IBAC Business Aviation Environment Brief
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Introduction

The business aviation community takes its environmental responsibilities very seriously and is actively promoting environmentally responsible practices for business aircraft operators. To reduce their environmental footprint, business aircraft operators are purchasing aircraft that are far more efficient than previous models and they are working with air traffic service providers to be able to operate these aircraft even more efficiently. As a result of demands from operators for more efficient aircraft, business aircraft manufacturers are working aggressively to improve aircraft designs with technology that will reduce the environmental impact of their aircraft. Business aviation is proud of its record in reducing aircraft noise and emissions, but the community is resolved to do more.

Benefits of Business Aviation

Business aviation has an important role as a global economic enabler. Business aircraft move employees and equipment efficiently where they are needed, when they are needed. Because they fly point to point from dedicated business aviation satellites or from smaller airports, business aircraft can often be operated more efficiently than scheduled airline operations. Business aircraft operations are conducted to task rather than on a scheduled basis. This reduces the potential for unnecessary flight times and avoids wasting fuel. The typical business jet flies, on average, only 500 hours per year which is about one sixth of the average hours flown by commercial aircraft on scheduled routes.

This brief will give an insight into how the business aviation community along with aircraft and engine manufacturers and air traffic service providers are addressing environmental concerns with better technology, operational improvements and market based measures.

Facts and Figures on Aviation and the Environment

The October 2006 report by Sir Nicholas Stern states that the largest contributor to human-induced CO_2 is power generation at 24%, mostly produced in coal and gas fired stations. Next is land use change at 18%, then agriculture, industry and transport at 14% each. According to the United Nations Intergovernmental Panel on Climate Change (IPCC), aviation accounts for 2% of man-made global CO_2 emissions. General aviation represents just about 2% of total aviation or about 0.04% of overall global CO_2 emissions. This latter figure was calculated using known fuel use and includes general aviation, business aviation and helicopter use.

Although the Kyoto Protocol targets pursuant the United Nations Framework Convention on Climate Change focused on CO_2 emissions, there are other greenhouse gases that are thought to contribute to climate change. These include methane, water vapour, and oxides of Nitrogen (NOx).The IPCC concluded that the total contribution of aviation to climate change once these other gasses are considered is approximately 3%. To put this into perspective, the United Nations` 2006 report Livestock`s Long Shadow, estimates that industrially raised cattle account for 18% of all greenhouse gases, 6 times more than aviation's contribution and 300 times more than business aviation`s contribution to climate change.

Despite the fact that business aviation is a very small contributor to global emissions, the industry accepts that it must operate in a responsible manner and must continue to reduce the environmental impact of its operations.

Aviation and Environmental Issues

Aviation's main environmental issues are noise, local air quality and green house gas emissions.

Aircraft noise is created by both the engine and by the airframe. Although not a health hazard, noise is an annoyance which can have a serious impact on some individuals.

Local air quality environmental concerns tend to pertain to the effects created by aircraft emissions during the landing and take-off cycle. These emissions occur close to ground level and are of concern to people living in the vicinity of airports. Potential adverse effects of air pollutants for these residents are the same as general concerns about air pollution that result from burning fossil fuels. In the immediate vicinity of airports, emissions of NOx, volatile organic compounds (VOCs), carbon monoxide (CO) and particulate matter (PM) are usually considered to be the most important contributors to local air quality concerns.

Global climate change is becoming one of the major environmental concerns for most people today. Aircraft and all other forms of transportation that burn fossil fuels produce greenhouse gas emissions. These emissions are directly related to the amount of fuel burned.

Technical Improvements

Sustainability of the planet and protection of the environment have long been of significant interest to the general public, business and governments alike. In response, the whole aviation community has been active in research and development activities in search of ways to mitigate the impact of aviation on the environment. Business aviation benefits both directly and indirectly from the research efforts that are being widely conducted throughout aviation. As a result

of these efforts, much has been done to improve the effect that business aviation has on the environment. This issue must be considered from an aviation industry point of view, rather than just from a business aviation standpoint. The following are examples of the improvements being made now and what will be coming in the future that will reduce the impact of aviation on the environment.

a) Aircraft Noise

The International Civil Aviation Organization (ICAO) has been addressing the issue of aircraft noise since the 1960s. The first Standards and Recommended Practices (SARPs) for aircraft noise certification were published in 1971. These Standards have been updated regularly to reflect improvements in technology. All business aircraft produced today meet the applicable ICAO noise standard.

Aircraft coming off the production line today are about 75% quieter than they were 40 years ago. Engines, such as the new geared turbofan engines produced by Pratt & Whitney, demonstrate that further improvements will continue to reduce engine noise. On average, today's business aircraft are about 7 dB quieter than most commercial aircraft and manufacturers are working on producing even quieter aircraft. Until recently, the engine was the primary source of noise but with the introduction of new technology such as the high bypass ratio engines, this source of noise has been reduced to the point where airframe noise is now a greater concern. Manufacturers are now devising methods to further reduce both engine and airframe noise. By paying close attention to parts of the aircraft that induce drag such as the landing gear, manufacturers are finding ways to reduce both noise and fuel consumption.

b) Engine Emissions

The International Civil Aviation Organization (ICAO) has very strict design standards for aircraft engine emissions. All aircraft engines produced today meet all applicable ICAO standards. These standards are constantly being revised by ICAO to ensure that aircraft engines incorporate the best available technology to reduce their environmental impact. Regulated emissions are for soot or carbon (C), NOx, CO, and particulates. Emissions of CO_2 are not regulated at this time. Oxides of sulphur are also produced by the combustion process but are not regulated because they are entirely dependent on the amount of sulphur in the fuel.

The primary concern about NOx is its contribution to ground level air pollution. In the presence of sunlight, NOx reacts with volatile organic compounds (gases or vapours emitted by various substances such as paint stripper, cleaning fluids, gasoline, adhesives or glue) to produce ozone or smog, a known health hazard. Air quality measurements at airports conducted by Transport Canada concluded that aircraft sources of NOx in the vicinity of airports are very small compared to other sources such as local industries and automobiles but the aviation industry

recognizes that all sources of NOx need to be reduced. NOx is also considered to be a contributor to climate change, another incentive for manufacturers to reduce NOx emissions from their engines. In response to these concerns, manufacturers have reduced emissions of NOx from aircraft by 50% during the last 15 years.

Airport operators are also assisting in reducing emissions and improving air quality by providing electrical power and pre-conditioned air to aircraft at terminal gates. This allows aircraft to switch off their auxiliary power units, reducing fuel burn and reducing emissions of gases effecting local air quality. Taxiing and queuing times are being reduced by constructing more direct taxiways and by holding aircraft at the gate until departure slots are ready.

Particulates which are unburned hydrocarbons, are thought to contribute to cirrus cloud formation, another contributor to climate change. At ground level, particulates are considered to be a health hazard. Thanks to the highly efficient combustion process of aircraft engines, emissions of unburned hydrocarbons are very low.

Carbon monoxide, a known health hazard, is produced during incomplete combustion of fossil fuels. Aircraft engines, because of their highly efficient combustion process are not a significant source of CO. All aircraft engines manufactured today have CO levels that are well below the limit set by ICAO. According to the International Aerospace Industries Association, as a result of technical developments since the 1960s, today's new aircraft engines emit 50% less CO and 90% less smoke and unburned hydrocarbons than they did 50 years ago.

CO_2 is believed to contribute to climate change and this has increased the demand for engines that are more efficient. The amount of CO_2 produced by an engine is directly related to the amount of fuel that is burned so the challenge for engine manufacturers is to develop new engines that consume fuel more efficiently. Aircraft operators, for many years, have been demanding engines that are extremely efficient because fuel is a large part of the cost of operating an aircraft. With efficient engines, aircraft do not have to carry as much fuel. With less fuel on board, they can carry more passengers and /or cargo or fly farther. The rising cost of fuel was one of the incentives for more efficient aircraft engines but now, environmental concerns are becoming the dominant driving force. As a result of this demand by operators for efficient engines, the engine manufacturers have made environmental improvements of their engines a high priority. This incentive is working. According to the International Air Transport Association, modern aircraft are 70% more efficient than 40 years ago and 20% more efficient than 10 years ago. The latest aircraft designs achieve efficiencies of 3.5 litres per passenger kilometre which is better than most automobiles. The goal of the next generation of aircraft is 3.0 litres per passenger kilometre which no doubt will be achieved since aircraft engines are forecast to be another 25% more efficient by 2020.

Four of the major engine manufacturers, Pratt & Whitney, GE, Honeywell and Rolls Royce continue to conduct research into the next generation of improvements for aircraft engines. For example; Honeywell's new combustor for reduced emissions, is estimated to reduce NOx, smoke and unburned hydrocarbon levels by significant levels.

Combinations of engine and airframe improvements will deliver the most significant reductions in environmental impact. However, there are other aspects of the aviation system listed below that will also contribute to this.

c) Alternative Fuels

Considerable research and development into alternative fuels is providing alternatives to kerosene, the traditional aviation fuel. Bio-fuels have the potential to reduce aviation CO_2 emissions by up to 60%. They are derived from recently grown biological materials and when they are burned, they emit only the amount of CO_2 that they previously absorbed during their growth.

A very important consideration related to bio-fuels is that they must meet the current exacting technical specifications of jet kerosene so the bio-fuel can be a direct replacement for Jet-A fuel. Another very important consideration related to bio-fuels is that they can be made from a wide variety of plant material and must not compete with food for land-use and they must not harm bio-diversity.

Ethanol, a well known bio-fuel is made from corn and has caused an increase in the price of corn to the detriment of developing countries for whom corn is a staple. One very likely replacement candidate is a bio-fuel produced by algae. There is also a lot of promising research into bio-fuels made from waste material like sawdust, harvest remnants and municipal waste. Another acceptable bio-fuel option is the jatropha plant, an oil-rich tropical plant growing on very dry and otherwise unusable land. All of these options do not compete for land or for the food supply.

d) Airframe Improvements

The main incentive for airframe improvements has always been the desire to achieve a competitive advantage over other manufacturers and to provide customers with aircraft that had more range, improved efficiency, and greater capability. This applies to both airliners and to business aircraft. To design aircraft for greater fuel efficiency, it is necessary to reduce the weight of the aircraft and/or to reduce its drag with improved aerodynamics.

To reduce drag, external shapes have been refined, and optimized. Particular attention has been paid to areas such as the wing-body fairings, the nose, windscreen, the cockpit roofline, the aft-fuselage, and the tail assembly.

Complex curves reduce the coefficient of drag and help avoid shock waves, which can cause an abrupt increase in drag. Wings have been redesigned thanks to research by NASA and are now both lighter and more efficient. Winglets are an effective innovation that counter the effect of wing tip vortices, and thus reduce the induced drag of wings. They are widely used on both business jets and airliners to reduce fuel consumption.

New materials, in particular composites, are enabling aircraft manufacturers to make aircraft that are substantially lighter yet retain the strength of earlier, heavier materials. Composites are made up of two or more different materials such as carbon fibre that are joined to create stronger and lighter materials that are ideal for many aircraft parts. These lighter materials help to reduce fuel consumption significantly.

e) Maintenance

Improved maintenance procedures can provide significant improvements in efficiency, and therefore will decrease the environmental impact. For example; the Pratt & Whitney “EcoWash” system, which is an on-wing cleaning system can deliver a 1% improvement in fuel consumption.

Aircraft engines have very sophisticated electronic devices that measure fuel flow. If the computer detects higher than allowed fuel consumption, the problem is identified and rectified as soon as practicable. This is primarily for safety reasons but this practice also contributes to environmental efficiency.

Aircraft have maintenance schedules that are rigidly followed and prior to every flight, aircraft are inspected to ensure that they are serviceable. Surface vehicles do not have the same maintenance and inspections as aircraft and can be operated for long periods in an inefficient manner. Aircraft maintenance standards are much higher than for surface vehicles.

Air Traffic Management

Efforts to increase aircraft operational efficiency are reducing fuel consumption and are therefore decreasing greenhouse gas emissions from business aviation. Modern air traffic management practices such as point to point navigation and RVSM have already made significant improvements in fuel efficiency but there is still the potential for further reductions in fuel burn with the introduction of NextGen in the USA and SESAR within Europe. Satellite based navigation aids make direct routing possible with shorter flights and reduced total fuel burn. With the introduction of Reduced Vertical Separation Minimums (RVSM), more aircraft are now able to operate at their optimum altitude for fuel efficiency. In Europe for example, fuel burn and associated emissions were reduced by approximately 5%

and NOx emissions were reduced by up to 4.5% because of the introduction of RVSM.

Other direct and indirect benefits to the environment will result from additional improvements to the air traffic control system such as the increased use of enhanced procedures such as the Dynamic Airborne Rerouting Program, Continuous Decent Arrival/Approaches and Required Navigation Performance. These procedures have the potential to reduce both fuel burn and noise. To be able to take advantage of these ATM improvements; aircraft must be equipped with the appropriate modern navigational aids.

Market Based Measures

Market based measures are another promising option to reduce the impact of aviation on the environment. They are designed to achieve environmental goals at a lower cost and give operators more flexiblity. ICAO is currently studying a number of market based measures including emissions trading, voluntary measures, and levies.

a. Emissions Trading

Emissions Trading Schemes (ETS) under Kyoto Protocol are recognized to be a potential means of achieving emissions reductions at the lowest possible cost. ETS provide operators with the flexibility to reduce their own emissions or to purchase equivalent reductions from others, if doing so would be less expensive. IBAC agrees that this can be an effective method of reducing the impact of aviation on the environment provided that the administrative costs are reasonable and would prefer that the money collected be reinvested in R&D to improve aviation technology.

The European Business Aviation Association is currently working with Eurocontrol to develop a better tool for business aviation operators to meet the European ETS requirements. The PAGODA model is a tool that can estimate fuel burn and GHG emissions directly from Eurocontrol traffic data for all air traffic operating within the airspace overseen by the organization, thereby minimizing the administrative burden.

b. Voluntary Measures

An increasing number of operators are voluntarily offsetting their emissions. Execujet Aviation Group has aligned with the Swiss-based *Myclimate* non-profit organization, to allow its charter customers to offset the CO_2 generated when they fly. NetJets Europe, the largest business aircraft operator in the region, has developed a program designed to make it 100% carbon neutral by 2012 and provide its fractional owners an opportunity to offset emissions for their flights.

For this, they have partnered with EcoSecurities. Original equipment manufacturers such as Bombardier and Embraer offer their business aviation customers the option of participating in carbon offset schemes. This enables operators to offset the carbon emissions of their aircraft

c. Levies

In a Resolution adopted on 9 December 1996 the ICAO Council strongly recommended that any environmental levies on air transport, which States may want to introduce, should be in the form of charges rather than taxes and that the funds collected should be applied in the first instance to mitigating the environmental impact of aircraft engine emissions by repairing specific damages, and by funding research on development of technology. It also recalled that in application of ICAO principle expressed in Article 15 of the Chicago Convention and in accordance with the guidance provided in the Council Statements:

- there should be no fiscal aim behind the charges
- the charges should be related to costs; and
- the charges should not discriminate against air transport compared with other modes of transport.

Summary

This paper has explained the interaction of business aviation and the environment. It has highlighted improvements that have been made and has discussed future opportunities for reducing the impact of aviation on the environment. IBAC intends to expand on what has been described in this paper with a selection of briefs that provide additional information on the subjects described in this paper.

Business aviation has long been proactive in seeking solutions to reduce its impact on the environment. The International Business Aviation Council and its member organizations are fully prepared to assume a shared responsibility to seek ways to mitigate the impact of aircraft on the environment and are willing to take a leadership role to address emissions from business aviation on a harmonized worldwide basis. There are still additional initiatives that would further mitigate environmental impact that will be adopted when available. These include new technologies already in development and further improvements now in research and development programs. These initiatives will ensure that business aviation will remain a sustainable part of the international aviation industry.