included in the total emissions reported and subject to the above targets. Emissions from international aviation, due to the methodological and legal issues involved (including provisions under the Chicago Convention) were included under Art. 2.2 of the Kyoto Protocol, which reads: *"The Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively"*.

ICAO has been at the forefront of environmental stewardship since the early 1970s through its work on reducing aviation noise, improving local air quality, and encouraging fuel efficiency. As a result of ICAO's efforts, the aircraft of today are much quieter and have far less emissions than a few decades ago. ICAO has promulgated standards for emissions of oxides of Nitrogen, Carbon Monoxide, Hydrocarbons, and smoke. Worldwide there has been tremendous improvement in this regard. Local air quality pollutants have declined steadily over the past several years although, admittedly, NOx has been the most challenging pollutant to constrain.

Similarly, aircraft energy efficiency has improved substantially, especially when compared to the other form of mass transit that move passengers. As an example, Figure 1 shows this trend for the US where aircraft energy efficiency has improved by more than 70% from 1960s to today. This downward trend directly translates into less impact on climate change.

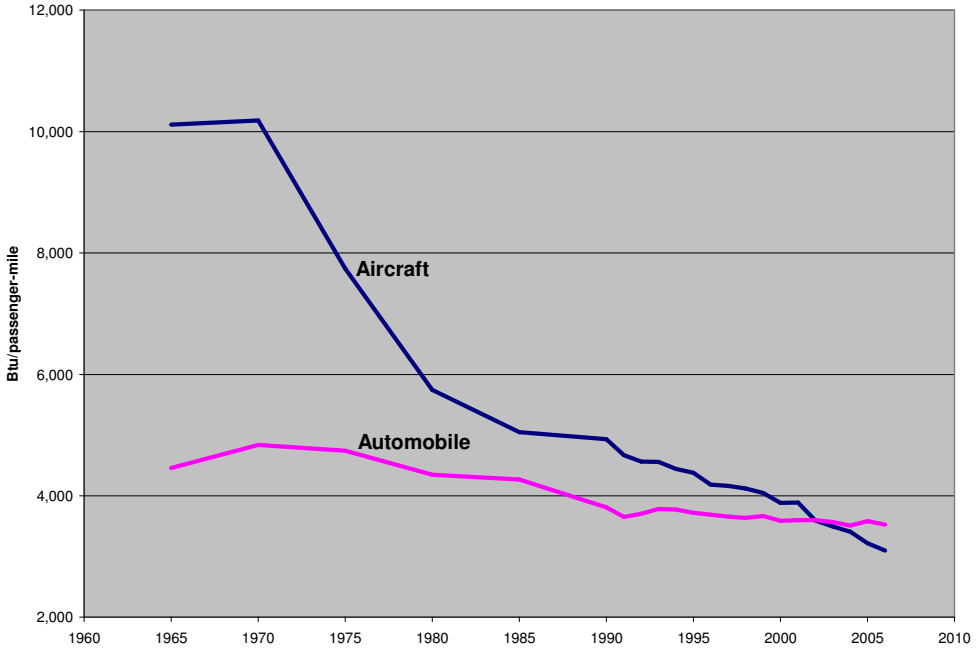

Figure 1: Energy Intensity per Passenger Mile Source: US BTS, National Transportation Statistics 2008

In terms of aviation's contribution to the world, it is agreed that aviation is a major catalyst of economic development. Around 2.2 billion passengers are transported by air every year. International traffic represents almost 60% of the total scheduled passenger traffic and about 83% of freight air traffic. International aviation's contribution to the total CO_2 emissions generated by anthropogenic activities is relatively small compared to other energy and transport sectors, but it is growing. Total scheduled passenger traffic worldwide is forecast to increase at an average annual rate of 4.6% (2005–2025). This increase, although of tremendous benefit to the global economy and especially to the developing world, can off-set the gains obtained improved technology.

Figure 2 shows the trend of CO_2 growth due to aviation despite the improvements in aircraft technology. This trend is expected to continue if the economic growth meets its forecast of 4.6% average annual increase at a global level.

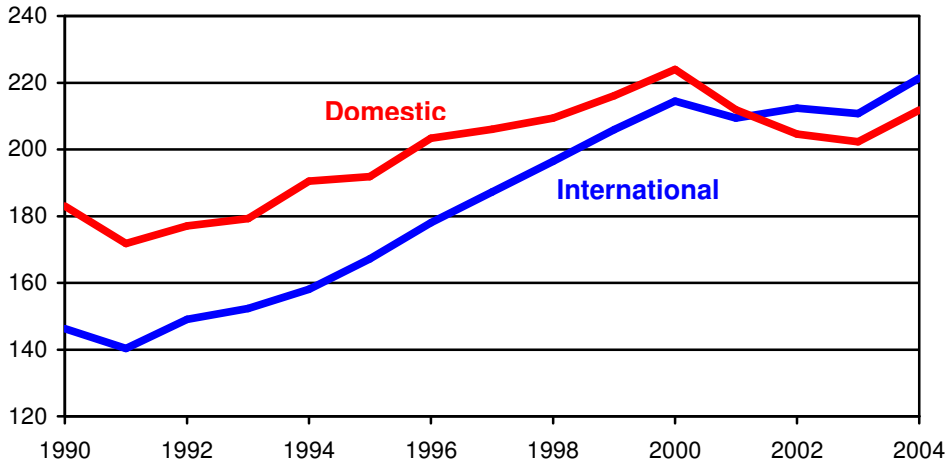

Figure 2: Annex I Parties - International and domestic aviation emissions CO_2 growth Source: UNFCCC (data excludes the Russian Federation)

Clearly, we need to redouble our efforts to reduce aviation emissions through technological innovation, operational initiatives, and utilizing market based measures realizing the constraints that aviation, by its very nature, faces regarding these issues. The following paragraphs describe the opportunities and challenges that research and development offers to aviation in order to reduce its environmental impact.

3. Research and Development of Current, New and Innovative Technology

Aircraft engine emissions are directly linked to fuel consumption. Overall fuel efficiency for civil aviation can be improved through a variety of methods, for example, by increasing aircraft efficiency through technology, improved operations and efficient air traffic management. ICAO's work on environmental protection began as far back as the 70's. In 2001, the ICAO Assembly requested the Council to continue studying policy options to limit or reduce the environmental impact of aircraft engine emissions calling for special emphasis to be placed on the use of technological solutions.

3.1. Fuel-Burn Reduction Technology

With constant improvements in fuel efficiency from technological innovations, carbon dioxide emissions from aviation are growing at a slower rate than air traffic. Today's modern, large transport aircraft are 70% more efficient than they were 40 years ago. Improvement in engine fuel efficiency has come mainly from the use of modern high-bypass engine technology that relies on increasing engine pressure ratios and higher temperature combustors as a means of increasing engine efficiency.

There are several practical issues when designing aircraft for fuel efficiency. Aerodynamic add-on technologies such as riblets and winglets reduce fuel consumption on long flights by reducing aerodynamic drag but may increase fuel consumption on shorter flights due to increased weight. They may also increase LTO emissions due to weight/performance tradeoffs and are not equally effective on all wing designs.

There are advanced propulsion concepts such as the unducted fan or the geared fan. The unducted fans reduce fuel consumption by increasing propulsive efficiency but result in higher noise since the fan duct is eliminated. In addition, fuel consumption benefits may be reduced by added weight to accommodate a large fan. The geared fan concepts improve aerodynamic efficiency by optimizing fan and turbine speeds but the fuel consumption benefits may be reduced by added gearbox weight. They do however reduce noise by decreasing fan speed.

The most prominent win-win technologies for improving aircraft efficiency are:

- Reduced weight materials and designs decrease NOx/noise/CO_2
- Components with improved aerodynamics decrease NOx/noise/CO_2 if weight is not affected

Weight saving is very important to aircraft design for obvious efficiency reasons. Weight saving has been and will be mainly achieved due to new materials, improved calculation methods, and possibly different airframe layout. Figure 3 shows an example of how materials technology (composites and advanced materials) has resulted in overall structural weight reductions.

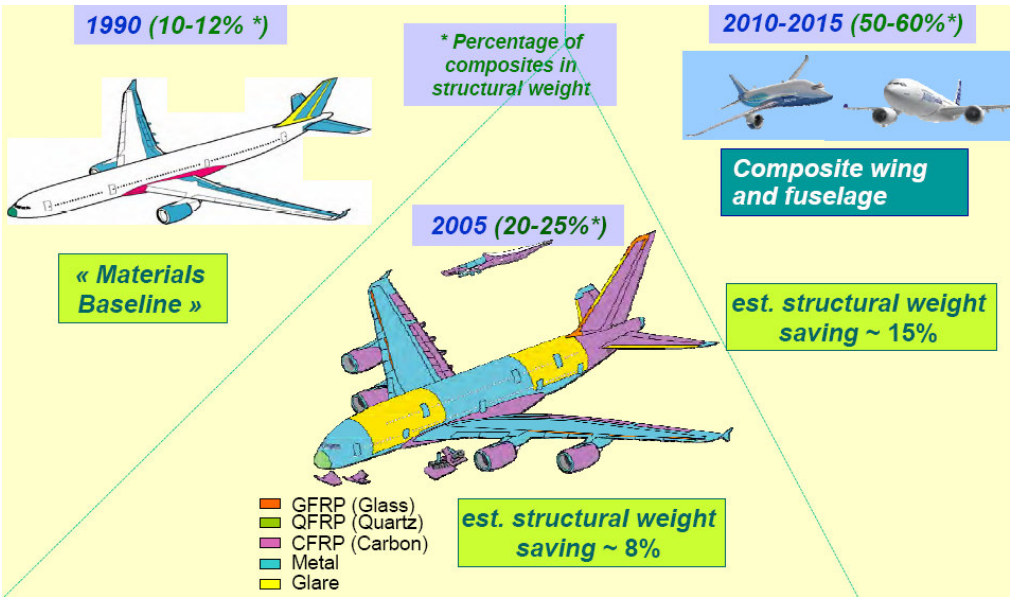

Figure 3: Structural Weight Reductions Source: ICCAIA

The main challenge in improved aerodynamics is to design components that have less drag and therefore require less thrust to fly the aircraft. This results in less thrust per unit of weight, therefore, better efficiency and lower fuel burn. The other aerodynamic improvement is generally achieved through laminar airflow which is done through structural optimization and improved integration (slats, flaps). Many improvements in wing design and engine integration optimization have been made over the years. Figure 4 demonstrates the efficiency improvements that have been achieved through improved wing design.

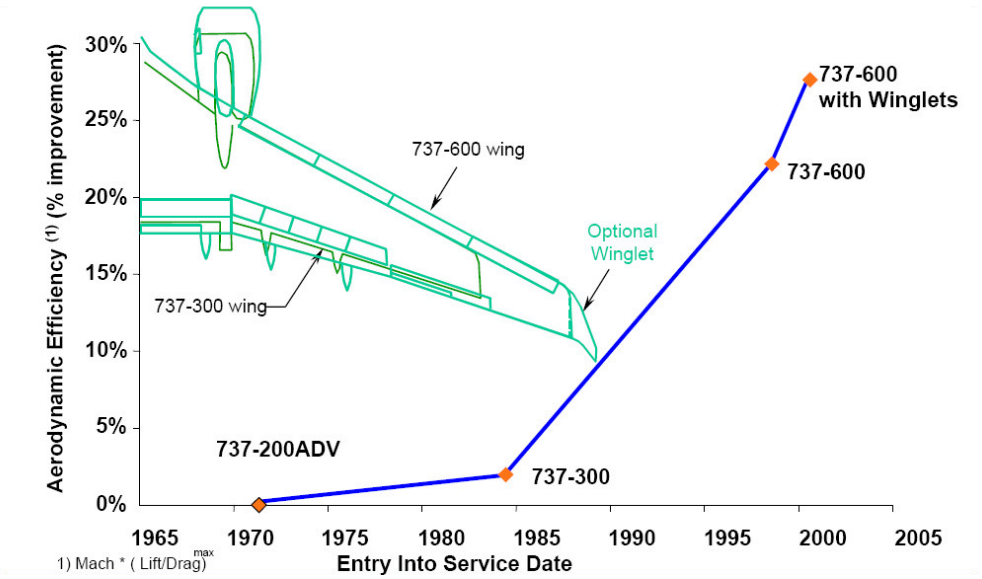

Figure 4: Aerodynamics: Airfoil technology has been improving Source: ICCAIA

Despite the significant improvements in efficiency over the last few decades, the challenge in aviation is to maintain continuous improvement.

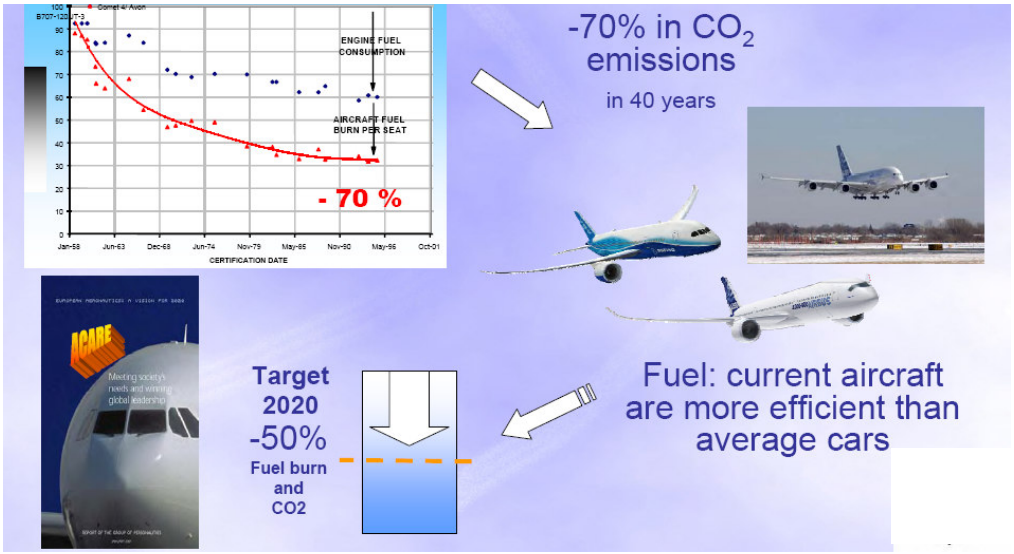

Figure 5: The challenge is continuous improvement Source: ICCAIA

Establishing Fuel Burn Reduction Technology Goals

For the work on establishing mid and long term goals for fuel burn technologies, a phased approach has been agreed upon whereby, as a first step, the manufacturers will produce a paper on fuel burn technology advances to date with preliminary views on prospects for future fuel burn technologies. An initial report is expected to be made available by February 2009. A fuel burn technology workshop will be arranged in March 2009 and the output of this workshop will be the basis for a report on available technologies in the mid and long term. Following this, an Independent Expert (IE) Panel would propose/comment on the range of any fuel burn/efficiency projections the workshop suggests for future analysis. The outcome of this activity will then be reviewed by technical committees of ICAO.

Aviation stakeholders are committed to continuously improving the aircraft efficiency realizing that lower fuel burn means less CO_2 emitted. It is estimated that technology alone can bring more than 1% improvement per year. However, to achieve this or faster improvement, strong and powerful research

programmes supported by governments are needed. Improved coordination between governments and regions will mean less duplication of efforts and more efficient use of resources, especially in today's economic situation.

3.2. NOx and Other LTO Emissions Reduction Technology

There has been a notable increase in NO_x stringency translating into a reduction in allowed NOx levels, of about 40 percent beyond the original ICAO standard for NO_x adopted in 1981 (applicable in 1986), as shown in Figure 6. Although NO_x Standards were initially intended to address local air quality, they also contribute to reduce the impact of aviation on climate, as NO_x may be a precursor of ozone formation.

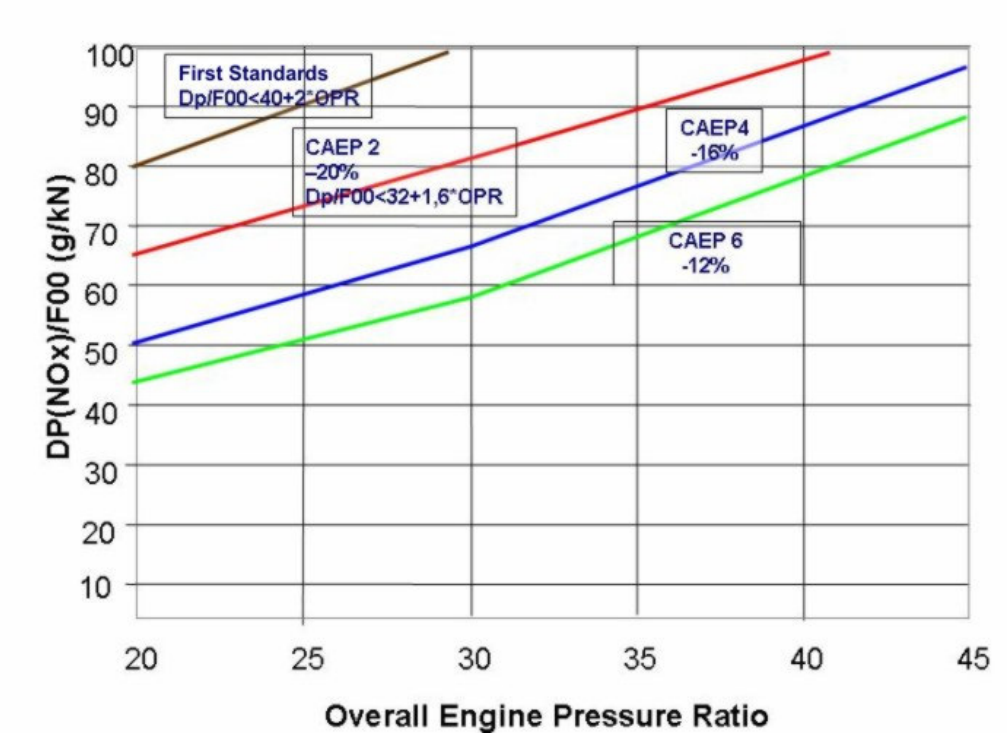

Figure 6: ICAO NOx Emissions Stringency Trends Source: ICAO

The introduction of ICAO Standards has contributed to the introduction of new technologies in the in-service fleet and to substantial reductions of NOx, HC and CO_2 and continued improvement is expected. Mandatory certification of new aircraft according to ICAO Standards has resulted in more efficient and cleaner aircraft.

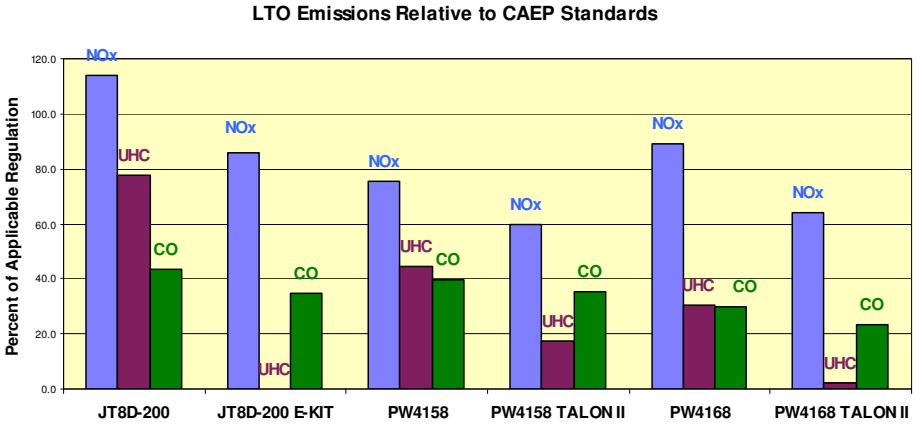

Figure 7: Relative Reductions in Pollutants from Aviation by Engine Type Source: Pratt & Whitney

Figure 7 shows examples of relative reductions in emissions levels from landings and take-off (LTO) before and after implementation of ICAO's Standards. For example, in the first comparison from left to right for the Pratt & Whitney JT8D-200 engines, emissions levels for NOx, UHC, and CO are at their highest. However, after compliance with ICAO's Standards from P&W JT8D-200 E-Kit, the overall levels of emissions dropped significantly. In fact, unburned hydrocarbons have been virtually eliminated. Similar examples exist for aircraft engines from other manufacturers.

Establishing NOx Reduction Technology Goals

A six member IE panel met in 2005 to review industry capability to reduce emissions of NOx as defined in certification parameters. They looked at the past trends and considered medium and long terms technology projections. After the review and following a thorough consultation and evidence based process, 10 and 20 year goals for NOx reduction technologies were established (The complete report has been published as ICAO Doc 9887). More specifically, the 2016 Medium Term Goal was set at 45% better than the 2004 Standard and the 2026 Long Term Goal was established at 60% better compared to the same baseline.

This was the first goal setting review of this kind for the whole aviation industry. A review of the NOx goals is planned to be held in early 2009, with a report available in mid 2009.

3.3. Reducing Environmental Impact through Improved Operational Measures

A significant way of achieving reduction in emissions is to shorten flight times and hence fuel consumption through improvements to the air traffic management (ATM) system. Such improvements have the potential to provide more direct routings for aircraft, as well as reducing the time spent in holding patterns waiting to land or queuing while waiting to depart.

According to the 1999 IPCC Special Report, improvements in ATM operational procedures could reduce aviation fuel burn by between 6 and 18%. A further 2 to 6% could come from improvements in other operational measures.

ICAO's main focus for operational measures is on the Global Air Navigation Plan. This plan requires environmental aspects to be taken into account right from the outset, when designing, developing and operating ATM systems. Emissions-related aspects of the plan include the flexible use of airspace; air traffic flow management; dynamic and flexible route management; terminal area design and management; aerodrome design and management; and performance based navigation.

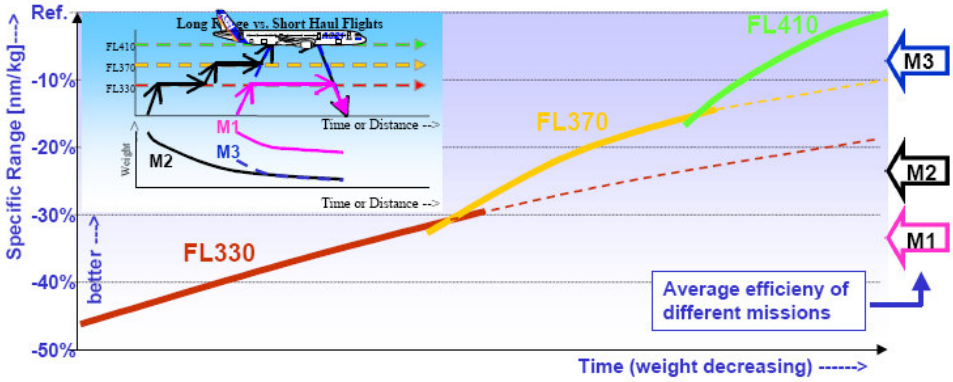

Figure 8: Typical Flight Profiles and Related Changes in Efficiency Source: ICCAIA.

The aviation community has been working on ATM operational improvements for decades. The work accelerated with the onset of Communication/Navigation/Surveillance and ATM systems (CNS/ATM). Technology development has been more rapid in recent years and improvements are now coming about even quicker. A major operational improvement was the implementation of Reduced Vertical Separation Minima (RVSM), which brought significant operational benefits to aircraft operators in terms of reduced fuel burn, availability of optimal flight levels, and increase in capacity, while also benefiting the environment. Figure 8 shows the relationship between efficiency and the cruise altitude as aircraft consumes fuel during its flight.

ICAO supported the development of RVSM, which was first implemented in 1997. RVSM has led to significant environmental benefits and will soon cover all airspace around the world. Studies in the European regions have shown that **RVSM leads to an average saving of 80 kg of fuel per flight in addition to significant reductions in NOx and sulphur oxide emissions** (EUROCONTROL January 2002).

Additional ICAO guidance to achieve fuel efficiency through operational measures is provided in ICAO Circular 303 - Operational Opportunities to Minimize Fuel Use and Reduce Emissions. That document identifies and reviews various operational opportunities and techniques for minimizing fuel consumption, and therefore emissions, in civil aviation operations. Operations covered in the guidance are: aircraft ground-level and in-flight operations, ground service equipment (GSE) and auxiliary power units (APUs), with potential actions to facilitate their broader application.

ICAO member States and regions have also launched initiatives to improve air transport systems in their areas of responsibility. Most notable among these are NextGen in the US and SESAR in Europe. ICAO is leading efforts to link these regional initiatives in broader globally harmonized networks and arranged a NextGen/SESAR Coordination Meeting in Montreal in September 2008. In addition, programs such as ASPIRE (Asia and South Pacific Initiative to Reduce Emissions) and AIRE (Atlantic Interoperability Initiative to Reduce Emissions) are helping reduce emissions by streamlining operations across wide areas of air traffic control. The potential for such initiatives was demonstrated on Nov 14, 2009 when a flight, using optimized procedures, between Sydney and San Francisco undertook 11 gate-to-gate operational procedures, from priority take-off clearance to a tailored arrival, that resulted in **savings of 1,564 gallons (5,920 litres) of fuel and 32,656 pounds (14.81 tonnes) of carbon emissions over normal conditions**. This was a collaborative effort between the airlines and regulatory authorities of several countries. Global cooperation through ICAO can help make such optimized flights routine.

ICAO has a central role to play in planning for the implementation of operational improvements. In addition to developing the necessary Standards and guidance material, ICAO has developed a global ATM Operational Concept that was widely endorsed and used as the basis for planning. ICAO also provides the planning framework through the Global Air Navigation Plan and several other documents and tools that support planning and implementation efforts.

Every ICAO region has identified performance objectives and has developed work programmes to bring near and medium term benefits, while integrating those programmes with the extensive work already accomplished. For example, ICAO is supporting a major technical cooperation project to implement an advanced air navigation system in the Caribbean region that is expected to substantially reduce aviation emissions in this region.

Establishing Environmental Improvement Goals for Operational Initiatives

Work is under way to define operational goals for fuel burn and to develop new guidance material on efficient operational procedures such as Continuous Descent Approach. An IE panel has been established to review the operational initiatives and to quantify environmental improvements expected from these initiatives in the mid and long term (10 and 20 years). ICAO's ATM (Air Traffic Management) experts' involvement in the process and coordination with relevant Panels is anticipated from the outset. The first meeting of this group is going to take place in early December, the review planned for January 2009 and a detailed report is expected in mid 2009.

The format of the results expected from this work are somewhat similar to those from the IPCC 1998 Special Report on Aviation and the Global Atmosphere that, in its chapter related to "air transport operations and relation to emissions", concluded that estimated improvements in ATM could improve overall fuel efficiency by 2 to 12 percent and that the potential for other operational measures was 2 to 6 percent. This data is now at least 10 years old. In view of current climate change concerns and in light of ICAO's leadership role, it is essential for ICAO to produce up-to-date data regarding potential reduction of fuel burn/CO_2 from improved operations.

3.4. Alternative Fuels Technology

A new and very promising area for research and development is aviation alternative fuels. This could be a win-win solution in that it will reduce aviation's dependence on climate changing fossil fuels while stabilizing the economic volatility associated with conventional fuels. The possibility of using alternative fuels is also being researched by fuel producers as well as the major aircraft manufacturers and it is foreseen that ICAO will play a crucial role by assisting with the development of the regulatory framework.

Currently, most civil aviation aircraft around the world use crude oil based kerosene. This fuel provides a good balance of properties required for aviation. The advantages of this fuel include high energy density and operation over a wide range of temperatures. However, concerns over volatility in fuel costs, energy supply security and the environment, have led to the need to investigate the development of alternative fuels. A viable alternative aviation fuel could offer important benefits by increasing the environmental performance of air transport, allowing it to substantially reduce CO_2 emissions. In addition to a potential reduction in CO_2, alternative fuels could have the added advantage of eliminating SOx in the exhaust (no sulphur in the fuel) and emitting 50% to 90% less particulate matter.

The alternative fuel technologies can be grouped broadly under three categories:

- XTL or Anything To Liquid (GTL, CTL, BTL)
- Biofuels (additive to conventional fuels)
- Exotic Fuels with a long-term horizon (e.g. Hydrogen)

Research organizations, manufactures, and users are currently investigating synthetic jet fuels (e.g. from coal, natural gas, or other hydrocarbon feedstock). Much progress has been achieved to date and there are high expectations for the certification of more environmentally friendly drop-in alternative fuels for aviation in the near term. The "drop-in" fuel is of immediate interest to aviation since it would be a direct substitute fuel that can be used without any substantial modification to engines or aircraft. The main challenge in XTL fuels is management of the CO_2 emitted during the fuel transformation process. The assessments on total life cycle impacts are continuing. Along with the work being carried out on carbon sequestration, these technologies may offer significant environmental benefits.

For the mid to long-term, research is underway on alternative fuels such as bio-fuel, available on a global basis, with a much higher environmental benefit. Bio-fuels present the challenge of chemical compatibility with traditional fuels since they are mainly foreseen as additives in the short to medium term. They also have generally lower efficiency and the affordability questions still has not been answered satisfactorily. However, feedstock such as algae, are being researched to answer some of these questions.

For exotic fuels, it can be argued that these are not fuels in the traditional sense since energy is needed to produce them. In addition, new infrastructure for storage and supply might be required. Also, since the energy density is low, a bigger volume is needed for on-board storage resulting in potential new aircraft configurations. Nevertheless, because of the potential for breakthrough technologies in this area, significant resources need to be dedicated for research and development.

There are several regional initiatives to advance alternative fuel technologies. In the US, a consortium CAAFI (Commercial Aviation Alternative Fuels Initiative) including all major stakeholders has been formed to coordinate alternative fuels research. Similarly in Europe, Omega is hosting a conference on alternative fuels in November 2008 to improve coordination in this area.

Whether for short term XTL, or medium term bio-fuels, or even long term exotic fuels, concerted international action is absolutely necessary to minimize duplication and share lessons learned across regional boundaries. Global coordination is the only way to translate today's possibilities into tomorrow's realities. ICAO is at the forefront of this international coordination and is leading the way to a internationally agreed road map that will identify the roles and responsibilities of the main stake-holders as well as provide a timeline of actions.

Establishing a Global Plan for Alternative Fuels

As a first formal step in international coordination, ICAO will hold a preparatory/ exploratory workshop on aviation alternative fuels from 10 to 12 February 2009. This event will provide a forum to explore challenges to development and deployment of alternative fuels for aviation, as well as initiatives to promote cooperation. The main purpose of the workshop is to encourage initiatives in global cooperation across national and regional boundaries. On the last day of the workshop, a meeting is planned to establish the organizing committee of a conference to be held in November 2009. This committee will include all major players, including fuel producers, consumers, designers, and regulators, with the aim of establishing a detailed programme for the November 2009 conference so that a internationally-agreed "road map" for alternative fuels can be issued at the end of the conference. This "road map" will identify the roles and responsibilities of the main stake-holders as well as provide a timeline of actions.

The workshop and the conference will outline of the importance of alternative fuels for aviation and discuss state of the art of different fuel alternatives in a panel format. It is expected that solid recommendations will come out of these events in terms of the short, medium and long term plans of action with timelines and benchmarks to measure progress. The issues covered for both synthetic and bio-fuels will be R&D efforts, production, commercial availability, fuel and engine certification, environmental assessment, and infrastructure Issues (transportation, storage, and interoperability). As described before, these events are being organized to examine production and delivery, certification and qualification, economic, business and environmental issues and research and development with the objective of establishing a "road map" for development and deployment of aviation alternative fuels.

ICAO realizes that aviation, because of its high acceptability threshold, faces a more serious challenge in alternative fuels. But the promise of environmental and economic benefit underscores the urgency of pursuing this option. Aviation stakeholders also represent the leading edge of technology in our society and therefore must lead the efforts to implement alternative fuels in our products. This is the only sustainable way to improve aviation's environmental footprint while allowing economic growth.

4. Next steps and concluding remarks

International aviation's contribution to the total CO_2 emissions generated by anthropogenic activities is relatively small compared to other energy and transport sectors, but it is growing. While domestic action to address aviation emissions can be treated similarly to other sectors under the Convention and the Kyoto Protocol, emissions from international aviation are, by definition, global in nature and cannot be circumscribed to national or recognized geographic boundaries. Assigning international emissions is an extremely complex task at best and difficult to implement or enforce.

ICAO has developed Standards, policies, and guidance on aircraft engine emissions for the use of parties in their national policies to reduce emissions. This has lead to 70% more fuel efficient aircraft today than the first generation of jet aircraft. General improvements accrued from a more efficient air navigation system are to be expected when the ICAO Global Air Traffic Management Plan is implemented worldwide. Furthermore several ICAO Contracting States, like Japan and Canada, have already initiated voluntary initiatives based on ICAO guidance.

ICAO provides an official, unbiased and effective international forum that has demonstrated its effectiveness in developing globally harmonized environmental Standards that have substantially increased the energy efficiency of air transport worldwide while increasing its level of safety at the same time.

It is essential that ICAO continue the collaborative effort with key aviation stakeholders including manufacturers, airlines, airports, air navigation providers, regulators, and governments to improve efficiencies in the overall air transport system. Manufacturers are keen to design aircraft that are optimized for the airlines and public use. In turn, airlines aim to optimise operations and maintenance (clean aircraft, performance monitoring, flight planning) in order to reduce the environmental impact of their operations while reducing costs and delivering better service to their customers. Airports are ready to implement innovative solutions (late engine run, reduce taxi time, innovative taxiing techniques, efficient power supply on ground) in doing their part in environmental improvement. There are key initiatives in air traffic management to improve operating procedures (more direct routes, better low-speed procedures, improved separation, CDA) that translate directly into less CO_2 emitted. Developments in alternative fuels offer the promise of environmental improvement and economic growth simultaneously. Governments and regulators need to work in an international, global framework, that can only be facilitated by ICAO, to set a long-term vision. This will promote internationally applicable Standards and goals resulting in coordinated robust research activities that will ultimately help achieve our shared long term vision.

ICAO is progressing well towards finalizing an ICAO Programme of Action on International Aviation and Climate Change. As mentioned in earlier paragraphs, several sub-groups in ICAO are in the process of establishing short, medium and long-term aspirational goals for fuel burn. The outcome of the smaller groups will be consolidated in early to mid 2009 with a high-level review and finalization expected by the end of 2009.

ICAO realizes the urgency to implement solutions that reduce aviation's environmental footprint while allowing economic growth, especially in developing countries and islands that greatly depend on aviation for travel and trade. Research and development in aviation technologies, such as advanced materials, improved aerodynamics, and use of alternative fuels, offers great promise. These are win-win technologies and, once developed for aviation, will also trickle down to other sectors for an overall better environmental performance.

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