PARE

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CHAPTER 9

Cooperation Beyond Europe's Borders

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Chapter 9 – Cooperation Beyond Europe's Borders

There are a few areas of aeronautics of common interest to the worldwide community, including education, research, industry, airlines, airports, service providers and ultimately passengers and travelling public, and the governments and the national and international institutions representing them. Some of these areas that clearly justify cooperation beyond Europe's borders are Air Traffic Management (ATM), harmonized certification rules, environmental effects, safety and security, fair trade and open markets and are considered next.

9.1 Air Traffic Management

Air traffic is expected to continue to grow at a rate of 2 to 7% per year depending on the region of the world. It is generally agreed that the main potential limitation to this continuing growth is the capacity of the air traffic system including airports and Air Traffic Management (ATM). Airports are a local issue, although with far reaching geographical implications in the case of major hubs. ATM is a global issue in the sense that it should function seamlessly worldwide, over continents and across oceans, and in densely, sparsely or uninhabited regions.

The air traffic is densest in Europe and the north-eastern corridor of the US. Past experience in these areas has shown that when traffic approaches the available capacity there is a combination of entirely undesirable consequences: (i) departure and arrival delays that cause passenger dissatisfaction and can hinder business activities; (ii) aircraft in flying holding patterns awaiting permission to land and take-off queues of airplanes waiting to gain access to a runway; (iii) associated with (ii) there is an increase in fuel consumption, and also increased pollution and noise, precisely near the airport areas where these issues are more sensitive; (iii) the economic losses are not just increased fuel costs and lost revenues for airlines but also the loss of valuable time for passengers and business travel.

Through advances in technology and procedures ATM in Europe and the US has mostly managed to stay ahead of the growth of air traffic, but not by a wide margin all the time, so that there are still occasional delays and the overall challenge remains. This challenge is recognized at a political level as testified by the large programs SESAR in Europe and NextGen in the US that are under some pressure to provide evidence of results and progress in the quest to keep air traffic capacity ahead of air transport growth and avoid the risk of massive flight delays and cancellations.

Progress in ATM is more marked in Europe and the US both because of the market pull of having the densest air traffic in the world and by the market push of being able to provide the most advanced relevant technologies, such as radars, navigation and communication systems, satellite links, equipment for Air Traffic Control (ATC) centres and control towers, including operator consoles and other hardware and operating systems incorporating sophisticated software. The market for ATM equipment and services is considerable and not to be underestimated compared with the market for aircraft and airlines services, since they are all complementary and interdependent.

The situation is simpler in the US which as a single nation has the same procedures and compatible equipment under the auspices of the FAA that is both the only Air Navigation Services Provide (ANSP) and also the certification authority. In Europe: (i) there is a division in ATM sectors affected by national borders; (ii) the national ANSPs coordinate their activities through Eurocontrol and operate a diversity of hardware and software ;(iii) the membership of Eurocontrol is wider than that of the European Union and does not coincide with the certification authority (EASA) which groups the national certification authorities. The Single Sky is a given in the US and work in progress in Europe. Despite all these factors Europe betters the US in most ATM performance metrics like timeliness of flights and achieves the same or higher safety standards.

While there is healthy and desirable competition in the supply of ATM equipment and systems, the requirement for seamless operation over continents and across oceans should be preserved. Also, many of the basic technologies are common and it is their implementation in commercial products that is competitive. The seamless integration of SESAR and NextGen across the Atlantic Ocean is as good example of the need for and benefits of cooperation and coordination among the two world leaders in ATM technology. The benefits will be felt worldwide since the same issues of seamless air transport apply across national borders and the Pacific and Indian Oceans, and major suppliers of hardware are Europe and the US.

Considering the likely and needed progress in ATM (Key Topic T9.1), a comparison can be made between the two largest programs in the world (Key Topic T9.2): SESAR in Europe and NextGen in the US.

KEY TOPIC T9.1 EVOLUTION OF ATM IN EUROPE AND ELSEWHERE

T9.1.1 Steps Toward the Single European Sky (SES)

The Single European Sky (SES) initiative was launched in the beginning of the present century by the European Commission, mainly driven by important delays in aviation operation in Europe by the end of the 19^{th} century. In other words, its primary goal was and is still to meet future capacity and safety needs through different tools, mainly legislation framework and research.

The first step taken was a legislative package drafted by the European Commission at the end of 2001 which was adopted by the European Parliament and Council in March 2004, since which the European Union has gained competences in air traffic management (ATM) and the decision-making process has moved away from an intergovernmental practice to a common European framework.

The legislative package adopted in 2004 comprised four basic regulations, which addressed the reinforcement of safety and air navigation services. The regulations provided the framework for the creation of additional capacity and for improved efficiency and interoperability of ATM system in Europe. These four basic regulations were [1]:

- Framework Regulation (EC Nº 549/2004), which addresses the framework for the creation of the Single European Sky.
- Service provision Regulation (EC Nº 550/2004), which addresses the provision of air navigation services in the Single European Sky.
- Airspace Regulation (EC Nº 551/2004), which addresses the organization and use of airspace in the Single European Sky.
- Interoperability Regulation (EC Nº 552/2004), which addresses the interoperability of the European air traffic management (ATM) network.

These four regulations formed the SES I Package, and the result of its implementation was the insufficient progress in key areas hence deep modifications were needed. The key areas that needed to be developed were, mainly [2]:

- Performance review of service providers: The Framework Regulation foresaw Performance review of Air Navigation Service Providers (ANSP) in which data gathering and benchmarking were expected to commence in 2008 in order to form a solid basis for future development of the Single Sky initiative.
- Peer review of supervisory authorities: it was foreseen in order to ensure a uniform level of safety and even application of the Common Requirements. With the completion of the first Certification exercise by the NSAs in July 2007, the peer review was established with first visits in early 2008.
- Transparency of charging: the first review under the Common Charging Scheme Regulation was expected to guarantee a greater transparency for the determination, imposition and enforcement of charges for air navigation services.
- Airspace design: the mandate process to Eurocontrol was initiated on a number of draft Regulations related to airspace such as the establishment of a European Upper Flight Information Region (EUIR), airspace classification in the lower airspace or common principles for route and sector design. In this manner, progress in all three areas was slow and the Commission studied alternative mechanisms.
- Functional Airspace Blocks (FABs): a key element of SES was the establishment of Functional Airspace Blocks (FABs), which were foreseen as the mechanisms for ensuring maximum capacity and efficiency of the air traffic management network.

Back in 2007, SES did not deliver the expected results in some important areas. In general, the FAB approach was not producing the benefits hoped for in terms of improved flight efficiency, cost reduction and "defragmentation". It was recognized that the creation of FABs was a new challenge and suffered from significant technical and organizational difficulties, sovereignty, particularly concerning Member States responsibilities and associated liability for their airspace and the involvement of the military remained an issue. Besides, even though legislation had powerful tools to improve performance through: designation of service providers; unbundling of services; use of economic incentives; setting of user charges; changes in route structure; establishment of FABs; rationalization of infrastructure; etc., Member States did not make sufficient use of them to improve cost or operational efficiency of service provision [2].

In this manner, the SES II Package was defined in 2009 through Regulation EC Nº 1070/2009 in which the main aim was to increase the overall performance of the air traffic management system in Europe, based on the insufficient progress in key areas from the start of the SES I

Package, as explained above. Thus, the Commission adopted and implemented extensive and exhaustive implementing legislation in which more than 20 implementing rules and community specifications (or technical standards) were adopted by the European Commission in order to ensure the interoperability of technologies and systems [3]. Therefore, with the SES II Package, a step forward was made towards establishing targets in key areas of safety, network capacity, effectiveness and environmental impact.

This SES II Package was intended to accelerate the realization of the SES and its benefits with high-levels goals to achieve by 2020 relative to 2005. To achieve these goals the European Parliament established a framework of five pillars (Figure 9.1) based on technology, safety, performance-based regulation, airports and human factors. This framework is based on an integrated approach towards safety by the extension of the competencies of the EASA in the field of aerodromes, air traffic management and air navigation services, through the establishment of a joint undertaking (JU) on research & development, the SESAR JU (SESAR standing for the Single European Sky ATM Research). A Network Manager for the European ATM network has been created, while an independent Performance Review Body (PRB) supports the Commission in the development and management of the SES performance scheme in which Functional Airspace Blocks (FABs) have a key role to play [3].

Figure 9.1 - SES implementation five pillars
Source: A Blueprint for the Single European Sky by IATA

Each one of these five pillars will help to achieve the overall SES objectives through a holistic approach and they are specifically explained below [4]:

Technology Pillar

The Single European Sky ATM Research (SESAR) program has been a strong focus for many stakeholders across the industry. More than €2 billion has been committed to the development phase and is estimated that around 3,000 people are currently engaged in this unprecedented research and development effort to improve ATM efficiency. The encouraging results of this development phase have demonstrated that new concepts are feasible however the benefits will be much delayed and at a reduced level than originally planned. Additionally, SESAR deployment will only deliver a portion of the SES high-level goals and, if the technology component is not deployed in synchronization with the other pillars, it will lead to further waste and non-delivery of benefits.

Safety Pillar

To date the SES, I and II packages focused on making progress in areas of safety and clarified the respective roles of regulators, supervision authorities and service providers. The evolution of the European Aviation Safety Agency (EASA) to cover ATM and airports is also an important step towards the supervision of safety across the entire air transport supply chain. However, at this point, it is considered that EASA must improve its cost-efficiency. Importantly, it is lacking some of the necessary resource capability in order to effectively perform new responsibilities, especially with respect to appropriately experienced and skilled professionals. Reporting and transparency are also insufficient. For example, it is concerning that in the PRR for the 2011 calendar year, that 12 European Civil Aviation Conference states did not submit safety template data to the Eurocontrol Safety Regulation Commission.

Legislative Pillar

The legislative pillar consists of three components which have close interrelationships; the Performance Scheme, the FABs and the Network Manager.

Performance Scheme

The Regulation established that a Performance Scheme should be set up to improve the performance of air navigation services and network functions as much as the scheme aims to ensure that capacity is increased. As a result, flights will be significantly less delayed, saving unnecessary costs for airlines and passengers. In addition, the environmental impact of air traffic will be reduced due to more efficient and shorter flight paths. Air travellers should benefit from a punctual, greener and more cost-efficient mode of transport with a maintained or even enhanced level of safety. In this manner, the scheme should include Community-wide performance targets on the key performance areas of safety, environment, capacity and cost-efficiency. National plans ensuring consistency with this as established by this Regulation and Community-wide performance targets must be defined, and moreover periodic review, monitoring and benchmarking of air navigation services and network functions should be conducted to ensure that targets are met. The Regulation also establishes reference periods (periods of validity and application of Union-wide performance targets and the performance plans): the first reference period, known as RP1, covered the calendar years 2012-2014, the current one, RP2, includes the calendar years 2015-2019 and RP3 will start in 2020 and subsequent periods will cover five calendar years.

As example of monitoring, en route ATFM delay has changed along the past years (see Figure 9.2). At the beginning of RP1, the average delay was lower than the target set for 2012 (0.63 vs 0.7) and, although the target has been even more restrictive every year, the average delay was also lower than the target in 2013 (0.54 vs 0.6). However, since 2014 until now, the average en route ATFM delay has been higher than the target set and, even worse, the average delay has continued increasing until set the maximum difference in the current year (1.07 vs 0.5). Therefore, as an increasing trend is underway, air traffic stakeholders should implement mitigating measures in order to chase the fulfilment of the targets for each reference period during the following years.

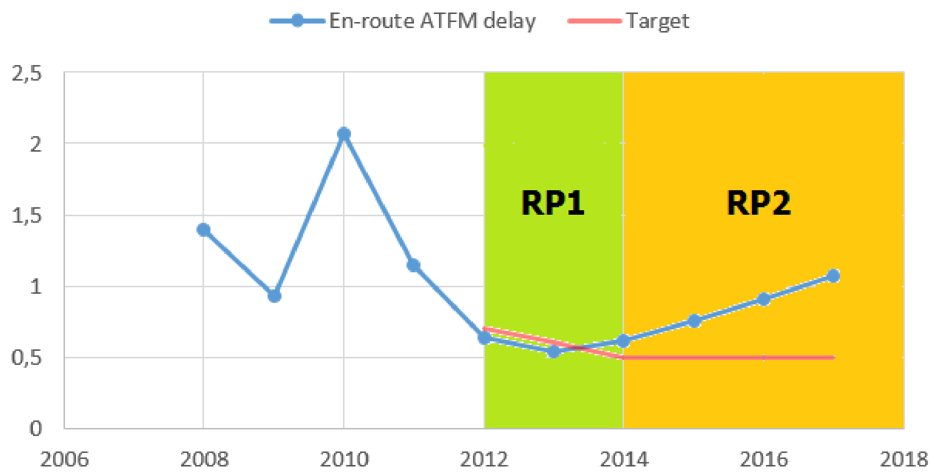

Figure 9.2 - En-route ATFM delay (RP1-RP2) (min/flight)

Functional Airspace Blocks

The FABs are a vital foundation element of the SES, designed to rationalize European ATM. There are currently 9 FABs established as can be seen in the following Figure 9.3:

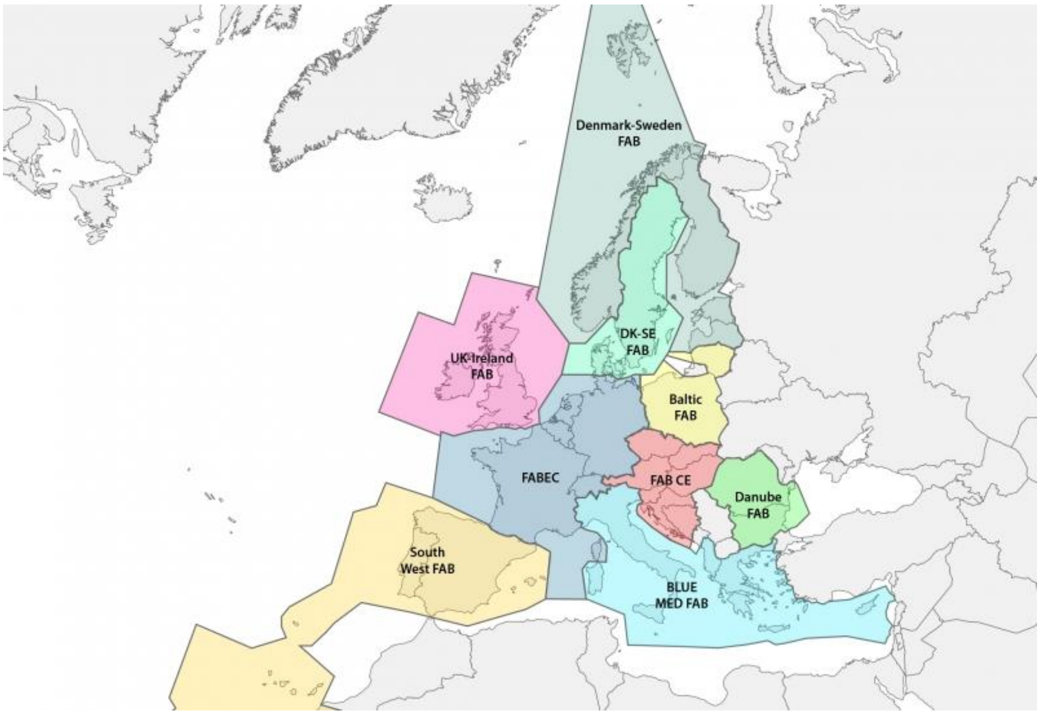

Figure 9.3 - Functional airspace blocks (FABs)
Source: EUROCONTROL

The establishment of Functional Airspace Blocks (FABs) is a key mechanism of the Single European Sky (SES) and represents the framework established by Member States to enable this increased cooperation and integration leading to a more rational organization of airspace and service provision poised to meet the performance expectations of the airspace users and that of the European Union through its performance scheme [5]. In this way, route design has seen an increase in operational efficiency, however, major technical, cultural and industrials challenges still need to be addressed. Most European ANSPs continue to develop their own ATM systems and their own training capability, which leads to difficulty in standardizing EU-wide service delivery, inhibits staff mobility and adds significantly to overall costs.

Network Manager

The Network Manager function was established at the beginning of 2012. The function has a governance structure supportive of airspace user needs and will be a useful tool to drive the implementation of SES operations towards increased performance. However, there are also some unresolved matters that relate to the on-going EUROCONTROL network technology research and development. To ensure the effectiveness of this role, the SES regulation should explicitly state that the Network Manger has the authority to enforce coordinated actions by ANSPs. Additionally, the Network Manager role needs to be strengthened to ensure that it can rationalize the network and identify opportunities for service quality improvement by FABs.

Airports Pillar

The need to better integrate airport processes with airspace management using a standardized approach is evident if the capacity goals of the SES are to be realized and we are not to continue wasting €2.35 billion in additional costs attributable to the airport and associated terminal airspace.

Human Factors Pillar

Of all the pillars, the least tangible progress has occurred with respect to the human factors and social issues involved in SES implementation. It is well recognized that this is a challenging area and will take commitment and diligence by ANSP management and staff to work through this transition. Without a successful human factors element to this transition, the SES will result in the deployment of new technology that will not be fully utilized and not deliver the anticipated benefits. A clear focus on better planning the engagement with ANSP staff is needed.

In conclusion, the experience gained with SES I since 2004 and SES II since 2009 has shown that the principles and direction of the SES are valid and warrant a continuation of their implementation. However, the initiative is experiencing significant delays in its implementation, notably in the achievement of the performance goals and the deployment of its basic elements (such as functional airspace blocks (FABs) or National Supervisory Authorities (NSAs)).

In 2009, when adopting the SES II Package, the legislator decided that SES II would be done in two stages and invited the Commission to come back to do an alignment of SES and EASA regulations after the initial set of EASA implementing measures and audit experiences concerning ANS was in place. A recast of the legislative package was therefore already foreseen, primarily aiming at simplifying and clarifying the border line between EASA and SES legal frameworks.

The process of recast also gives the opportunity to assess the effectiveness of the existing legal provisions in the light of the lack of timely implementation of the SES initiative. This process of revision of the SES legal framework, known under the abbreviation of SES 2+, is intended to accelerate the implementation of the reform of air navigation services without departing from its original objectives and principles.

The purpose of the SES 2+ Package is to introduce improvements in oversight of rules, the performance scheme, the customer focus of the service providers and in overall performance. In addition, the SES 2+ Package will simplify the legislation by eliminating certain overlaps in the existing framework. Concerns have been raised about several overlapping areas existing in the SES framework and there is also a need to clarify the roles of the various actors at EU-level. This alignment between the four SES Regulations and the EASA Basic Regulation, is a purely technical adaptation measure already required by the legislation. Due to the extent of overlap between the Regulations, a recast of the remaining parts of the four SES Regulations into one is a logical consequence of that adaptation [6].

T9.1.2 Comparison of SESAR with NextGen

Within Single European Sky framework, particularly on the technology side, Single European Sky ATM Research (SESAR) Programme supports the technological development in order to provide advanced technologies and procedures with a view to modernizing and optimizing the future European ATM network. These technological solutions are aimed to increase the performance of Europe's ATM system and moreover they contribute to the implementation of the Single European Sky. This modernization and harmonization of ATM systems are expected to be achieved through the definition, development, validation and deployment of innovative technological and operational ATM solutions.

Figure 9.4 - SESAR main pillars
Source: SESAR webpage

As one of its pillars (Figure 9.4), SESAR is defined in the European ATM Master Plan which is the agreed roadmap that connects ATM research and development activities with deployment scenarios to achieve the SES performance objectives. These development and validation activities are carried out by SESAR Joint Undertaking (SJU) and they are deployed through Common Projects. All three of these pillars (definition, development and deployment) are components of a virtual lifecycle that actively involves the stakeholders and the Commission in different forms of partnerships.

While the SES packages (I and II) were defined, two SESAR programs were also established. These SESAR programs are named SESAR I and SESAR 2020.

The Programme for SESAR 2020 is structured into three main research phases, beginning with Exploratory Research, then is further expanding within a Public-Private-Partnership (PPP) to conduct Industrial Research and Validation then further exploits the benefits of the PPP in Demonstrating at large Scale the concepts and technologies in representative environments to firmly establish the performance benefits and risks.

On the other hand, the Next Generation Air Transportation System (NextGen) is the Federal Aviation Administration (FAA)-led modernization of the United States' air transportation system to make flying even safer, more efficient, and more predictable, according to NextGen webpage.

In this manner, NextGen is composed of a comprehensive suite of upgrades, technologies and procedures that improve every phase of flight and enable aircraft to move more efficiently from departure to arrival. For example, one of the most important goals in NextGen is to use satellite technology to enhance navigation and surveillance, deploy digital systems for communication, and improve information management. Since the first demonstrations, trials and initial deployments of new systems and procedures, national airspace system (NAS) operators and users are benefiting from NextGen.

Globally, each one of these development programs (SESAR and NextGen) are focused on the specific problems that each region has. On the one hand, SESAR is mainly focused on the technological development that allows to set a common framework for the entire European Union from a holistic point of view. This common framework is intended to remove the fragmentation present in European aviation (for example each Member State has its own supervision authorities and air navigation service providers) in such a way that the functioning is as uniform as possible in the whole EU regardless of the Member State where the service is provided. On the other hand, the United States are not as fragmented as the European Union (the US only has a unique air navigation service provider) hence its development program is focused on improving the performance through new technologies that allows to reduce delays produced in its airspace and airports and also to increase its capacity.

Likewise, these differences between SESAR and NextGen make sense if the US and Europe ATM-related operational performance is compared. For example, according to 2010 data (see Figure 9.5), some areas are pretty similar and other areas are too different. In this manner, with similar sized airspace (11.5 million km^2 for Europe, 10.4 million km^2 for the US), a comparable number of airports (450 in Europe for 509 in the US) and with very similar service levels, the US ATM system is able to manage 67% more flights (15.9 million flights in the US compared to 9.5 million flights in Europe) with less air traffic controllers (14600 in the US for 16700 in Europe) and 38% less staff (35200 in the US for 57000 in Europe). The main drivers behind such difference is the fragmentation of the European ATM system as there were 38 ANSPs in Europe (for only one in the US) and 63 en-route centres in Europe (for 20 in the US).

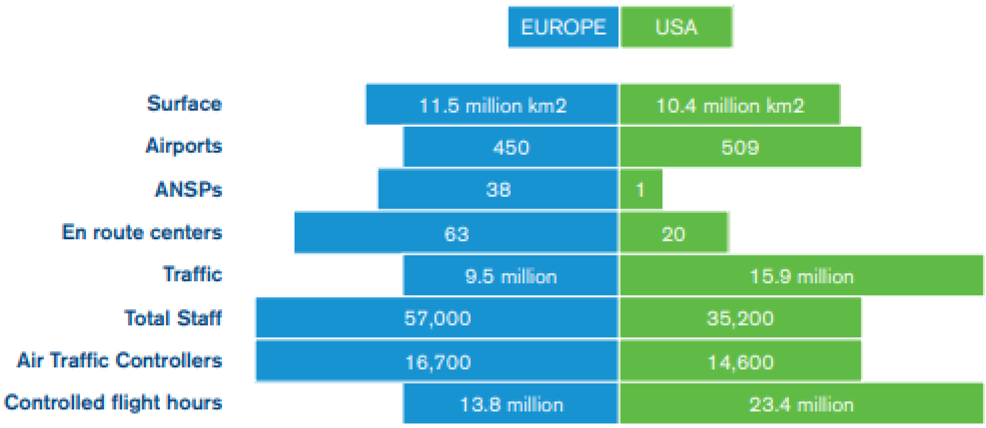

Figure 9.5 - 2010 U.S./Europe Comparison of ATM-Related Operational Performance
Source: A Blueprint for the Single European Sky by IATA

Comparing to more recent data, 2010 figures have remained almost undisturbed through the years. Therefore, while the US and the European ATM system are operated with similar technology and operational concepts, there is still a key difference: the US ATM system is operated by one single service provider (ANSP) which uses the same tools and equipment, communication processes and a common set of rules and procedures. However, even though ATFM and ASM in Europe are provided and coordinated centrally by the Network Manager, at the ATC level the European system is much more fragmented, and the provision of air navigation services is still largely organised by State boundaries [7].

In total, there are 37 different en route ANSPs of various geographical areas which have been operating different systems under slightly different sets of rules and procedures, and also different tools and equipment.

Therefore, as since 2004 the Single European Sky (SES) initiative of the European Union aims at reducing this fragmentation, SES 2+ Package is also addressing these issues.

Thus, the first problem addressed in SES 2+ Package is the insufficient efficiency of air navigation due to ANS provision remains relatively inefficient in terms of cost and flight efficiency as well as the capacity offered. The main issues to be solved are the shortcomings in setting up and enforcing the performance scheme, ineffective supervisory authorities and the disproportionally high amount of support staff in the service providers.

The second key problem addressed in SES 2+ Package is a fragmented ATM system. The European ATM system consists of 27 national authorities overseeing in total over a hundred Air Navigation Service Providers (ANSPs) – en route, approach and aerodrome providers-, with the associated variance in systems, rules and procedures. There is a large amount of additional costs caused by the fact that Europe has a large number of service providers, each procuring their own systems, mostly training their own staff, creating their own operating procedures and being limited territorially to providing services in a small airspace. To overcome fragmentation, the SES has introduced the ideas of cross-border Functional Air Blocks (FABs) and the centralised Network Manager to run certain network level services. However, FABs and the Network Manager still remains too weak hence developments should be carried out in these areas [6].

T9.1.3 The World Market for ATM Equipment

Firstly, ATM service and infrastructure have to be differenced. The ATM service is organized through a certain form of supply chain: most of service providers are state-owned companies which buy systems (radar stations, navaid stations, control centres, communication systems) from equipment suppliers. These systems form a cluster of tools that help to provide air traffic management (ATM) thereby they are considered as part of the ATM infrastructure.

From an economic point of view, international rules set up by the International Civil Aviation Organization (ICAO) prevent the transformation of the ATM service into a real market. In this manner, a state is not authorized to raise money in selling the access to its sky in such a way that it can only ask airlines to pay for the services given to their aircraft passing through its sky: communication, surveillance, navigation, airspace design, control and flow management.

To be able to deliver the service, air navigation service providers (ANSPs) have to be equipped. Providing ATM service requires different equipment such as radars to determine the position of the aircraft, navaid stations to help aircraft knowing exactly where they are, communication systems to secure exchanges between controllers and pilots, avionics systems, and so on. However, new technologies are allowing that exchanges between controllers and pilots are partly automated and managed by satellites (via datalink), moreover nowadays aircraft usually navigate using their position obtained by satellite instead of ground navaid stations (via performance-based navigation), thereby the equipment market is also adapting to new technologies [8].

In this context, the ATM equipment market is "small" in the sense of that equipment development and manufacturing companies are few so everybody in the market knows everybody. Some of the main companies involved are: BAE Systems Plc, Northrop Grumman Corp., Indra Sistemas SA, Thales SA, Intelcan Technosystems Inc., Frequentis and so on.

Some of these companies are focused on specific equipment. For example, Toshiba only manufactures PSRs, SSRs, VORs and DMEs whilst Frequentis is focused on communication and information systems. On the other hand, other companies are focused on a wide market. This is the case of Thales or Indra. For example, the last one manufactures many systems such as digital voice communications control system, signal multichannel recorders, DVORs, DMEs, ILSs, integrated ATC automation systems, ACC, APP and TWR simulators, PSRs, 3D Radars, monopulse SSRs, SMRs, ADS-B ground stations and so on [9].

As ATM equipment is made of complex systems in which connections, electronics and reliability are key factors, its development and manufacturing entail many complications and usually needs an important investment from the company hence it is difficult to enter in the market for new interested companies. Thus, some segments of the market are run by what seems to be a duopoly. This is the case of the ILS systems in whose market two companies are the main suppliers in the world: Indra and Thales. On the one hand, Thales have sold more than 700 ILS systems worldwide whilst Indra have sold more than 1200 ILS systems worldwide.

KEY TOPIC T9.2 COMPARISON OF SESAR WITH NEXTGEN

T9.2.1 Introduction

For both the SESAR and NextGen, the change to operations includes shared situational awareness for more collaborative decision making and trajectory-based operations for safer, more efficient airspace utilization. This requires transforming the procedures and regulations as well as the organizations' fundamental concepts and technologies. Net Centric Operations allow migrating functionality among actors and facilities to improve the efficiency of the system as a whole but requires that basic tenets be changed. In the case of ATM, this means changing the paradigm from extrapolating the aircraft intent based on radar data to the aircraft explicitly sharing it.

SESAR

Supporting the entire ATM system, and essential to its efficient operation, is a netcentric, System Wide Information Management (SWIM) environment that includes the aircraft as well as all ground facilities. It will support collaborative decision-making processes, using efficient end-user applications to exploit the power of shared information. Interoperability between civil and military systems will also be a key enabler to enhance the overall performance of the ATM network.

Fundamentally, SESAR operational concepts place the business trajectory at the core of the system, with the aim to execute each flight as close as possible to the intention of the user. This is seen as a move from airspace to trajectory focus while introducing a new approach to airspace design and management. The collaborative planning will continuously be reflected through a common shared Network Operations Plan (NOP). Integrated airport operations will contribute to capacity gains and reduce the environmental impact. New separation modes will allow for increased capacity. Using these new integrated and collaborative features, humans will be central in the future European ATM system as managers and decision-makers.

SESAR has set the definition of the initial 2025 performance targets. ATM performance covers a broad spectrum represented by the 11 ICAO **Key Performance Areas (KPA)**. The KPA targets represent initial values (working assumptions), subject to further analysis and validation. Most KPAs are interdependent and will be the basis for impact assessment and consequent trade-off analysis for decision-making.

The 11 KPAs are as follows: Capacity, Cost-Effectiveness, Efficiency, Flexibility, Predictability, Safety, Security, Environmental Sustainability, Access and Equity, Participation, Interoperability. Those that are highlighted, below, are the KPAs that SESAR sees as directly linked to the achievement of the proposed SESAR Vision.

Capacity:

A 3-fold increase in capacity, while reducing delays on the ground and in the air (en route and airport network), is necessary to be able to handle traffic growth well beyond 2030. The ATM system is to accommodate a forecasted 73% increase in traffic by 2030 from the 2015 baseline, while meeting the targets for safety and quality of service.

Cost-Effectiveness:

2030 Target: Halve the total direct ATM costs. The ATM Performance Framework provides a common basis to ensure the effectiveness of the ATM system through a dynamic relationship between European States, institutions and regulations ("Institutional and Regulatory Framework"), and all aircraft operators, air navigation service providers and airports working in partnership to match the targets ("Business Management Framework").

Safety:

To improve safety levels by ensuring that the numbers of ATM induced accidents and serious or risk bearing incidents decrease. The traffic increase to up to 2030 requires an improvement factor of 3, and for the long term a factor of 10 to meet the threefold in traffic.

Environment:

As a first step towards the political objective to enable a 10% reduction in the effects flights have on the environment by emission improvements through the reduction of gate-to-gate excess fuel consumption, minimizing noise emissions and their impacts for each flight to the greatest extent possible, minimizing other adverse atmospheric effects to the greatest extent possible.

NextGen

NextGen is focused on ATM System Transformation via trajectory-based operations with an emphasis on user needs. It endeavours to increase efficiencies and decision making to account for growing demand and diversity of airspace participants and eliminate limitations caused by human decision making based on verbal communications. Transformation is enabled through distributed decision making, international harmonization, optimized division of human/automation roles, net-enabled probabilistic weather, integrated into automated decision tools, environmental sustainability, integrated safety management systems, and layered adaptive security. NextGen establishes principles and definitions of desired end-states in the varying domains associated with these services. This chapter does not discuss specific implementations or standards or methodologies of achieving these end-states or adhering to these principles.

T9.2.2 Net Centric Commonalities

NextGen

While the NextGen Concept of Operations uses different language to discuss desired performance improvements, the intent is very similar to the SESAR use of the KPAs. NextGen specifies Transformation Objectives in detail (in the IWP and in the domain chapters of the COO) for each area of the ATM system, and describes the fundamental goals of NextGen as the following:

- Meet the diverse operational objectives of all airspace users and accommodate a broader range of aircraft capabilities and performance characteristics;
- Meet the needs of flight operators and other NextGen stakeholders for access, efficiency, and predictability in executing their operations and missions;
- Be fundamentally safe, secure, of sufficient capacity, environmentally acceptable, and affordable for both flight operators and service providers;

NextGen also references the general goals of ATM Transformation from the NGATS Integrated Plan (2004). Six national and international goals and 19 objectives for NextGen are described. These are:

1. Retain U.S. Leadership in Global Aviation

a) Retain role as world leader in aviation;
b) Reduce costs of aviation;
c) Enable services tailored to traveller and shipper needs;
d) Encourage performance-based, harmonized global standards for US products and services.

2. Ensure Safety

a) Maintain aviation's record as the safest mode of transportation;
b) Improve level of safety of U.S. air transportation system;
c) Increase level of safety of worldwide air transportation system.

3. Ensure our National Defence

a) Provide for common defence while minimizing civilian constraints;
b) Coordinate a national response to threats;
c) Ensure global access to civilian airspace.

4. Expand Capacity

a) Satisfy future growth in demand and operational diversity;
b) Reduce transit time and increase predictability;
c) Minimize impact of weather and other disruptions.

5. Protect the Environment

a) Reduce noise, emissions, and fuel consumption
b) Balance aviation's environmental impacts with other societal objectives

6. Secure the Nation

a) Mitigate new and varied threats;
b) Ensure security efficiently serves demand;
c) Tailor strategies to threats, balancing costs and privacy issues;
d) Ensure traveller and shipper confidence in system security.

In addition to these key performance goals, NextGen sets forth guiding principles for the development and implementation of the enterprise. While not goals, they do establish important achievement markers for industry as the system moves towards the future. The principles are:

- Frequency Bandwidth/Spectrum Capacity Supporting Stakeholder/COI Information Sharing Needs – (i.e. adequate communications capacity and QoS;
- Voice by Exception and Improved Where Necessary;
- Protocol Resolution – Sufficient/Dynamic addressing, secure end-to-end connectivity;
- Data Availability – Push/Pull and Publish/Subscribe capabilities between COIs;
- Content Understanding – metadata tagging and federated search;
- Technology for Timely Decision Making – Data is relevant for action by COIs;
- No Single Point of Failure – an enterprise solution that dynamically allocates resources to continue operations (transport and services);
- Data Interface Oriented – vice a Hardware Interface model, this software and customizable COI interface facilitates ease of improvement and upgrade;
- Information Assurance – Appropriate access to information by authorized COIs
- Cross Domain (i.e. Multi-Level Security or Multiple Levels of Security) Exchange/Gateway Capability;
- A key element of both SESAR and NextGen is System Wide Information Management (SWIM), which is a focus on how the technologies and systems will enable shared awareness for operations;
- The planned technology is very similar – ADS-B, Data Link, Extended Conflict Detection
- Both Systems recognize the primacy of data communications to the cockpit and amongst ground systems (“voice by exception”), while maintaining the requirement for voice for emergency purposes, back up, and for communications with less completely equipped aircraft;
- Both systems embrace a network-centric infrastructure with shared services and distributed data environments interacting semi-autonomously to achieve system-wide efficiencies.

T9.2.3 Differences

SESAR and NextGen differ in their implementation frameworks because they are tied to very different European and US industry structures. NextGen tends to be closely tied to government in a hierarchical framework whereas SESAR appears to be a more collaborative approach, including, but not limited to, ATM ground activities. NextGen, while having a longer timeline to implement, takes a broader approach to transforming the entire air transportation system, including ground activities.

T9.2.4 Flow Management

SESAR

In parallel with all the phases of individual business trajectory planning, a Collaborative Decision Making (CDM) process is in place in which all stakeholders share the necessary information to ensure the long and short-term stability and efficiency of the ATM system and to ensure that the necessary set of ATM services can be delivered on the day of operation.

The key tool used to ensure a common view of the network situation will be the NOP. It is a dynamic rolling plan for continuous operations, rather than a series of discrete daily plans which draw on the latest available information being shared in the system. The NOP works with a set of collaborative applications providing access to traffic demand, airspace and airport capacity and constraints, scenarios to assist in managing diverse events and simulation tools for scenario modelling. The aim of the NOP is to facilitate the processes needed to reach agreements on demand and capacity.

The NOP, in its initial phase, enables collaborative Demand and Capacity Balancing (DCB) through an integrated airspace/airport organization and management in accordance with the nature of the traffic being handled. The NOP supports layered planning on local, sub-Regional and Regional level.

Long-term ATM planning starts with traffic growth forecasts, including user business strategy development, and planned aircraft procurement. The required new assets can be considered as available resources for DCB only when their date of delivery becomes firm. Airspace Users will then declare their intentions through Shared Business Trajectories possibly including the requirement for airspace reservations. Network Management, working collaboratively with all partners will assess the resource situation regarding potential demand. Network Management will facilitate dialogue and negotiation to resolve demand/capacity imbalances in a collaborative manner. Tools will be used to assess network efficiency.

NextGen

The US version places a great deal of emphasis on the collaborative and/or automated decision-making process between the Flight Operations Centres (FOCs)/cockpit and ground Air Traffic Management. The Key Characteristics paragraph of the COO states, "[t]o the maximum extent possible, decisions in NextGen are made at the local level with an awareness of system-wide implications. This includes, to a greater extent than ever before, an increased level of decision-making by the flight crew and FOCs."

Traffic information is available via the network to the ground and onboard displays, thus allowing pilots to collaborate with ground control operators on the best strategy for their preferred trajectory. More importantly, NextGen envisions a set of Infrastructure and Information services that, when provided; enable automated collaborative planning systems to achieve efficiencies for individual airlines and the overall system.

T9.2.5 Weather

The primary difference between SESAR and NextGen concerning weather is the way the information is acquired. In NextGen, a centralized government-run weather service is anticipated, and in SESAR the information will be derived from a variety of traditional sources. A more net centric solution would be to allow each carrier to be able to choose whatever information is available from certified sources to provide maximum safety.

SESAR

The information will be derived from a variety of (traditional) sources including an Increased reliance on remote sensing systems, aircraft derived data and satellite-based weather information. With enhanced digital communications services, the provision of Metrology (MET) information will encompass ground-based and potentially airborne automation systems and human users.

NextGen

NextGen foresees weather as moving from a stand-alone display to an integrated decision-making element. A primary objective of NextGen is the establishment of a single authoritative weather service available to all systems communicating within the network. While little is said about how this service will be run, great detail is provided on what type of service will be available. The service will draw data from traditional weather reporting systems, aircraft and other sensors in route including UAVs specifically deployed for weather collection, commercial weather services which will augment the system at the basic provision rate and presumably at premium rates as a choice of individual carriers and aircraft and potentially airborne automation systems and human users as well as from weather national service.

T9.2.6 Infrastructure Service Domains

SESAR

SWIM is supported by a set of architectural elements (so-called SWIM architecture) allowing exchange of data and ATM services across the entire European ATM system. SWIM is based on the interconnection of various automation systems. The SWIM architecture aims at providing specific value-added information management services: the SWIM services. They will:

- Support flexible and modular sharing of information, as opposed to closely coupled interfaces;
- Provide transparent access to ATM services likely to be geographically distributed;
- Assure the overall consistency.

SWIM services will be required to comply with potentially stringent Quality of Service (QoS) parameters, such as integrity, availability, latency, etc. The full impact of those QoS on the proposed architecture will require significant R&D activities. For instance, not all users will have permission to access all data within a domain because of operational, commercial or security reasons.

SWIM integrates Air-Ground and Ground-Ground data and ATM services exchange. The scope extends to all information that is of potential interest to ATM, including trajectories, surveillance data, aeronautical information of all types, meteorological data etc.

NextGen

NextGen establishes the requirement for the provision of a robust infrastructure on which the entire system will rely. The services provided across the enterprise are:

- Information Sharing Services: Enabling operational entities, COIs, services, and applications throughout the NAS to collaborate in a seamless information infrastructure with Air Navigation Service, airport, and flight operations, Shared Situational Awareness, compliance and regulation oversight, and security, safety, environmental, and performance management services.
- Ground Services: Providing surveillance, communications, and flight data management to any service provider regardless of its physical location, thus removing geography as a limiting factor for air assets and ground control.
- Air-Ground Network Services: Frequency-to-airspace sector mapping is abandoned in favour of a dynamic network environment – the "intelligent network." Data communications are central to Trajectory Based Operations, including the use of 4DTs (pushback and taxi inclusive) for planning and
- execution on the surface, automated trajectory analysis and separation assurance, and aircraft separation assurance… [with] situational awareness of the 4DTs and short-term intent of surrounding aircraft.
- ANSP Infrastructure Services: Summarized with the term "virtual tower." Such services provide the ability to locate ANSP facilities where optimal, without limitation to airspace proximity
- Aircraft Data Communications Link: Allowing aircraft and ground assets to connect to the data network for collaborative purposes
- Infrastructure Management Services – Insuring QoS
- Mission Support Services - provide information assurance, protocols, and standards applicable for the Net-Centric Infrastructure Services (Access, Connectivity, Processing, Posting, and Pulling).

T9.2.7 Information, Data and Information Services

Information and Data in SESAR and NextGen

A difference between the two documents lies in the treatment of information. While both indicate that data and information are key to integration and net centricity, SESAR, being a more decentralized model, calls for the establishment of a Reference Model for data and for data normalization and standardization. NextGen, envisioning a more centralized government-run approach, goes further, describing not only data but the provision of "information services" in a service-oriented and networked environment. Both concepts call for systems to make use of centralized and decentralized services, delivered in a network enabled, SOA environment, with NextGen suggesting a more centralized approach than SESAR. Collaboration on the development and fielding of these services, and agreement on the standardization of data reference models, could provide great efficiencies to both SESAR and NextGen efforts.

SESAR and NextGen both place a great deal of emphasis on the information enabling the processes, interaction, and automated support of the ATM enterprise. While there are differences in terminology and a core difference in how the information elements are described, the content of the information and that content's purpose are very similar. NextGen describes information elements in the terminology of "services" - using a service-oriented architecture context to describe the automated and ubiquitous nature of the key information elements serving the overall system. SESAR describes the information elements in terms of data models associated with different domains (flight, weather, surveillance, etc) and describes a reference model architecture that, when used, makes the data and information available for use by the system participants.

Key to the continued comparison of the two systems will be an in-depth comparison and integration of the data models and the network-centric services. Each system should be able to use the data and information available within the other to execute the integrated, collaborative, and automated analytical and decision-making functions necessary to execute this transformational ATM.

SESAR

ATM Information Reference Model:

- Within the SWIM, Interoperable ATM information will be precisely defined by a Reference Model;
- Application independent and not constrained by implementation solutions;
- Addresses different domains of information as needed by the Users and expressed in business terms;
- Describes cross-domains data in a consistent way;
- Allows fulfilling the SESAR overall information sharing requirement, across ground and air heterogeneous systems.

The information to be exchanged needs to be modelled explicitly, to allow a precise and concrete definition to be agreed.

Interoperability Models:

SWIM is first introduced for En route/Approach ATC and Network (NIMS) interactions, and later including interactions with Airports, AOC and the Aircraft. Flight information is accessible through SWIM services around 2013. Airspace, Demand & Capacity data are accessible through SWIM services around 2016.

The SWIM services will be organized around 5 data domains:

- Flight Data (including detailed trajectories);
- Aeronautical Data;
- Meteo Data;
- Surveillance Data;
- Capacity & Demand Data (including Air Traffic Flow and Capacity Management Scenario).

NextGen

In addition to the Network Centric Infrastructure, Chapter 5 of NextGen discusses the centralized provision of Information Services across that infrastructure. This is a central component of the NextGen Transformation – that is, the provision of a set of data and information services (a "service-oriented environment") from which each participant in the ATM system can draw capabilities, whether that is to access data for their own application uses or to actually use another application provided as a service to execute flight operations. The development of these services will be a challenging task, especially given the different data models in use across the industry. Collaboration with SESAR on the reference data models discussed in SESAR may benefit NextGen transformation efforts – just as collaboration on the development of centralized services might benefit SESAR participants.

In addition to the Network Centric Infrastructure, Chapter 5 of NextGen discusses the centralized provision of Information Services across that infrastructure. These are:

- Weather Information Services;
- Robust Precision Navigation Services;
- Surveillance Services (Cooperative and Non-Cooperative);
- Flight Plan Filing and Flight Data Management Services;
- Flow Strategy and Trajectory Impact Analysis Services;
- Aeronautical Information Services (AIS);
- Geographical Information System Services (GIS).

The development of services to support flight operations will be a challenging task, especially given the different data models in use across the industry. Collaboration with SESAR on the reference data models discussed in SESAR may benefit NextGen transformation efforts – just as collaboration on the development of centralized services might benefit SESAR participants.

T9.2.8 Aircraft Participation in SWIM

SESAR

The introduction of an Air to Ground Data Link Ground Management System, which is a SWIM node and offers the aircraft a single point of access on the ground with filtering of the shared information that is needed by the aircraft and the update of onboard databases while the aircraft is still at the gate. Benefits are expected through simplification of connectivity functions and on saving multiple connection infrastructures. Safety requires a high availability of the A/G Data link Ground Management System as failure of a system at sub-regional level would jeopardize the complete communication with the aircraft in that sub-region.

NextGen

SWIM is an integral part of the NextGen concept, with the aircraft serving as a node on the network. SWIM encompasses the ability of aircraft and ground assets to collaboratively participate within an enterprise that is providing automated information cockpit-to-cockpit, cockpit-to-ground, ground-to-cockpit, and ground-to-ground. NextGen envisions a virtual network in which each node represents a part of the system –so all information is "system-wide." Each node participates in the system all the time – and user access and automated tools and services are used to ensure adequate data provision and QoS.

T9.2.9 CNS Development and Impacts

Much ground-based equipment in Europe will reach end of life by 2018 – this is a major driver. Proposing 4 stages – Stage 1 is ADS-B out – then ATSAW, then self-separation (2020 to 2025) and finally the possible need for another link for advanced applications like ASAS (2025). There will be a focus on R&D for possible future applications that might require a better link than 1090 MHz CASCADE program fits into SESAR process. A Joint Undertaking will take place. NextGen and SESAR are working together on joint R&D and hold regular progress meetings.

SESAR

In its simplest form, the 2030 CNS baseline can be characterised as follows:

Communication:

- Communication technologies that enable improved voice and data exchanges between service actors within the system, such as those necessary to support the SWIM functionality and CDM process, for example:
    - Ground-Ground
        - A IP based ground-ground communications network supporting all the ATM applications and SWIM services, together with VoIP for ground segments, including VoIP for the ground segment of the air-ground voice link.
    - Voice
        - 8.33KHz is the standard for voice communications;
        - SATCOM voice for oceanic and remote areas.
    - Air-Ground Data link
        - VDL2/ATN.
    - Airport
        - A new Airport data-link to support surface communication, using a derivation of the IEEE 802.16.

Navigation:

- Navigation technologies that enable precision positioning, timing and guidance of the aircraft to support high performance, efficient 4D trajectory operations in all phases of flight, for example:
- Primary aircraft positioning means will be satellite based for all flight phases.
- Positioning is expected to rely on a minimum of two dual frequency satellite constellations (Galileo, GPS L1/L5 and potentially other constellations, assuming interoperability) and augmentation as required:
    - Aircraft based augmentation (ABAS) such as INS and multiple GNSS processing receiver;
    - Satellite based augmentation (SBAS) such as EGNOS and WAAS;
- Terrestrial Navigation infrastructure based on DME/DME is maintained to provide a backup for en route and TMA;

- Enhanced on-board trajectory management systems and ATS Flight processing systems to support the trajectory Concept.

Surveillance:

- Surveillance technologies that enable precision monitoring of all traffic to assure safe and efficient operations, including enhanced Traffic Situational Awareness and ASAS.
- For the airspace, Cooperative surveillance will be the norm, complemented as required by Independent Non-Cooperative surveillance to satisfy safety and security requirements. For the Airport both Cooperative and Independent Non-Cooperative surveillance systems will be necessary.
    - PSR will provide Independent Non-Cooperative surveillance;
    - Since aircraft will have the necessary mode S and ADS-B equipment, the choice of Cooperative surveillance technology (Mode S, ADS-B, MLAT) remains flexible, with the service provider determining the best solution for their particular operating environment, based on cost and performance;
    - SMR will provide the Independent Non-Cooperative airport surveillance
- ADS-B-In/Out is provided by 1090 ES;
- With a mandate of 1090 ES-ADS-B-Out, TIS-B will not be needed in the transition to support ASAS applications;
- Satellite based ADS-C for oceanic and remote areas.

CNS beyond 2030

Communication

- Data link becomes the primary means of communications. Voice remains as a back-up;
- Common inter-networking transport mechanism to support the various data-links, managing an end to end Quality of Service;
- Post 2030 implementation of new communications components, comprising terrestrial (wide or narrowband) and space-based components in complement of VDL2/ATN to support the new most demanding data-link services.

Navigation

The availability of other constellations enables increased accuracy and availability. Multi constellation receivers are able to exploit available constellations/satellites (e.g. China, Russia), if the benefits outweigh the added complexity compared to a basic GPS + Galileo combination. Ground based augmentation (GBAS) for Cat II/III approach and landing with backup provided by ILS/MLS, and specific GBAS features may be necessary to meet high performance guidance requirements for airport surface navigation

Surveillance

- PSR is replaced by cheaper forms of Independent Non-Cooperative surveillance;
- The 1090 ES system supporting ADS-B-In/Out is improved and/or complemented with
- an additional high-performance data link.

SESAR

CNS is formulated for 2030 that builds on 8, 33 kilohertz, VDL2/ATN for communication. Navigation builds on satellites for position determination Surveillance system has four fundamental principles that build on primary radar, SSR model S, Wide area Multilateration, ADS-B (builds on 1090 MHz) and monitoring in the aeroplane.

ADS-B equipment has been extensively and successfully tested in operational environments and is an example of a developed SESAR and NextGen technological component.

NextGen addresses transformation as a function of changes to the operational concepts and capabilities between the current state (2018) and 2035. There are interim transformation steps for various sub-domains, but no timelines are discussed for those interim steps to total transformation.

T9.2.10 Anticipated Risks

SESAR

SWIM (including the A/G Data Link Ground Management System) may not meet the required quality of service (which is still to be defined), e.g. with respect to integrity, consistency.

Stakeholders may fail to achieve the required certification of their systems since they will need to carry out a safety analysis of a system that is connected to other stakeholders' systems via SWIM.

Many problems remain particularly with data quality and interoperability.

A key limitation has been the absence of a globally accepted aeronautical information exchange format, but this is now being addressed by AIXM V5.0

NextGen

Automated tools, communications and enterprise management, and improved information flow will naturally provide for increases in efficiencies and effectiveness regarding the ATM System. The overall concept is not, however, without risks. NextGen COO addresses these risks within the appendixes describing additional policy and research needs. Some of the major ones are listed below:

- NextGen assumes a fully available (very high QoS) and robust enterprise network supporting ground, surface, and air assets through all stages of every flight operation. If this network is not reliable, if communications paths and data integrity are not adequately assured, then the automated decision making will not happen, and the efficiencies will not be achieved.
- Moreover, should the system rely heavily on TBO and Flow Management in dense environments and then suffer an outage or data compromise, serious safety or security implications may arise.
- New capabilities and technologies may over-burden the cockpit operation.
- New policies and standards may be needed to ensure data and information security.

- Transformation to "virtual towers" and satellite-based IAPs may present new difficulties in very low visibility conditions.
- There are changing rules, policies, security protections, responsibilities, and authorities for Safety Assurance and Safety Data Information sharing.
- Stakeholders must ensure data integrity across such a wide range of information services, weather, navigation, route planning, etc.)

Both:

- Need to ensure that architectural differences do not impact, for example, how the aircraft is included in the network.
- The investment side of things is a major challenge; stakeholders will need to be convinced that the benefits outweigh the costs.
- Achieving and providing safety for SESAR/NextGen is an enormously tough challenge.

T9.2.11 Contradictions and Major Concept Differences

- NextGen assumes a fully available (very high QoS) and robust enterprise network supporting ground, surface, and air assets through all stages of every flight operation. If this network is not reliable and if communications paths and data integrity are not adequately assured, then the automated decision-making will not happen, and the efficiencies will not be achieved.
- The SESAR Operational Concept time horizon is 2020+: NextGen time horizon is 2025;
- The SESAR Concept essentially has a strict ATM focus: NextGen also deals with other elements that may impact ATM either directly or indirectly (for example Homeland Security);
- The SESAR Concept adopts a largely Gate-to-Gate view with a window on the turn-round process that provides an Enroute-to-Enroute view through shared situational awareness of the status of the process. NextGen adopts a Curb-to-Curb view that encompasses all aspects of airport terminal and passenger operations.
- The SESAR Concept deals with certain issues, for example Safety and the Environment, through some high-level statements and at the KPA level and the detail is the responsibility of other Work Packages: NextGen deals with these issues in detail within the Concept.
- Europe seems to be ahead of the U.S. in data communication, and the U.S. is ahead in defining ADS-B Out.
- Both systems emphasis the increased use of underutilized airports, however there are minor differences. For example, NextGen includes an Airports Preservation Program to "increase community support and protect against encroachment of incompatible land use", while SESAR states that capacity goals can be met in airspace but that airports are limiting factor.
- SESAR and NextGen differ in the way that Europe comprises several member states that must agree and US is one nation from the start.
- SESAR and NextGen differ in their implementation frameworks because they are tied to very different European and US industry structures.
- The primary difference between SESAR and NextGen concerning weather is the way to acquire the information. In NextGen it seems to be a centralized government-run

weather service and SESAR considers the Weather information provision services as outside its scope of work (even it requires that it can use a variety of sources).

NextGen concepts are developed in anticipation of a widely expanding air traffic environment, but also in anticipation of greater technological capabilities for aircraft, ground control systems, surveillance, networks, and automated decision support systems. The overall vision is widely applicable to all operations related to air travel in the US Airspace - from commercial route and passenger planning through ATM and ground support operations.

T9.2.12 Conclusion

SESAR and the US NextGen both have the same basic aim – more efficient use of airspace and better air safety – the implementation frameworks for each are radically different, with the European approach based on a single, multi-stakeholder consortium, and the US model requiring close internal coordination between various government-led programmes to ensure interoperability of components delivered by a variety of consortia.

SESAR tends to focus primarily in Air Traffic Management but has a nearer term for completion. NCOIC highly recommends that the sharing of approaches and lessons learned from each program be made a priority in the other program in order to improve efficiency and avoid stove piping and potential incompatibilities across the Atlantic.

Both organizations are embracing basic network centric concepts. The way each is choosing to implement these is taking a different form.

The common vision is to integrate and implement new technologies to improve air traffic management (ATM) performance – a 'new paradigm'. SESAR and NextGen combine increased automation with new procedures to achieve safety, economic, capacity, environmental, and security benefits. The systems do not have to be identical but must have aligned requirements for equipment standards and technical interoperability.

SESAR:

- SWIM is a main feature of the SESAR ConOps.
- Information technologies are already available to support SWIM (Datalink may need further Development).
- Institutional barriers (property of data) will need to be mitigated through regulation (if not good will) before SWIM is possible.
- SWIM SUIT will prove the concept using legacy systems using wrapper techniques;
- By year 2025 new systems will be developed to be directly connectable to the SWIM infrastructure, interoperability will be the result.
- Each aircraft should be equipped so that it can achieve adequate end-to-end QoS by being able to receive the required data.
- Investment is a major challenge; stakeholders will need to be convinced that the benefits outweigh the costs.
- The SESAR Operational Concept time horizon is 2025+: NextGen time horizon is 2030+. As a result, all airlines with European routes will be required to harmonize with Eurocontrol solutions early, as each entity seeks long term interoperability solutions.

- Europe is now leading the world in controller pilot data link communications (CPDLC), with 15 airlines already using the service via the first operational implementation at Maastricht Upper Area Control Centre. But that lead is likely to be short-lived, thanks to the revival of US CPDLC plans through the FAA’s budget allocation for a new Datacom system and the expected issuing of a notice of proposed rulemaking on aircraft equipage in 2022.
- A key element of both SESAR and NextGen is System Wide Information Management (SWIM), which is a focus on how the technologies and systems will enable shared awareness for operations. Some on-going initiatives such as ICOG, D-AIM, and SWIM-SUIT will enable legacy systems to operate in the SWIM environment.
- The planned technology is very similar – ADS-B, Data Link, Extended Conflict Detection. ADS-B equipment has been extensively and successfully tested in operational environments and is an example of a developed SESAR and NextGen technological component. The United States is further along on the surveillance part, known as Automatic Dependent Surveillance - Broadcast (ADS-B) Out, while Europe's SESAR is further advanced on datalink communications. Both Europe and the U.S. clearly are moving toward the same goal, although the pace and emphasis during the transition to next-generation traffic management still must be worked out.
- Both systems embrace a network-centric infrastructure with shared services and distributed data environments interacting semi-autonomously to achieve system-wide efficiencies.
- Critical to consider global interoperability and harmonisation.

9.2 Harmonized Certification

The certification of an airliner is final stage of the development process, and can also be the most complex, time consuming and expensive. The certification of a modern airliner takes about 3 000 flying hours over a period of 3-5 years involving 3 to 6 prototype of pre-production aircraft, and it is difficult to compress without significantly increasing risks that could become delays and further costs. Although there has been much progress in ground testing and simulation, it is flight testing that is the ultimate proof that satisfies certification authorities. The increasing capabilities and complexity of successive generations of airliners means that there is more hardware and software equipment and functions to test, and the progress is absorbed in performing increased testing in a comparable time span.

The enormous progress over the past in flight testing and certification is testified by the fact that most current programs reach production and service without a single fatal accident in the development process. The days when a test pilot entered a prototype aircraft not knowing what to expect are long gone, and replaced by a much more scientific, disciplined, controlled and safer development process: (i) mathematical models are developed for the aircraft performance, stability and flying characteristics as a whole and of its constituent subsystems; (ii) the models are validated by extensive tests in aerodynamic wind tunnels, engine test facilities and ground test rigs covering structures and systems; (iii) the mathematical models are implemented in flight simulators giving test pilots many hours of experience before real flight.

The main benefit of all this modelling, simulation and ground testing is that flight testing and certification are much more efficient, going through a larger number of test points in a shorter time, with almost complete safety, because: (i) the telemetry data from flight testing is compared in real time with simulation models on the ground; (ii) in the case of agreement it is possible to proceed to the next test point without delay as long as flight endurance allows; (iii) in case a discrepancy appears the testing is suspended until the cause is identified and corrected, so that the incident does not become an accident; (iv) this process allows a faster exploration of the full flight envelope and operating conditions, starting from the safer central part and then gradually extending to the boundaries.

The extensive pre-flight testing does not mean that there are no surprises in flight testing: (i) some phenomena like laminar to turbulent flow transition cannot always be predicted accurately in wind tunnel tests; (ii) similarly some engine operating characteristics cannot be fully simulated on the ground; (iii) complex systems can have many combinations of partial failure modes. Even considering only aerodynamics, CFD (computational fluid dynamics), wind tunnels and in-flight measurements can all show different results. The substantial effort in ground testing and simulation serves to reduce the risks of flight testing and allow certification with minimal upsets.

The discovery of major deficiencies in flight testing or certification triggers a long and costly process: (i) identification of the cause(s) of the deficiency; (ii) design of a solution; (iii) testing of the design; (iv) implementation in at least prototype production; (v) incorporation in the existing prototype or additional aircraft; (vi) resumption of the flight testing and certification. This is an example of the fact that the later a deficiency is found the longer and the more expensive it will be to correct. The whole purpose of the development process is to use earlier and cheaper testing to identify and correct as many issues as possible so that less crop up at the last stage of flight testing and certification when the consequences in delays and cost will be greater.

The preceding account assumes that the certification process concerns only essential issues without duplication or unexpected requirements. That was not always the case in the past. There were instances some decades ago when different national certification required different tests for the same purpose, duplicating the effort and increasing cost with no benefit. The harmonization of certification standards avoids such costly duplications without benefit to safety or efficiency. Since FAA and EASA are the leading certification authorities the continuation of common or compatible certification standards, and the mutual acceptance of certification results, should continue as new technologies emerge and possibly new aircraft configurations as well.

Dissimilar certification rules or non-acceptance of other certification runs the risk of becoming disguised protectionism or lead to a non-level playing field. The acceptance of 'grandfather rights' allowed the second-generation Boeing B737 to keep earlier passenger evacuation rules, thus seating more passenger in a smaller cabin than the new Airbus A320 that had to meet more recent and stringent certification rules; this unfortunate episode had at least the positive consequence of the agreement between the FAA and EASA that 'grandfather rights' could not be invoked in the future. Another episode was the FAA requirement that in the event of an in-flight disintegration of an engine of the Airbus A340 there would be no possibility of severing fuel lines; this required a considerable redesign of the fuel lines in the wing of the aircraft; the EASA also raised some issues on updates to the Boeing B747, and eventually a broader based agreement was reached with FAA on certification rules, to the benefit of the worldwide aviation community.

The FAA and EASA certification rules are the 'de facto' world standard since aircraft that would not meet them could not fly in Europe and the US pre-empting much of the possible airline market. The EASA and FAA are an essential element in keeping aviation as the safest mode of transport, by making sure that all aircraft producers and their products deserve the trust of passengers. An inevitable consequence is that certification can become a hurdle to newcomers to the market that do not have either the technology demonstration or the program discipline capabilities to go through a complete certification process. The introduction of new technologies, and eventually of new aircraft configurations like flying wings or joined wings, will put new challenges on certification that must be addressed by close consultation between industry and the authorities, so that aircraft can be designed to meet all the requirements they will have to satisfy.

The harmonization of certification by EASA in Europe and FAA in the US (Key Topic 9.3) sets the standard for these processes essential for the safety of air transport.

KEY TOPIC T9.3 HARMONIZED CERTIFICATION

T9.3.1 Coordination Between EASA and FAA

The overall framework for harmonized and coordinated certification between EASA and the FAA is currently established by the agreement between the US and the European Union on cooperation in the regulation of Civil Aviation Safety. This agreement entered into force on the 1st of May 2011 and this formalises the mutual trust that was built over the years between the US and EU in the fields of airworthiness approvals of civil aeronautical products; and approval and monitoring of maintenance facilities; environmental testing and approvals of civil aeronautical products; and approval and monitoring of maintenance facilities. [1]

The agreement reflects the structure of a "classical" agreement in the areas of aviation safety, a "BASA" as are called the existing Bilateral Aviation Safety Agreements between the US and some EU Member States (EU MS). As in the cases of the BASAs, the agreement is based on mutual trust of each other's system and on the comparison of regulatory systems. Moreover, the FAA and EASA at authority level prepared the so-called 3rd level texts (**Technical Implementation Procedures**, TIP for Airworthiness and Environmental Certification and the Maintenance Annex Guidance – MAG for Maintenance) that define

how the Parties will implement and work in order to achieve the objectives set out in the Agreement and its Annexes).

1 Information Note. Agreement between the United States of America and the European Union on cooperation in the regulation of civil Aviation Safety. EASA web page.

The Agreement also establishes a series of committees/sub-committees ensuring its effective functioning:

- Implementation of the agreement, for handling disputes and the amendment and adoption of new annexes, will be responsibility of the Bilateral Oversight Board (BOB). The Union will be represented in the BOB by the European Commission assisted by EASA and accompanied by the Aviation Authorities as representatives of the EU MS.
- Discussions at technical level (FAA-EASA) and the development, approval and amendments of the TIP and MAG will be assured by the Certification Oversight Board (COB) and the Joint Maintenance Coordination Board (JMCB) respectively, being both boards accountable to the BOB.

The main purposes of the agreement are to automatically accept certain approvals issued within the other certification system and enable the reciprocal acceptance of findings of compliance during validation processes. Furthermore, the agreement supports the continuation of high-level regulatory cooperation and thus promotes a uniform high degree of safety in air transport. This will facilitate trade in goods and services covered by its scope and limit as much as possible, the duplication of assessments, tests and controls to significant regulatory differences.

Its scope covers the airworthiness approvals and monitoring of civil aeronautical products, the environmental testing and approvals of civil aeronautical products and the approval and monitoring of maintenance facilities.

To complement this agreement, series of guidelines have been commonly developed to establish the process through which the FAA and EASA intend to promote rulemaking co-operation in the early stages of the rulemaking process. The objectives of this rulemaking cooperation arrangement[2] are to:

- Exchange regulation intentions and priorities of the participants to align as much as possible their respective rulemaking programmes.
- Identify rulemaking initiatives of common interest that through regulatory collaboration would allow the FAA and EASA to: avoid unnecessary divergence and duplication of work, maximize available resources, and further harmonisation.
- Define the corresponding working methods to be followed by the participants when executing tasks which have been considered as of common interest.

The FAA and EASA rulemaking agreement foresee 3 possible working methods, as indicated in the Figure 9.6, by which the participants will execute rulemaking tasks in the areas of common interest.

2

"Rulemaking Cooperation Guidelines for the Federal Aviation Administration and the European Aviation Safety Agency". FAA, EASA, 2013.

Working Method # 1 - EASA Takes the Lead	Working Method #2 - FAA Takes the Lead	Working Method #3 – Authorities Cooperation
• The general process is the EASA rulemaking procedure. • This working method aims at giving the FAA sufficient involvement in the EASA rulemaking project to understand the content of the draft rule and to be able to contribute to this process as necessary to allow it, where appropriate, to launch an equivalent Notice of Proposed Rulemaking ("NPRM") or take other equivalent rulemaking decision. • The EASA focal point should lead the rulemaking process in regular coordination with the FAA focal point.	• The general process is outlined in the FAA Office of Rulemaking's Rulemaking Manual. • This working method aims at giving EASA sufficient involvement in the FAA's rulemaking project to understand the content of the NPRM and be able to contribute to this process as necessary to allow it, where appropriate, to launch an equivalent NPA or take other equivalent rulemaking decision. • The FAA focal point should lead the rulemaking process in regular coordination with the EASA focal point.	• FAA and EASA intend to develop their rulemaking projects separately, but concurrently (to the extent practicable). • However, as appropriate, the FAA and EASA focal points may follow the process described in Working Methods #1 and #2 in sharing information during concurrent development of the rule.

Figure 9.6 - FAA and EASA rulemaking agreement foresee 3 possible working methods

Finally, the agreement gives to the parties the possibility to agree on additional areas of cooperation by amendment of the agreement.

T9.3.1.1 Technical Implementation Procedures for Airworthiness and Environmental Certification (TIP)

The last revision of this document was made in September 2017.

The purpose of the TIP is to define the procedures for approving the design of civil aeronautical products and articles eligible for import into the U.S. and the EU, the process for obtaining eligibility for import, and the means for providing continued support of those civil aeronautical products and articles after import.

The TIP is based on continuous communication and mutual confidence in the FAA's and EASA's technical competence and ability to perform regulatory functions within the scope of the TIP.

The FAA and EASA mutually recognize each other's aircraft certification systems, which includes EASA recognition of FAA's designee system and FAA recognition of EASA's design and production organization system.

T9.3.2 Grandfather Rights

According to sources such as Skybrary, grandfather rights are defined as the arrangement under which later derivatives of an initial aircraft type design can be manufactured under variations to the original Type Certificate thereby avoiding the more complex procedures involved in gaining approval under a completely new Type Certificate.

The effect of this is that although the standards applied to enable the issue of as Type Certificate have always progressively increased over time, in the light of experience and general technological progress, these benefits are not reflected in the certification of 'similar' aircraft by means of variations. There is no general time limit to these grandfather rights and they can remain effective over a long period.

Grandfather rights refer to the right of a manufacturer to continue certificating successive derivatives of a mature aircraft type under the certification rules applicable when the original design was cleared, despite subsequent advances in safety regulation.

This following Figure 9.7 shows how to determine certification basis for derivative airlines types. The chosen method is a set of step-by-step guidelines for the certification of derivative types. These aim to enforce compliance with the latest regulations.

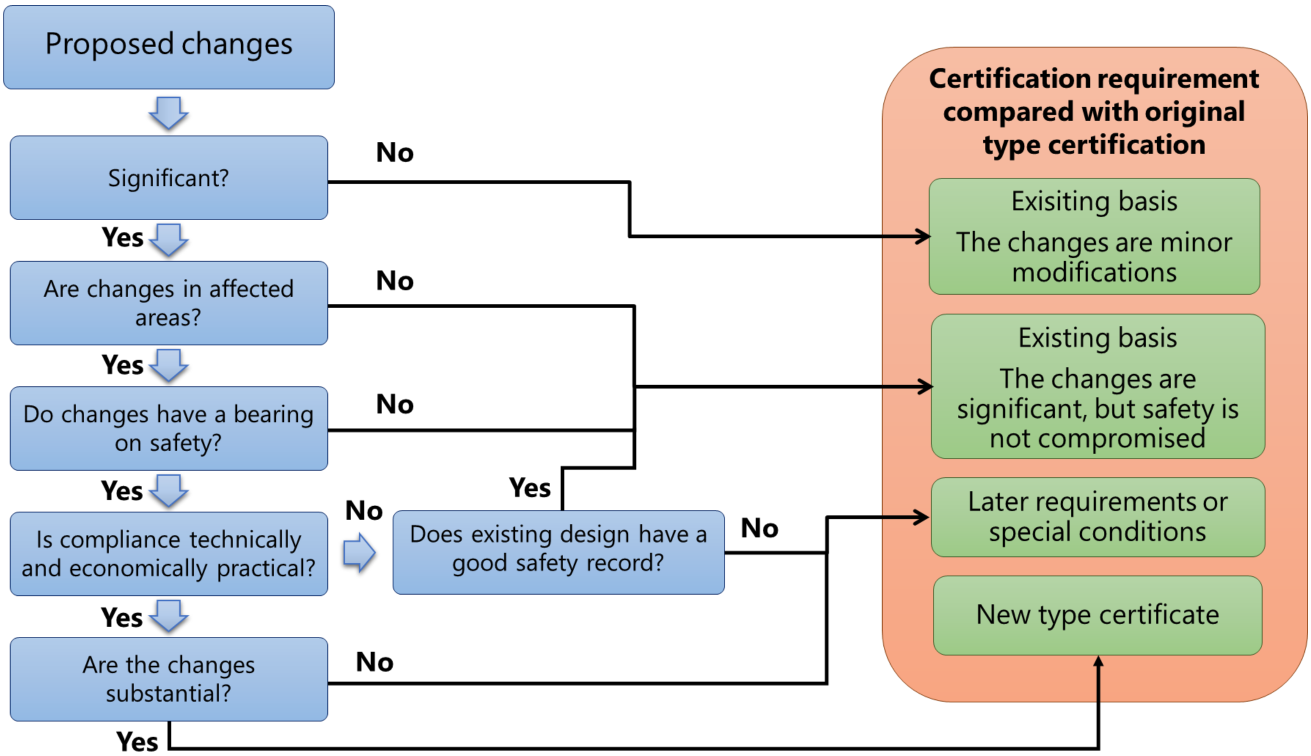

Figure 9.7 - Diagram about how to determine certification basis for derivative airliner types
Source: Boeing and the UK Civil Aviation Authority

Besides, grandfather rights are currently used in the European Union to allocate airport slots. Grand-fathered rights have also been stablished in the Commission Regulation 1702/2003, with the establishment of EASA. This grandfathering allows that now new type certificates for the related products need to be issued for certain type certificates dispensed prior to 28 September 2003 by Member States (JAA) in accordance with Regulation no 1702/2003.

T9.3.2.1 Historical Perspective of Grandfather's Rights

Relevant Boeing and Airbus aircraft families has made extensive used of the grandfather's rights to avoid the burden of complex and expensive certification process according to new safety requirement.

Derivatives have not posed much of a problem to the European Authorities (JAA). Its first certification was awarded to Saab's SF340, in May 1984. That aircraft, and all those which have followed it, including the ATR series, the Airbus fleet from the A320 onwards and British Aerospace's 146/RJ series, have all been original aircraft certificated to standards which have required little amendments to comply with the latest - and proposed - changes to the JARs. The FAA, on the other hand, has had to deal with the Boeing and McDonnell Douglas (MDC) fleets, the derivatives of which include the world's best-sellers.

Without grandfather rights, the 747-8 would have not been certified as the passengers in the nose section of the main deck only have one way of exiting the plane in an emergency, whereas the new legislation required all planes to have 2 directions for all passengers to go in case of an emergency evacuation, front and backwards. European regulators insisted at that moment on Boeing to be required to undertake a full evacuation demonstration of the new 747 variant - something it avoided doing when the -400 was introduced in 1989. Although under previous 747 stretch development studies, such as the 747X of 2001, Boeing had intended to adopt an all-new certification path, but it finally pursued certification for the 747-8I/8F under an amended 747-400 type certificate.

The 747-400 was itself approved as an amendment to the certification of the original 747-100 that was launched in 1966. European Joint Aviation Authorities') insisted in the 1980s that the cockpit/upper-deck floor of the Boeing 747-400 be strengthened to contemporary standards, to protect the flight-control runs which pass through it. Although at that moment the FAA disagreed, JAA insistence translated into that European-registered 747-400s having upper-deck floors built to a higher specification than those registered in the USA and elsewhere.

The latest issue concerns the Boeing 737-X series and whether, despite being a re-winged, reengined, re-instrumented version of the previous series, it will gain any advantage over the A320 by virtue of grandfathering anomalies. The Boeing's 737-X series (the 737-600/700/800) complied with 362 out of 377 of the latest FAR/JARs, and that the ten or so "reversions" (derivative privileges) granted complied with the ICPTF guidelines. By the end of 1995, Boeing had admitted that there were some five items yet to be clarified, but it is reluctant to list them. One of them was the issue of whether the 737-800 shall be permitted, given the limitations imposed by cabin emergency-exit regulations, to carry 179 or 189 passengers. A 737 has never been submitted to the JAA for certification - it was originally certificated by European national aviation authorities. The FAA, on the other hand, being the 737's original certificating authority, says that 189 is permissible under FAR grandfather rules.

On 2000 grandfather rights were finally killed on both sides of the Atlantic. A new US Federal Aviation Administration rule has replaced the regulation which allowed completely new aircraft models in a well-established family, like Boeing's 737 series, for example, to continue to be produced to some of the out-of-date certification standards in force when the first 737 was produced. The JAA upgrade also its previous regulation, that was a compromise solution requiring that new models in an existing family of aircraft do not have to meet the letter of the latest certification laws, provided that the new version could demonstrate "equivalent safety" by some other means. If it could not, the updated model had to satisfy the same certification standards that would apply to a completely new aircraft type.

T9.3.2.2 Future Perspective of Grandfather's Rights

Besides this overall agreement on not application of grandfather rights, there is some challenges that problem might be reactivated in the future, as could have been happened with the upcoming application of new ICAO regulation for emissions.

On 8 February 2016, the International Civil Aviation Organization (ICAO) finalized a proposed performance standard for new aircraft that will mandate improvements in fuel efficiency and reductions in carbon dioxide (CO2) emissions. The standard, the first ever to impose binding energy efficiency and CO2 reduction targets for the aviation sector, was hammered out at the tenth meeting of ICAO’s Committee for Environmental Protection (CAEP). It will apply to all new commercial and business aircraft delivered after 1 January 2028, with a transition period for modified aircraft starting in 2023. The standards will on average require a 4% reduction in the cruise fuel consumption of new aircraft starting in 2028 compared to 2015 deliveries, with the actual reductions ranging from 0 to 11%, depending on the maximum take-off mass (MTOM) of the aircraft.

If this standard would have been deeming to be applied only to new designs certified after the expected application date (instead to all aircraft rolled out of a factory), in-service aircraft, those already flying before the date the standard takes effect, will not be affected by this new regulation. Most of the “future” airplanes that are already announced (B777X, A330neo, etc) will acquire their type certificates well before 2024 and in essence would therefore grandfather in existing production lines and possibly derivative products as well, what could prolong the current period of limited efficiency improvements by delaying the introduction of new aircraft designs by manufacturers wishing to avoid triggering the standard [3]. If the grandfather clause would adopted, then a standard applied in 2020 would cover only 5 percent of the global fleet in 2030.

In the future, it is expected that these grandfather rights may reappear as modifications to the new aircraft models are extended. Therefore, the procedure to be followed will be very similar to the current one since aircraft owners will try to achieve maximum use of their investment.

The conflicting issues which have to be resolved are, on the one hand, the need for safety regulation to be able to advance, taking advantage of experience and technological improvement; and, on the other hand, the need for manufacturers to produce aircraft to approved designs which can remain basically unchanged long enough to be built, tested and put into operation, and then to achieve sufficient sales for a reasonable return on investment.

[3] Efficiency Trends for New Commercial Jet Aircraft, 1960 to 2008. ICCT: International council on Clean Transportation

T9.3.3 Certification Challenges in China with the ARJ21 and C-919

Although China's government has had a great interest in manufacturing commercial aircraft, it has not had much success. Until recently, China's aircraft manufacturing industry's production was limited almost exclusively to serving the Chinese military. Consequently, almost all of China's commercial aircraft have been imported from foreign manufacturers. In 2008, the Chinese government consolidated its efforts to develop a commercial aircraft manufacturing industry by setting up a new state-owned commercial aircraft manufacturing company, the Commercial Aircraft Company of China (COMAC), to build two domestic aircraft: a regional jet, the ARJ-21, already under development, and a narrow-bodied aircraft, the C919.

In the 1970s, China made the first of several attempts to build a commercial jet. The most successful of these was the Y-10 jet transport, an aircraft broadly similar to the Boeing 707. Altough a number of test flights conducted in the early 1980s were apparently successful, the plane cost significantly more than western planes. For this reason, Chinese airlines found that it was more profitable to purchase aircraft from Boeing and Airbus. Only three Y-10 aircraft were built, and the program was discontinued due to design and cost problems.

Following the cancellation of the Y-10 program in 1983, China developed a plan with the objective of proceeding from local production and assembly of foreign designs to local development with foreign assistance. The final step will consist of achieving completely independent local development without foreign assistance by 2010.

Following these objectives, an agreement was reached with McDonnell Douglas to assemble the MD-82 narrow-body airliner in Shanghai. Between 1986 and 1994, a total of 35 MD-82 were assembled. Then, the two partners planned to assemble 40 MD-90s, an upgraded derivative of the MD-80 series, but Boeing stopped producing the aircraft following its merger with McDonnell Douglas, and the program was suspended.

After the termination of the MD-80/90 attempt, in 1997, China persuaded a consortium that includes Airbus and Singapore Technologies to join AVIC in the development of a 100-seat regional jet, the AE-100. This program ended in 1999, when Airbus concluded that the program no longer fit into its strategic plan.

Subsequently, China focused on smaller regional jets and a consortium between several companies was formed in 2000 in order to develop and produce a regional jet, designed for flights of less than three hours and seating 70 to 105 passengers, known as the ARJ21.

In 2002, another Chinese aircraft manufacturer, the Harbin Aircraft Industries Group, formed a joint venture with Brazil's Embraer to assemble Embraer's ERJ-145 family of 30-to 50-seat regional jets in Harbin. However, the facility delivered only 41 ERJ-145 aircraft over seven years before production ended in 2011.

More recently, the Chinese industry appears to have shifted its focus to larger aircraft in the 130-to 170-seat class. In 2008, a joint venture between Airbus and a Chinese consortium to perform final assembly of the Airbus A320.

Finally, China's indigenous commercial jet project known as the C919 was launched in 2008.

In the following image (Figure 9.8), it can be seen a timeline of China attempts to manufacture commercial aircraft:

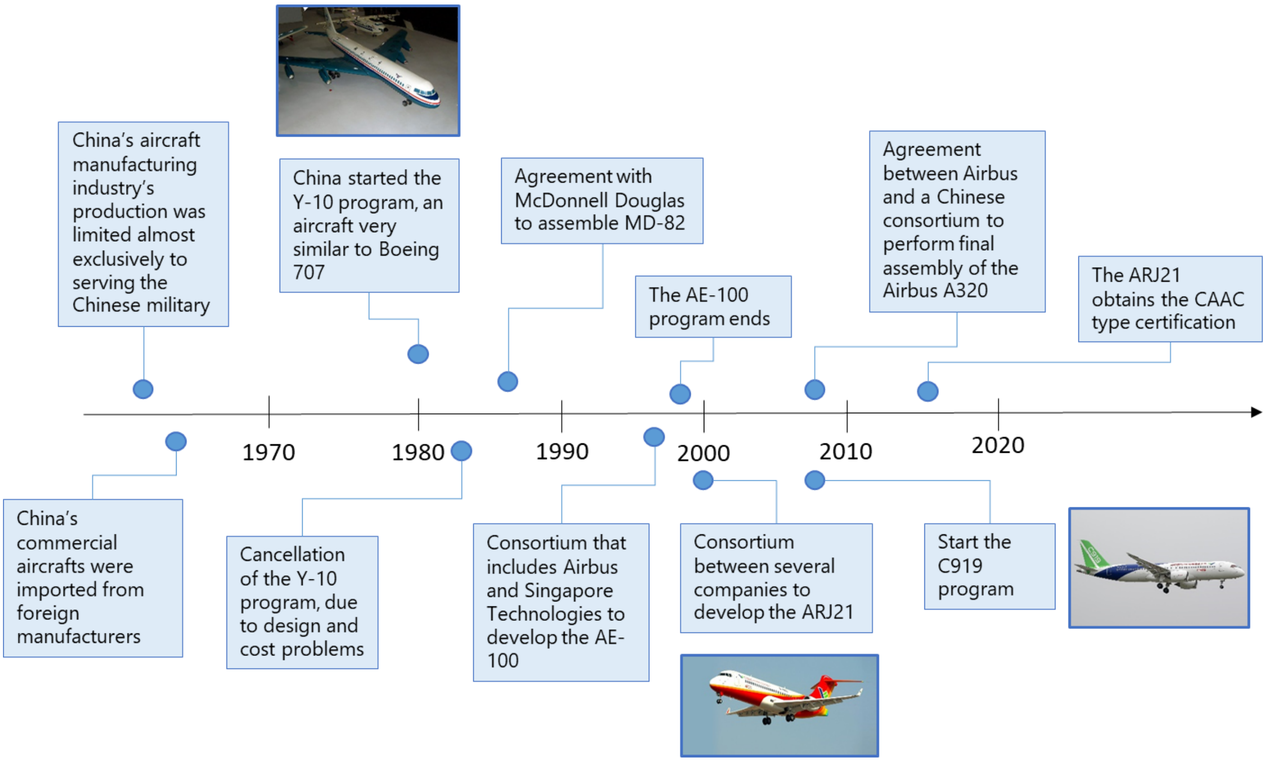

Figure 9.8 - China attempts to manufacture commercial aircraft

However, the China indigenous aircraft, the ARJ21 and the C919 have experience delays due to several problems during tests flights. A key problem of the delays has been a lack of systems integration skills. As several parts of the aircraft are produced by different manufacturers, the finished products are having compatibility issues during final assembly. Quality has also been a problem. Certain parts pf the aircraft have failed to meet quality requirements.

In addition, one of the main problems in the construction of China indigenous aircraft is that there is not intellectual property protection, which implies that international companies often agree to transfer only dated technology. This issue has been a great problem for the ARJ21 and it may be a problem too for the C919.

T9.3.3.1 ARJ21

The ARJ21 is a twin-engine regional jet, manufactured by the Chinese aerospace company COMAC.

This project started in 2002, and it has experienced significant delays compared to the initial plan. The first commercial flight took place in June 2016, six years later than planned, and only two ARJ21 aircraft had been delivered as of February 2017 (both to Chengdu Airlines, a company owned by COMAC).

Depending on the version, the ARJ21 has a maximum seating capacity of 105 and a maximum range of 3,700 km, which makes it a direct competitor to Embraer E175 and E190, as well as to Bombardier CRJ900 and CRJ1000.

As it was said before, the ARJ21 has had several delays. In 2010, an ARJ21 wing failed to reach the predicted load rating during static testing. This wing's failure led the Civil Aviation Administration of China (CAAC) to limit the aircraft flight envelope during its flight test program. In addition, other problems arose during the flight testing program: two components of the testing program had not been completed, icing tests had been delayed and stall speed tests had not begun yet. These problems lead to delays in obtaining type certification. Wing cracks and avionics were other problems that contributed to the delays.

Obtaining a FAA type certification is a precondition for the ARJ21 to enter the global aviation market. Since 2003, the aviation authorities of China and USA have been negotiating the ARJ21 application for FAA type without success.

However, the ARJ21 achieved the type certification from the Civil Aviation Administration of China (CAAC) in 2014, which allows the aircraft to carry out regional flights. On 29 November 2015, COMAC delivered the first ARJ21 to Chengdu Airlines and the first commercial flight took place in the Chengdu Shuangliu Airport on June 28 2016.

T9.3.3.2 C919

The COMAC C919 is a narrow-body twinjet airliner developed by Chinese aerospace manufacturer COMAC. The programme was launched in 2008 and production and its first flight took place on 5 May 2017. The C919 can carry 156 to 168 passengers with a range of 3000 nautical miles. It is intended to compete primarily with the Boeing 737 and Airbus A320neo and it is planned to enter commercial service in 2021 with China Eastern airlines.

On the 24th November 2011, the preliminary design phase for the C919 ended and the assembly of the first C919 prototype began on December 2011. The flight testbed was expected to complete final assembly in 2014 and perform its first flight in 2015. However, there were several delays due to technical difficulties and supply issues. Finally, the first flight took place in 2017 and the first 150-seat C919 is scheduled to be delivered in 2021.

The C919 has not obtained yet a type certification from CAAC, which will take about three to four years. In April 2017, European Aviation Safety Association (EASA) agreed to help validate Chinese aviation authorities' certifying process of the C919's airworthiness. An EASA endorsement of the C919's airworthiness would increase its export prospects, especially in Asia and the Middle East. After EASA certification, the C919 could hope to win approval from the FAA sometime in 2020.

T9.3.3.3 C929

In 2016, COMAC and United Aircraft Corporation of Russia (UAC) signed an agreement to co-develop a 250-seat, 290-ton, 7,450-mile-range plane tentatively designated the C929. Its first fight is targeted for 2022, and it will potentially enter into service by 2025. The C929's construction will use large percentages of composite and titanium parts in order to reduce its weight, thus boosting payload, range, and fuel efficiency to compete with the Boeing 787 and Airbus A350. Like the C919, the C929 will likely use foreign parts, especially in the engines.

T9.3.4 Certification of Novel Aircraft Configurations

The configuration of civil aircraft has evolved little since the 1920s. Almost without exception, passengers have been transported in a tubular fuselage, with the empennage at the rear and the engines mounted either under the wings, or at the rear. Although major advances in aerodynamics and flight control systems have contributed greatly to improve the performance of the classic configuration, the advent of new design materials and design processes, along with a far better understanding of the aerodynamic and structural interactions that occur in different phases of flight, are driving some radical ideas for the future.

Regarding aircraft configurations, several options are being considered for the future:

- Development of integrated and interdisciplinary functional aircraft design methods, including systems, software and integration aspects considered from the conceptual design phase
- Integrated blended wing body and tail-mounted open rotor concepts
- Aircraft configurations regarding type of energy (e.g. hydrogen, electrical engine…)

The following image (Figure 9.9) shows some different types of possible aircraft configurations based on the level of investment required (low, medium and high), as a function of time (2015, 2025 and 2050):

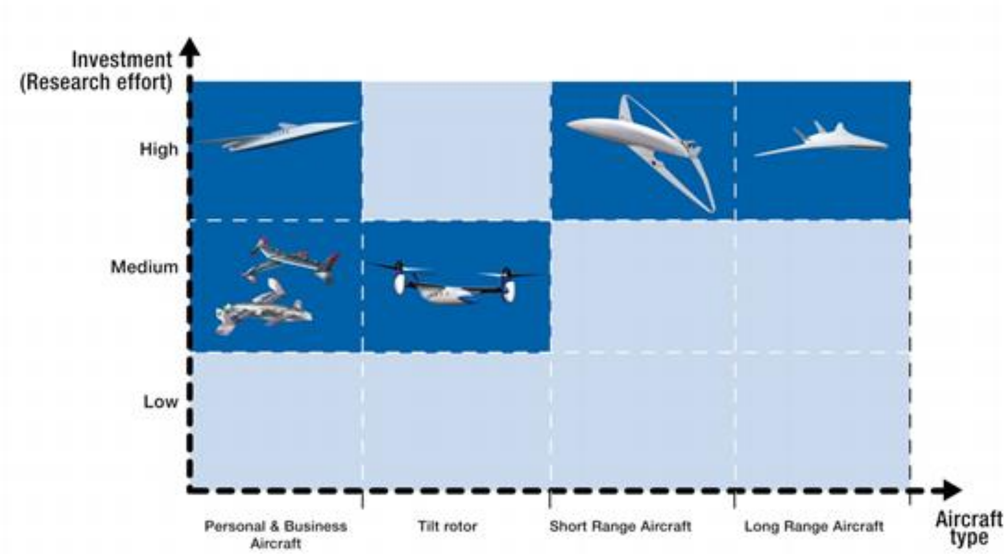

Figure 9.9 Revolutionary aircraft configurations
Source 1: From Air Transport System 2050 Vision to Planning for Research and Innovation, EREA

Then, they are described some of the revolutionary aircraft configuration that could be expected for the future:

- **Blended wing body**: today's classical aircraft configurations features separate structures for providing lift (wings) and carrying the payload (fuselage). This results in a heavier structure, additional wetted surface and associated viscous drag. The flying wing configurations is recognised as the most efficient aerodynamic solution, but presents challenges in many other areas, such as its great structural complexity, that could be mitigated with the development of advanced composite materials and production processes.

- **Prandtl joined-wing plane concept**: for a given wing span and lift, the Prandtl-type biplane, with wings connected at the tip, could provide a theoretical induced drag during low-speed phases such as take-off, climb, descend and landing. In addition, this radical change in configuration could provide a potential fuel burn reduction of 10%.

- **Tilt-rotor aircraft**: Tilt-rotors combine to some extent the hover advantages of helicopters with the higher-speeds of turboprop aircraft, overcoming the problem of helicopter speed being limited by the loss of main rotor efficiency at higher forward speeds. The next generation of tilt-rotors will feature a partially tilted wing to improve rotor efficiency at hover.

- **Personal air transport**: for personal air transport, short-range small aircraft that provide low emissions and easy handling could be used. Such aircraft would be operating along with others at lower altitudes and speeds with features as reduced weight, reduced fuel consumption, simpler maintenance or increased reliability. However, this concept will require the resolution of a number of major technological issues, including environmental control, ice protection systems and engine technology.

Supersonic business transport: using supersonic business transport to link growing business metropolises in North America as well as in Europe and Asia would provide a potential reduction in flight time, being capable of travelling long distances in only a few hours. However, significant technological challenges remain, including:

- Development of high temperature carbon fibre materials;
- Sonic boom overpressure on the ground;
- Airport noise;
- Easy to handle, reliable aircraft;
- Low-emission, high-speed propulsion.

The previous aircraft configurations considered are only a few examples of the radical changes that are currently being studied. However, these revolutionary configurations could present challenges in the certification process as they present a great change compared to current configurations.

Aircraft certification is the process whereby an applicant requests an approval from an aviation regulatory authority, such as the FAA or the European Aviation Safety Agency (EASA), for manufacturing a new aircraft model or making changes to an existing aircraft. Aircraft certification processes use approved standards, guidance, tests, methods, procedures as well as data submittals and plan documentation to achieve regulatory approval for aircraft type certification.

In order to certify the revolutionary aircraft configurations that are expected in the future, it will be necessary to improve current certification methods or to develop new ones in order to assure that these aircraft are safe and efficient. The certification methods that will be required are based in three pillars:

1. One pillar represents computational capabilities, which consist of high-speed super computers that can model the physics of air flowing over an object, be it a wing, a rudder or a full airplane. Improved computational tools would allow to reduce costs, time, risk and it would provide a great increase in aircraft design efficiency and quality. In addition, unconventional configuration concepts could be explored more easily and with greater confidence during early design stages. Therefore, to certify new aircraft configurations through computational methods, it will be necessary to develop faster and more accuracy algorithms.

   One of the main goals, which is expected to be achieve by improving computational tools, will be to certify new technology or vehicle concept with more limited use of ground or flight testing for validation. This will require the ability of the computational tools to predict absolute performance within known uncertainty bounds over the entire operating conditions.

2. A second pillar represents the experimental methods. In this case, scientists usually put a scale model of an object or part of an object (be it a wing, a rudder or an airplane) in a wind tunnel to take measurements of air flowing over the object. These

measurements help improve the computer model, and the computer model helps inform about improvements to the airplane design, which can then be tested again in the wind tunnel. As the computational tools become increasingly reliable in predicting system performance, the role of wind tunnels should evolve towards physics-based testing for increased understanding of various flow phenomena and for developing extremely high-fidelity data for physical model development and code validation.

Therefore, wind tunnels will continue to play a significant role aircraft certification and testing, which will provide a significant reduction in costs and flight testing.

3. Finally, the third pillar is the flight testing of the design developed. The data recorded in the flight test can be used to validate and improve the computational and experimental methods used to develop the design in the first place.

   In the future, one of the main objectives will be to reduce the time required in this phase, since flight testing is the most expensive process and detecting errors in this phase could delay the whole certification process.

KEY TOPIC T9.4 CERTIFICATION PROCEDURES

The certification of an airliner is final stage of the development process, and can also be the most complex, time consuming and expensive.

The Type Certification (TC), i.e. the design approval for the model, should be complemented by the approvals by the Authority of the Design Organisation and of the Production Organisation (organisation demonstrates competence and compliance with regulatory requirements). The Authority empowered to approve products and organizations is an agency of an ICAO member state and is supposed to compile the respective requirements in accordance with Annex 8 to the ICAO Convention "Airworthiness of Aircraft" Part II Chapter 1 "Type Certification". However, this is just the minimum requirements, so different countries might choose a range of levels of severity of the conditions.

To be granted the TC, the designer is asked to demonstrate the compliance to the Authority set of requirements, including analyses (aerodynamic, airframe loading, systems safety), structural tests, other ground tests (functional, fatigue, reliability), flight tests (performance, handling, flutter etc.). Applying for a TC is the start of the certification process and the timing is important because this is where the clock starts ticking. Part 23 airplanes generally have three years from the date of application to be certified; Part 25 airplanes have five years. The certification basis is structured in Mandatory Requirements, the applicable certification code in place at time of TC application, e.g. CS-25 at Change 18. When a company applies for a type certificate, the rules that are in force at the time of application are the rules with which the applicant must comply. If, for example, the Authority changed the certification rules after someone applied for certification, requiring that icing tests be done with 100-micron freezing drizzle instead of the current 40-micron droplet size, the applicant would not have to meet that new regulation. This is where a protracted certification program can run into problems, because if there are delays that push the program beyond the three- or five-year limit, then the applicant has to apply for an extension and might have to comply with rules that took effect after the initial application. This is the case of the Japanese MRJ, still struggling after more than 10 years to complete the certification.

The flight testing for certification of a modern airliner takes about 3 000 flying hours over a period of 3 to 5 years, involving 3 to 6 prototypes. Before the OEM flies a prototype of the design, the Authority will need to issue an experimental type certificate. Authority personnel will conduct a safety review and check that the airplane conforms to its design. A plan for test flying will cover all requirements. And before Authority test pilots fly in the airplane it must have flown through its full flight envelope. Flight testing is a challenging part of the certification program and it is difficult to compress without significantly increasing risks that could become delays and further costs. Although there has been much progress in ground testing and simulation, it is flight testing that is the ultimate proof that satisfies certification authorities. The increasing capabilities and complexity of successive generations of airliners means that there is more hardware and software equipment and functions to test, and the progress is absorbed in performing increased testing in a comparable time span.

Besides the certification programme for the aircraft, separate certification requirements are specified for engines as well as for propellers and for Auxiliary Power Units (APUs). The time for the development and TC of a new engine is now around 5-6 years and about 10-15 test prototypes are employed (and sometimes destroyed) in ground tests (including subassemblies tests), altitude bench tests and flight tests on the airplane equipped.

The preceding account assumes that the certification process concerns only essential issues without duplication or unexpected requirements from different certification responsible agencies. Before the 90s the standard recognized level worldwide was that of FARs, the regulations issued by US' FAA. The harmonization somehow existed, the first European unified JARs (e.g. JAR-25 'Large Airplanes') were nothing else than the declared transcription of the equivalent FARs. There are, however, a number of areas in which variations and additions to FAR Part 25 have been considered necessary in order to reach agreement to a code acceptable to JAA participating countries, and these differences (Complementary Technical Conditions) were indicated in the specifications. After the creation of EASA in 2003, the requirements began to diverge, as can be observed in an ever growing list of Significant Standard Differences (SSD) between U.S. Code of Federal Regulations (CFR), Part 25 and Joint Aviation Regulation (JAR), Part 25, or European Aviation Safety Agency (EASA) Certification Specifications (CS) 25 published by FAA (see www.faa.gov/aircraft/air_cert/design_approvals/transport/transport_intl/sd_list/ssd_nonssd_list/).

Similar negative effects would produce a proposal to grandfather in a large number of current aircraft designs in terms of emissions. If such a grandfathering clause is adopted, then any standard applicable beginning in 2020 would cover only 5% of the global fleet in 2030.

The "grandfathering right" is an Anglo-Saxon general legal principle, still controversially applied in aviation, besides in the certification practices, also in allocating airport slots. Another example of "grandfathering", this time perfectly justified, was introduced when EASA was established through Commission Regulation (EC) No 1702/2003 of 24 September 2003. It contains a grand-fathering mechanism for certain type certificates issued prior to 28

September 2003 by Member States. These type certificates are deemed to have been issued in accordance with Regulation no 1702/2003 and, as a consequence, EASA does not need to issue new type certificates for the related products. However, since 28 September 2003, all changes to these type certificates or associated datasheet must be approved by EASA.

EASA delivers the primary certification for European aircraft models which are also being validated in parallel by foreign authorities for operation in their airspaces, e.g. the FAA for the US or TCCA for Canada. Conversely, EASA will validate the FAA certification of US aircraft models (or TCCA certification of Canadian models) according to applicable Bilateral Aviation Safety Agreements between the EU and USA, respectively Canada. As an example, the existing "Agreement Between the United States Of America And The European Community On Cooperation In The Regulation Of Civil Aviation Safety" (EU_USA_BASA/en 1 - Revision 3_ March 2016) is continuously extended and improved to cover more situations and to provide regulatory cooperation and transparency. The parties established a Bilateral Oversight Board which is responsible for ensuring the effective functioning of the Agreement. Based on this, a more detailed "Technical Implementation Procedures for Airworthiness and Environmental Certification" (known as TIP) was signed between FAA and EASA, currently at Revision 6 from September 22, 2017. As part of the continued maintenance of confidence in each other's system, the FAA and EASA develop procedures to share and exchange information regarding airworthiness and environmental standards, certification systems, etc. The FAA and EASA recognise that certain approvals can benefit from mutual acceptance. There are specific approvals that will be accepted by the Validating Authority without issuance of its own approval, and therefore no application for validation is required. APPENDIX D of TIP lists 15 FAA and EASA mutually recognized airborne systems standards considered to be equivalent for the purpose of issuing approvals under TIP. This is a good start but far too modest. The reverse, the non-accepted differences, lead to extra efforts and spending in the certification process an avoidable waste.

A harmonisation programme, initialised years ago, should be accelerated to completely eliminate the differences, moving things toward the so-called WORLDWIDE harmonization.
A good step was achieved on September 16, 2015, when the leadership of the certification services/departments of the Agência Nacional de Aviação Civil (ANAC) of Brasil, European Aviation Safety Agency (EASA), Federal Aviation Administration (FAA), and Transport Canada Civil Aviation (TCCA) signed a charter establishing the CERTIFICATION MANAGEMENT TEAM (CMT). The CMT oversees and manages collaboration efforts to permit the development and implementation of regulatory and policy solutions common to certification issues and support greater harmonization. In May 2016, the CMT signed its Collaboration Strategy (see https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/air/transformation/certification_strategy/media/cmt_strategy.pdf).
Also the existing co-operation structure of 18 national agencies in the general field of safety, the Safety Management International Collaboration Group (SM ICG) might be extended as scope to cover Certification as well. SM ICG was founded by FAA, EASA and TCCA and is a joint cooperation between many regulatory authorities for the purpose of promoting a common understanding of Safety Management Systems /State Safety Program principles and requirements, facilitating their implementation across the international aviation community. (The current core membership of the SM ICG includes the Aviation Safety and Security Agency (AESA) of Spain, the National Civil Aviation Agency (ANAC) of Brazil, the Civil Aviation Authority

of the Netherlands (CAA NL), the Civil Aviation Authority of New Zealand (CAA NZ), the Civil Aviation Authority of Singapore (CAAS), Civil Aviation Department of Hong Kong (CAD HK), the Civil Aviation Safety Authority (CASA) of Australia, the Direction Générale de l'Aviation Civile (DGAC) in France, the Ente Nazionale per l'Aviazione Civile (ENAC) in Italy, the European Aviation Safety Agency (EASA), the Federal Office of Civil Aviation (FOCA) of Switzerland, the Finnish Transport Safety Agency (Trafi), the Irish Aviation Authority (IAA), Japan Civil Aviation Bureau (JCAB), the United States Federal Aviation Administration (FAA) Aviation Safety Organization, Transport Canada Civil Aviation (TCCA), United Arab Emirates General Civil Aviation Authority (UAE GCAA), and the Civil Aviation Authority of United Kingdom (UK CAA). Additionally, the International Civil Aviation Organization (ICAO) is an observer to this group.

9.3 Aviation Effects on the Environment

The effects of aviation on the environment can be considered at two levels: (i) locally as the emission and noise near airports; (ii) globally as in-flight emissions worldwide. The aims of reduction of environmental impact can be either compatible or contrasting at the (i) local or (ii) global level. For example, the reduction of fuel consumption is beneficial in all cases because it reduces emissions. The design for high efficiency and low fuel consumption is different at low speeds (glider like configuration) and high speeds (swept wings) and thus lowering local emissions is a trade-off with lowering global emissions. Concerning the type of emissions, CO2, NOx and particles that all result from the combustion process again compromises may be necessary among the amount of each that is produced.

The noise regulations of ICAO have long been the standard, although local airports can apply stricter standards that aircraft manufacturers cannot afford to ignore; in principle a single noise standard that could be adhered to worldwide would be ideal. Concerning emissions, like other aspects of global warming and climate change, progress requires considerable international negotiation, with the European Union often the most active promoter. The emerging of the ICAO scheme on emissions is even more desirable than on noise because aircraft emissions are a global issue that cannot be solved at local level like noise.

The environmental effects of aviation could be greater in regions of higher traffic density like Europe and the US; rightly so these are the regions of the world that apply stricter environmental standards, applying to new aircraft, and requiring older non-compliant aircraft either to be modified or retired from service. In the case when the modification of older aircraft for compliance with new environmental standards is not economical, many of them are sold to operate in other regions of the world. Thus, some less developed regions, with lower air traffic densities, operated older aircraft with larger environmental impact, that may or may not be felt locally, but certainly contributes to global pollution. These older aircraft can also pose some safety issues.

KEY TOPIC T9.5 AVIATION EFFECTS ON THE ENVIRONMENT

Contaminants

Contaminants from Aircraft Engine Emissions

- Commercial air travel is expected to double in the next 20 years, which will in turn increase the amount of contaminants emitted to the atmosphere. The following contaminants are emitted during the different phases of operation:

- NITROGEN OXIDES (NO_x) – which includes nitrogen oxide (NO) and nitrogen dioxide (NO_2);
- CARBON MONOXIDE (CO)
- UNBURNED HYDROCARBONS – which have almost been completed eliminated from the exhaust stream due to newer engine technologies
- SULPHUR OXIDES
- PARTICULATE MATTER (PM) – which leaves the exhaust as carbon black soot
- VOLATILE ORGANIC COMPOUNDS (VOCS) – such as benzene and acrolein
- OZONE (O3)– which is formed from the nitrogen oxides and volatile organic compounds emitted
- SEMI-VOLATILE ORGANIC COMPOUNDS (SVOCS)
- METALS
- NOISE – this contaminant is discussed in the Aircraft Noise section of the ICAO site ODOUR

Most of the focus of international efforts have been on the reduction of NO_x so far (ICAO has an engine certification standard for NO_x which is contained in Annex 16 — *Environmental Protection, Volume II — Aircraft Engine Emissions* to the Convention on International Civil Aviation). Further assessment of the impact of some of these contaminants (for example, particulate matter and metals) needs to be conducted in order to assess the risk to human health and to further the goal of reducing emissions.

Besides NO_x, ICAO has established limits for emissions of CO and unburned hydrocarbons in Annex 16, Volume II. This volume also contains provisions regarding smoke and vented fuel.

Auxiliary power units are also sources of contaminants. However, they are not certified for emissions and it is difficult to estimate emissions from these sources as manufacturers consider the emission rate information proprietary.

Aircraft engine emissions and auxiliary power units are the only sources under the remit of ICAO.

Contaminants from Airports and Associated Sources

Airports also release contaminants from activities such as:

- Ground service equipment;
- Motor vehicles (parking, road traffic);
- Construction;
- Boilers;
- Generators;
- Airport fire training facility;
- Food preparation;
- Engine testing;
- Electricity;

- De-icing;
- Fuel storage facilities.

The contaminants listed above can also been found emitting from airport sources. The VOCs emitted may vary for those emitted by aircraft depending on the fuels used in ground service and road traffic vehicles, and fire training exercises.

Health Effects

Exposure to the contaminants listed above can result in serious health effects. The Table 9.1 presented below lists some of these effects. Local and regional air quality officials are responsible for creating standards to protect human health from the adverse effects of these contaminants.

Table 9.1A – Representative health effects of air pollutants

Pollutant	*Representative Health Effects*
Ozone	Lung function impairment, effects on exercise performance, increased airway responsiveness, increased susceptibility to respiratory infection, increased hospital admissions and emergency room visits, and pulmonary inflammation, lung structure damage.
Carbon Monoxide	Cardiovascular effects, especially in those persons with heart conditions (e.g., decreased time to onset of exercise-induced angina).
Nitrogen Oxides	Lung irritation and lower resistance to respiratory infections
Particulate Matter	Premature mortality, aggravation of respiratory and cardiovascular disease, changes in lung function and increased respiratory symptoms, changes to lung tissues and structure, and altered respiratory defense mechanisms.
Volatile Organic Compounds	Eye and respiratory tract irritation, headaches, dizziness, visual disorders, and memory impairment.

Table 9.1B – Representative environmental effects of air pollutants

Pollutant	*Representative Environmental Effects*
Ozone	Crop damage, damage to trees and decreased resistance to disease for both crops and other plants.
Carbon Monoxide	Similar health effects on animals as on humans.
Nitrogen Oxides	Acid rain, visibility degradation, particle formation, contribution towards ozone formation.
Particulate Matter	Visibility degradation and monument and building soiling, safety effects for aircraft from reduced visibility.
Volatile Organic Compounds	Contribution towards ozone formation, odors and some direct effect on buildings and plants.

Table 9.1 -Representative health effects of air pollutants
Source: Evaluation of Air Pollutant Emissions from Subsonic Commercial Jet Aircraft, EPA

The following diagram (Figure 9.10) illustrates the percentage of deposition of particulate matter of a specified particle diameter that will reach different segments of the respiratory system.

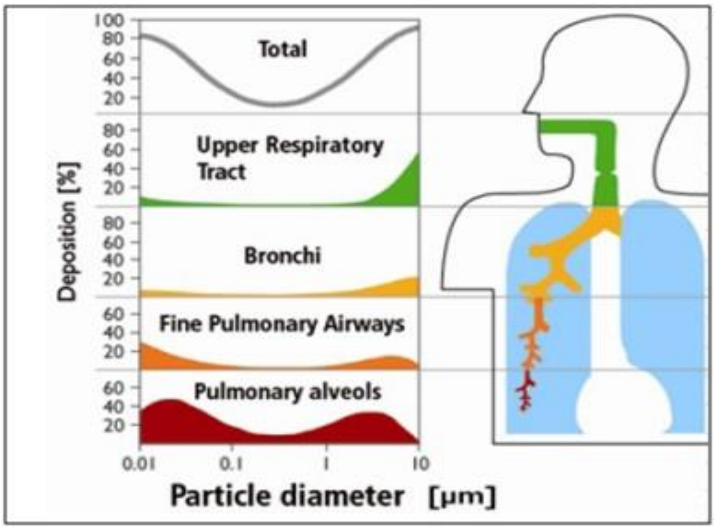

Figure 9.10 – Polluting particles matter

Source: ICAO Information Paper CAEP-SG/ 20082-IP/05

Environmental Effects

Aircraft and airport emissions can also have serious effects on the environment. These contaminants can affect crop productivity and ecosystem response. In particular, NO_x in the troposphere can contribute to ground-level ozone, excess nitrogen loads to sensitive water bodies, and acidification of sensitive ecosystems according to the U.S. Environmental Protection Agency.

Particulate matter contributes to visibility and soiling issues. They play a key role in creating the hazy smog often found surrounding cities on sunny, warm, dry days.

VOCs also contribute to ozone formation and damage plants, crops, buildings and materials when released at high levels.

ICAO Initiatives to Improve Local Air Quality

One the initiatives that ICAO has undertaken to improve air quality is the creation (and continued updating) of the document Airport Air Quality Guidance Manual. The manual provides guidance to assist with the assessment of airport emission sources, emission inventories and emissions allocation. The first step to addressing local air quality is to obtain an accurate estimate of the types and amounts of contaminants being introduced to the airshed. Then efforts to reduce these emissions can be pursued.

ICAO is also promoting numerous mitigation measures to reduce local air quality emissions. These mitigation measures include: technology and standards; operational measures; market based measures; and alternative fuels.

Aviation Emissions

Aviation emissions in context

In 2012, aviation represented 13% of all EU transport CO_2 emissions, and 3% of the total EU CO_2 emissions. It was also estimated that European aviation represented 22% of global aviation's CO_2 emissions. Similarly, aviation now comprises 14% of all EU transport NO_X emissions, and 7% of the total EU NO_X emissions. In absolute terms, NO_X emissions from aviation have doubled since 1990, and their relative share has quadrupled (Table 9.2), as other economic sectors have achieved significant reductions (Figure 9.11):

	2005	2014 (% change vs. 2005)	Base forecast 2035 Advanced – Low Technology (% change vs. 2005)
Average fuel burn (kg) per passenger kilometre	0.0388	0.0314 (-19%)	0.0209 – 0.0222 (-46%) (-43%)
CO_2 (Mt)	144	151 (+5%)	207 – 219 (+44%) (+53%)
NO_x (1,000 t)	650	732 (+13%)	920 – 1049 (+42%) (+61%)
NO_x below 3,000 feet (1,000 t)	53.3	58.8 (+10%)	73.3 – 83.1 (+37%) (+56%)
HC (1,000 t)	20.8	17.0 (-18%)	22.9 (+10%)
HC below 3,000 feet (1,000 t)	7.8	6.4 (-18%)	11.0 (+40%)
CO (1,000 t)	143	133 (-7%)	206 (+44%)
CO below 3,000 feet (1,000 t)	52.4	48.2 (-8%)	85.5 (+63%)
volatile PM (1,000 t)	4.18	4.47 (+7%)	6.93 (+66%)
volatile PM below 3,000 feet (1,000 t)	0.27	0.27 (-1%)	0.41 (+50%)
non-volatile PM (1,000 t)	2.67	2.38 (-11%)	3.16 (+18%)
non-volatile PM below 3,000 feet (1,000 t)	0.15	0.13 (-14%)	0.17 (+11%)

Table 9.2 - Summary of emission indicators based on IMPACT data

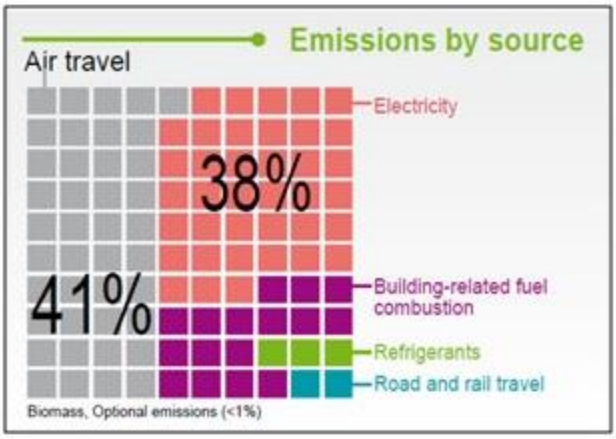

Figure 9.11 - Emissions by source
Source: ICAO

Emissions are expected to increase further

The main aircraft engine emissions are considered here in terms of either full-flight (gate-to-gate), or a landing-take-off cycle below 3,000 feet for local air quality purposes.

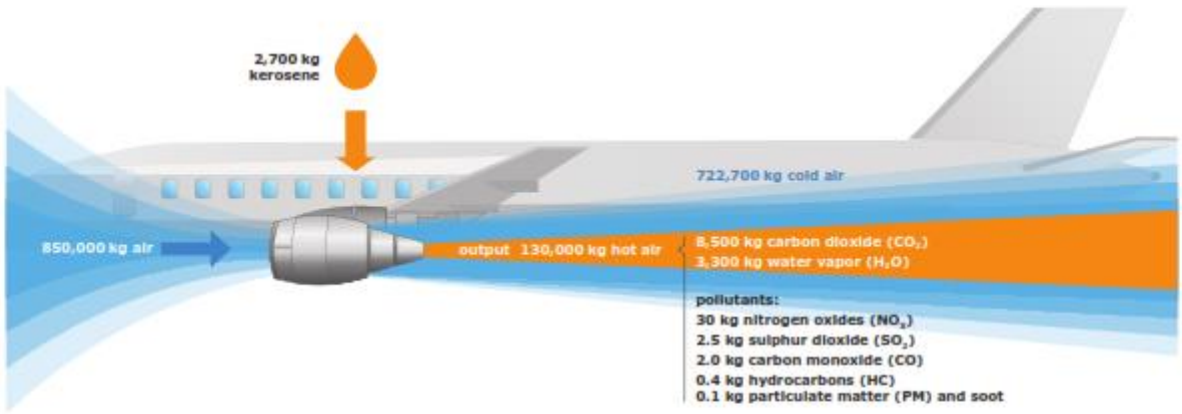

Figure 9.12 - Emissions from a typical two-engine jet aircraft during 1-hour flight with 150 passengers
Source: FOCA

Aircraft CO_2 emissions (Figure 9.12) increased from 88 to 156 million tonnes (+77%) between 1990 and 2005 according to the data reported by EU28 and EFTA Members States to the United Nations Framework Convention on Climate Change (UNFCCC). According to data from the IMPACT emissions model, CO_2 emissions increased by 5% between 2005 and 2014. The increase in emissions is however less than the increase in passenger kilometres flown over the same period (2005 to 2014). This was due to an improvement in fuel efficiency driven by the introduction of new aircraft, removal of older aircraft, and improvements in operational practice. The average fuel burn per passenger kilometre flown for passenger aircraft, excluding business aviation, went down by 19% over this same period. However, projections indicate that future technology improvements are unlikely to balance the effect of future traffic growth.

Under the base traffic forecast and advanced technology improvement rate, CO_2 emissions increases by 44% from 144 Mt in 2005 to 207 Mt in 2035.

NO_X emissions have also increased significantly: +85% (316 to 585 thousand tonnes) between 1990 and 2005 according to the Convention on Long-Range Transboundary Air Pollution (CLRTAP) data from the UN Economic Commission for Europe, and +13% between 2005 and 2014 according to IMPACT data. Under the base air traffic forecast and assuming an advanced NO_X technology improvement rate, emissions would reach around 920 thousand tonnes in 2035 (+42% compared to 2005).

Emissions of HC, CO and non-volatile PM have decreased between 2005 and 2014, while full flight emissions of volatile PM have increased by 7%. However, the total emissions of each of these pollutants are forecast to increase over the next twenty years.

Emissions Monitoring Plan

An Emissions Monitoring Plan (Figure 9.13) is a collaborative tool between the State and the aeroplane operator that identifies the most appropriate means and methods for CO2 emissions monitoring on an operator-specific basis and facilitates the reporting of required information to the State. The State and aeroplane operator should maintain clear and open communication during the development of the plan. Working collaboratively during CORSIA preparation and implementation reduces potential errors and increases effectivity.

Contents of the Emissions Monitoring Plan include:

- Aeroplane operator identification
- Fleet and operations data
- Methods used for fuel monitoring
- Methods and means of calculating emissions from international flights
- Data management, data flow and control

Figure 9.13 - Emissions monitoring

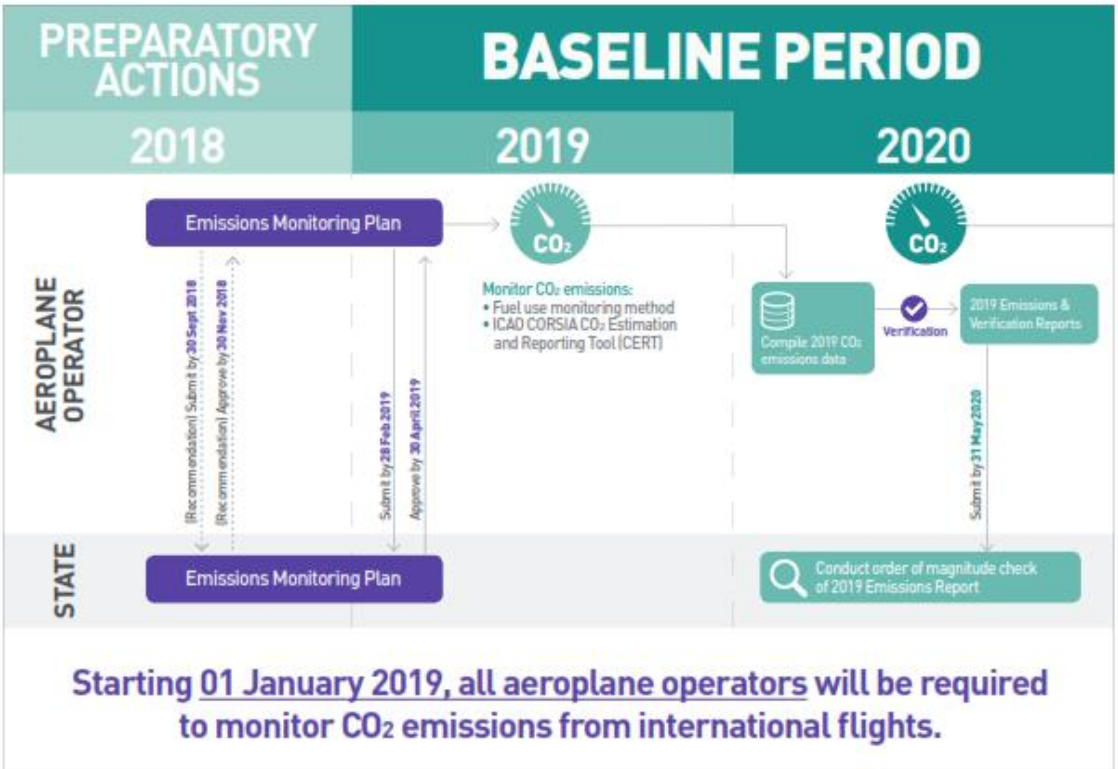

Figure 9.14 – Implementation of emissions monitoring

Emissions Monitoring Options

Draft CORSIA SARPs request (Figure 9.14) an aeroplane operator to monitor and record its fuel use from international flights to determine its annual CO_2 emissions, in accordance with an eligible monitoring (Figure 9.15) method approved by the State to which it is attributed.

To simplify the estimation and reporting of CO2 emissions from international flights for operators with low level of activity in fulfilling their monitoring and reporting requirements, ICAO has developed the CORSIA CO_2 Estimation and Reporting Tool (CERT).

CERT also supports all aeroplane operators in determining if their CO_2 emissions are under the threshold to be exempt from the CORSIA reporting requirements (= 10 000 tonnes of CO2 annually).

Aeroplane operators who emit = 500 000 tonnes of CO_2 annually in 2019 and 2020 from international flights, are not eligible to use CERT to monitor and report emissions and must choose one of the five eligible methods for Fuel Use Monitoring (the five methods are equivalent and there is no hierarchy for selecting a method).

However, all aeroplane operators are able to use CERT to fill in any CO_2 emissions data gaps, regardless of their emissions levels.

Emissions can be taxed (Table 9.3), depending on airport (Table 9.4) and are generally higher for older aircraft (Figure 9.16).

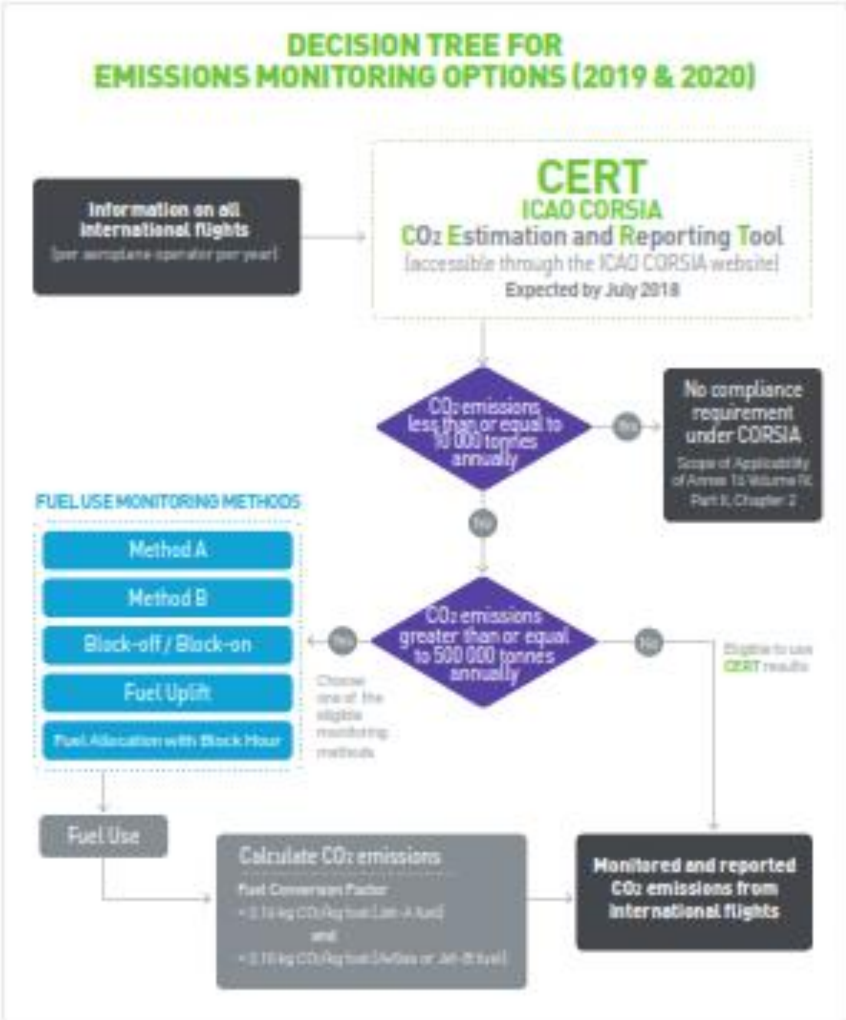

Figure 9.15 – Emission Monitoring Methods

Emissions Costs

Aircraft Type	Cost per LTO (Euros/LTO)	Aircraft Type	Cost per LTO (Euros/LTO)
B737	296	DH8	225
B757/767	583	ATR72	108
B787	872	ERJ-190	177
A320	254	MD-90	315
A321	375	MD-82/83	311
A330	756	Business jets	167

Table 9.3 Average emission cost for commonly used aircraft types at Taipei Songshan Airport

Metropolitan Area	NO_x%	VOC%	$PM_{2.5}$%
Washington, DC	1.22	0.57	0.21
Philadelphia	0.64	0.35	0.20
New York	1.40	0.42	0.41
Denver	1.42	0.54	0.31
San Francisco	1.57	0.63	0.29
Dallas	1.76	0.58	0.23
Minneapolis	1.07	0.59	0.39
Chicago	1.27	0.49	0.36

Table 9.4 Aircraft Emissions Contribution to Metropolitan Area Emissions Inventories

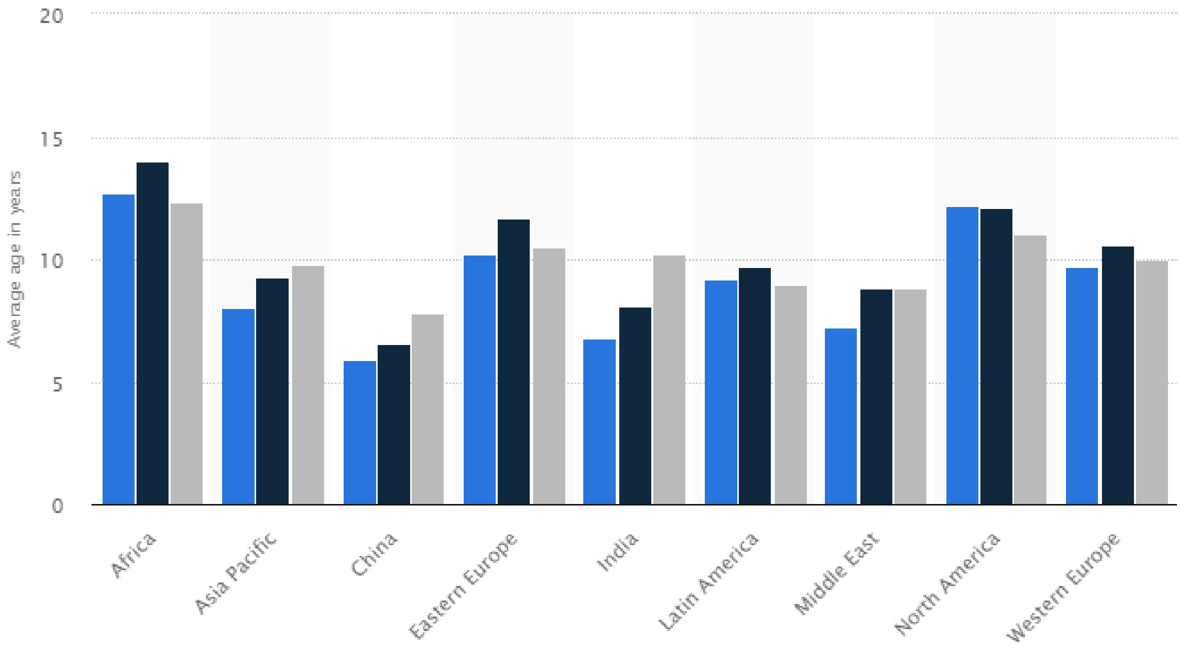

Figure 9.16 - Average age of the global operating aircraft fleet from 2018 to 2028, by region or country (in years)

Exhaust Emissions

For almost all types of emissions, narrow body aircraft emit less greenhouse gasses per seat. Variations between single aisle (narrow body) and twin aisle (wide body) aircraft as well as between different airlines can be seen depending on the type of emission. Since the various airlines used many of the same aircraft types, variations within each emissions species are similar. Carbon Dioxide emissions followed the trend of fewer emissions from narrow bodies across all air fleets examined. The highest emitter of CO2 was American wide bodies, 28.5534 kg of CO2 per seat. The lowest emitter was US Airways narrow bodies at 18.5989 kg per seat (Figures 9.16 – 9.22)

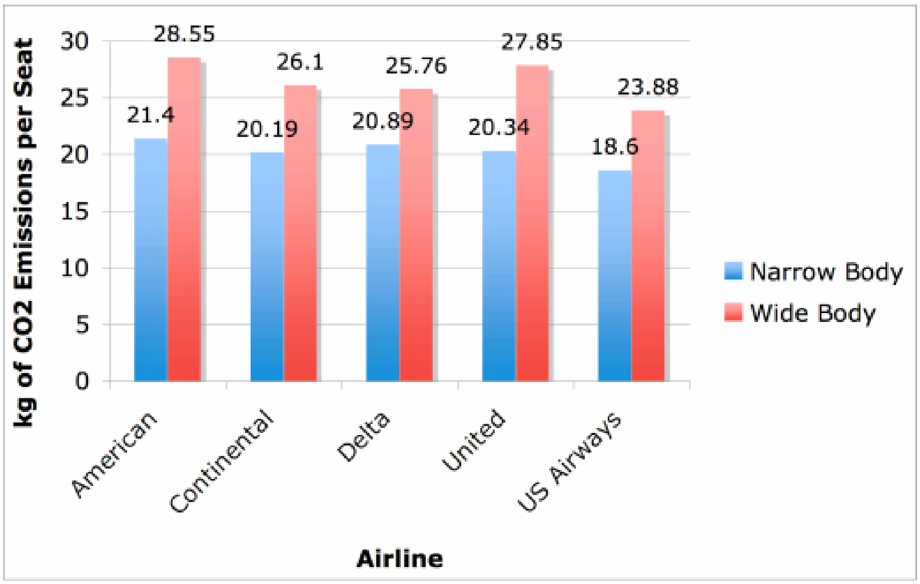

Figure 9.17 - Average CO2 Emissions per Seat for Narrow and Wide Body Aircraft for Each Airline

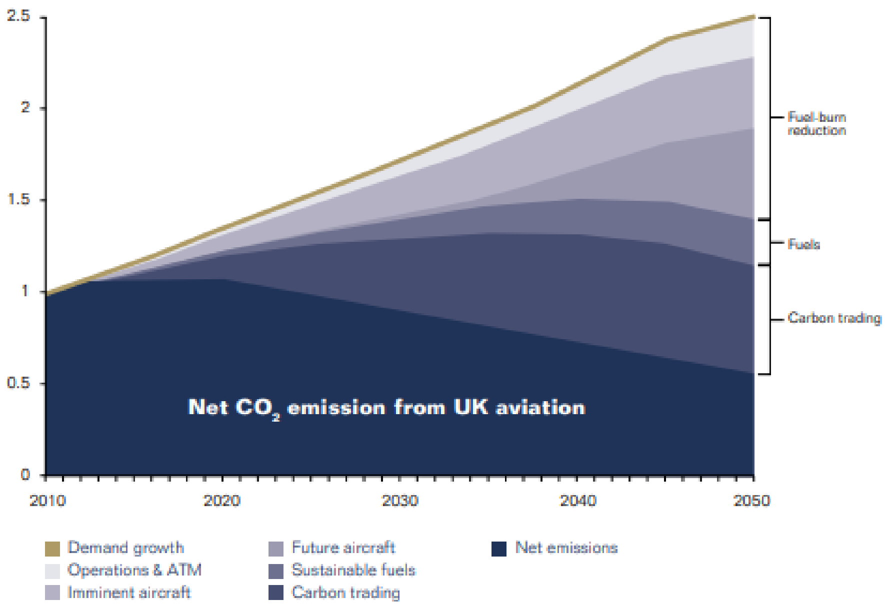

Figure 9.18 - Sustainable Aviation Carbon Roadmap (Source: Sustainable Aviation CO2 Roadmap)

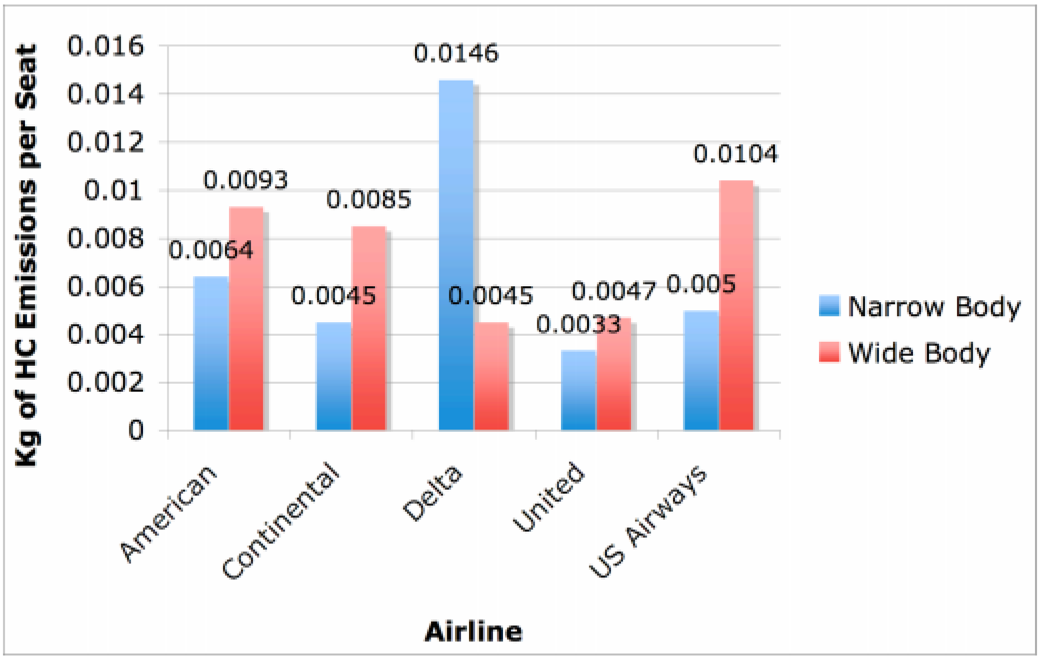

Figure 9.19 - Average HC Emissions per Seat for Narrow and Wide Body Aircraft for Each Airline

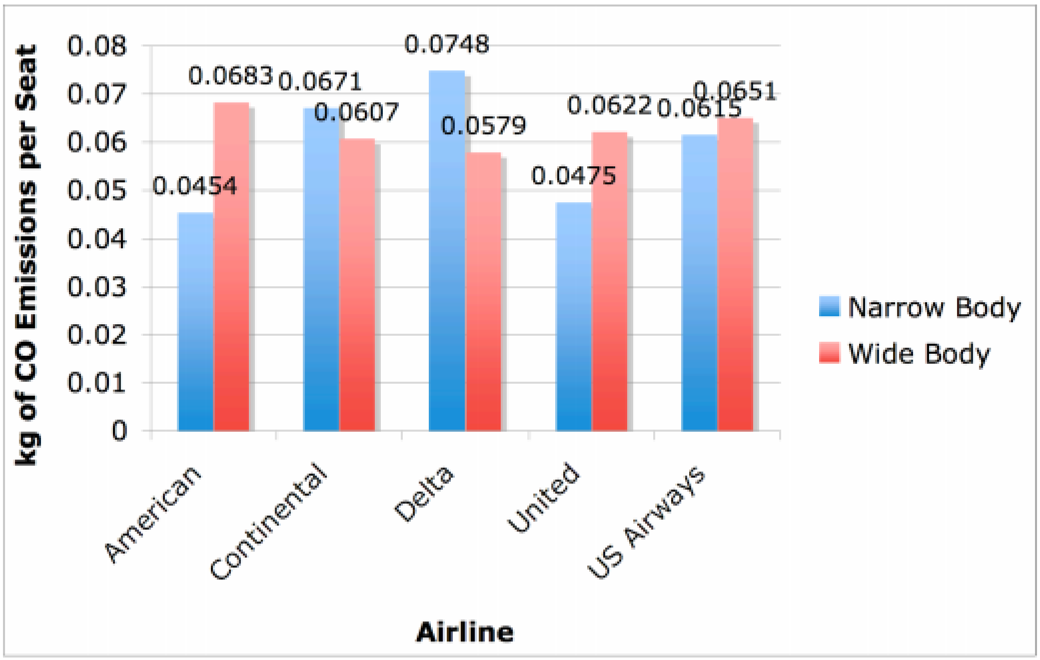

Figure 9.20 - Average CO Emissions for Narrow and Wide Body Aircraft for Each Airline

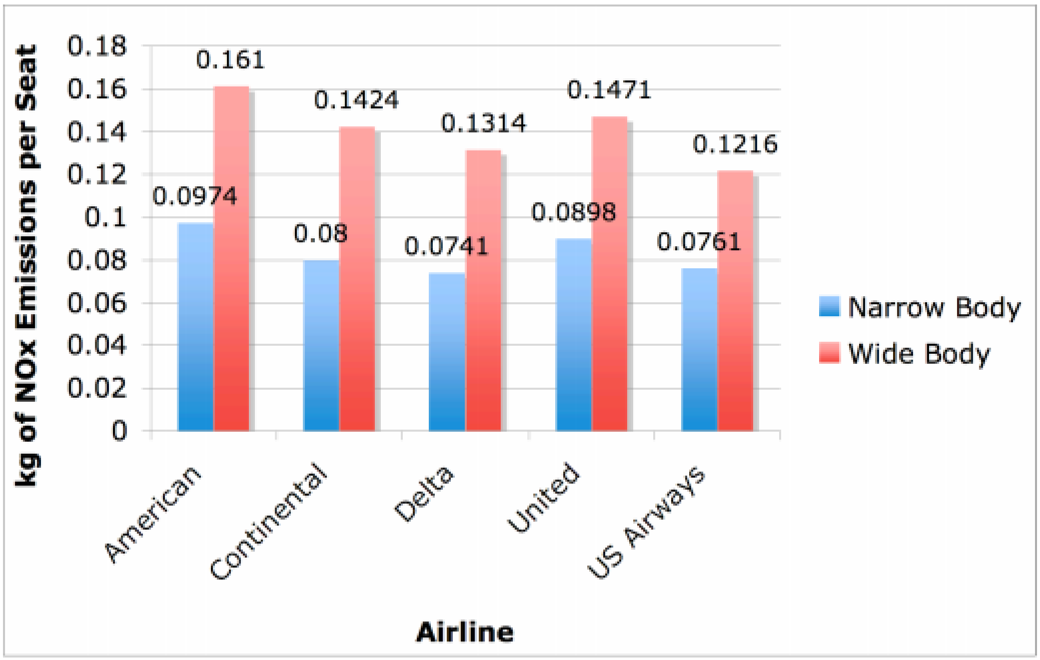

Figure 9.21 - Average NOX Emissions per Seat for Narrow and Wide Body Aircraft for Each Airline

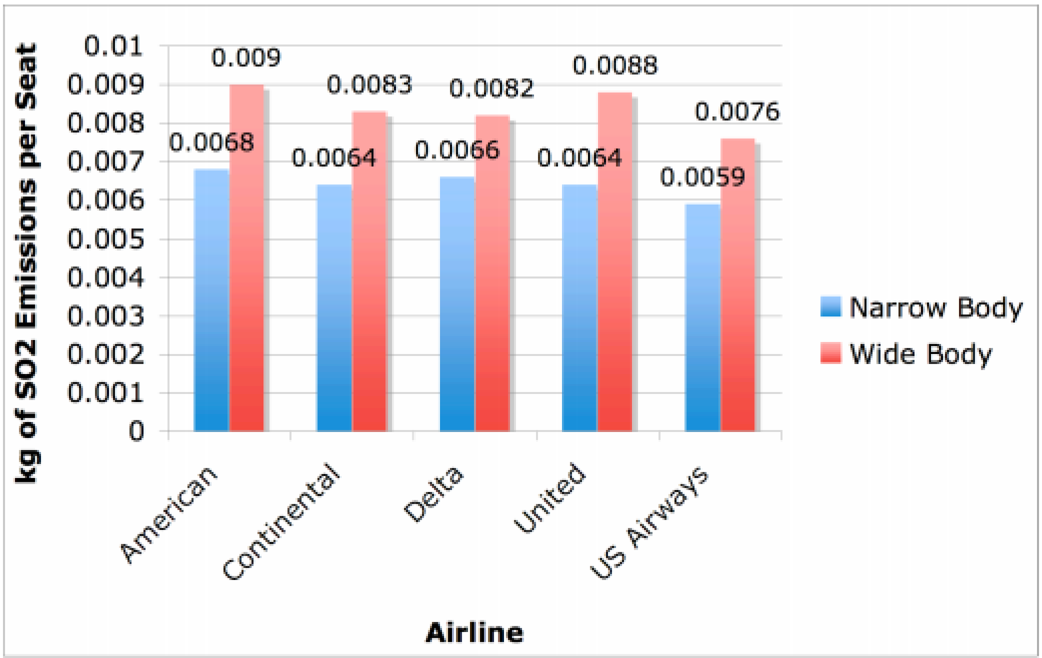

Figure 9.22 - Average SO2 Emissions per Seat for Narrow and Wide Body Aircraft for Each Airline

Fuel

The most basic of the results was which type of aircraft burned more fuel in an hour of operation. In overall fuel consumption for each airline, wide body aircraft burned more gallons per hour for all airlines (Figure 9.23).

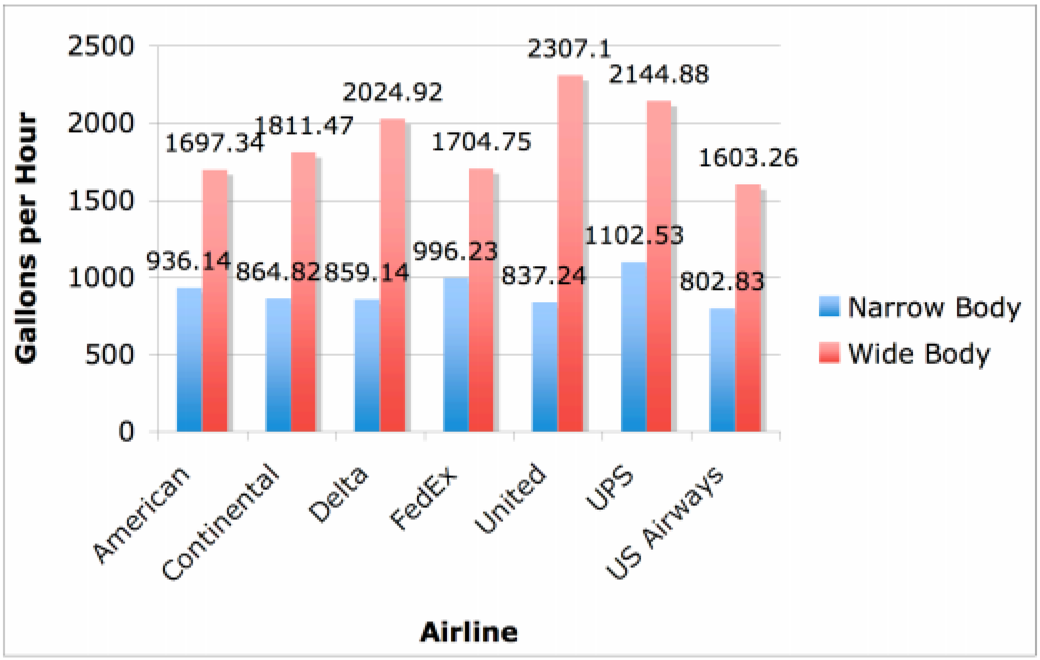

Figure 9.23 - Gallons of Fuel per Hour for Each Airline Broken Down by Narrow and Wide Body Aircraft

Fuel Efficiency

Fuel efficiency of aviation has developed continually since the 1960s. Studies undertaken by the International Council on Clean Transportation (ICCT)6 found that the gains were particularly large in the 60s and 70s, and though efficiency gains have slowed since 1990, they are estimated to be less than 50% of 1960 levels. A further study has been made by the International Coordinating Council of Aerospace Industries Associations (ICCAIA) using a metric of fuel burn per person per 100km. This interpretation suggests that fuel efficiency gains have continued since 2000, perhaps driven by a greater focus on improving load factors, which would not be accounted for in the ICCT model (Figure 9.24 – 9.26).

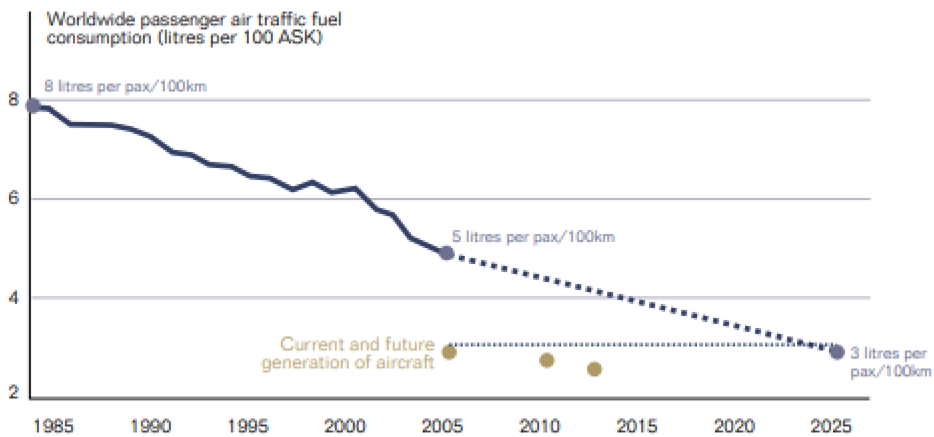

Figure 9.24 - Fuel Efficiency and Forecast v Today (Source: ICAO and ICCAIA)

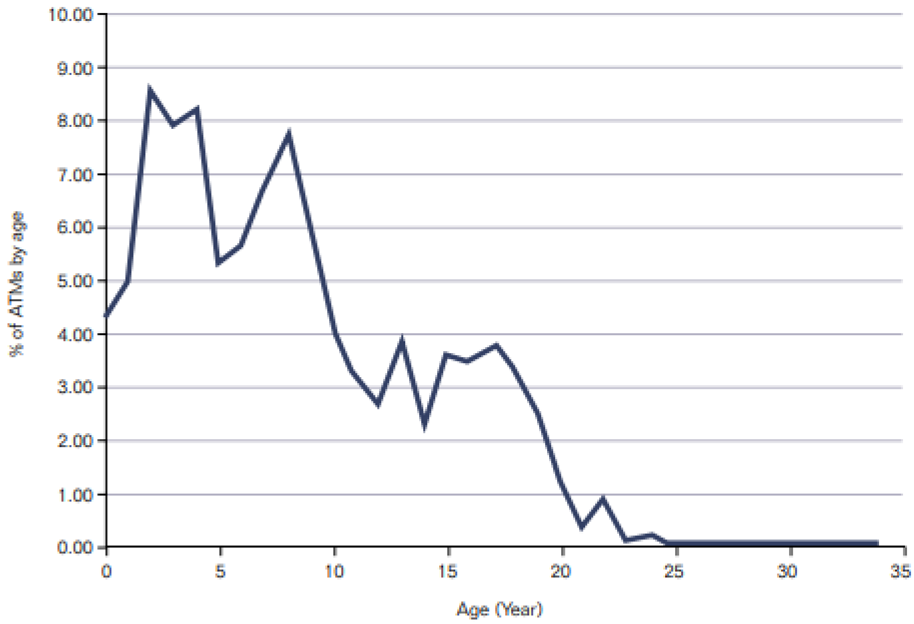

Figure 9.25 - UK Fleet, Average Age (Source: EMRC/AEA (for DfT))

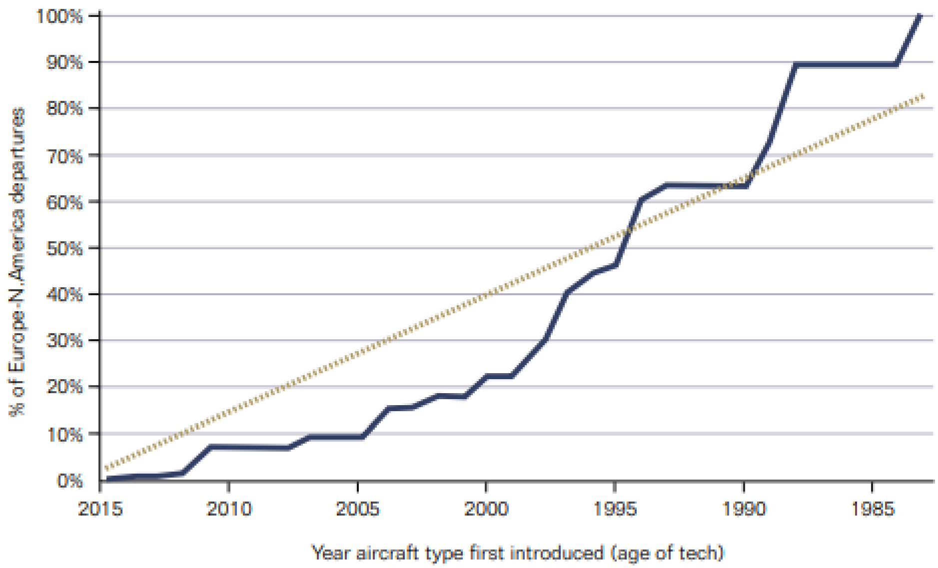

Figure 9.26 - Europe to North America Proportion of Flights in 2015 by Technology Age (Source: Capstats.com)

Future Regulations

The FAA is working through ICAO to evaluate policy options to limit or reduce greenhouse gas emissions from international aviation. ICAO has developed a range of standards, policies and guidance material for the application of integrated measures to address aircraft noise and engine emissions. Efforts include progress on new aircraft technology advancement, operational improvements and development and deployment of alternative fuels, as well as a commitment to develop a global market-based measure for international aviation and appropriate airport and land-use planning. Through the ICAO's CAEP, FAA is supporting development of an aircraft CO2 emission standard. The standard is expected to reduce aircraft

CO2 emissions by integrating fuel-efficient technologies into aircraft design and development. It has been developed such that effective improvements observed through the CO2 standard will correlate with reductions of CO2 emissions by aircraft during day-to-day operations. CAEP is developing an aircraft engine PM certification standard as well. In October 2013, the 38th ICAO Assembly adopted a comprehensive climate change resolution that includes a commitment to develop a global market-based measure to address GHG emissions from international aviation. The U.S. is committed to pursuing development of a global market-based measure (MBM) proposal. It has to be considered as gap filler in the basket of measures that includes technology, operations and alternative fuels. These efforts contribute to achieving ICAO's aspirational goal of carbon neutral growth by 2020 using a 2005 baseline. The U.S. is engaged both in supporting policy and technical work contributing to the proposal for a global MBM. Under this multidimensional regulatory and voluntary structure, aviation has made significant environmental progress. Given the complexity of the industry and the need for different strategies and technological approaches for different types of vehicles and equipment, a coordinated effort will continue between the aviation industry and the many regulatory agencies that share environmental responsibilities.

Noise

Noise development to the present day: down by 80%. The most effective way of preventing noise is to invest in new aircraft technologies and to continually modernize existing aircraft. Major advances have been made in this area over the past few decades, with latest-generation aircraft 25 decibels, or around 80 per cent, quieter than 60 years ago (Figures 9.27 – 9.28).

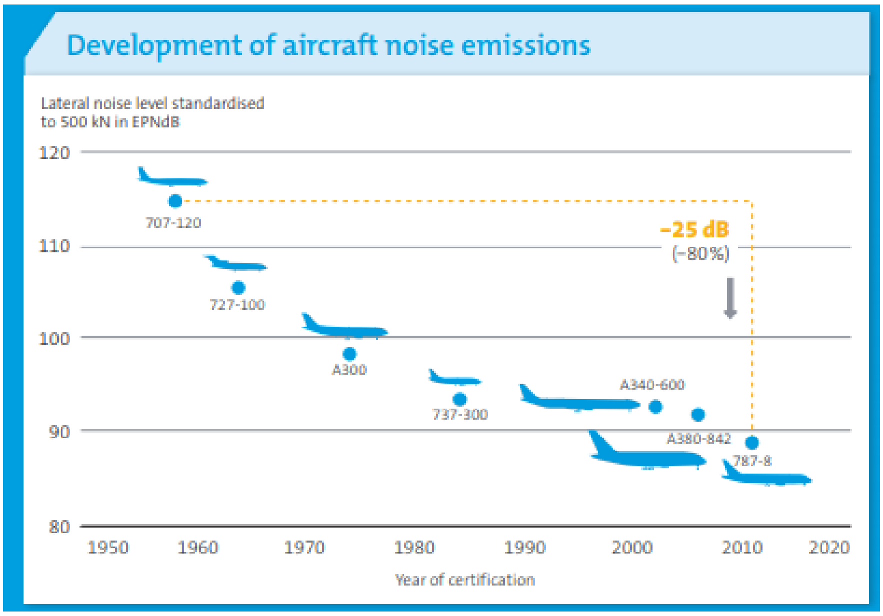

Figure 9.27 - Development of aircraft noise emissions

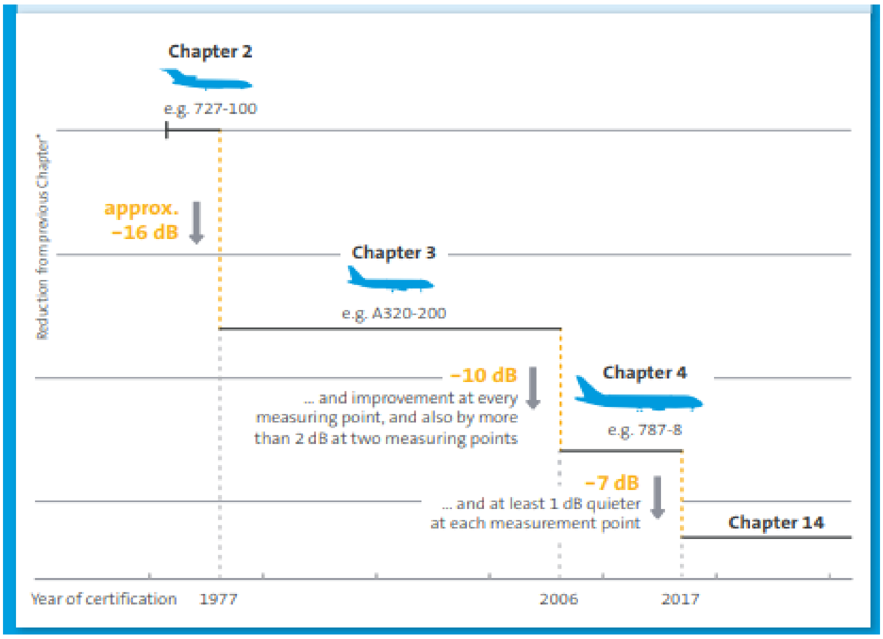

Figure 9.28 - Tightening of international noise levels

Many aircraft not only meet these limits but fall significantly below them (Figure 9.29). An Airbus A319-100, a Chapter 3 aircraft, is up to 19.4 decibels quieter than the limit for its Chapter. And some aircraft models fall well below the noise levels for Chapter 4. These include the Boeing 747-8, which is 15.6 decibels below the level, and the Airbus A380, which is 16.7 decibels below.

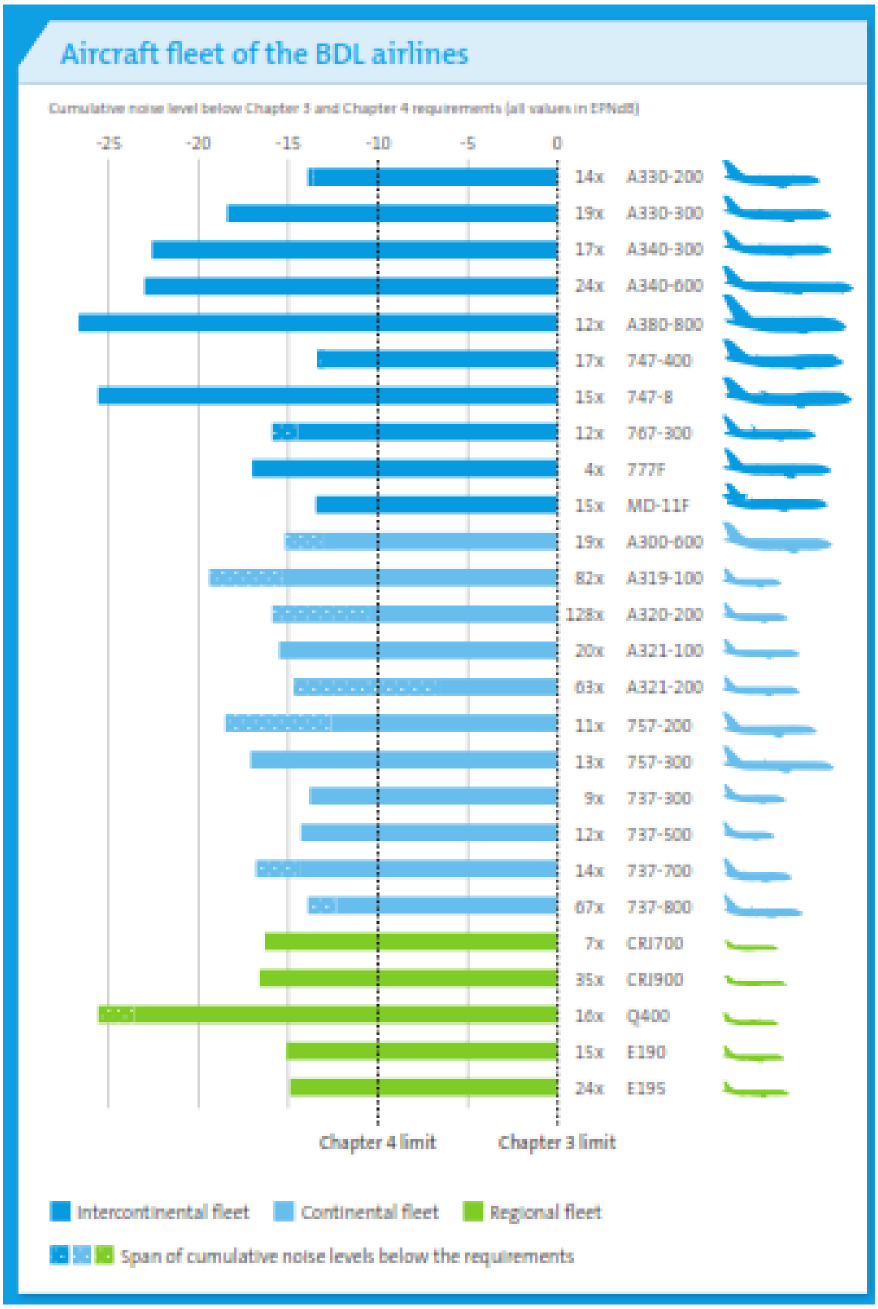

Figure 9.29 - Aircraft fleet of the BDL airlines

Noise Reduction at Source

The most important method of noise reduction is the replacement of old, and therefore loud, aircraft with newer, quieter ones. An additional option is the upgrading of existing aircraft (Figure 9.30).

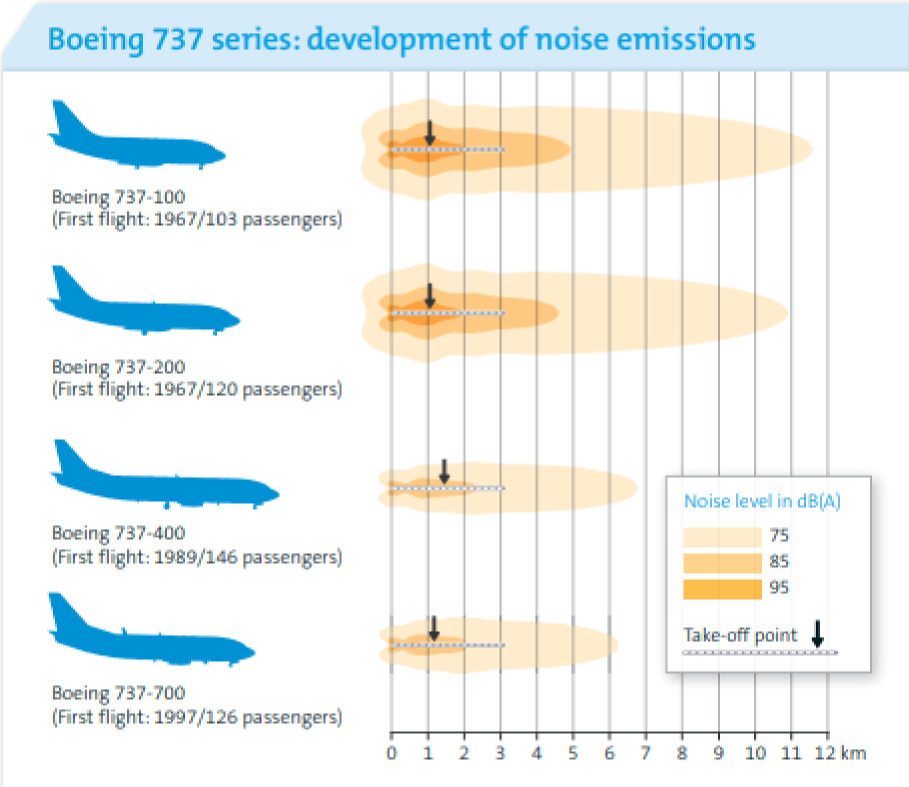

Figure 9.30 - Boeing 737 series: development of noise emissions
Source: Harris Miller & Hanson Inc.

Continued efforts may stabilize noise exposure by 2035 but it will continue to be a key challenge

Aircraft noise exposure is typically assessed by looking at the area of noise contours around airports, as well as the number of people within these contours. A noise contour represents the area around an airport in which noise levels exceed a given decibel (dB) threshold (Figure 9.31). The noise metrics and thresholds presented in this report are the LDEN 55 dB and Lnight 50 dB indicators, in line with what Member States are required to report under the EU Environmental Noise Directive (END). Total contour areas and populations were computed for 45 major European airports using the STAPES noise model. These two metrics were complemented by noise energy, which was computed for all airports in the EU28 and EFTA region (about 2100 airports in 2014).

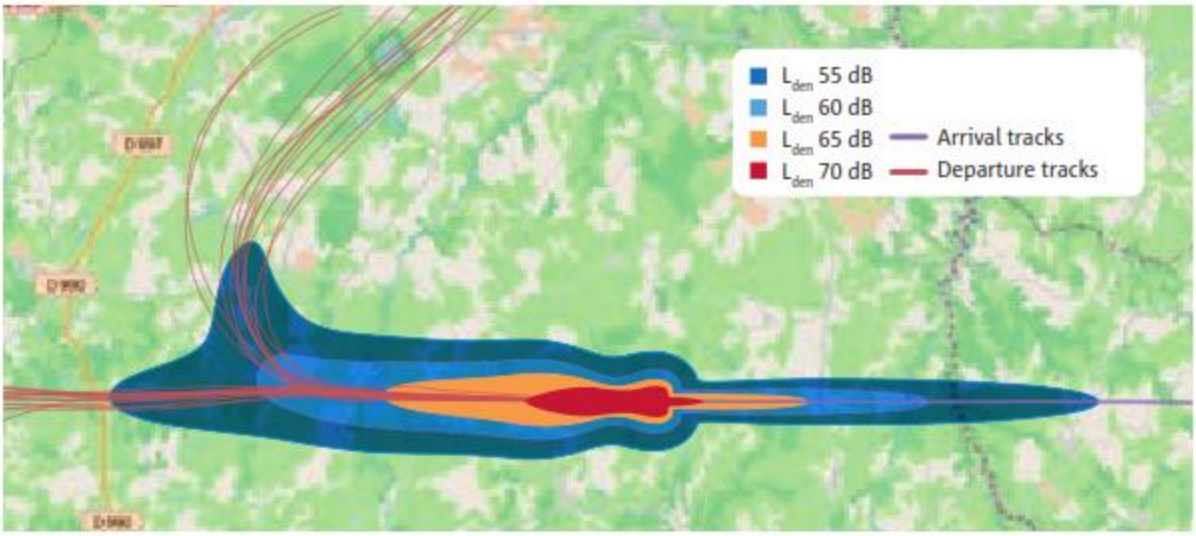

Figure 9.31 - Example of notional airport noise contours

Noise exposure has stabilized over the past ten years. The total population inside the STAPES Lden and Lnight contours decreased by only 2% (Lden) and 1% (Lnight) between 2005 and 2014, to reach 2.52 and 1.18 million people respectively in 2014 (Figure 9.28, Table 9.5). A similar trend is observed for the total noise energy in the EU28 and EFTA region, which decreased by 5% during the same period. This overall noise reduction is due to technological improvements, fleet renewal, increased ATM efficiency and the 2008 economic downturn. Fleet renewal has led to a 12% reduction in the average noise energy per operation between 2005 and 2014.

Under the base (most likely) traffic forecast, continued 0.1 dB reduction per annum for new aircraft deliveries (low technology improvement rate) could halt the growth of the overall noise exposure in the 2035 timeframe, while a 0.3 dB reduction per annum (advanced technology improvement rate) could lead to a net reduction of the exposure compared to 2014 even under the high traffic forecast. However, in the absence of continuing technology improvements for new aircraft, the population inside the increased Lden 55 dB contour areas could reach 2.58, 3.54 and 4.29 million in 2035 under the low, base and high traffic forecasts respectively. The effects of different trends on total noise exposure are shown in the Figure 9.32:

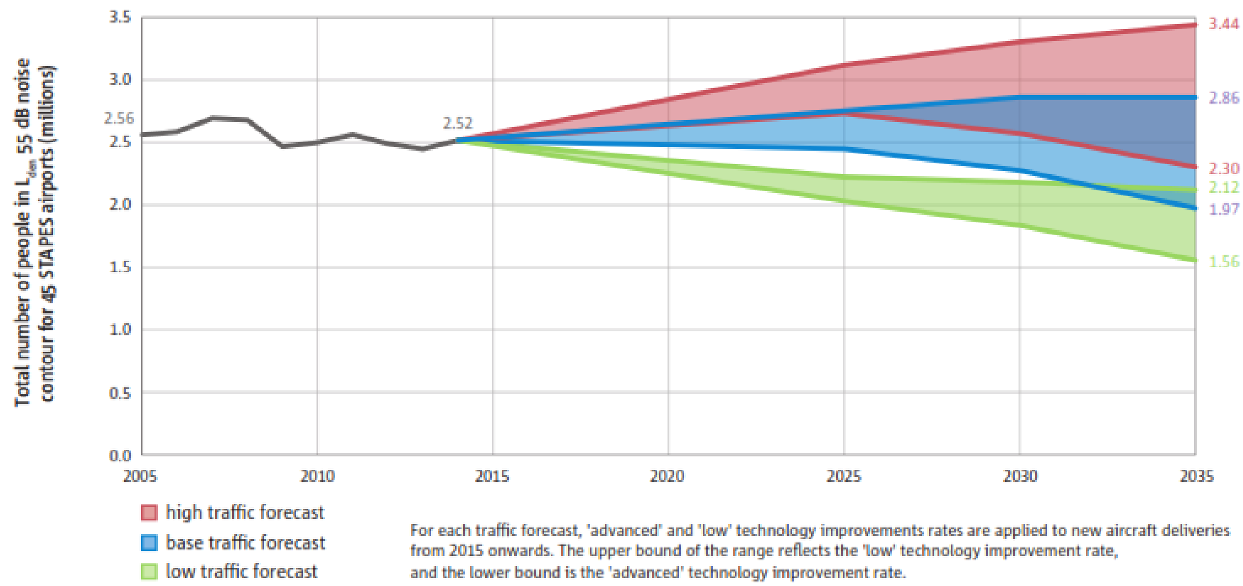

Figure 9.32 - Future technology improvements could stabilize overall aircraft noise exposure in the 2035 timeframe

Aircraft Noise in Context

Under the Environmental Noise Directive, aircraft noise data from 56 out of 91 airports having more than 50,000 movements/year, were reported by EU Member States. These data showed that for these 56 airports 2.4 million people were exposed to noise levels of 55 dB Lden and above in 2012. An analysis was conducted on the remaining 35 European airports having more than 50,000 movements/year and, combined with the reported data, showed that around 5 million people in Europe were exposed to noise above 55 dB Lden that year.

World Health Organization (WHO) Noise Research

The Lden and Lnight indicators represent average noise over a given time period, so they do not capture the specific characteristics of each noise event or differences between sources of noise (e.g. noise from single events are smoothed out).

In order to support Member States, the WHO regional office for Europe is reviewing the latest scientific evidence and is expected to propose revised dose-response functions in 2016 to help better quantify the consequences of noise on health. As part of this work, WHO is also reviewing the harmful effects of aircraft noise at lower dB levels than the Lden 55 dB and Lnight 50 dB indicators used in this report. Past work on noise dose-response curves and health effects shows that aircraft typically generate more annoyance and sleep disturbance than other sources at the same Lden levels.

	2005	2014 (% change vs. 2005)	Base forecast 2035 Advanced – Low Technology (% change vs. 2005)
L_{den} 55 dB area, 45 STAPES airports (km^2)	2,251	2,181 *(-3%)*	1,983 – 2,587 *(-12%) (+15%)*
L_{night} 50 dB area, 45 STAPES airports (km^2)	1,268	1,248 *(-2%)*	1,058 – 1,385 *(-17%) (+9%)*
L_{den} 55 dB population, 45 STAPES airports (millions)	2.56	2.52 *(-2%)*	1.97 – 2.86 *(-23%) (+12%)*
L_{night} 50 dB population, 45 STAPES airports (millions)	1.18	1.18 *(-1%)*	0.78 – 1.19 *(-34%) (+1%)*
Noise energy, all EU28-EFTA airports (10^{15} J)	9.60	9.16 *(-5%)*	9.37 – 12.9 *(-2%) (+34%)*
Average noise energy per operation, all EU28-EFTA airports (10^{8} J)	7.29	6.41 *(-12%)*	4.14 – 5.70 *(-43%) (-22%)*

Table 9.5 - Summary of noise indicators

Quieter Aircraft Design

The historic picture

There is no doubt that over more than fifty years of the jet age, technology has significantly improved aircraft noise performance, to the point that in 2012, the 57 dBA Leq aircraft noise contour area around Heathrow (Figure 9.32) covered just over a tenth of the area it did in 1974. Even considering significant population growth, 2012 saw a near ten-fold reduction in people within the contour compared with 1974. Gatwick has seen similar reductions (Figure 9.33), with the 57 dBA Leq contour area now around 20% of the size it was in 1979 when noise contours were first generated, and the population affected by that level of noise is just over 10% of the number it was in 1979.

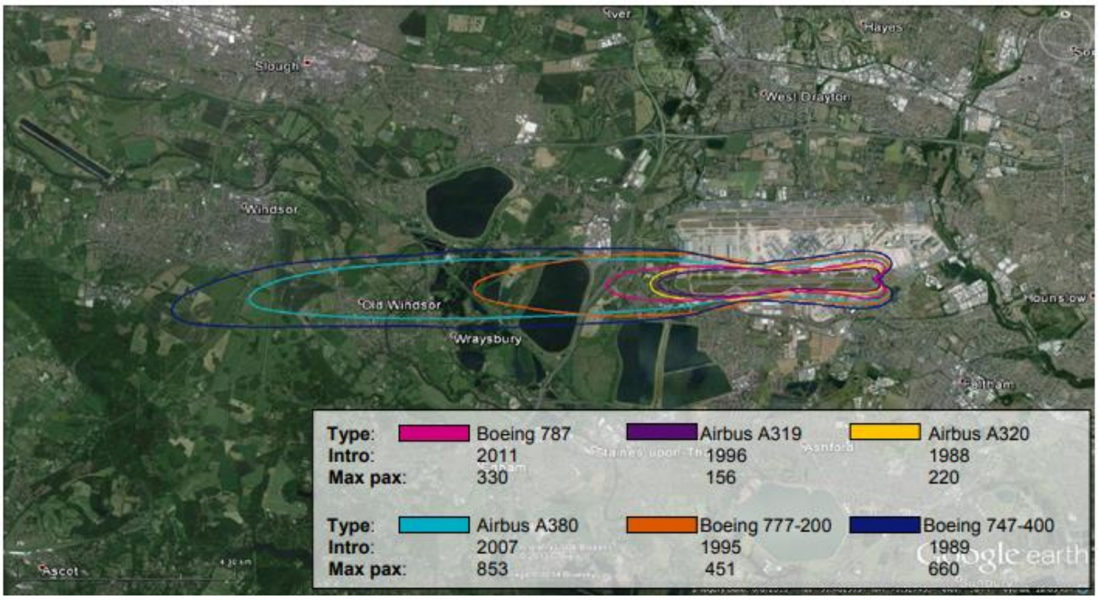

Figure 9.33 - Heathrow departure 90 dBA SEL contours on 27L CPT for selected aircraft

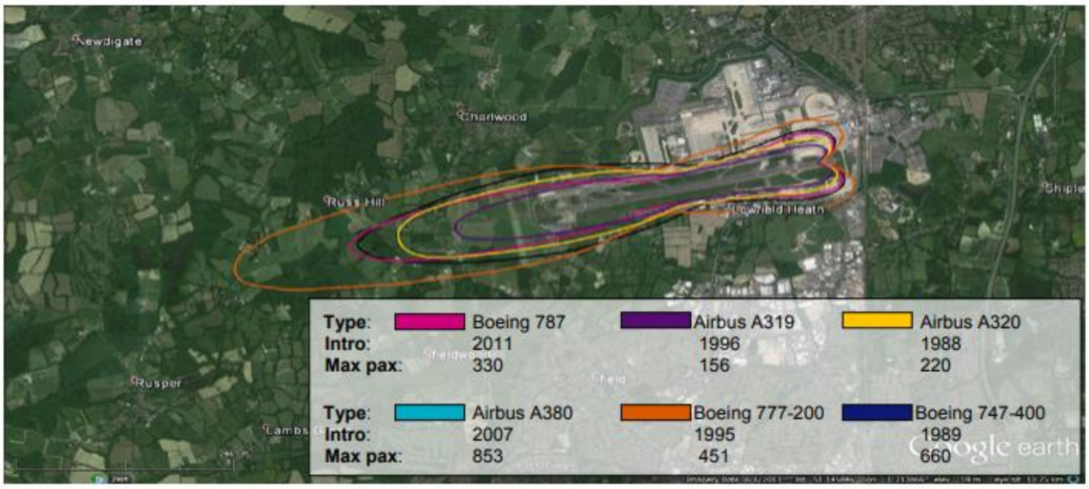

Figure 9. 34 - Gatwick departure 90 dBA SEL contours on 26 SAM for selected aircraft

Despite the impact of the 2008 financial crisis and subsequent recession on passenger demand (and flight numbers at most airports), noise improvements over the past decade have been slower than in previous years. In part this is because following the retirement of the Concorde by both Air France and British Airways, the number of flights by extremely noisy, older aircraft from the 1960s and 1970s reduced to close to zero at Heathrow and many other UK airports. It may also be in part because the post-9/11 and financial crisis downturns, combined with the cyclical nature of airline fleet renewal and type introduction mean there hasn't been a significant number of new aircraft operating during the period, and in part because there are fewer potential improvements in noise performance through manufacture following the step changes in performance over the previous 40 years. At Heathrow due to tightening capacity constraints, there has also been a steady increase in aircraft size, the proportion of long haul flights has increased, and many domestic routes have reduced frequency or disappeared; all of which would have seen noise increasing without the accompanying technological and operational developments.

Today's technology

Airbus A380 The Airbus A380 entered service in October 2007 operated by Singapore Airlines, and began flying into Heathrow in March 2008. In a typical configuration, it is capable of carrying around 525 passengers. If operated as a fully economy class service, it would be able to carry over 850 people. The A380 is one of the quietest wide-body jet aircraft currently in operation, with only the newer and significantly smaller Boeing 787 being quieter. Throughout its design, there was a conscious focus on reducing noise, and ensuring that it was able to meet ICAO's Chapter 4 Standard adopted in 2001 and implemented in 2006. The focus on noise performance was in part to ensure that delayed departures could still operate during the night period at Heathrow Airport, where the Quota Count (QC) system imposes much stricter controls for night-time operations than ICAO's Chapter 4 standard, limiting operations for any aircraft with a QC/2 rating or higher from being scheduled between 2300 and 0600.

The A380 is rated (Figure 9.34) as 2 for departure and 0.5 for arrival noise, allowing its use within the total night period. By contrast, the 747-400 is rated as QC 4 for departure and QC 2 for arrival, meaning it is prohibited from being scheduled to depart from Heathrow after

2300 and before 0700, though it may operate as a delayed departure. The newer Boeing 747-8 model falls within the applicable QC limits.

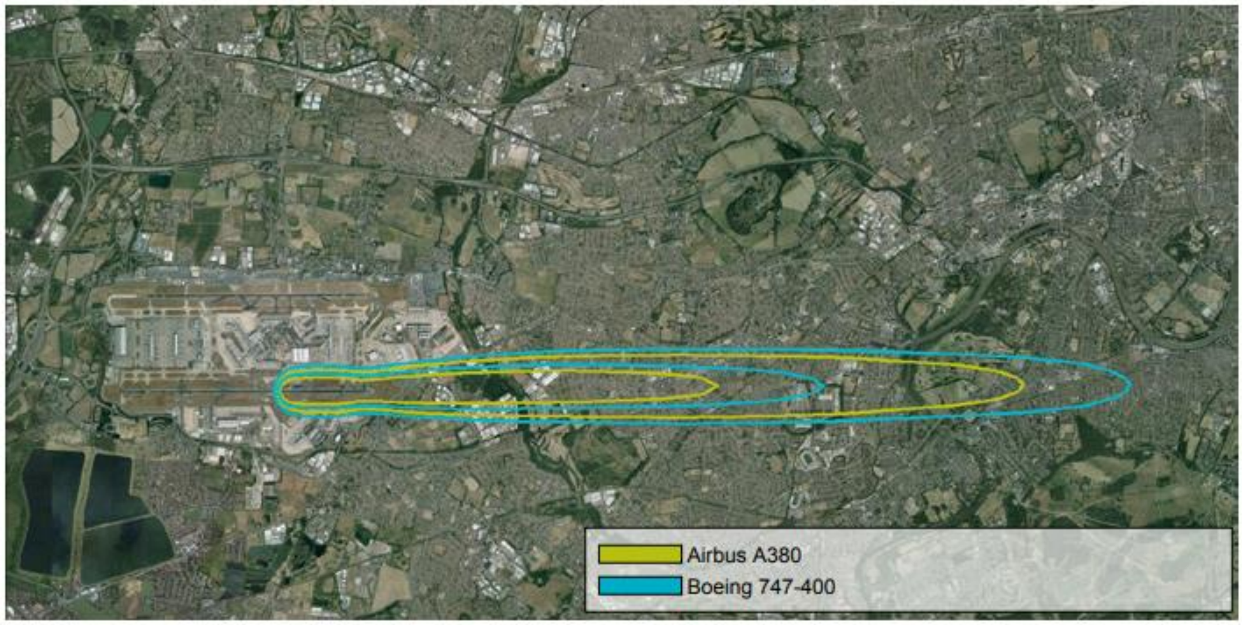

Figure 9.35 - Heathrow arrival 85 and 90 dBA SEL contours for an Airbus A380 landing 27L compared with a Boeing 747-400, the principle aircraft it is replacing

To put the A380's size and noise performance within its historical context, in a typical configuration, the aircraft allows for a seat capacity increase of 90% over 1992's A340-300, for no additional noise. This step change underlines the potential for quota-based incentives to drive airline and manufacturer action to improve noise performance. Upon its introduction at Heathrow in 2008, operated by Singapore Airlines, the airline, airport, and NATS jointly trialled and implemented new departure procedures to reduce fuel burn and CO2 emissions while remaining within noise limits - highlighting the potential for noise to be managed within strict limits on other environmental impacts.

Boeing 787 Dreamliner although they were developed at a similar time, and introduced to service within five years of one another, the Airbus A380 and Boeing 787 Dreamliner are quite different types of aircraft. While the A380 is capable of carrying over 800 passengers, the 787 has a more traditional maximum passenger configuration of 330 people. The 787 is the world's first composite commercial transport aircraft and was designed to achieve fuel savings of up to 20% over the Boeing 767 which it replaces. Like the A380, the 787 also operates within Heathrow's strict Quota Count operational restrictions for night-time flying and is quieter than the aircraft types it aims to replace. Airbus A350 In 2004 Airbus began a programme of work to create a new wide-body aircraft capable of longer flights and with a similar capacity to the 787. This has grown into the A350 XWB (extra wide body), a twin-engined aircraft carrying between 250 and 350 passengers depending on configuration. It is expected to begin commercial operations during 2014. Like the 787 it features a composite airframe and is designed to be very fuel efficient. As with other new types, noise performance is promised to significantly improve over existing wide-body aircraft, but data is not yet available to quantify the gains. Improving existing types Introducing new aircraft types is a slow and typically cyclical process that can be fraught with delays and issues, as recent experience with the introduction of both Airbus and Boeing's new models, the A380 and 787, has shown. Even when new aircraft types are available, reflecting is a lengthy and expensive process for airlines, with significant resource impacts. In addition, despite the existing incentives to improve fleet noise performance, even at Heathrow, there has been no evidence that airlines have changed their normal fleet replacement cycles (for instance, in early 2014, British Airways' long-haul fleet consisted of four Airbus A380s, 55 Boeing 747-400s, 21 Boeing 767-300s and 55 Boeing 777s covering an age range of 0 to 25 years).

The introduction of newer models of existing types does offer the potential for improving noise (and other environmental and efficiency) performance, which, while still representing a significant outlay for airlines, reduces some of the costs and risks associated with purchasing brand new aircraft types. To put that in context, the latest version of Boeing's 747, the 747-8 Intercontinental, introduced in 2005, claims a 30% noise performance improvement over that of its predecessor the 747-400, originally introduced in 1989.

The future

Given the significant improvements in performance in the latest types of aircraft, and the general trend of slowing noise contour reduction over the past decade, in future when new types are introduced, the noise improvements may not be as significant as with previous generations of aircraft. In this context, we welcome industry's ambition to drive further improvements, set out for instance in the Flightpath 2050 vision 20. Assuming a standard fleet life of 25 years, in line with usual depreciation assumptions, and take the last generation of aircraft as being purchased up until 2013 (which does not factor in continuing purchases of older aircraft by both legacy and low cost carriers), we can expect to see significant noise improvements arising from normal fleet renewal exercises as airlines switch from older types to the latest aircraft until at least 2038. To provide context, the Figure 9.35 shows the ages of the fleet in operation at Heathrow during 2013 - significant numbers of aircraft predating the latest generation are still in operation, showing the potential for normal fleet renewal to improve noise performance.

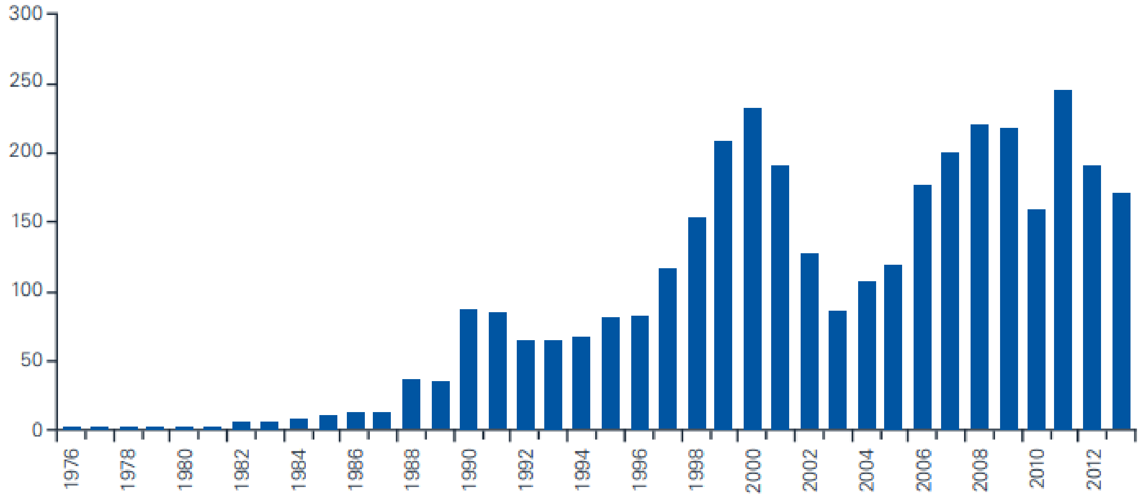

Figure 9.36 - LHR Aircraft fleet 2013 - No. aircraft vs. year built (Source: ERCD data)

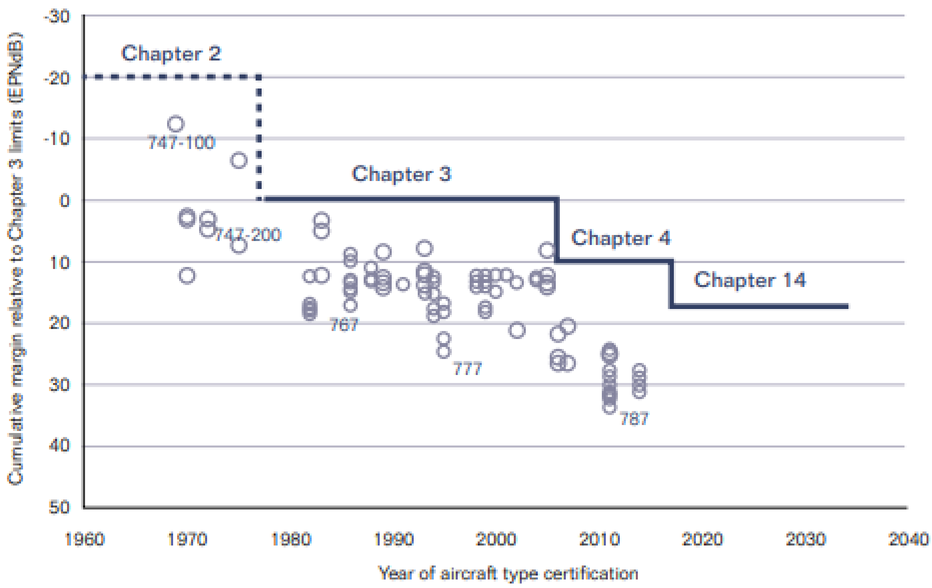

Figure 9.37 - ICAO noise chapter performance of wide-body aircraft since 1960 (Source: EASA European Aviation Environmental Report)

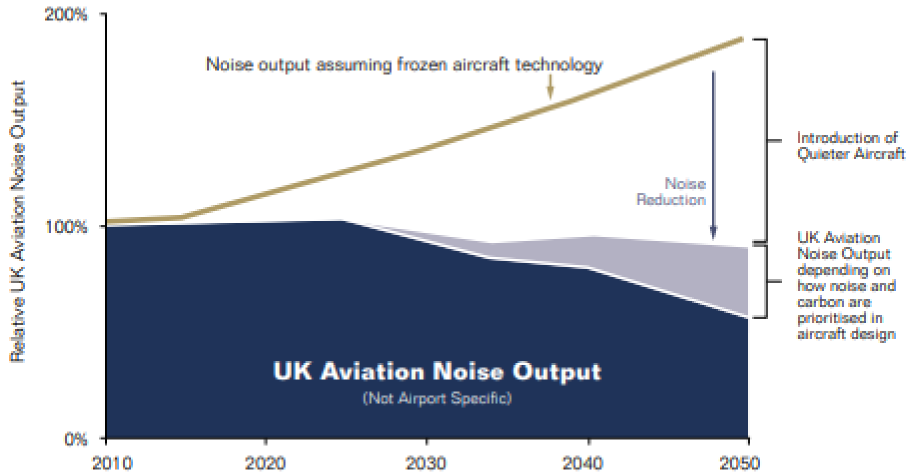

Figure 9.38 - Sustainable Aviation Noise Roadmap (Source: Sustainable Aviation Noise Roadmap)

The impact of quieter aircraft (Figures 9.36 – 9.37) can be illustrated from the noise maps of Heathrow and Helsinki airports, which are shown in the Figure 9.38. Both charts show the size of the noise envelope over time and suggest that a combination of engine/airframe improvements and changes to navigation patterns can dramatically alter the shape of noise nuisance.

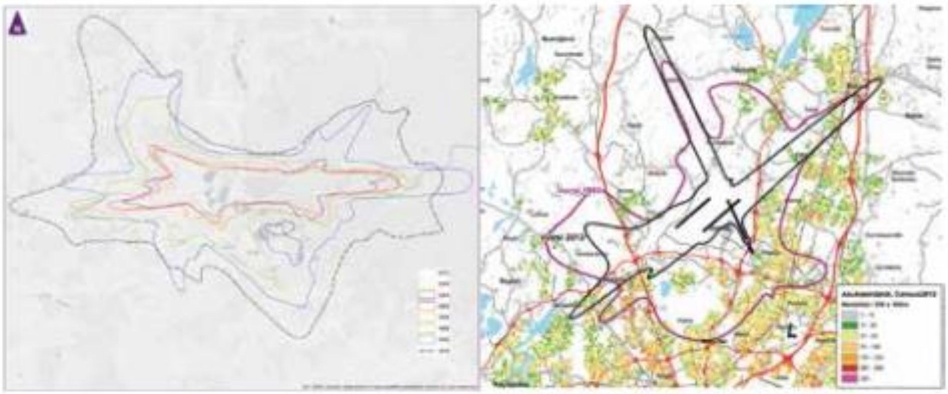

Figure 9.39 - Shrinking Airport Noise Contours: Heathrow, 1974-2012 (left) and Helsinki, 1990-2013 (right) (Source: Heathrow Airport Ltd, Helsinki Airport)

Aircraft Design

The improvement in the efficiency of technology is frequently cited as the main source of improvements in sustainability for the industry.

The improvements in technology can be easily demonstrated by the diagram below (Figure 9.39), produced by the International Energy Agency (IEA). Whilst it is immediately apparent that the greatest increases in efficiency were made in the early years of the jet age, the industry is continuing on a steep path of improvement (Table 9.6).

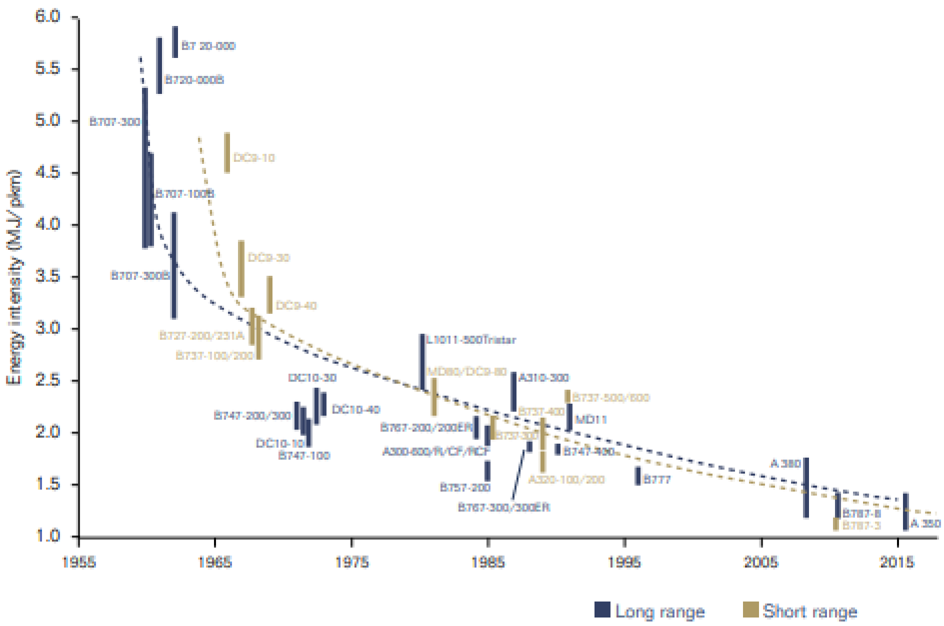

Figure 9.40 - Aircraft Efficiency Gains since 1955 (Source: IEA)

Decibel Levels by Aircraft Type

Airline Aircraft type	Engine Type	Takeoff EPNdB	Landing EPNdB	Total EPNdB
American				
MD-80	JT8D-217A/C; JT8D-219	91.4333	93.7	185.1333
737-800	CFM56-7B24/3	88.6	96.5	185.1
757-200	RB211-535E4B	85.7	95.2	180.9
767-200/ER/EM	CF6-80A	92.8	101.7	194.5
767-300/300ER	CF6-80C2B6	91.1	98.4	189.5
777-200/200lr/233lr (ER)	Trent 892	94	99.5	193.5
Continental				
737-300	CFM56-3B1	87.5	100.1	187.6
737-500	CFM56-3B1	87.3	100	187.3
737-700/700LR	CFM56-7B24	88.6	96.1	184.7
737-800	CFM56-7B26	85.6	96.6	182.2
737-900	CFM56-7B26	87.2	96.4	183.6
757-200	RB211-535	88.1	99.6	187.7
757-300	RB211-535E4B	88.4	95.4	183.8
767-200/ER/EM	GECF6-80C2B4F	88.5	96.5	185
767-400/ER	GECF6-80C2B8F	91.2	98.7	189.9
777-200/200lr/233lr (ER)	GE90-90B	91.3	97.8	189.1
Airtran				
717-200	BR700-715C130	82.1	91.6	173.7
737-700/700LR	CFM56-7B22	86.3	95.9	182.2
UPS				
757-200	PW2040; RB211-535E4	88.5	96.65	185.15
767-300/300ER	CF6-80C2B6F	90.9	98.5	189.4
A300B/C/F/-100/-200	PW4158	93.1	101.9	195
MD-11	CF6-80C2D1F; PW4462; PW4460	94.5333	104.1333	198.6666
747-400F	CF6-80C2B1F	99.7	101.4	201.1

Table 9.6 - Engine Type, Take-off, Landing, and Total Decibel Levels for Each Aircraft Type Within Selected Airlines

Aviation's Contribution to Protecting from Air Pollutants

The aviation industry is working to reduce the level of pollutants emitted through improvements to aircraft and engine design, operational procedures and fuels.

Changes Made by Airlines

Airlines can help to improve air quality by:

- Switching off main engines on arrival and, where possible, limiting the use of aircraft auxiliary power units by using fixed electrical ground power, ground power units and pre-conditioned air.
- Delaying the switching on of main engines until absolutely necessary on departure.
- Whilst parked at aircraft stands, operating aircraft on the lowest possible energy draw (e.g. turning off unnecessary electrical systems such as In-Flight Entertainment).
- Reducing the number of engines used when taxiing.
- Applying reduced-thrust take-off.

Changes Made by Airports

Airports can help to improve air quality by:

- Providing fixed electrical ground power and pre-conditioned air for aircraft.
- Optimizing the most efficient flow of aircraft when moving between runways and stands.
- Investing in lower emission ground vehicles for use at the airport.
- Considering charging higher landing charges for aircraft with higher NOx emissions.
- Developing surface access strategies that encourage the use of public transport.
- Using electric towing aircraft.

Air Quality Policies

EU Member States have set air quality targets through European legislation. Some of these targets are reflected as UK-wide objectives whilst others are devolved objectives with separate targets for England, Scotland, Wales and Northern Ireland.

Defra is the Government department with responsibility for setting national policy on air quality to meet these targets. At a local level, local authorities are required to assess air quality and Air Quality Management Areas (AQMAs) are declared if national air quality objectives are not being met.

Two of these targets are for average mean levels of 40µgm -3 for NO2 and PM10 in the UK. Data is available below for a number of UK airports in relation to both targets. There are no specific air quality targets for the UK aviation industry. Instead, air quality at airports is measured as part of a local authority's duties around air quality and any issues are dealt with between the airport and local authority.

Different airports have different obligations for monitoring and reporting air quality, with some reporting requirements necessary by law through planning obligations.

Solutions: Use of Next Generation Biofuels

The Table 9.7 shows which of the 15 airlines carrying the most passengers in the UK have a stated policy on the use of biofuels.

Airline	Commitment to biofuel development	Proposed feedstock source	Source
Aer Lingus	None stated		
American Airlines	None stated		
British Airways	Yes	Domestic waste	British Airways Corporate Responsibility Report 2012
EasyJet	None stated		
Emirates	None stated		
Flybe	None stated		
Jet2.com	None stated		
Lufthansa	Yes	A number of trials operated	Lufthansa Sustainability Report 2014
Monarch	None stated		
Ryanair	None stated		
Thomas Cook	None stated		
Thomson	Yes	Used cooking oil	Thomson Airways press release, Oct 2011
United Airlines	None stated		
Virgin Atlantic	Yes	Waste gases	Airline website
Wizz Air	None stated		

Table 9.7 - Publicly stated policies on use of biofuels by airline.
Source: airline websites

9.4 Safety

In principle all airliners should be equally safe because they meet the same applicable EASA/FAA certification standards, Airbus/Boeing/Bombardier/Embraer and other manufacturers have comparable engineering skills and thoroughly develop operating and maintenance procedures. As consequence, aviation remains the safest mode of transport, although with relatively large differences across the globe. Airlines in Europe and the US have managed on more than one occasion to have a completely accident free year despite operating in the densest air traffic regionally as well as having international flights all over the globe in various weather and other conditions.

The reasons for reduced relative safety in other regions of the world can be several: (i) persistence of extreme weather conditions in some regions, like arctic, tropical or deserts; (ii) operation of older aircraft requiring more careful maintenance; (iii) less adherence to maintenance and operating procedures that conditions (i) and (ii) require; (iv) weaker oversight by authorities. It must also be acknowledged that in all regions of the world the safety standards also vary considerably depending on the type of operation: (i) airliners and business jets are much safer than private aircraft; (ii) transport is safer than crop spraying or firefighting that involve low altitude flying near obstacles and obscurants.

Despite all these differences the quest for higher safety across all operations must continue. The aviation authorities in the US first, and next also in Europe, have banned foreign airlines deemed not to meet adequate safety standards. This is necessary to protect the safety of those flying into and out of Europe and the US and also of residents that could become the victims of eventual accidents. The list of banned airlines could be of use to warn passengers that might be attracted to fly with those airlines in other regions of the world. An effort to cooperate with aviation regulatory authorities worldwide, helping them to implement safety standards, would be a preventive measure leaving bans as the necessary last resort in fewer cases.

Safety in aviation (Key Topic T9.6) is enhanced by analysing accident/incident data (Key Topic T9.7).

KEY TOPIC T9.6 SAFETY IN AIR TRANSPORT

T9.6.1 Introduction

Safety is the top priority for all involved in aviation—and aviation is the safest form of long-distance travel. At 2016 there were over 40 million safe flights. It was made, among others, by a framework that incorporates respect for global standards, cooperation and the value of data. Global standards exist, but they are not being applied universally.

T9.6.2 Safety Standards in Different Regions of the World

The air transport industry plays a major role in global economic activity and development. One of the key elements to maintaining the vitality of civil aviation is to ensure safe, secure, efficient and environmentally sustainable operations at the global, regional and national levels.

A specialized agency of the United Nations, the International Civil Aviation Organization (ICAO) was created in 1944 to promote the safe and orderly development of international civil aviation throughout the world. ICAO promulgates Standards and Recommended Practices (SARPs) to facilitate harmonised regulations in aviation safety, security, efficiency and environmental protection on a global basis. ICAO is the primary forum for cooperation in all fields of civil aviation among its 191 Member States.

Improving the safety of the global air transport system is ICAO's guiding and most fundamental strategic objective. The Organization works constantly to address and enhance global aviation safety through coordinated activities and targets outlined in its Global Aviation Safety Plan (GASP). The Global Aviation Safety Plan or "GASP", is the document which supports the prioritization and continuous improvement of aviation safety. The GASP follows an approach and philosophy similar to that of the Global Air Navigation Plan (ICAO, Doc 9750), also referred to as the GANP. Both documents promote coordination and collaboration among international, regional and national initiatives aimed at delivering a harmonized, safe and efficient international civil aviation system. The GASP initiatives are monitored by ICAO's appraisal of global and regional aviation safety metrics on the basis of established risk management principles — a core component of contemporary State Safety Programmes (SSP) and Safety Management Systems (SMS). In all of its coordinated safety activities, ICAO strives to achieve a balance between assessed risk and the requirements of practical, achievable and effective risk mitigation strategies.

Technical assistance is a major component of ICAO's "No Country Left Behind" (NCLB) initiative which focuses on assisting all States on priority basis to provide support for implementation of ICAO SARPs under all ICAO strategic objectives. Building partnerships and pooling resources among States, international organizations, development institutions and industry is essential for collaboration on and contribution to technical assistance for effective implementation of SARPs and policies by States with sustainable results.

As part of this effort ICAO established the Aviation Safety Implementation Assistance Partnership (ASIAP) during the Second High-level Safety Conference in 2015, as the platform for ICAO and its safety partners to coordinate efforts for the provision of assistance to States. Its members include Canada, China, France, Japan, Malaysia, Republic of Korea, Singapore, South Africa, United Kingdom, United States, Airports Council International (ACI), African Civil Aviation Commission (AFCAC), Airbus, Boeing, the Civil Air Navigation Services Organization (CANSO), the European Aviation Safety Agency (EASA), the International Air Transport Association (IATA), the World Bank and the Arab Civil Aviation Commission (ACAC).

T9.6.2.1 Europe

In the last 25 years, the aviation sector in Europe has undergone a revolution that would have been unthinkable without key measures taken at EU level. Up to the late 1980s, air transport was fully controlled by State governments and overregulated by rather rigid bilateral agreements and obsolete international conventions. Since then, progressively, the European Union became a leading force and a respected policy maker in the field of air transport. Being highly successful in liberalising the aviation sector in Member States, the EU took the opportunity to pursue its action further. Other important aspects – such as competition rules, traffic management, safety, security, airport capacity, environmental protection, passenger rights and external relations – were given similar attention. The term air safety designates technical aspects of flying, such as rules for construction and use of aircraft. Europe has a long tradition in rulemaking cooperation in aviation safety, with the first common standards developed around 1990 within the framework of the currently no longer existing Joint Aviation Authorities (JAA). At that time, the European aviation safety authorities collaborated in the development of the Joint Aviation Requirements (JAR) and related procedures, initially in the field of aircraft manufacturing and design, and later also in respect of flight operations, maintenance and crew licensing. The current EU aviation safety system – a set of common safety rules – is based on close relations between the European Commission, the European Aviation Safety Agency (EASA), Eurocontrol, national civil aviation authorities, as well as aircraft manufacturers, airlines and other undertakings participating in the Single Aviation Market.

In 1991, the Council Regulation No 3922 – based on JAR – on the harmonisation of technical requirements and administrative procedures in the field of civil aviation safety – commonly referred to as EU-OPS – focused, in particular, on measures applicable to the operation and maintenance of aircraft and to persons and organisations involved in those tasks. It was updated in 2006 by Regulations No 1899 and 1900 of the European Parliament and of the Council.

In 2002, the European Aviation Safety Agency (EASA) came into being with the adoption of the Regulation No 1592 of the European Parliament and of the Council on common rules in the field of civil aviation and establishing a European Aviation Safety Agency. EASA was supposed to cover all aspects related to airworthiness and environmental certification of aeronautical products, parts and appliances, building on the experiences and cooperation of the former group of European aviation regulators (JAA).

The Regulation No 1592 has been amended in 2003 by the Regulation No 1643 of the European Parliament and of the Council and repealed in 2008 by the Regulation No 216 of the European Parliament and of the Council that extended the powers of EASA to aircraft operations and crew licensing and training and also set safety rules on design, production, maintenance and operation of aircraft, certification of organisations and personnel in the aircraft sector and harmonisation and recognition of national certificates throughout the EU. The latest Regulation No 1108 of the European Parliament and of the Council, which was negotiated during the 2009 Czech Presidency, amended the Regulation No 216 in the field of aerodromes, Air Traffic Management and air navigation and enlarged further the powers of EASA to cover safety aspects of airport operations and provision of air navigation services and Air Traffic Management.

The extended duties of EASA are to help the European Commission to develop common standards on safety of civil aviation in EU legislation, ensure uniform application of these standards, issue certificates to EU companies in air transport and conduct inspections. These significant powers in the fields of airworthiness, environment, flight crews, aircraft operations, third-country aircraft, airport operations, air navigation services and Air Traffic Management was executed by a progressive adoption by 2013.

In order to improve air safety and prevent future disasters, it is essential to evaluate all aircraft accidents and incidents and come up with relevant conclusions. To this end, the Council Directive No 56 has been adopted in 1994, establishing the fundamental principles governing the investigation of civil aviation accidents and incidents, facilitating investigations and transposing into the EU legislation a number of fundamental international principles. In 2010, the Directive No 56 has been updated by the Regulation No 996 of the European Parliament and of the Council on the investigation and prevention of accidents and incidents in civil aviation. The effectiveness of air accident investigations has been strengthened, cooperation between authorities facilitated and the rights of victims of air accidents and their relatives reinforced.

Due to the fact, that not only EU airlines fly the EU sky, the Regulation No 2111 of the European Parliament and of the Council established in 2005 a Community list of air carriers subject to an operating ban within the Community and imposed the obligation to inform air transport passengers of the identity of the operating air carrier. The so-called European Blacklist of airlines with low safety standards, regularly updated, includes airlines banned from operating in the EU and airlines which are restricted to operating under specific conditions.

Air safety issues are mainly air carriers' concern. On one hand, airlines are in favour of achieving the highest possible safety performance and harmonising the rules across Member States. On the other hand, they complain that the European Commission does not take due account of their professional views.

Europe plays a leading role as regards aviation safety. Despite the excellent safety performance of aviation in Europe, recent events remind the need to always remain vigilant and constantly search for weaknesses in the system before they manifest in an accident.

At the heart of this system is the concept of safety risks management, namely hazards identification, risks assessment and decision-making on the best course of action to mitigate those risks. The European Aviation Safety Agency (EASA), Member States (MS) and industry work closely together in this process. At European level, this process is coordinated by the EASA and documented in the European Plan for Aviation Safety (EPAS).

The fifth edition of EPAS covers the five-year period between 2016 and 2020 and is now an integral part of the EASA's programming activities. This means that the safety priorities identified in EPAS are addressed by specific actions in the EASA's rulemaking or safety promotion programmes, specific actions in the State Safety Programmes (SSPs) or through focused oversight activities performed either by the Agency or the MS.

In comparison with previous editions, the current one is more data driven, providing a clear link with the Annual Safety Review (ASR) and with the EASA's Rulemaking Programme. An increased emphasis has been put on using safety promotion and focused oversight activities to mitigate safety risks.

T9.6.2.2 United States of America

US aviation industry leaders, from the beginning, believed the airplane could not reach its full commercial potential without federal action to improve and maintain safety standards. At their urging, the Air Commerce Act was passed in 1926. This landmark legislation charged the Secretary of Commerce with fostering air commerce, issuing and enforcing air traffic rules, licensing pilots, certifying aircraft, establishing airways, and operating and maintaining aids to air navigation.

To ensure a federal focus on aviation safety, President Franklin Roosevelt signed the Civil Aeronautics Act in 1938. The legislation established the independent Civil Aeronautics Authority (CAA), with a three-member Air Safety Board that would conduct accident investigations and recommend ways of preventing accidents. On May 21, 1958, Senator A. S. Monroney introduced a bill to create an independent Federal Aviation Agency to provide for the safe and efficient use of national airspace. Two months later, on August 23, 1958, the President signed the Federal Aviation Act, which transferred the Civil Aeronautics Authority's functions to a new independent Federal Aviation Agency responsible for civil aviation safety.

The FAA mission is to provide the safest, most efficient aerospace system in the world. In fact, thanks to the work of FAA, it was created the safest, most reliable, most efficient, and most productive air transportation system in the world. To ensure aviation's future viability, FAA is now working with its federal and industry partners to develop a flexible aerospace system that fully responds to the changing needs of businesses and customers in the 21st century. The strength of the NextGen system depends on lower costs, improved service, greater capacity, and smarter security measures. That is why FAA has defined a vision of the future that integrates achievements in safety, security, efficiency, and environmental compatibility.

The Federal Aviation Regulations, or FARs, are rules prescribed by the Federal Aviation Administration (FAA) governing all aviation activities in the United States. The FARs are part of Title 14 of the Code of Federal Regulations (CFR). A wide variety of activities are regulated, such as aircraft design and maintenance, typical airline flights, pilot training activities, hot-air ballooning, lighter-than-air aircraft, man-made structure heights, obstruction lighting and marking, and even model rocket launches, model aircraft operation, sUAS & Drone operation, and kite flying.

The rules are designed to promote safe aviation, protecting pilots, flight attendants, passengers and the general public from unnecessary risk. Since 1958, these rules have typically been referred to as "FARs", short for Federal Aviation Regulations. However, another set of regulations (Title 48) is titled "Federal Acquisitions Regulations", and this has led to confusion with the use of the acronym "FAR". Therefore, the FAA began to refer to specific regulations by the term "14 CFR part XX".

T9.6.2.3 Bilateral Agreements

As globalisation advances, aviation safety is increasingly a cooperative, global effort. Civil Aviation Authorities from different countries or regions must cooperate in order to harmonize and coordinate joint efforts aimed to aviation safety.

As safety doesn’t stop at European borders, EASA works with authorities worldwide to raise global standards. Being an authority itself, it can understand and address the challenges, and bring different stakeholders together.

In 2014, the Certification ManagEment Team: ANAC (Agência Nacional de Aviação Civil), EASA (European Aviation Safety Agency), FAA (Federal Aviation Administration), and TCCA (Transport Canada Civil Aviation), agreed to greater collaboration between authorities „to more efficiently and effectively develop and implement regulatory and policy solutions to common certification issues”. Globalization of aviation business and emerging countries trigger growing resource demands on authorities. Maximum use of the BASA (Bilateral Agreement of Safety in Aviation) and full recognition of certificating authorities 'capabilities are essential to reduce efforts in validation.

The Technical Implementation Procedures (TIP) were authorized by Article 5 and Annex 1 of the Agreement between the Government of the United States of America (U.S.) and the European Union (EU) on Cooperation in the Regulation of Civil Aviation Safety. In accordance with Article 5 of the Agreement, the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) have determined that the aircraft certification systems of each Authority for the design approval, production approval, airworthiness approval, and continuing airworthiness of the civil aeronautical products and articles identified in this document, are sufficiently compatible in structure and performance to support these procedures.

The TIP is based on continuous communication and mutual confidence in the FAA's and EASA's technical competence and ability to perform regulatory functions within the scope of the TIP. The FAA and EASA, when acting as the Authority for the importing State, shall give the same validity to the certification made by the other, as the Authority for the exporting State, as if they were made in accordance with its own applicable laws, regulations, and requirements. When a finding is made by one Authority in accordance with the laws and regulations of the other Authority and the TIP, that finding is given the same validity as if it were made by the other Authority. Therefore, the fundamental principle of the TIP is to maximize the use of the exporting Authority's aircraft certification system to ensure that the airworthiness and environmental requirements of the validating Authority are satisfied.

As required by the Agreement, the FAA Aircraft Certification Service and EASA Certification Directors have established the Certification Oversight Board (COB), consisting of management representatives from each Authority. The COB shall be responsible for the effective functioning, implementation, and continued validity of these procedures, including revisions and amendments thereto. The COB shall establish its own rules of procedure, its membership, and meeting schedules. The frequency of these meetings will be mutually agreed upon by the COB and will depend on the number and significance of the issues to be discussed between the authorities. These meetings will also be used to discuss and harmonize any major differences in standards and their interpretation that are identified during certification projects between the FAA and EASA and, when significant differences are identified, formal proposals will be raised through the applicable rulemaking committee. The COB will invite management from the responsible policy office to participate on all discussions focused on operational issues (e.g. Maintenance Review Board and Operational Suitability Data).

T9.6.3 Safety Standards for Different Services

T9.6.3.1 Business Aviation

Business Aviation has established a record as one of the world's safest forms of transportation. Professionally flown aircraft of all sizes are operated on unscheduled routes to all corners of the globe, yet the safety record continues to be excellent despite the very challenging operating environment. The exemplary safety record of business aviation can be attributed to professionalism and attention to safe operating practices. The business aviation community promotes safety through industry standards and good training, as well as through monitoring and analysing safety information to facilitate continuous improvement.

The global population (2013) of Business Aircraft consist of about 19,000 business jets and 14,500 Turbo Props. Business aircraft in North America represent 61.2% of the global fleet. South and Central America have approximately 11.6% and Europe 13.0% of the world's fleet. Other regions account for the remaining 14% of the fleet.

The 2013 summarized flight hour totals are as follows (2013): Business Jets – 7,700,000 hours and Turbo Props – about 4,000,000 hours. The flying hours in North America represents 63.4% of the total, Europe 13.2%, Central/South America 12.5%, and the rest of the world 11%.

At business aviation safety requirements are based on Regulation (EU) 376/2014 on the Reporting, Analysis and Follow Up of Occurrences in Civil Aviation, which was built on Directive 2003/42 and on reporting and modern SMS requirements under IRs of BR216/2008. The Key Areas of the Regulation:

- Improved reporting and follow up of occurrences from both mandatory and voluntary reporting processes.
- Introduction of occurrence risk classification.
- Rules on confidentiality of information and Just Culture.
- Provision of Guidance Material and other useful supporting information for industry.
- Analysis-a key part Safety Risk Management process to use and share what is learnt.

The following concepts and actions are elements of safety culture that can be found in many organizations:

- Unqualified commitment to safety as a behavioural pattern and pervasive way of life by top management.
- Unambiguous expectations by each level of management as well as each peer group that, for all employees, safe life patterns and work habits are as normal as breathing and must be practiced off the job as well as on the job.
- Availability of quality, standardized equipment with which to accomplish the assigned tasks.
- Clear, easily understood operating procedures, followed without deviation.
- Inclusive system of communications for collecting, analysing, and exchanging incident data related to safety.
- Non-retribution for submission of incident data.
- Retraining without penalty or stigma when safety is involved.
- System for tracking incident and accident data, analysis of trends, and feedback of results.
- Peer acceptance that accidents are preventable, regardless of operations.
- Peer acceptance that safety is a matter of lifestyle - a matter of culture.

T9.6.3.2 Private Aircraft

The sub-sector of General Aviation (GA) covers noncomplex aircraft operations with an emphasis on non-commercial operations. This embraces aeroplanes, helicopters, sailplanes (gliders) and balloons (including airships). Their uses range from purely sport and recreational activities to general private flying, owner-operators own business use through to some commercial activities such as aerial work, all of which are included in the scope of the non-commercial use.

The regulation for GA must be proportionate: specific activities should lead to specific requirements, just fit to mitigate for the risk. Consequently, the group chose to adopt a wide area of applicability, and principles and guidelines of a sufficiently general nature to be used as appropriate in different cases. This does not preclude that, when coming to specific regulation elaboration, it will be necessary to identify very precise boundaries for application.

GA should be treated differently to Commercial Air Transport (CAT), because it is important to recognise the differences between commercial and non-commercial environments from a safety management perspective.

- Control of Risk: end-use stakeholders in non-CAT aviation generally have much more ability to assess and control the risk of the operation. In many cases, except for very limited risk to third parties, the operators are the only stakeholders exposed to risk.
- Level Playing Field: in the competitive CAT market, driven by a profit motive, a level playing field between actors is necessary to ensure that safety does not enter a vicious downward spiral.
- Cost Burden and Economies of Scale: CAT operations are typically much more repetitive than non-commercial operations. CAT aircraft may fly up to 4,000 hours p.a. whereas non-commercial aircraft may typically fly only 50 to 100 hours p.a. This leads to significant economies of scale for CAT in dealing with fixed costs and other resource requirements including those generated by regulatory compliance.
- Flexibility: CAT operations are usually planned in detail in advance with a limited need for short-term flexibility. By contrast, non-CAT operations are often planned at relatively short notice, tend to be dynamic and may even be opportunistic (e.g. highly weather dependent).
- Private flying including sporting and recreational / leisure aviation as well as personal transport. This form of flying has only one thing in common with CAT, the 3-dimensional aspect and only three areas of overlap or adjacent proximity, which are use of airspace, communications frequencies, and some airports.

GA must therefore be treated as a sector in its own right and not as a watered-down "Commercial Air Transport (CAT) by–product".

As highlighted by ICAO and for the reasons mentioned above, the level of safety expected for GA may not be the same as the one required for CAT. The available data in various European States show that the currently observed level of safety for GA activities – the least complex ones - is currently indeed not as high as CAT's.

Public perception seems to accept the current levels of safety demonstrated by the GA community. It is however essential not to compromise that level of safety, by the modification of the regulatory approach.

The group considers that the regulatory approach is not the sole method of assuring a minimum acceptable level of safety, but that both education and the development of an improved safety culture across the community are equally valid. A more liberal attitude to product approvals is also expected to promote innovation and to lead to the rapid introduction of more modern and safer equipment.

Applying safety management principles, careful monitoring of the evolution of the GA safety situation will be of high importance, to be able to take appropriate measures (not necessarily new regulations, as mentioned above) to ensure the safety level remains appropriate.

Transparency for the participants to GA activities will have to be increased: they need to be adequately informed that the level of safety they will encounter may not be the same as in a commercial air transport flight, in order for them to understand and accept the level of safety knowingly.

T9.6.3.3 Agricultural Aviation

Most aerial agricultural operations are flown in heavily laden aircraft, at low level in challenging terrain. Specialised equipment and highly skilled people are needed to operate this sector. Apart from the obvious operational concerns, participants are also subject to many other factors affecting safety. These include business performance, local weather conditions, and personal issues. Despite significant effort from the CAA (Civil Aviation Authority) and the aviation industry, the safety performance in this sector remains poor. The CAA and industry have agreed that a new approach to managing risk is needed.

It was seen the development of Safety Management Systems, known as SMS, as a positive approach to safety related risk. When in place, SMS structure ensures a proactive approach to risk identification and risk management. Risks can then be identified and treated before they lead to unsafe or dangerous outcomes. This is not only for safety, but also for business enhancement. SMS is part of a global change to how regulators carry out their obligations – risk based regulatory oversight.

The CAA is committed to the concept of adopting a risk-based approach to regulatory oversight. This is in line with International Civil Aviation Organisation (ICAO) requirements for regulatory bodies to develop a State Safety Programme (SSP). The development of the SSP will be in accordance with ICAO Annex 19 Standards and Recommended Practices. This includes the implementation of a formal SMS by aviation organisations.

The aviation industry is dynamic and safety-risk factors also change. Without ongoing effort, there is a potential for risks to increase due to factors such as introducing new technology, and commercial pressures. The regulator and aviation organisations need to employ a risk-based approach to safety management. One of the main objectives of risk-based regulation for the CAA, is to have structured means to effectively use resources. This ensure that the highest risk sectors of industry will be managed first.

This is one of the main reasons why the agricultural aviation sector was selected to undergo a Sector Risk Profile.

Risk can be defined as the chance something could happen, and risk management as the identification of safety risks enabling proactive control of the potential outcome of these risks.

Many risk elements can be identified in the agricultural aviation SRP. Placing them into risk levels ranging from Medium to Very High. These levels are determined by assessing the likelihood of the risk occurring and the possible consequences. Examples of identified risk elements include aircraft performance and maintenance; operator obligations; pilot training; and airstrip conditions.

T9.6.4 Air Carriers Operating Ban

T9.6.4.1 European Union

The list of air carriers banned in the European Union is a list of airlines failing to meet regulatory oversight standards of the EU, and which are banned from entering the airspace of any member state. All Member States and the European Aviation Safety Agency (EASA) have the obligation to communicate to the Commission all information which may be relevant to updating the list. This may include reports showing serious safety deficiencies of an air carrier (such as reports of Safety Assessment of Foreign Aircraft inspections performed at airports within the European Community), operating bans imposed by third countries, audit reports drawn up by the International Civil Aviation Organisation (ICAO) following safety inspections (in the framework of the Universal Safety Oversight Audit Programme) of the civil aviation authorities of the 189 Contracting parties to the Chicago Convention, as well as accident-related information or other serious incident-related information.

For the purpose of updating the list, the Commission is assisted by the Air Safety Committee composed by technical air safety experts from all the EU Member States (plus Iceland, Norway and Switzerland which, however, have no voting rights) and chaired by the Commission (the Commission does not have any voting rights). Acting on a proposal by the Commission, the Air Safety Committee adopts its opinion by qualified majority, which is then submitted to the European Parliament before final adoption by the Commission and subsequent publication in the Official Journal.

The decision to include or remove a carrier (or a group of carriers certified in the same State) is taken based on the common safety criteria annexed to the "Basic Regulation" (Regulation 2111/2005/EC establishing a Community list of banned carriers). These criteria take into consideration, for instance, the existence of safety deficiencies on the part of an air carrier, or the lack of ability (or willingness) by an air carrier or authorities responsible for its oversight to address safety deficiencies, operating bans imposed by third countries, audit reports drawn up by third countries or international organisations (ICAO) and substantiated accident related information. All criteria are based on international aviation safety standards.

If an airline considers that it should be taken off the list because it complies with the relevant safety standards, it can address a request to the Commission or a Member State, either directly or through its civil aviation authority. Only the Commission or a Member State may ask for the list to be updated. The Air Safety Committee will then assess the evidence presented by the airline and/or its oversight authority to substantiate its request for being withdrawn from the EC "blacklist" and formulate its opinion to the Commission.

The procedure of adding the airline to the list is the same as that for updating the list. If the Commission or a Member State acquires evidence indicating serious safety deficiencies on the part of an airline or its oversight authority anywhere in the world, they ask for the list to be revised immediately. Indeed, in such cases Member States have the obligation to ask for the update of the "blacklist". A decision is then taken in the light of the common safety criteria for banning established by the "Basic Regulation".

Where the Commission is of the opinion that the continuation of operations into the Community of an air carrier is likely to constitute a serious risk to safety and that such risk has not been resolved satisfactorily at national level (by measures taken by the civil aviation authority of a Member State) it can take provisional measures, whereby the carrier is banned from entering the European air space. These measures are then presented to the Air Safety Committee for confirmation or modification.

As long as the air carrier is subject to a total ban, it cannot operate with its aircraft and personnel in the EC. The airline is placed on Annex A to the regulation whereby the "blacklist" is updated. Equally, as long as an air carrier is subject to a partial ban it can operate only with the aircraft stipulated in the Regulation and cannot expand its network. The airline is placed on Annex B to the regulation whereby the "blacklist" is updated.

Nevertheless, banned airlines can still fly their aircraft into the Community for maintenance (notably to resolve safety deficiencies in this area) without carrying any passengers or payload – the so-called "ferry flights". Also, banned airlines can use other airlines (their aircraft and personnel) on the basis of contracts called "wet-lease agreements". In this way, passengers and cargo can still be transported but only by airlines which fully comply with the safety rules. Furthermore, aircraft which are used for government or state purposes (e.g. transport of the heads of state and/or government), escape the requirements of ICAO. Therefore, these aircraft are considered to be operating "state flights" and can therefore fly into the EC even if they are banned from operating commercial flights. Such flights need however a special authorisation as foreseen by ICAO, from all the Member States that the plane flies over as well as from the state of destination.

Finally, banned airlines cannot enter the airspace of any Member State and fly over their territory while they are banned (totally or partially).

Airlines which have been banned, or which are being investigated in view of a potential ban, have the right to express their points of view, submit any documents which they consider appropriate for their defence, and make oral and written presentations to the Air Safety Committee and the Commission. This means that they can submit comments in writing, add new items to their file, and ask to be heard by the Commission or to attend a hearing before the Aviation Safety Committee, which then formulates its opinion based on these proceedings and the materials submitted prior to or during the hearing. The rules foresee that carriers and authorities are given a deadline within which they have to respond.

T9.6.4.2 United States of America

In the US the equivalent of EASA is FAA (Federal Aviation Agency). FAA is the part of the United States Department of Transportation. It is basically the National Aviation Authority of the US. The FAA has a blacklist of sorts as well, but its list bans certain countries, not specific airlines, from entering U.S. airspace. This ban may be implemented due to a failure to meet international aviation standards for operations and maintenance (so, the criteria is somewhat similar to the EU list).

Under the International Aviation Safety Assessment (IASA) program, the FAA determines whether another country's oversight of its air carriers that operate, or seek to operate, into the U.S., or codeshare with a U.S. air carrier, complies with safety standards established by the International Civil Aviation Organization (ICAO). The IASA program is administered by the FAA Associate Administrator for Aviation Safety (AVS), Flight Standards Service (AFS), International Programs and Policy Division (AFS-50).

The IASA program focuses on a country's ability, not the ability of individual air carriers, to adhere to international aviation safety standards and recommended practices contained in Annex 1 (Personnel Licensing), Annex 6 (Operation of Aircraft), and Annex 8 (Airworthiness of Aircraft) to the International Convention on Civil Aviation "Chicago Convention" (ICAO Document 7300).

IASA assessments determine compliance with these international Standards by focusing on the eight critical elements of an effective aviation safety oversight authority specified in ICAO Document 9734, Safety Oversight Manual. Those eight critical elements include primary aviation legislation; specific operating regulations; State civil aviation system and safety oversight functions; technical personnel qualification and training; technical guidance, tools and the provision of safety critical information; licensing, certification, authorization, and approval obligations; surveillance obligations; and resolution of safety concerns.

T9.6.4.3 Airline SAFETY Rating

If the airline has an International Air Transport Association Operational Safety Audit certification (IOSA), it earns two stars. This certificate is actually difficult to get, so either the airline didn't sign up to be assessed (which is a little suspicious) or they have failed. The International Air Transport Association awards this certificate biannually to the airlines that meet its standards of operational management and control systems. The IOSA certificate is worth two stars—double some of the other criteria—because the IOSA certificate is a pretty good indicator of an airline's safety rating. Airlines with an IOSA certificate had 77 percent less accidents than those without one in 2012.

If the airline is not on the European Union (EU) Blacklist, it receives one star. If the airline hasn't had one fatality in the past ten years, it receives one star. This includes passengers or crew and the fatality must be due to an accident, which does not include any fatalities due to terrorism or fatalities due to something out of their control (an unidentified object obstructing the runway, etc.). If the Federal Aviation Authority (FAA) has endorsed an airline, it receives one star.

If the country of airline origin has met all eight of the International Civil Aviation Organization (IACO) safety parameters, it receives two stars. They can receive partial credit here—if they meet at least five, they get one star. The eight parameters include Airworthiness, Accident Investigation, Air Navigation Service, Aerodromes, Legislation, Operations, Licensing, and Organization.

There are two exceptions that may cause an airline to lose a star, which are:

- If the airline operates only Russian-built aircraft.
- If the country of origin has grounded an airline's fleet due to safety concerns in the last five years.

Out of 449 airlines, 149 scored the highest safety rating (seven out of seven stars). Below are listed the top ten, each with a seven out of seven rating. Qantas got the top spot, and the rest are listed in alphabetical order.

- Qantas;
- Air New Zealand;
- British Airways;
- Cathay Pacific Airways;
- Emirates;
- Etihad Airways;
- EVA Air;
- Finnair;
- Lufthansa;
- Singapore Airlines.

T9.6.5 References

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Regulations:

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Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC.

Regulation (EC) No 1108/2009 of the European Parliament and of the Council of 21 October 2009 amending Regulation (EC) No 216/2008 in the field of aerodromes, Air Traffic Management and air navigation and repealing Directive 2006/23/EC.

Council Directive 94/56/EC of 21 November 1994 establishing the fundamental principles governing the investigation of civil aviation accidents and incidents.

Regulation (EU) No 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC.

Regulation (EC) No 2111/2005 of the European Parliament and of the Council of 14 December 2005 on the establishment of a Community list of air carriers subject to an operating ban within the Community and on informing air transport passengers of the identity of the operating air carrier, and repealing Article 9 of Directive 2004/36/EC.

Web Pages:

ICAO, International Civil Aviation Organization, www.icao.int, access: March 2018.

EASA, European Aviation Safety Agency, https://www.easa.europa.eu/, access: March 2018.

FAA, Federal Aviation Administration, https://www.faa.gov/, access: March 2018.

KEY TOPIC T9.7 ANALYSING INCIDENT/ACCIDENT DATA

For preventing risks related on safety, one opportunity is analysing accident/incident data and decide about which actions will be most effective by using new approaches. In fact, in the past many aviation accidents have been attributable to non-sensitive and non-precise tools, malfunction of sensors, aircraft design, engines, detectors and so on. Nowadays, the use of the principle of active system control offers a good opportunity for further improvements in safety levels.

Statistically, the riskiest phases of flight are taking off and landing especially in bad weather conditions. In fact, as shown in the bottom sketch of Figure 9.41, the landing-related phases of flight have the largest percentage of total accidents: landing (27.3%), manoeuvring (14.8%), approach (11%), descent and go-around (57.8%). Among these latter, the manoeuvring phase of flight represent the fatal accident first occurrences (33.4%), probably related, to human factors and weather conditions.

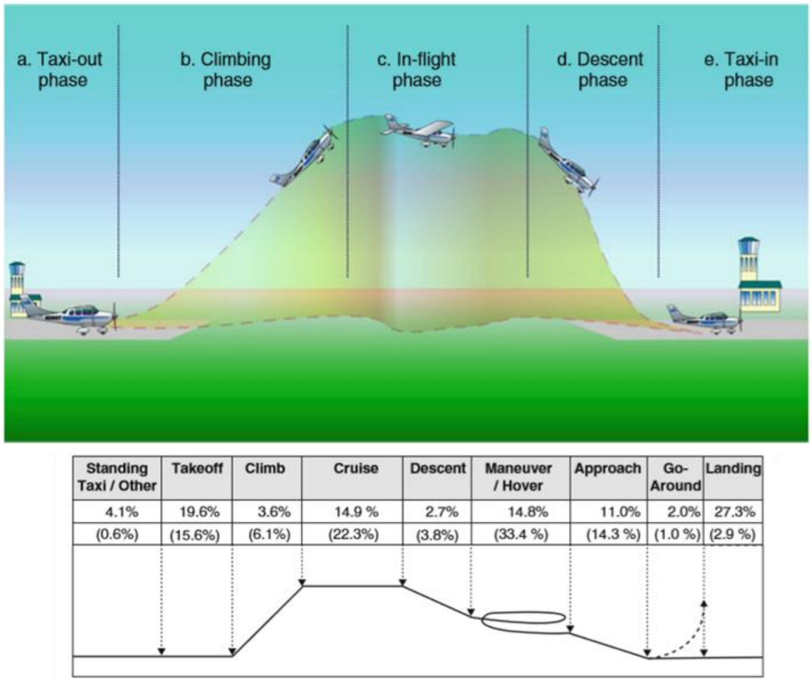

Figure 9.41 - Upper panel: typical phases of flight, and bottom panel: related - phases percentages of total accidents | Source: I. Schagaev, B.R. Kirk, Active System Control, DOI 10.1007/978-3-319-46813-6_1 Springer International Publishing AG 2018

Over the past 50 years, security and flight safety have improved significantly, and their level is expected to grow even in presence of an increasing volume of air traffic foreseen for the future. 2016 and 2017 are the years with lowest number of fatalities in aviation history, thanks to the continued improvements in safety across almost every operational domain. According to a preliminary EASA safety overview depicted in the Figure 9.42, 2017 shows the lowest number of fatal accidents in modern aviation history for commercial air transport with large airplanes. This preliminary analysis covers both worldwide operations and those involving the 32 EASA Member States. When all the safety data will be available, a more detailed analysis will be provided and published in the 2018 EASA Annual Safety Review.

In Table 9.8 a recent overview of the statistical analysis in security and safety, performed by IATA, is depicted. However, even if we have seen an important advance in safety systems, the fatal accident occurrence demonstrates the importance of joining forces with the goal to improve safety in aviation community.

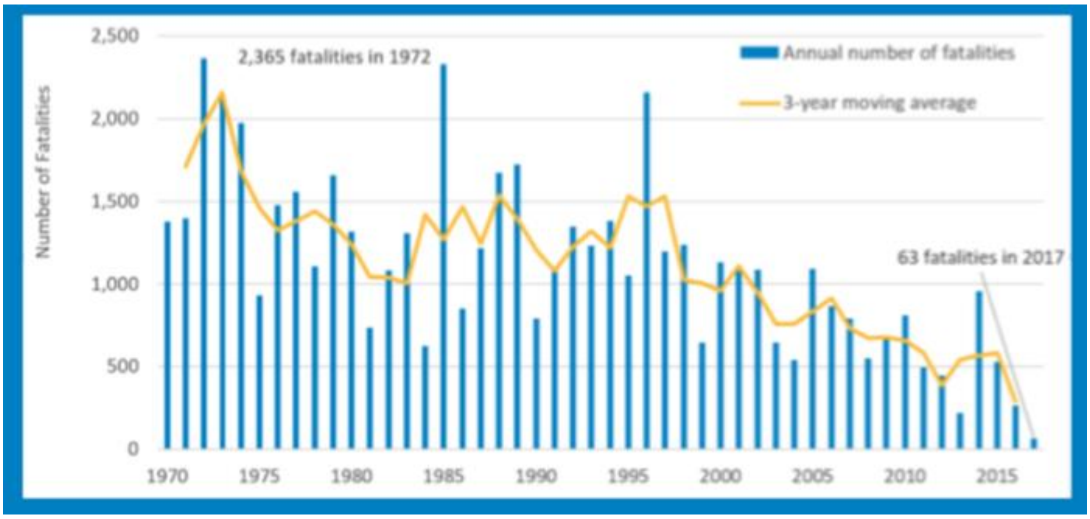

Figure 9.42 - Number of fatal accidents in aviation history for worldwide commercial air transport with large aeroplanes. Source: 29191-Preliminary_Safety_Overview_2017_-_Publication.pdf

Rendement en matière de sécurité en 2017

	2017	2016	Moyenne sur 5 ans (2012-2016)
Décès à bord [i]	19	202	314,6
Nombre total d'accidents	45	67	74.8
Accidents mortels	6	9 [ii]	10,8
Risque de décès [iii]	0,09	0,21	0,24
Accidents mortels touchant des vols de passagers	2	3	5,6
Accidents mortels touchant des vols de fret	4	6	4,6
% des accidents causant des décès	13,3	13,4	14,4
Pertes de coque d'avion à réaction	4	13	10
Pertes de coque d'avion causant des décès	1	4	3,4
Pertes de coque de turbopropulseur	9	7	15
Pertes de coque de turbopropulseur causant des décès	5	4	7,2

Table 9.8 - Statistical yield in security and safety in 2017 compared to 2016. Source: IATA document 2018

Safety Standards in Different REGIONS of the world

In USA the major cause of aeronautic accidents is related to human factor (1468 accidents in 2000) and performance. These accidents records include lack of total experience, lack of recent experience, human performance and inadequate training. However, the USA is deemed to have the best safety management infrastructure developed so far, as illustrated in the Figure 9.43:

Figure 9.43 - Safety management infrastructure in the USA based on figures from Boeing. Source: I. Schagaev, B.R. Kirk, Active System Control, DOI 10.1007/978-3-319-46813-6_1 Springer International Publishing AG 2018

In US, the National Transportation Safety Board (NTSB) is responsible for investigations when an accident occurs and together with FAA and NASA provide recommendations, propose practical actions to avoid similar accidents in the future.

In 2002, the European Parliament Directive on Occurrence Reporting in Civil Aviation established an aviation safety management regime similar to that in the USA. **Eurocontrol** is the leading organization in air traffic management in Europe, and together with **EASA** and **EUROCAE**, works in synergy to control function related aviation safety.

In contrast to USA, EU initiatives in aviation safety have been focused mainly on human factor, e.g., training and inspections. However, in the past, this strategy has failed as it concerns the increase in safety levels.

The introduction of satellite links has provided an opportunity to store and analyse the flight data, evaluate the safety aspect of the flight in real time, etc. as shown in the Figure 9.44:

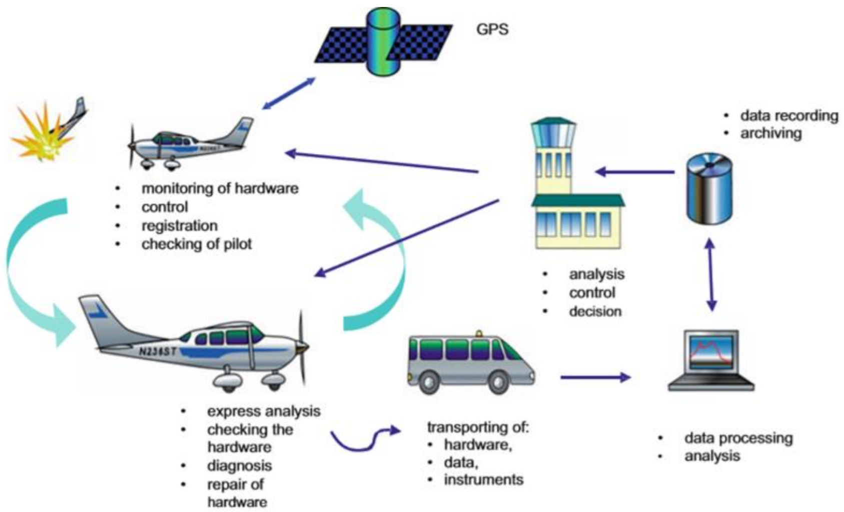

Figure 9.44 - Conventional cycle of information processing of flight information. Source: I. Schagaev, B.R. Kirk, Active System Control, DOI 10.1007/978-3-319-46813-6_1 Springer International Publishing AG 2018

For long-term analysis, this innovation has allowed to find safety trends over several flights and elaborate new management schemes.

In this contest, an important point to be addressed is the pilot's and crew's training about the regulation protocols. Another safety issue is the mental health of the pilot related to human factor. In this regard, many areas of medicine have looked to the aviation industry to develop improvements in safety through regulated, standardized practices. In fact, it is reported that the pilot's fatigue plays an important role in safety risks. Different meta-analysis confirmed that, in general, the mental health of pilots is a key element for improve safety in aviation (Fanjoy, R.O., Harriman, S.L., DeMik, R.J. 2010. International Journal of Applied Aviation Studies. Individual and environmental predictors of burnout among regional airline pilots).

According to the EASA Annual Safety Review 2017, it is possible to establish a list of safety issues based on the past performance of the system by counting high-risk occurrences, or the number of fatalities or through the aggregated risk score. This review provides a statistical summary of aviation safety in the EASA Member States (MS) and provide the possibility to understand, which are the most important safety challenge. The major top safety issues are:

Perception and situational awareness:

- Icing in flight;
- Handling of technical failures;
- Turbulence;
- Airborne conflict;
- Flight planning;
- Decision making and planning;
- Experience, training and the competence of individuals;
- Wind-shear;
- Flight- path management;
- Mental health.

The European Plan for Aviation Safety (EPAS) is developed through the European safety risk management (SRM) process, which is articulated in five steps as shown in the Figure 9.45:

Figure 9.45 - The European Safety Risk Management Process.
Source: EASA AST summary 2017

The EPAS is a key component of integrated Safety Management System (SMS), and is constantly being reviewed and improved.

Safety standard in Europe are assured thanks to the efforts of EASA. The main issue is to apply these standards also outside Europe. EASA maintains close working relations with the International Civil Aviation Organization (ICAO) to support States in fulfilling ICAO safety standard. ICAO promulgates **Standards and Recommended Practices (SARPs)** to facilitate harmonised regulations in particular in aviation safety, and security, hence efficiency and environmental protection on a global basis. In 2015, ICAO established the **Aviation Safety Implementation Assistance Partnership (ASIAP)** to coordinate efforts for the provision of assistance to member States (depicted in the Figure 9.46) and participating organizations. (https://www.icao.int/safety/Documents/ICAO_SR_2017_18072017.pdf)

Figure 9.46 - ASIAP State and Organisational Partners. Source: ICAO Safety Report 2017 Edition

Existing on-board checking systems are designed with the goal to improve aviation safety in future flights using as a reference the available and stored data recorded in-flight. With an on-board processing capability, it becomes possible to simultaneously record and analyse data making possible to check the aircraft conditions in real-time. Signals are recorded by the **Digital Fight Data Acquisition Unit (DFDAU**) which can also accept digital inputs from sensors and another avionics equipment. So far, new standards and available technologies enable to store 2h of cockpit voice data and record 256 12-bit data words per second. Further plans for the development of flight recording are underway, *i.e.,* the use of flash memory which improves the reliability of these records.

Today the "black box" is the major tool and way to improve the existing safety system. In 1999, the FAA introduced new aircraft black box rules, and in 2004, the FAA requested recording of controller pilot data link communication messages. In addition to voice and flight data recording, ICAO, EUROCAE and ARINC are considering video recorder. Moreover, by the end of 2006, the NTSB and FAA have requested video recorders and cameras in the cockpit, especially for small turboprops that do not currently have safety recorders.

The Figure 9.47 shows some advanced international black box trends, and highlight that Europe is somewhat behind about the recent research focus on implemented and announced "black box" projects worldwide:

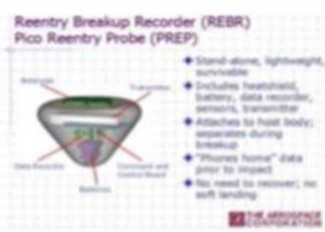	NASA FAA mandates major aircraft "black box" upgrade http:// www.cnn.com/2008/US/03/10/black.boxes/
	China . . .and a new data recorder—a spacecraft black box—is also being tested. The black box is faster than its Shenzhou 5 counterpart and contains more storage space, but at only half the size, Xinhua reported (Xinhuanet, 05) (Malik, 05)
	USA • Time recorded, 25 h continuous • Number of parameters, 18–1000+ • Impact tolerance, 3400Gs/6.5 ms • Fire resistance, 1100°C/30 m • Water pressure resistance submerged, 20,000 ft • Underwater locator beacon, 37.5 KHz • Battery has shelf-life of 6 years or more • Capability upon activation with 30-day operation
	"Izmeritel" (Russia) new flight recorder • Time recorded, 25 h continuous • Number of parameters, 18–1000+ • Impact tolerance, 3500Gs/6.5 ms • Fire resistance, 1100°C/45 m • Water pressure resistance submerged, 20,000 ft • Underwater locator beacon, 37.5 KHz • Battery has shelf-life of 6 years or more • Capability upon activation: 30-day operation *http://www.izmeritel.smolensk.ru/spec1.html*

Figure 9.47 - Existing and developmental flight safety recorders.
Source: I. Schagaev, B.R. Kirk, Active System Control, DOI 10.1007/978-3-319-46813-6_4 © Springer International Publishing AG 2018

The next generation of black boxes has to be compact, extremely resilient, active, and with enhanced capability to improve recorded time. Moreover, the smaller size and the decreased weight could provide great improvements in such devices. However, these features, i.e., decreased weight and size and, at the same time, increased resilience, durability and ability to be recovered still represent a great challenge.

The Global Aviation Safety Program (GASP) by ICAO provides a continuous improvement strategy for the implementation of effective safety oversight systems, State Safety Programmes (SSPs) and the development of advanced safety oversight systems, including predictive risk management. The GASP also sets out timelines for the global collective achievement of these near-, mid- and long-term objectives. These timelines are aligned with the established update process for the GASP and the Global Air Navigation Plan (GANP), which are revised on a triennial basis. The GASP is a high level, strategic, planning and implementation policy document developed in conjunction with the Global Air Navigation Plan (Doc 9750). Both documents promote coordination of international, regional and national initiatives aimed at delivering a harmonized, safe and efficient international civil aviation system [Global Aviation Safety Plan, Doc 10004, ISBN 978-92-9258-118-3].

ICAO has established five comprehensive strategic objectives, which are revised on a triennial basis. ICAO strategic objective dedicated to enhancing global civil aviation safety is focused primarily on the State's regulatory oversight capabilities in the context of growing passenger and cargo movements, taking into account efficiency and environmental changes.

More information on the Strategic Objectives can be found on the ICAO website at www.icao.int/about-icao/Pages/Strategic-Objectives.aspx.

The GASP objectives require that the States put in place robust and sustainable safety oversight systems leading to a more sophisticated means of managing safety. In order to meet these objectives, regional aviation safety groups (RASGs) and regional safety oversight organizations (RSOOs) should be involved actively in the coordination and harmonization of all activities undertaken to address aviation safety issues at a regional level, including the use of the global aviation safety roadmap by individual States or a group of States.

The Figure 9.48 provides an overview of the GASP objectives and their associated timelines. The States must first establish an effective safety oversight system prior to implementing an SSP. It is expected that all States will continually progress implementation of Standards and Recommended Practices (SARPs) in order to achieve the GASP objectives and priorities set out in the GASP.

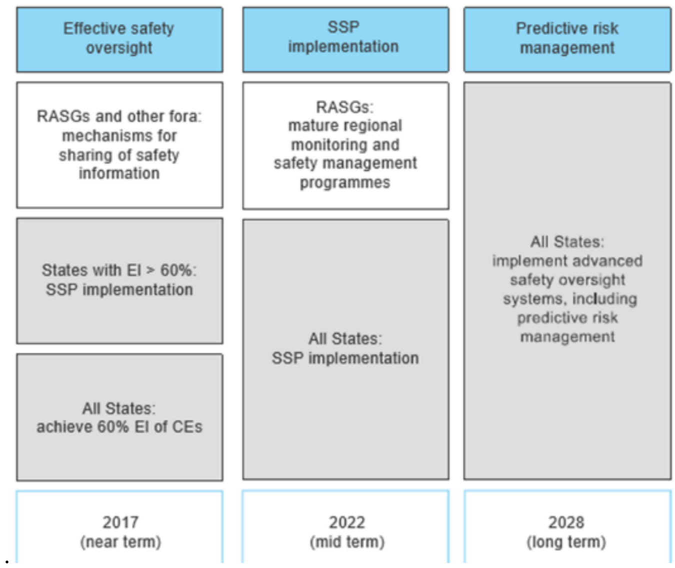

Figure 9.48 - GASP objectives and associated timelines.
Source: ICAO Doc 10004 Global Aviation Safety Plan 2017 – 2019

A target was set for all African States to attain 60 per cent effective implementation (EI) of the critical elements (CEs) of a State safety oversight system by 2017. This target was adopted by the ICAO Council and endorsed by the ICAO General Assembly as a global measure and formed the basis for the near-term objective included in the 2014-2016 edition of the GASP. It corresponds to a minimum level necessary for a State to perform effective safety oversight and move towards SSP implementation.

The near-term objectives, to be achieved by 2017, take into account the current level of safety oversight systems implementation at the regional and national levels.

The near-term objectives are as follows:

a) States lacking fundamental safety oversight capabilities are to achieve an EI of at least 60 per cent overall of the eight CEs of a State safety oversight system. States should prioritize the resolution of deficiencies or findings which have the highest impact in terms of safety improvements. The universal safety oversight audit programme (USOAP) protocols, used to assess implementation of ICAO provisions, are categorized according to eight CEs (see Figure 9.49).

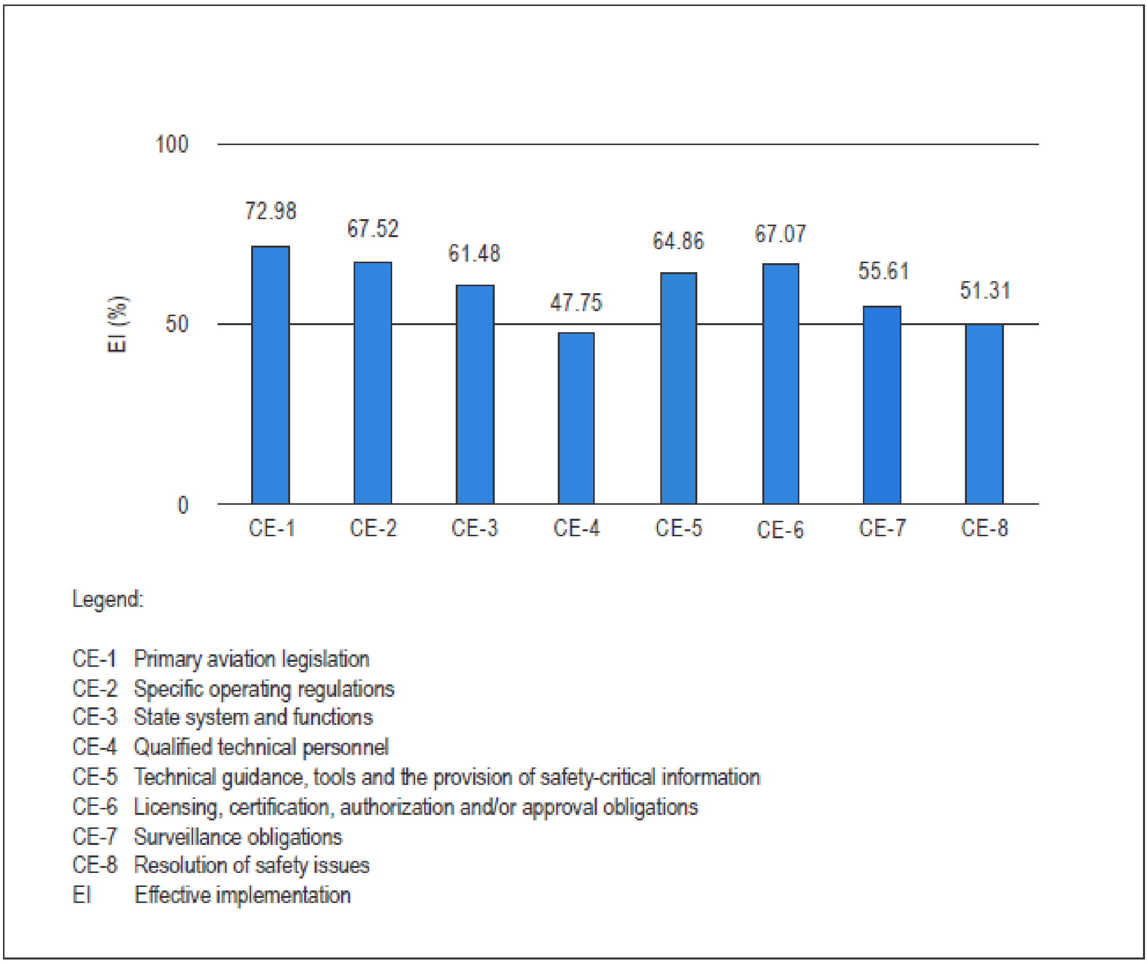

Figure 9.49 - Per cent effective implementation (EI) of the critical elements (CEs) worldwide
Source: ICAO Doc 10004 Global Aviation Safety Plan 2017 – 2019

Implementation of CE-6, which addresses licensing, certification, authorization and/or approval obligations, is fundamental to the reduction of accident rates. Furthermore, through a root cause analysis, deficiencies in CE-6 can be traced to protocol questions in CE-1 to CE-5, which establish a safety oversight system. Each deficiency in CE-6 should therefore be associated with a specific action plan for a State's improvement efforts. Effective execution of the action plan provides the basis for prioritized compliance.

b) States which have an EI of 60 per cent or greater should implement SSP, which will facilitate addressing risks specific to their aviation systems.
c) All States and stakeholders are encouraged to put in place mechanisms for the sharing of safety information through their RASGs and other regional or sub-regional fora.

An interesting and important ICAO SARPs is represented form Document namely "Manual for the Oversight of Fatigue Management Approaches (Doc.9966)" which support the approaches to fatigue management. Annex 6 (Operation of Aircraft) Part I – International Commercial Air Transport – Aeroplanes, which is relate to flight and cabin crew. Annex 6 (Operation of Aircraft) Part II – International General Aviation – Aeroplanes, this section 2 applies to all international GA operation and Section 3 refer to all operator personnel involved in the operation and maintenance of large and turbojet aeroplanes in GA operations. Annex 11 (Air Traffic Services), which pertain to air traffic controllers.

In addition to the Safety Report, ICAO has created lists of State safety performance indicators (SPIs). A sample set of SPIs was presented at the second High-level Safety Conference held in 2015 (HLSC 2015), through an information paper (IP/01) entitled "Safety data, performance metrics and indicators". The HLSC 2015 recommended that ICAO improve and harmonize those SPIs, taking into account others that were currently in use. Metrics are the core of the SPI process. They constitute the basis from which indicators are drawn. Once a list of metrics is available, providing information such as a definition, the data source, update frequency, unit, scope and safety relevance, State or regional specific indicators can be defined which address the uniqueness of each situation but use the same metrics.

The usage of identifiable metrics allows benchmarking between States and regions even though their safety indicators may differ with regard to their scope, coverage or target. The collection of data is crucial to the development of SPIs. Data can be collected through various ways such as auditing, inspections or reporting.

Occurrence data is typically stored in a database such as the European Coordination Centre for Accident and Incident Reporting Systems (ECCAIRS). The collection of accident and incident data is a well-established aviation safety data collection process executed at the State level.

ICAO USOAP programme has evaluated whether States have effectively implemented an accident and incident database (protocol question 6.507). As of August 2014, only 42 per cent of all audited States have effectively implemented such a database. The regional implementation rates range from 64% in the European region to 13% in Africa as can be seen on the map in the Figure 9.50:

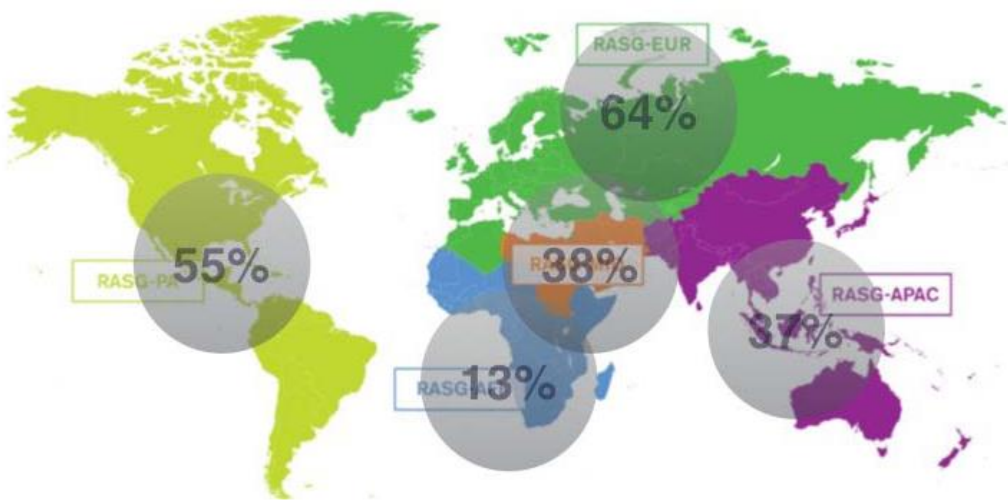

Figure 9.50 - Effective implementation of incident and accident databases
Source: ICAO Secretariat "Safety data, performance metrics and indicators". Presented at 2015 High-level Safety Conference (HLSC 2015)

The list of safety indicators (see the Table 9.9) has been defined which can be used by States for their safety monitoring programme and to establish baselines which can be used ultimately to define targets and acceptable levels of safety.

A- Safety Indicators

#	Indicators and Metrics	Type	Usage
1	**Effective Implementation of State Safety Oversight System** *Metrics:* • *USOAP EI Scores overall* • *USOAP EI Scores by technical area* • *USOAP EI Scores by critical element*	Predictive	Target
2	**Progress in SSP Implementation** *Metrics:* • *Percentage of completed gap analysis questions* • *Percentage of implemented gap analysis questions overall* • *Percentage of implemented gap analysis questions by element*	Predictive	Target
3	**Progress in SMS Implementation** *Metrics:* • *Percentage of completed gap analysis questions by operator* • *Percentage of implemented gap analysis questions overall by operator* *Percentage of implemented gap analysis questions by element and by operator*	Predictive	Target
4	**Frequency and Severity of Accidents and Incidents** *Metrics:* • *Number and distributions of occurrences by severity level (accident, serious incidents, etc.) and ADREP occurrence category* • *Number and distribution of fatalities by ADREP occurrence category* • *Occurrence per number of departures (rate)* *Note: Occurrences should be limited to specific categories of aircraft and operations like "aircraft above 5 700 kg operating scheduled commercial flights"*	Reactive / Proactive	Target
5	**Certification of Aerodromes** *Metrics:* • *Number and percentage of certified international aerodromes overall and by airspace*	Predictive	Target
6	**Significant Safety Concerns** Metrics: • *Number and duration of USOAP CMA significant safety concerns by technical area*	Predictive	Target
7	**Presence of notable hazardous conditions** *Metrics:* • *Number, duration and distribution of safety-related NOTAMS by Doc 8400 Q-code categories*	Predictive	Monitor
8	**Fleet Modernization** *Metrics:* • *Average age of all registered and operated aircraft and their distribution by operator* • *Percentage of all registered and operated aircraft above 20 years and their distribution by operator*	Predictive	Monitor
9	**Effectiveness of Foreign Operator Safety Assessment Programmes** *Metrics:* • *Compliance scores by foreign and national operator*	Predictive	Monitor
10	**Industry Certification** *Metrics:* • *Number and percentage of operators holding industry certificates by type (IOSA, ISBAO, ISAGO etc.)*	Predictive	Monitor
11	**Extend of Environmental Hazards** *Metrics:* • *Average terrain elevation around airports* • *Percentage of METARS indicating low ceiling or visibility by month and location*	Predictive	Be aware

Table 9.9 - Safety indicators
Source: ICAO Secretariat "Safety data, performance metrics and indicators". Presented at 2015 High-level Safety Conference (HLSC 2015)

Safety Standards for Different Services: Airlines, Business Jets, Private Aircraft, Agricultural

Significant improvements in safety have been made since the start of commercial aviation. The aviation industry continues to evolve, but its top priority is the same: getting passengers to their destinations safely.

Airbus is committed to safety standards and supporting the safe operation of all its aircraft and those that fly aboard them. Therefore, Airbus works to ensure safety in different levels from the design, to the materials/manuals supplied to customers to operate and maintain the aircraft; form the worldwide services delivered in support of the aircraft's operation to the training to the flight – cabin and maintenance crews.

Airbus works with its customers to introduce safety management systems (SMS) as part of its commitment to improving global flight safety and decreasing accidents. Moreover, it is in constant contact with other aircraft manufacturers, airlines and air safety organisation around the world. Furthermore, Airbus Helicopters develops Safety Information Notices and other technical publication to provide customers with valuable information relate to the company's products and services and to improve safety control.

Airbus Helicopters customers can consult the entire library of technical publications through the company's Technical Information Publication on Internet (T.I.P.I) according to their subscription. The European Helicopter Safety Team (EHEST) regularly releases guidance to improve helicopter safety.

Airbus Helicopter's activities are focused on meeting industry safety standards and supporting the safe operation of its aircraft. In 1960s, this company developed the Fenestron® shrouded tail rotor which introduced a new level of helicopter safety on the ground and in the air. It is important to share the safety information in order to continue enhancing safety and preventing accidents.

Airbus has several safety information – sharing initiative such as Project "**Destination 10X Together**", a platform upon which Airbus and operators can collaborate to propose pragmatic solutions to key identified safety issues; ***Safety First*** magazine, that shares lessons-learned with operators and the wider aviation community, and highlights new safety enhancements that Airbus or others have made available; "**Statistical Analysis of Commercial Aviation Accidents".** Focusing on all Western-built aircraft since the beginning of the commercial jet age, this statistical analysis of the air transport sector examines the evolution of hull-loss and fatal accident rates during revenue flights from 1958-2016.

(http://www.airbus.com/company/safety.html#commercialjetlinersafety).

According to IATA's Six Point Safety Strategy, a comprehensive data-driven approach to identify organizational, operational and emerging safety issues such as reducing operational risk i.e., Loss of Control In - Flight (LOC-I), Controlled Flight Into Terrain (CFIT), lithium batteries and integrating remotely-piloted aircraft systems (RPAS) into airspace, and Runway Safety.

In addition to other areas of operational risk, IATA support consistent implementation of SMS, Flight Management System, Cabin Safety, Fatigue as well as enhance quality and compliance through their programs such as IATA Training Qualification and Initiative programs (**SAFETY STANDARDS: CHRONIC CHALLENGES AND EMERGING PRINCIPLES Ibrahim Habli).**

International aviation safety standards are the product of U.S. and EU aviation leadership. These standards are reported in ICAO Annexes and Manual, and since 2013, the number of annexes has grown to 19. Indeed, this last annex was created to improve safety systems. However, standards vary dramatically, as safety analysis is an ongoing process. Safety standards are regularly revised and updated, and typically include a mandatory part covering the necessary requirements for compliance. The creation and the process of news SARP is shown in the Figure 9.51. This entire process takes about two years from initial proposal to formal adoption of a SARP within an annex or procedure for air navigation service (PANS) manual. Since the Chicago Convention, ICAO has incorporated over 12,000 SARPs within the 19 annexes and five PANS, along with supplementary and guidance materials.

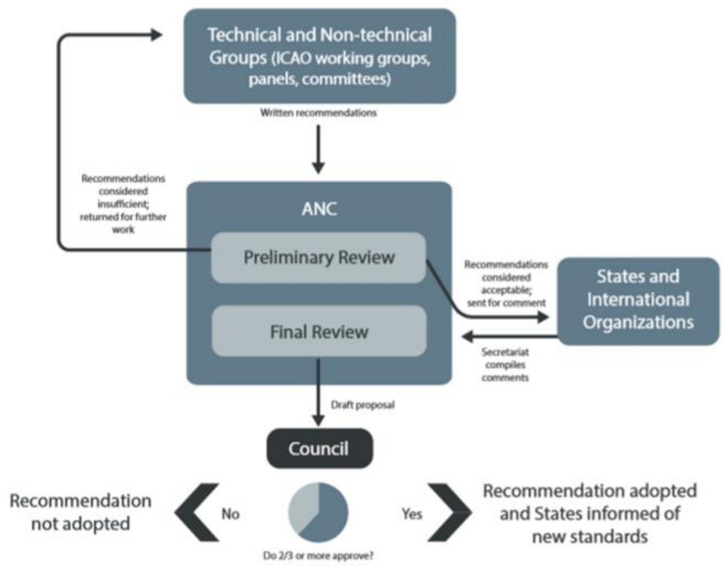

Figure 9.51 - Standard making process.
Source: Suzanne K. Kearns Fundamental of International aviation. Routledge, Taylor and Francis.

In accordance with ICAO Standards and Recommended Practices (SARPs), States must develop their safety oversight capabilities and implement SSPs. The Global Aviation Safety Plan (GASP) provides a strategy to enhance the implementation of the safety initiatives presented in the global aviation safety roadmap, and to assist States to meet their safety responsibilities.

However, States' priorities should be coordinated through the Regional Aviation Safety Group (RASGs) to address specific safety concerns in line with the global safety priorities and standards. In addition, States and regions should prioritize initiatives associated with the safety performance enablers to first establish effective safety oversight and then address safety risks effectively. Furthermore, States have an obligation under the Chicago Convention to provide timely notification to ICAO when their national regulations or practices differ from those established by SARPs. By this way, States enhance safety by implementing SARPs through the development, publication and implementation of harmonized regulations at the international, regional and national levels. Similarly, the implementation of industry best practices serves to enhance standardization among service providers (ICAO -2017-2019 rod, in ICAO folder document).

RASGs serve as regional cooperative for an integrating global, regional, sub-regional, national and industry efforts in continuing to enhance aviation safety worldwide. RASGs develop and implement work programmes that support a regional performance framework for the management of safety based on the GASP. The Regional Offices of RASGs are the following:

- Bangkok: Asia and Pacific (APAC) Office
- Cairo: Middle East (MID) Office
- Dakar: Western and Central African (WACAF) Office
- Lima: South American (SAM) Office
- Mexico: North American
- Nairobi: Eastern and Southern African (ESAF) Office
- Paris: European and North Atlantic (EUR / NAT) Office

Industry stakeholders- i.e., ICAO, States, international and regional organizations, industry representatives, air navigation service providers, operators, users, aerodromes, manufactures and maintenance organizations- are involved to continually improve safety (Figure 9.51). In fact, they are encouraged to review the roadmap to identify safety initiatives and actions that support national and regional programmes and work collaboratively with the aim of enhancing safety in a coordinated manner.

General-purpose aviation includes various kinds of aircraft application: administrative, business, air-taxi, tourism, medical, life-saving, agricultural, prospecting, sporting, training, and experimental. Users of GA aircraft, in turn, can be private and corporate owners as well as state and local administrative bodies such as police or fire departments.

Safety standards for GA must be elaborated in a different manner respect the CA and military one. This feature need not have smart devices, which are expensive, and no prof. data record for GA respect the other. In any way, to improve safety in aviation safety standard should be elaborate in an international and common way.

Safety Management Failings by Cause	%
Airframe and Power Plants	32.90
Pilot/Owner and operator licensing	12.97
Past overhaul time	3.78
Past or no 100 hour inspection	3.24
Past or no annual inspection	1.62

Figure 9.52 - Percentage of failures in the practice of Safety management.
Source: Aviation: Landscape, Classification, Risk Dataaleas

IEC 61505 is one of the most widely used standard in the safety domain. One of the key objectives of the IEC 61505 standard is to provide a basis for the development of domain – specific standards and covers all safety lifecycle activities. One safety standard evolving form this is IEC 61508, which include standards in health care, machinery, nuclear, and automotive. A recent similar and derivate of IEC 61508 in the automotive functional safety standard is ISO26262, which provides a full coverage of the safety lifecycle activities. The ISO 26262 standard is focus on the development activities at the system, hardware, and software levels**.** It is important to note that safety standards underline is the need to demonstrate an integration between the development processes and the safety activities.

The lack of existing and published rational, results in making safety standards is one of the major cause of companies' mistakes in this field, due to a poor understanding of the directive that the authorities aim to asses and/or due to lack of experience, *i.e.* due to turnover of staff or lack of engagement with the standardization community. Both researchers and practitioner are working to overcome this challenge.

The lifecycles in both IEC 61508 and ISO 26262 start with a definition and an analysis of the system and environment.

Another important safety standard: the Guidelines for Development of Civil Aircraft and Systems, the ARP4754A safety assessment model, emphasizes the bidirectional relationship between the main development activities (function definition, system architecture, and implementation) and the primary safety analyses, namely: functional hazard assessment (FHA), preliminary aircraft safety assessment (PASA), preliminary system safety assessment (PSSA), system safety assessment (SSA), and aircraft safety assessment (ASA). Independence between functions, systems, or items is often used as a key risk reduction strategy.

The relationship between safety at the design stage and safety at the operational stage is illustrated in the Federal Aviation Administration's (FAA) framework for Safety Management Systems (SMS) (AC 120-92A) (FAA, 2010), depicted in the Figure 9.53:

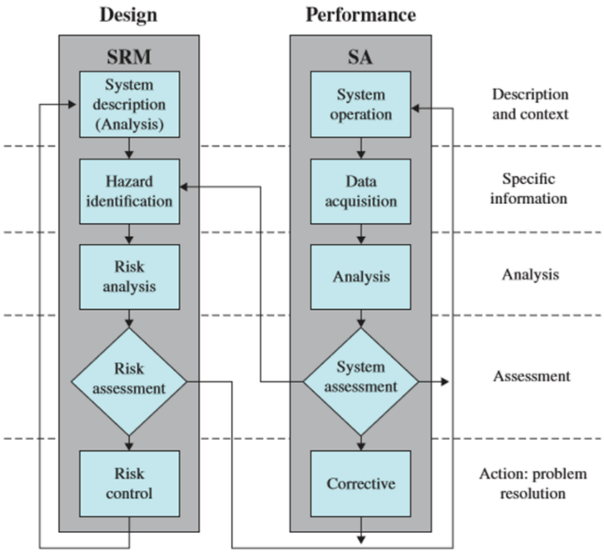

Figure 9.53 - FAA SMS framework – Feedback between SRM and SA.
Source: FAA 2010

The feedback between SRM and SA is used for providing ongoing safety assurance, and as a means for understanding design and operational weaknesses and improving the effectiveness of the safety controls, aiming to help institutionalize a learning and evolving safety culture.

How do the FAA and EASA ban foreign airlines or remove the ban?

The European Commission with the support of the European Aviation Safety Agency (EASA) chairs the EU Air Safety Committee (ASC). The Commission is constantly looking at ways to improve air safety standards by working with aviation authorities worldwide. According to International Aviation Law Institute, safety standards are clearly not being met globally. As an example, ICAO has identified Latin America, Africa, and Asia as disproportionately responsible for airline accidents. Moreover, other concerns have been raised by the absence of transparency and accountability in the growing Chinese aviation market.

In Europe, the Blacklist program began, in December 2005. EU Member States identify carriers subject to operating bans within their territory. Then, the FAA and EASA, in coordination with the EU Commission evaluates on common criteria the carriers and publishes at least every three months the EU Air Safety List in the Official Journal of the European Union. This includes one list of all airlines banned from operating in Europe and another one includes airlines that are restricted from operating under certain conditions in Europe. The EU Air Safety List helps to maintain high levels of safety in the EU, but it also helps affected airlines and countries to improve their levels of safety, making the EU Air Safety List a major preventive tool. In fact, banned carriers can request a compliance review from the Commission to be removed from the list.

The European Commission in Nov. 2017 updated the list of non-European airlines that do not meet international safety standards and are therefore subject to an operating ban or operational restrictions within the European Union. Following this last update, a total of 178 airlines are banned from EU skies:

- 172 airlines certified in 16 states, due to a lack of safety oversight by the aviation authorities from these states
- 6 individual airlines, based on safety concerns with regard to these airlines themselves

Moreover, six airlines are subject to operational restrictions and can only fly to the EU with specific aircraft types [http://europa.eu/rapid/press-release_IP-17-4971_en.htm].

It is important to note that, the civil aviation authorities of Member States of the European Union are only able to inspect aircraft of airlines that land at each Union airport. Therefore, the fact that an airline is not included in the list does not automatically mean that it compliant with all safety standards. With this in mind, it is necessary to improve the international safety standard as the assessment is made against them, and notably the standards promulgated by the International Civil Aviation Organization (ICAO). (http://europa.eu/rapid/press-release_IP-17-4971_en.htm).

EASA is therefore implementing technical cooperation projects with partner countries and regions. An example is the "Improving air transport in Central Africa" (ATA-AC) project, where EASA works with a number of African states on several aspects of aviation safety.

In light of this, there are several ways to improve safety such as the need of a new approach, better if it will be dynamic rather than static, to safety management and modelling accident analysis/prevention, which takes account of the varying risks during the different phases of flight and dynamically adapts the safety strategy accordingly. The "soft" regulation of aviation and the lack of strict enforcement also constrain improvements in safety management. These existing schemes of safety management in aviation, easily avoidable by GA aircraft owners and users, are mostly focussed on after flight. The "human" factor being the weakest link in the chain hence it should be better investigated.

The US ("country-based" approach) list is distinct from EU ("carrier-based" approach). The US approach to Blacklist, ensure that all foreign air carriers that operate to or from the U.S. are properly licensed and with safety oversight provided by a competent Civil Aviation Authority (CAA) in accordance with ICAO standards. In this regards the FAA look at the foreign CAA's capability for providing safety certification and at the foreign CAA's ability to provide continual oversight of its carriers. A country's failure to meet ICAO standards is published by the FAA. Moreover, in US the Flight Safety Foundation, which is an international non-profit organization, performs research, inspection, advice, and publishing to improve safety since 1947. This organization has helped protect everyone who benefits from air travel, everywhere in the world and works closely with other aviation organizations, including the Airline Pilots Association, Air Transport Association of America, ICAO, IATA, etc. The Foundation is in a unique position to identify global safety issues, set priorities and serve as a catalyst to address these concerns through data collection and information sharing, education, advocacy and communications.

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9.5 Security

Security is a global issue at least as much as safety because passengers can fly to airports worldwide, outside the jurisdiction of the authorities that apply stricter standards like Europe, the US or Japan. Many of these are popular tourist destinations besides important business hubs. The tendency for some airports to attract smuggling facilitates the infiltration of security threats. As for safety the regions with higher safety standards like Europe and the US could support security cooperation with other countries, especially those chosen as business or tourist travel destinations of its citizens.

Besides airport security another aspect is airways security about which each state should provide adequate warning. The shooting down of Malaysian Airways MH370 over the Donbass region of Ukraine is a tragic example of how easy it is to fail in this domain. The Ukrainian rebels were armed with shoulder-fired surface-to -air missiles that had been used to shoot down several Ukrainian military aircraft. The Ukrainian air force had restricted flying to altitudes above 9 km above the reach of such missiles. They did not know that longer range vehicle mounted surface-to-air missiles had been deployed in the region, and considered airline flights safe at typical cruise altitudes of around 10 km.

Ukrainian air force transport aircraft were also flying at those altitudes, and the missile was intended as a surprise shooting down of one of them and was advertised at internet as such. When it was realized that the target had been an airliner the internet announcement was quickly withdrawn, and a long process of denial, obstruction and destruction of evidence was started, including jamming of investigators communications near the crash site and hacking of their office in the Netherlands. Several airlines had simply decided not to overfly Ukraine, which in retrospect was a far better decision. Ensuring the security of air travel may require cooperation with intelligence services that can inform airlines on measures to safeguard their passengers, by evaluating the risks that their nationals could incur in certain regions of the world.

KEY TOPIC T9.8 ASSISTANCE PROGRAMMES TO IMPROVE AIRPORT SECURITY

Integrating security systems and operations into the planning and design of airport construction and refurbishment projects can be a very complex task. The term “security system” covers a broad range of equipment, technologies, procedures, and operational approaches that need clear and concise guidelines. The task is further complicated by an environment of evolving threats, often accompanied by the implementation of new legal or regulatory requirements and operational updates to counter the changing threat conditions. Finally, security systems are inherently difficult to plan, design, and implement when applied to airports, which are designed to facilitate the fast and efficient movement of customers and goods.

Airports tend to be in a constant state of change in terms of their physical layouts, operations, and tenants. Even as the industry has seen significant mergers of domestic and international airlines, new, alternative carriers are entering the market. And while the number of new airports being built is relatively small, many airports and terminals are being remodelled, expanded, and upgraded. The majority of changing security requirements will be accomplished in existing facilities that are often decades old, designed at a time when the threat profile and the security environment were dramatically less stringent than they are today.

All these points emphasize that there is not a single, one-size-fits-all solution to the unique problems encountered at each airport when designing and integrating security systems, nor is there a single planning and design approach for the physical space and facilities that can be universally applied to all airports.

In response to the September 11, 2001, terrorist attacks in the United States, and with the potential for future attacks, the President signed into law the Aviation and Transportation Security Act (ATSA) on November 19, 2001. The creation of the DHS (Department of Homeland Security) by the Homeland Security Act of 2002 realigned a patchwork of government activities into a single department with the primary mission to protect US homeland, resulting in the most significant transformation of the U.S. government since World War II. There are numerous advantages to incorporating security concerns into the airport planning and design process at the earliest phases of planning and development.

Timely consideration of such needs will result in less obtrusive, less costly, and more effective and efficient security systems. Such systems are less likely to provoke passenger complaints or employee resistance and are more able to fully meet regulatory and operational requirements. Proper planning can also result in reduced manpower requirements and consequential reductions in airport and aircraft operator overhead expenses. Careful review of the prevalent threat environment, and applicable security standards and countermeasures prior to finalization of construction plans, will help determine an airport's most appropriate security posture. Such a review may also help to reduce reliance on labour-intensive procedures and equipment, which is common when an airport is required to quickly retrofit security.

Inclusion of security experts early in the planning process will result in a better coordinated and more cost-effective approach to security.

Planning for security must be an integral part of any design project undertaken at an airport, including physical structures and IT systems, among others. The most efficient and cost-effective method of instituting security measures in any facility or operation is through planning and analysis at the start of the design process, supported by monitoring and amendment of those analyses, if required, throughout the project. Selecting, constructing, or modifying a facility without considering the security implications for the protection of the general public, the facility, passengers, and airport and air carrier personnel can result in increased risk to persons and assets, as well as have a costly impact on facility modifications, or cause project delays.

The airport operator has a responsibility to provide a safe and secure operating environment and infrastructure. The extent of necessary facility protection should be examined by the local Airport Security Committee, based on the results of a comprehensive security assessment of the existing facility. High priority should be placed on protection of the aircraft from the unlawful introduction of weapons, explosives, or dangerous substances.

Perimeter protection (e.g., fences, gates, and patrols) is the first line of defence in providing physical security for personnel and property at a facility. Some more advanced technologies can reach outside the fence to identify approaching threats or may be used in an environment where there is no fence or physical barrier, such as a water boundary or swamp.

The second line of defence, and perhaps the most important, is interior controls (e.g., access control and checkpoints). The monetary value and criticality of the items and areas to be protected, the perceived threat, the vulnerability of the facility, and the cost of the controls necessary to reduce that vulnerability, will determine the extent of interior controls.

The primary objective of facility protection planning is to ensure both the integrity and continuity of operations, and the security of assets. Any area designated as requiring control for security and/or safety purposes must have identifiable boundaries for that area to be recognized and managed. In some cases, boundaries must meet a regulatory requirement to prevent or deter access to an area. In many instances, however, boundaries may not be hard physical barriers, such as fences or walls; they might instead be painted lines, lines marked and monitored by electronic signals, grass or pavement edges, natural boundaries such as water or tree lines, or simply geographic coordinates. The distinctions between these different areas must be understood by the design team, such that they are clear on how the physical design of space and structures relates to the physical and virtual boundaries.

In order to implement security at an airport, it is necessary to understand and quantify the degrees of security into three key issues:

1. What is the threat to the airport?
2. What is an airport's level of vulnerability relative to each element of that threat?
3. To what extent is the threat/vulnerability likely to change, and why?

A vulnerability assessment is an excellent tool and the primary means for determining the extent to which a facility may require security enhancements. It serves to bring security considerations into the mix early in the design process, which reduces the risk of a more expensive retrofit after the design or construction has begun. Many tools and methodologies are available; all are subjective to varying degrees, largely because, in every case, one must first have a thorough understanding of both short- and long-term threats in order to understand and respond to the three key issues noted above. With this in mind, the planning and design team's response to these points will be a recommendation of a combination of security measures, both physical and procedural, to provide enhanced security and ease of movement for both passengers and employees.

The Airport Security Committee may offer recommendations that consider the following:

- Known threat(s) specific to the airport and/or to the airlines serving it;
- History of criminal or disruptive incidents in the area surrounding the facility, but not primarily directed toward airport operations;
- Domestic and international threats and the general integrity of the transportation system;
- Facility location, size, and configuration;
- Extent of exterior lighting;

- Presence of physical barriers;
- Presence of access control and alarm monitoring systems, closed-circuit television systems, and other electronic monitoring systems;
- Presence and capabilities of onsite staff, law enforcement, and/or security patrols;
- Other locally determined pertinent factors, such as general aviation, commercial operations, and intermodal transportation facilities.

Airport and aircraft operators provide protection through a combination of mobile patrols or fixed posts staffed by police, other security officers, or contract uniformed personnel; security systems and devices; lockable building entrances and gates; and cooperation of local law enforcement agencies. The degree of normal and special protection is determined by completion of a vulnerability assessment and a crime prevention assessment.

The local police department may collect and compile information about criminal activity on or against property under the control of the airport, provide crime prevention information programs to the occupant and federal agencies upon request, and conduct crime prevention assessments in cooperation with appropriate law enforcement agencies.

In addition to physical protection, airport operators also need to keep records of incidents, personnel access, or other activities. Some of the records (such as personnel access) may be collected automatically. Recordkeeping needs, including some video applications, may affect IT systems, cable designs, and equipment locations, as well as require secure data storage. These needs should be coordinated early in the design process.

It is important to consider security systems and procedures from the beginning of the design phase through completion, so that space allocation, appropriate cabinetry and furnishings, conduit runs and system wiring, heavy-duty materials, reinforcing devices, seismic requirements, and other necessary construction requirements are provided in the original plans.

The first step toward integrating security into airport planning, design, or major renovation is the analysis and determination of the airport's general security requirements. The range of available options, configurations, and functions is very broad. There is no single solution, and with very little examination, it is apparent that there are a large number of issues that must be addressed before a best approach and optimal solution can be achieved at any given airport.

The place to start is defining operational requirements, and most common views on the development of a Concept of Operations characterize the process in terms of eight basic questions:

- *What does the project involve: an update of existing infrastructure, a move or expansion into new facilities, operational reorganization, new interfaces with airport departments and government agencies, or mutual aid?*
- *Why is this project happening? What is the impetus: system integration, physical expansion, growth forecasts, outdated technology, new regulatory requirements, inadequate or failing infrastructure, or administrative restructuring?*
- *Who are the users and stakeholders, both internal and external to the organization? What are their operational goals, and what information do they require?*

- *What infrastructure exists? What threats and vulnerabilities exist?*
- *Which new technologies will be most appropriate to best serve the different priorities and interactions among user groups?*
- *What human factors need to be accommodated, such as ergonomics, lighting and noise levels, sight lines, design factors for dealing with multiple technologies and/or multiple events, and certain staffing and training criteria?*
- *What is the realistic budget and where it is coming from? What are the additional related costs, such as those for staffing and long-term training, operations, and maintenance?*

Asking the question "what?" seeks to identify the depth and breadth of security functionality to meet appropriate user requirements. What array of services is the facility expected to offer? What information is it expected to provide, to whom, and for what purposes? This can include a range of points, all needing early identification, as they will drive the detailed approaches to planning and design. What systems and services are needed to meet the user requirements? This is limited to a high-level definition of systems in operational terms rather than in technical terms. Unless there is a specific reason for identifying details of a system, this should initially be generalized. The reasons to identify a new or upgraded system or service may include: a legacy system may exist and continue to be used; or the owner of the facility may have other operational, legal, policy, budgetary, physical space or contractual constraints that limit the ability to make changes to or replace a system. Developing a description of the appropriate level of functionality requirements will serve as the foundation for more detailed design of the systems.

Answering "Why?" will lead to identification of the objectives of the security system project. Why is it needed? For airport expansion and growth projections or consolidation of operational and administrative functions? For outdated or failing technologies and infrastructure, or possibly new regulatory requirements that address operational gaps and user needs? Or, perhaps, for all of the above? As a subset to this, the answer should also identify operational and administrative issues, policies, and constraints affecting the facility, which inform the planning process in determining how the project will be executed to achieve its objectives.

This emphasizes the importance of having all stakeholders engaged in development of the Concept of Operations. The comparison and contrast of views between the executive level and the operational level should identify gaps in the objectives; identify conflicts and redundancies to be addressed and resolved; allow for the identification and resolution of differing levels of criticality and priorities; and provide a baseline for establishing near-term and long-term objectives.

"Who?" addresses the identity of stakeholders, e.g., individual or organizational, internal and external to the security system and its operational elements. It should address the user requirements as classes or descriptions of users who are meaningful to the organization. In addition, it should include the operational requirements necessary for their primary responsibilities. This also begins to identify the support activities of stakeholders that arise beyond the anticipated operational activities—who owns the facility, who maintains it, who manages and pays for it—thus, also identifying persons or offices who, while not primary users, significantly influence how the project is ultimately designed and operated.

It should also provide the initial identification of the types of personnel, and the number and type of functions that will be located in the facility or interact with it in some form; identify the level and priorities of personnel or organizations that will be engaged in the process during design and development; and identify at a high level the roles and responsibilities of the stakeholders with a definition of their operational interactions, both internal and external.

For any security system, a typical stakeholder list might include the following groups:

- Management/executive staff;
- Communications staff/dispatchers;
- Law enforcement, contract security;
- Airside operations;
- Landside operations;
- Curbside and ground transportation;
- Airport facilities and maintenance;
- Airport development/engineering;
- IT;
- Risk Management;
- Air Traffic Control;
- Airlines;
- Military joint use;
- Adjacent commercial/industrial parks;
- Local/state/regional government;
- Surrounding community.

To answer "when?" one should realize that the development of a security system may not be an isolated project. It will frequently be a part of a larger effort such as a new or renovated terminal and have an effect on many other related activities. It is essential to have a clear but flexible schedule to allow for coordination with related programs, conflict avoidance, and incorporation of opportunities for collaboration with other projects or actions. Often, the timing may be driven by a need to meet regulatory, policy, or other procedural requirements, the nuances of which must be thoroughly understood as part of the driving force behind development.

A preliminary project schedule should reflect at least the following five periods:

- Concept development period;
- Pre-design phase;
- Planning and design period;
- Construction or implementation period, including changeover;
- Useful life of the facility past construction or implementation – This element is often overlooked, but it can establish a basis for later planning for anticipated upgrades, replacement, or expansion, all of which must be reflected in long-term planning and budget considerations.

During planning and design phases, this baseline schedule will be refined and enhanced by the design team based on budgets, resource availability, project scale, and other evolving factors.

Addressing where to locate a new facility can become somewhat complex, especially when the facility has special requirements, or future moves, additions, or changes are planned. These can include different requirements for physical separation or proximity to another facility. For example, regulatory or operational limitations on the facility site may reflect requirements for setbacks from another area for reasons of safety or security; limits in the amount or suitability of the space; infrastructure constraints; adequacy of IT capabilities in alternate locations; budget considerations; threats and vulnerabilities relative to its operations; and access requirements.

"How?" addresses how the facility can be successfully developed and implemented, based on the information developed throughout the process. It includes such issues as funding, personnel, integration of existing and planned infrastructure, architectural constraints, coordination of planning and design concerns, and a list of other locally unique activities and assets to be accommodated in order for the project to move forward. The resolution of "how" is a particularly critical element of the Concept of Operations as it establishes each sequential set of activities, to be set in place for the guidance to be fully effective.

This will vary depending on the particulars of each project, but, in general, should include a rough order of magnitude of "soft" costs such as planning, design, and consulting fees required to develop the project; a similar rough order of magnitude of the "hard" costs such as capital expenses for construction of facilities, IT and communications infrastructure expansion, equipment, labour, and related costs; internal and external professional resources necessary to complete and support the project, such as maintenance and training; and a proposed schedule of steps to be undertaken throughout the process, and milestones to be accomplished.

A key element of the Concept of Operations for the development of an airport security system is a Risk Assessment, the principle components of which are a determination of threats and vulnerabilities. The standard risk formula is risk = threat x vulnerability x consequences [R= T x V x C]. In fact, a risk assessment is necessary in the general development of airports and other mission critical facilities and should be a standard element of the early supporting activities. The risk assessment can establish some starting points: what systems are in place, what changes are planned, what their strengths and vulnerabilities are with respect to a range of likely threats, and how the security planning and design process can address them in an optimal operational and cost-effective manner. The actions taken in response to the risk assessment will often include measures designed to increase the ability of a facility to respond to an event or multiple simultaneous events, as well as provide increased safety and security measures as the irregular operations evolve. As some of these measures can increase costs for the development of the security system, it is essential that the assessment provide a clear definition of the risks and vulnerabilities to be addressed during planning and design.

The key elements of a threat and vulnerability assessment include the following:

- Develop a clear perspective of the interrelationships among the facility, the organization, and its assets. Assets include property, systems, structures, business, information/data, and people.
- Identify the threats and vulnerabilities and the risks associated with each. An outside party, preferably a party with expertise in the risk assessment process, can do this initially. The approach used by the outside party may vary from the relatively benign to the very aggressive. Regardless of the approach, the external assessment should be combined with information on the range and probability of threats and vulnerabilities known to the facility owner.
- Quantify the probabilities associated with each of the identified risks. To the greatest extent possible, the probabilities should be based on factual data. Probabilities of risk can be gathered from a range of sources, including local, state, and national agencies that have experience with events and incidents.

Once a set of risks has been identified, planners should quantify the value of losses associated with each risk. This includes financial costs, costs due to loss of use of a facility or function, cost to recover, loss of life, loss of earnings or revenue, and loss of good will and trust. The value of a loss resulting in direct relation to the risk needs to be measured against an established system of values.

Threats and vulnerabilities change over time, as does an organization's response to both. A risk assessment should not be a one-time activity, but should be revisited when experiencing major organizational, facility, or operational changes. An airport operator should not go more than five years between thorough threat and vulnerability assessments; more often if changing conditions warrant.

Situational Awareness

Situational awareness is the perception of events and activities in real or near-real time seen by an individual or group, and their understanding of how those events and activities may be related. More simply stated, one should know what is going on from moment to moment so that the Security Operations Centre (SOC) operator can react, if required.

Situational awareness can be developed through a number of different means. It can include:

- Direct observation of an event or situation;
- Observation reported by third parties;
- Observation through CCTV systems;
- Observation through sensing systems (e.g., fire alarms, security alarms);
- Observation related by news and media outlets.

Too much information, particularly if it is irrelevant or distracting from a critical event, can be detrimental to effective decision making by the SOC operator. Excess information can place such a high demand on human operators or responders that they cannot absorb or process it all and may miss or misinterpret critical points.

This is not to suggest that available information should be limited. An SOC should have access to information where it is appropriate and useful to decision making. Several approaches can be taken to avoid overloading the SOC without losing vital information:

- Disperse blocks of information to different people or teams, who filter critical data to a manager or team charged with decision-making.
- Establish levels of criticality for information or alarm conditions, such that more urgent concerns are elevated for attention sooner.
- Provide a smaller number of points to focus on, while allowing different information streams to be viewed. An example of this is a video wall with a limited number of screens but a high number of video feeds, allowing the SOC operator to select and change their primary views as the situation develops.

Key considerations and elements of effective situational awareness include:

- Good quality information delivered in a timely manner;
- Where situational awareness drives organizational response to an event or activity, reliable bi-directional communications are essential;
- Flexibility to allow for changing conditions;
- The level of situational awareness required of the SOC staff drives the information sources that need to be delivered.

9.6 Fair Trade

Trade disputes are not unknown in aviation at the highest level of the World Trade Organization (WTO). After having initially dismissed Airbus as a 'government aircraft', when it realized this was a serious competitor, Boeing tried to prove its claim at the WTO. The United States on behalf of Boeing filled a complaint that Airbus was subsidized by European governments since it received low interest loans for aircraft development, refundable from subsequent sales. The counter argument was that Boeing benefitted from US Air Force and NASA contracts, for example the Boeing 707 was based on the military transport C-135 and KC-135 tanker. The Air Force owns factories that it can lend to industry at nominal or zero cost; the NASA contracts cover 100% of costs whereas in some EU research programs the industry pays 50%. It is unclear whether the protracted litigation was of benefit to anyone, certainly not to airlines that want competition between Airbus and Boeing, not a monopoly of either of them.

The reverse process occurred with the EU on behalf of Airbus filling a complaint with the WTO about the US export-import bank low rate loans in support of the exports of Boeing aircraft. The case was won by European side that was allowed to apply penalties as a compensation but may have elected not to do so. The response on the US side was to change the export support law, to one protecting employment in the US and discouraging delocalization of industrial activity abroad. The practical effect in terms of 'export subsidies' was the same except that they now covered a range of industrial sectors wider than just aviation. An example that WTO rulings can be sidestepped by new legislation that aggravates rather reduces the trading inequalities. At present the future of the export-import bank in the US is under discussion in spite of the support of Boeing because it gives loans to foreign airlines competing with US airlines. In the meantime, Airbus has plentifully refunded European governments for the former development loans and is healthy enough not to need them anymore.

The Airbus-Boeing duopoly of large airliners is not alone to come to WTO fillings, since the Canadian government on behalf of Bombardier has accused Brazil of subsidizing Embraer. More recently the tables were turned around in the context of the sale of C-Series in the US at low prices after major cash injections of the Quebec government into Bombardier, that are suspect of financing dumping. Bombardier noted among other things that more than 50% by value of a C-series is American, and that percentage will go higher when the production line moves from Canada to the US as part of the deal with Airbus. Even some Airbus aircraft with American engines have more than 50% American content due not only to propulsion but also several other systems.

Boeing maximizes value in final production that takes place at three sites; the third in a southern state whose laws give less bargaining power than the trade unions have in Seattle. Airbus maximizes value at its partners and has the main two production lines in Europe plus final assembly lines in China and the US, the latter increasing local content. There is substantial international content both in the Airbus and Boeing aircraft, often starting with engine options and continuing with a worldwide supply chain. The airlines have no interest in trade disputes and the Boeing-Airbus competition suits well their bargaining power when buying new aircraft as the Bombardier-Embraer competition did. The link Airbus-Bombardier and Boeing-Embraer if they strengthen would mean that: (i) for more than 150 seats there would still be the choice of Airbus or Boeing and likewise for jets of less than 100 seats a choice between Bombardier and Embraer; (ii) in the range 100 to 150 seats the choice might narrow down from 4 to 2, extending the duopoly to almost all the jet airliner market.

KEY TOPIC T9.9 FAIR TRADE

T9.9.1 International Content in Airbus, Boeing, Bombardier and Embraer Airliners

Aircraft manufacturing is arguably the most contested industry in international trade governance.

The two lead actors in this topic are Boeing and Airbus for long-range aircraft, and Bombardier and Embraer and others for regional aircraft. Ever since Airbus emerged some 40 years ago to challenge Boeing's position as the world's dominant aircraft manufacturer, governments have been accusing one another of illegitimately propping up their respective national champions, while simultaneously professing their own innocence in providing support.

The traditional tools of trade governance are particularly ill-suited to aircraft manufacturing. The basic logic behind trade enforcement mechanisms, whether pursued unilaterally or multilaterally through the WTO, is an attempt to "level the playing field," or to correct the market for the distortions of government interventions. The problem is, when it comes to aircraft manufacturing, there has never been anything close to a perfectly competitive, distortion-free market: It is politics and subsidies all the way down. Not only are subsidies on the production side, but governments are also the most important consumers of aircraft, buying both military planes and consumer planes for publicly-owned national airlines.

Thus, the aircraft market consists of governments subsidizing production by their national champions, then lobbying other governments to buy their planes, often linking these procurement decisions to diplomatic relationships. There is not a good methodology to reasonably price this subsidy. Moreover, this points to the larger problem in trying to arrive at a "fair" outcome in the aircraft subsidy complaints: Given how governments are so deeply and fundamentally involved in the industry, asking what a jet would cost in the absence of government distortions to the market is an impossible question.

Furthermore, the aircraft manufacturing industry shows both the strengths and limits of the rules-based, legal approach to global economic governance. The WTO has made a valiant attempt to discipline some of the more direct subsidies governments provide to their aircraft manufacturers. But the legal record shows it has been a long, drawn-out fight, with no signs of easing. And the institution is not cut out to weigh into the informal, indirect subsidies provided by defence contracts, let alone adjudicate how much diplomatic pressure is appropriate in pushing for a jet sale.

Meanwhile, looming on the horizon is a bigger and potentially far messier aircraft subsidy fight. Recently, China's COMAC, a state-owned aircraft manufacturer, completed a successful first flight test of its new jetliner, designed to compete with Boeing and Airbus. For now, neither Boeing nor Airbus wants to take an aggressive stance against COMAC, as the two Western companies don't want to risk losing out on lucrative sales to China's domestic airlines. But ultimately, they, along with their government backers, will need a strategy for dealing with this new challenger. Perhaps this will finally prompt Boeing and Airbus to aim their attacks away from one another and toward a common threat, just as Siemens and Alstom recently joined forces to take on the China Railway Rolling Stock Corporation, China's state-backed train maker that's winning more and more contracts overseas. In the meantime, expect the aircraft subsidy feuds to continue; at the moment Boeing seems to have lost the battle, but the war is far from over.

T9.9.2 Europe/ Airbus versus US/Boeing at the WTO

Before the US took on Canadian subsidies to Bombardier, it had long been decrying the "launch aid" European governments gave Airbus to help it bring new models to market. The Europeans, for their part, complained about the indirect subsidies Boeing received in terms of inflated defence procurement contracts and NASA research expenditures. The two sides reached something of a truce in a 1992 agreement that set limits on subsidies, but that deal broke down about a decade ago, and since then the disputants have been fighting it out in a series of seemingly never-ending World Trade Organization (WTO) disputes.

The following Figure 9.54 shows the data of the last 10 years where the U.S. has pursued a case before the World Trade Organization (WTO) against illegal European subsidies for Airbus.

The US allege that the low interest loans have given Airbus an unfair advantage, enabling it to capture 50% of the global market for large commercial airplanes, at America's expense, when in fact Airbus has repaid all loans with a profit to the European governments that acted as lenders.

The European Union has filed baseless counterclaims against the US based on military and NASA contracts. It is time for both sides to meet their global trade obligations and eliminate the $22 billion of illegal subsidies the WTO has said must go.

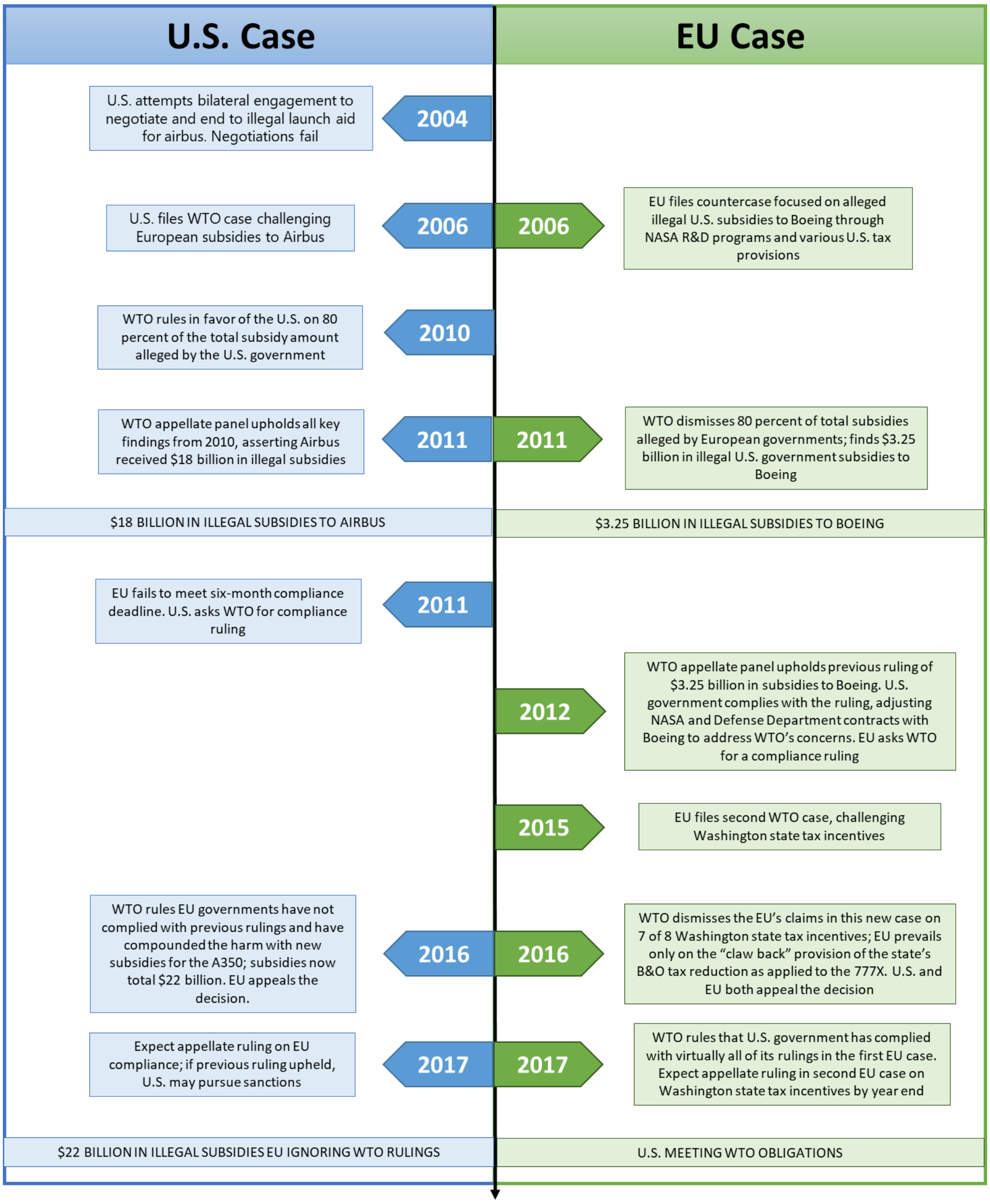

Figure 9.54 - Aerospace Subsides Dispute Timetable
Source: Boeing

T9.9.3 Canada/Bombardier versus Brazil/Embraer at the WTO

Brazil and Embraer have also brought their complaints against Bombardier, which are very similar to the grievances alleged by Boeing, to the WTO, in a case that is still pending. All in all, aircraft manufacturing is arguably the most contested industry in international trade governance.

The Airbus-Boeing duopoly of large airliners is not alone to come to WTO fillings, since the Canadian government on behalf of Bombardier has accused Brazil of subsidizing Embraer.

Therefore, the main problem between Canada / Bombardier and Brazil / Embraer centres on a conflict over the Canadian government's aid to Bombardier. The aim is to prevent the poisoning of bilateral relations, which recently recovered completely from the impact of a similar struggle in the past.

The conflict has reached the point that the Canadian government threatened to use hundreds of millions of dollars in trade sanctions against Brazil for the use of short-term loans for Embraer, a direct competitor of Bombardier in the global aerospace market.

T9.9.4 The Saga of the C-Series Scale to Eastern Airlines

The Bombardier C Series is a family of narrow-body, twin-engine, medium-range jet airliners by Canadian manufacturer Bombardier Aerospace. The C Series models are the CS100 and the CS300, which have been built with leading-edge technology and systems integration, advanced materials and aerodynamics. They have been designed specifically for the 100- to 150-seat single-aisle market. They are very efficient and economic aircraft, thanks to significant reductions in fuel burn and operating costs. The CS100 aircraft carries between 100 and 135 passengers and offers a great flexibility for many airline business models. On the other hand, the CS300 aircraft is a good solution for mid-sized markets with up to 160 passengers per flight. The CS100 and the CS300 have a range of 3100 and 3300 nautical miles respectively.

According to Bombardier market forecast, in the next years China will be a region with one of the largest fleets in the 60-to 150-seat segment. It is expected that the passenger traffic in cities away from the main hubs of Beijing, Shanghai and Guangzhou grows significantly, which is an opportunity for convincing airlines to opt for the 110-150 seat C Series planes.

Nowadays, Bombardier has a strong presence in the Asian-Pacific region, with 40 airlines that operate 330 Bombardier regional and small single-aisle aircraft, which a great success in the 100-70 150-segment. The launch customer for the C Series in Asia was Korean Air, who ordered 10 CS300 with 10 options. Korean Air have taken delivery of two CS300 aircraft to date and had their first revenue flight from Seoul to Ulsan on January 20, 2018. Therefore, one of the objectives of Bombardier will be keep focusing in the China market and obtaining deliveries from Chinese airlines.

In the following Figure 9.55, it can be seen the number of C series orders in recent years:

Figure 9.55 - C series orders, cumulative by year
Source: Bombardier web page

As it can be seen from the previous image, the number of orders of the C series has increased in recent years. The first Bombardier C series deliveries were carried out in 2016, five CS100 to Deutsche Lufthansa and two CS300 to airBaltic. In 2017, a total of 24 C series aircraft were delivered, eight CS100 and seven CS300 to Deutsche Lufthansa, seven CS300 to airBaltic and two CS300 to Korean Air.

In 2016, Bombardier and Delta Air Lines announced that they had executed a firm agreement for the sale and purchase of 75 CS100 aircraft, which meant the largest C series order, as it can be seen in the next Figure 9.56:

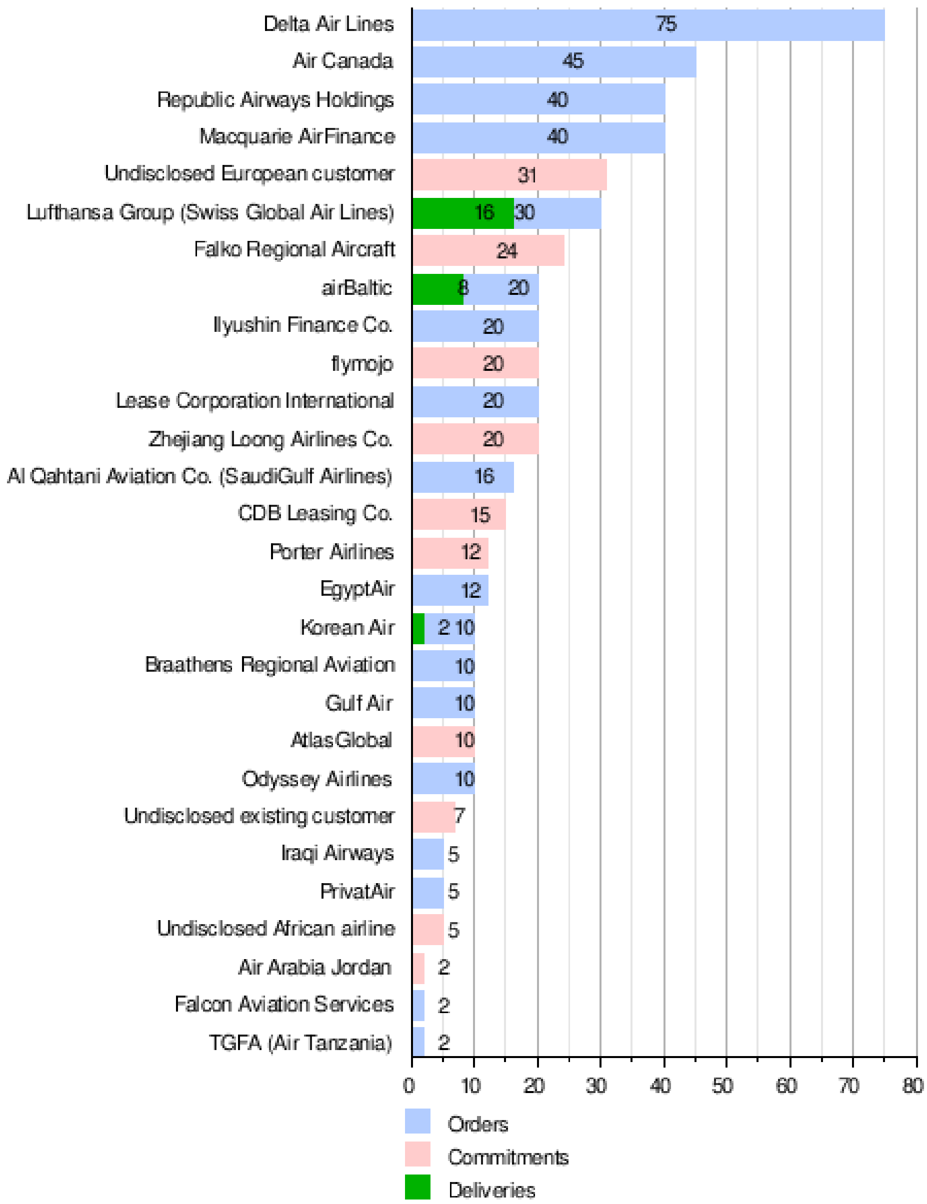

Figure 9.56 - C series orders and deliveries by customer
Source: Wikipedia web page

In addition, in 2017 Airbus and Bombardier signed an agreement through which Airbus would manufacture the C series. Being a part of the model manufactured in US soil, Bombardier will avoid the tariffs of 300% recently imposed by the US Government on C series airplanes. In addition, it will share resources, costs and technology with Airbus, which will be a relief for its deteriorating finances.

This agreement will be very beneficial for both sides, since it will allow Airbus to compete against Boeing, which is its biggest rival. The agreement will be continued even though Boeing lost the case.

The orders from the C-Series pale by comparison with the 10,000 deliveries of the B737 and 8,500 of the A320, both much longer in the market.

9.7 Open Markets

Major exceptions to open markets in civil aviation do exist, generally uncontested. Perhaps the most visible and long-standing is that the Japanese airlines tended to buy Boeing aircraft more often than from Airbus, though the difference has reduced over time. The reason is the Japan to the US trade surplus, that the Japanese government tries to reduce through various measures, including airliner purchases. The Japanese airlines are happy and willing to oblige by buying Boeing aircraft, as long as it is in the national interest, but not otherwise. A possibly isolated instance of the latter was the indictment of former Prime Minister Kokuei Tanaka for prompting some Japanese airlines to buy Lockheed Tristars instead of other American widebodies. When this become known through the enquiry of the US congress on the Lockheed bankruptcy, Tanaka was still prime minister and refused to resign; his party, that had majority in parliament, voted him and itself out of power with a non-confidence vote.

Boeing has consolidated its hold in the Japanese market by including Japanese industry in the production of its aircraft; it has gone further with Japan financing part of the development of the B787 together with some American states. The Japanese have limited their indigenous production to regional aircraft or smaller, for example the Nanc YS-11 in the past and the Mitsubishi MRJ-100 and Honda business jet at present. China has apparently tried to use airliner purchases as a political instrument, depending mostly on its relations with the US, buying more Boeing aircraft during the up periods and less in the down periods. The Airbus final assembly line for the A320 in China is a more stable prospect. It is also possible to find the opposite example of Japan, with Italy and other producing assemblies for Boeing and Airbus.

The times when the US market was closed to Airbus are long gone, and most airlines make the most they can of the Airbus-Boeing competition. In the past Boeing could charge high prices for the Boeing 747, when it was the only jumbo available, possibly financing the rest of the range. More recently in the twin-aisle long range market the preference of major airlines for a twin-engine instead of the Airbus A380 may have allowed Boeing to charge high prices for the B777X stretch. In most sectors of the airline market the Boeing-Airbus duopoly is desirable not only to give airlines bargaining power to keep prices in check; it also promotes technological progress and efficient air travel ultimately for the benefit of airline passengers.

The development of a modern long-range airliner costs over 10 B€ over 5 years. An aircraft manufacturer needs big, sustained profits to finance the development and production until break-even is reached. Bank loans at commercial rates of interest are hardly viable when break-even is 10 or more years away.

The Boeing 787 is an example. Optimistic predictions put development at 10 B$ over 3 years. At the end of an 8 years development program Boeing had accumulated a 30B$ debt. Despite favourable conditions from the US states where the facilities are located and a sizeable contribution (20-40%) from Japan.

The B787 was the most successful airliner programme ever, with over 1,000 orders before entering service. Boeing is not stating when the 30 B$ debt will be covered. With unit prices of around 300 M$ a 10% profit percentage of 30 M$ a piece would cover the debt with 1,000 sales, less than those already achieved.

The development of the A380 costs over 16 B€. It is not clear if it will ever be recovered or even if it low rate production is self-sustaining. Yet with a backlog of more than 5,000 aircraft costing 100-450 M$ each, both companies can survive some large holes in their balance sheets.

KEY TOPIC T9.10 OPEN MARKETS

T9.10.1 The Japanese Market Captive of Airbus

For more than half a century, Boeing has been the top provider of commercial jetliners to Japanese airlines and a major supplier of military equipment and aircraft to the Japanese Ministry of Defence (JMoD). Boeing opened its doors in Japan in 1953, just two years after Kawasaki Heavy Industries and Showa Aircraft were contracted by the US government to maintain US military aircraft, a move that restarted Japan's aircraft industry.

The US's relationship with Japanese industry started in 1956, when Mitsubishi Heavy industries commenced the licensed production of the North American F-86 Sabre Jet fighter. The relationship continued to grow over the coming years in both the defence and commercial areas, and Boeing expanded the number of programs on which it collaborated with Japanese Industry, as well as the number of partners. During those years, Boeing transferred new technology to Japan and, in turn, Japan used that acquired technology in support of Boeing programs.

Today, Boeing retains deep supplier, customer and partner relationships across Japanese government, industry and civil society.

In the following sections, it will be described the relationship between Boeing and Japan in the military and commercial areas in the past years. The following Figure 9.57 summarizes this relationship:

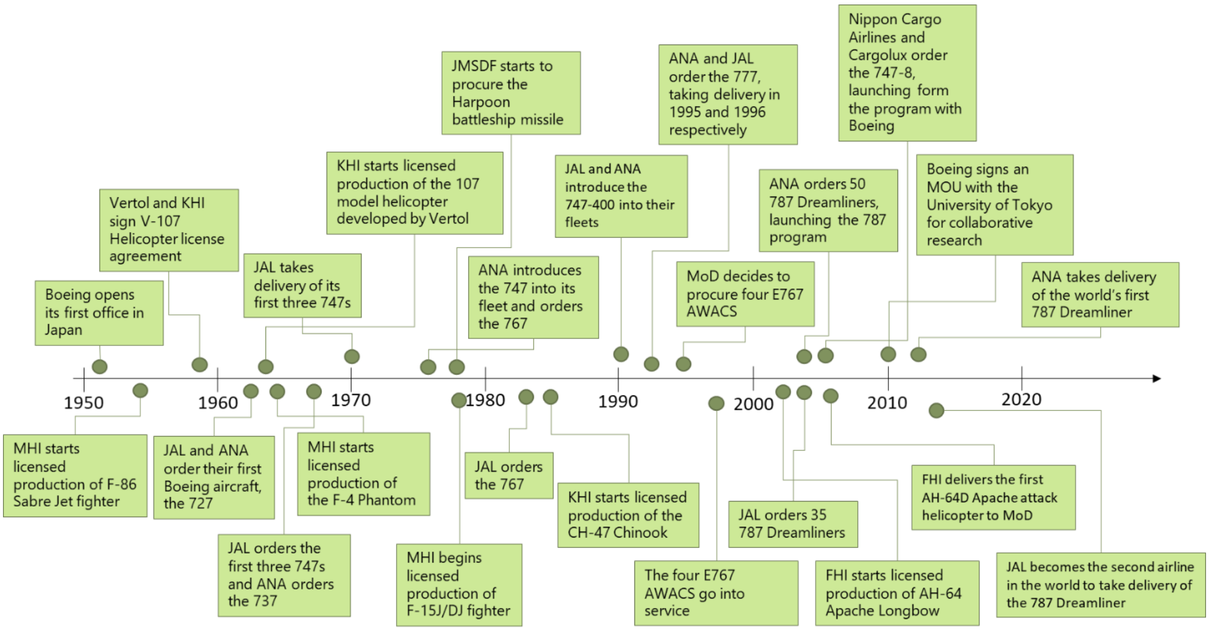

Figure 9.57 - Relationship between US industry, including Boeing and Japan timeline
Source: Boeing

Commercial Airplanes

Japan has long served as one of the largest financial international markets for Boeing Commercial Airplanes. Over the past 50 years, Japanese carriers have ordered more than 970 Boeing jetliners, and Japan is one of Boeing's largest twin-aisle markets.

In the past decade, nearly 80 percent of the commercial aircraft ordered by Japanese customers have been Boeing products. Japan is the single biggest customer for the 787. Japan Airlines (JAL) purchased more 747s than any other airline customer and All Nippon Airways (ANA) is the largest international customer for the 767 family of airplanes. Together, Japan's major carriers make Japan one of the largest international customers for the 777, with more than 100 ordered.

Japan also plays an important role in launching major new programs. Japan's Nippon Cargo Airlines, together with Cargolux, launched the 747-8 Freighter in 2005. In addition, Japan Airlines and All Nippon Airways were among a number of carriers with whom Boeing held intensive discussions to define and develop the 777 configurations. All Nippon Airways was also a 777 launch customer and became the first Asian operator. Moreover, Japan airlines served as launch customers for the 767-300, 767-300 Boeing Converted Freighter and 737-700ER.

In 2004, All Nippon Airways (ANA) launched the 787 Dreamliner with 50 orders, which represented the largest launch order for a Boeing commercial airplane at the time. In addition, Japan Airlines (JAL) selected the 787 Dreamliner as its next-generation midsized twin-aisle airplane and joined the 787 launch team with an initial order of 35 airplanes. All Nippon Airways (ANA) and Japan airlines (JAL) both collaborated with Boeing in the development of the Dreamliner, sharing their expertise in passenger amenities, airplane performance and aircraft maintenance. All Nippon Airways and Japan airlines became the first customers to fly the 787 Dreamliner in September 2011 and April 2012, respectively. Since then, both airlines have made incremental 787 orders that include all members of the Dreamliner family: 787-8, 787-9 and 787-10. Japan has more than 90 787s flying todays, more than any other country.

Military Airplanes

Boeing Defence, Space and Security and Japan's Ministry of Defence (MoD) have a long history of working together to meet Japan's defence needs. This cooperation dates back to 1956 and the licensed production of the F-86 Sabre by Mitsubishi Heavy industries (MHI). Boeing continued collaboration with the Japanese industry through licensed production of the Vertol 107 helicopter and the F-4 Phantom.

In 1981, the first non-US delivery of 10 F-15 Eagles began under the Peace Eagle program. Four more F-15s were delivered to Japan in 1983, and in total, Mitsubishi Heavy Industries (MHI) built nearly 200 F-15J/DJ Eagles under licensed production. Today, Japan operates the second largest fleet of F-15s in the world. Boeing is currently involved with Mitsubishi Heavy Industries in upgrading the F-15J/DJ aircraft to fulfil Japan's desired mission effectiveness well into the 21st century.

The F-1 and F-2 fighters developed by Japan, involved the American companies and technology transfer to the US.

Defence, Space and Security has provided many other defence solutions to Japan's Self-Defence Forces. In 1978, the Japan Maritime Self-Defence Force first placed orders for Harpoon anti-ship missiles and, currently, it is second only to the US Navy in terms of the number of Harpoon missiles in its inventory.

Boeing began delivering CH-47 Chinook helicopters to the Japan Air and Ground Self-Defence Forces in 1984. Since then, Kawasaki Heavy Industries (KHI), under license by Boeing, has manufactured and delivered 100 CH-47s to Japanese forces, providing Japan with the world's second largest operational Chinook fleet.

Other deliveries provided by Boeing have been 13 AH-64D Apache Longbows, with the first of them delivered in March 2006, through a license agreement with Subaru. Boeing has also delivered four KC-767 tankers and four Airborne Warning and Control System (AWACS) aircraft to JASDF and continues to provide ongoing support and upgrades for these platforms.

Boeing Partners in Japan

Around 150 Japanese companies are suppliers to Boeing across its commercial and defence product lines. Mitsubishi Heavy Industries, Kawasaki Heavy industries and Subaru produce components for Boeing commercial models and manage licensed production of Boeing defence products (Figure 9.58). These companies designed and developed 35% of the 787 Dreamliner airframe structure, including the main wing box (the first time that the design and build of such a critical part was entrusted outside the company). Together, they also supply 16 percent and 21 percent of the 767 and 777 airframes, respectively, and have contracted with Boeing to provide 21 percent of the 777X.

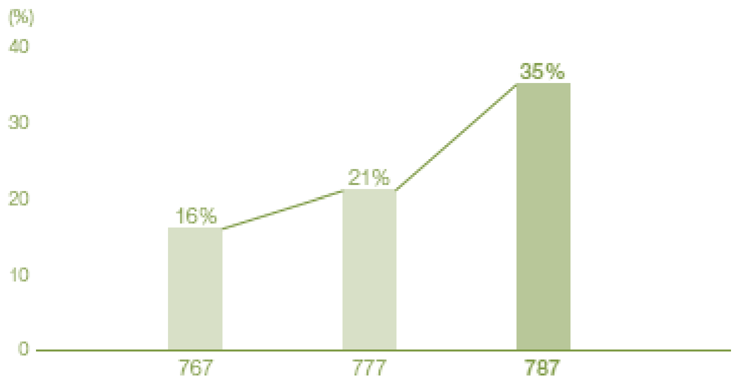

Figure 9.58 - Japanese Industry Work-Share Growth
Source: Boeing

Other components provided by Japanese firms include tires, gear boxes, trailing-edge flaps, lavatories, flight deck interiors, altimeters, actuators, valves and video entertainment systems. In addition, Toray Industries is providing composite materials for the 787.

Boeing's partnerships in Japan extend well beyond the above examples. In fact, the company has meaningful collaborations in the technology and environmental areas with Japanese universities, research institutions and various government agencies.

In addition, Boeing also maintains close relationships with the Government of Japan's Ministry of Land, Infrastructure Transport and Tourism (MLIT) and the Japan Civil Aviation Bureau (JCAB) to help ensure ever safer air transportation. The Ministry of Economy, Trade and Industry (METI) is another key partner in terms of Boeing's collaboration with Japan's aerospace industry, as the Aeronautics and Space Research Agency (JAXA).

Airbus in Japan

In recent years, Airbus has significantly strengthened its position in the Japanese commercial aircraft market. Japan airlines' major order for the A350 XWB was an important breakthrough and it was soon followed by orders from All Nippon Airways Holdings for the A320 family and, early in 2016, for the A380. The first of All Nippon Airways' three A380s it is expected to be delivered in 2019. In addition, over 20 major Japanese companies work with Airbus on various commercial aircraft programmes. For example, the A380's forward and rear cargo doors come from by Mitsubishi Heavy Industries while the vertical tail plane's (VTP) leading and trailing edge are manufactured by Fuji Heavy Industries.

In relation with defence and space, Airbus is contributing to Japan's successful space sector by supplying state-of-the-art components for Japanese satellites. Moreover, some of Airbus space technologies were developed in Japan.

T9.10.2 The Japanese Market Captive of Airbus

The commercial air transport industry of the last 20 years has been characterized by the duopoly competition between Boeing, the American aircraft manufacturer, and Airbus, the European aircraft manufacturer.

In relation to orders and deliveries, there has been a strong competition between both companies, as it can be seen in the following figures:

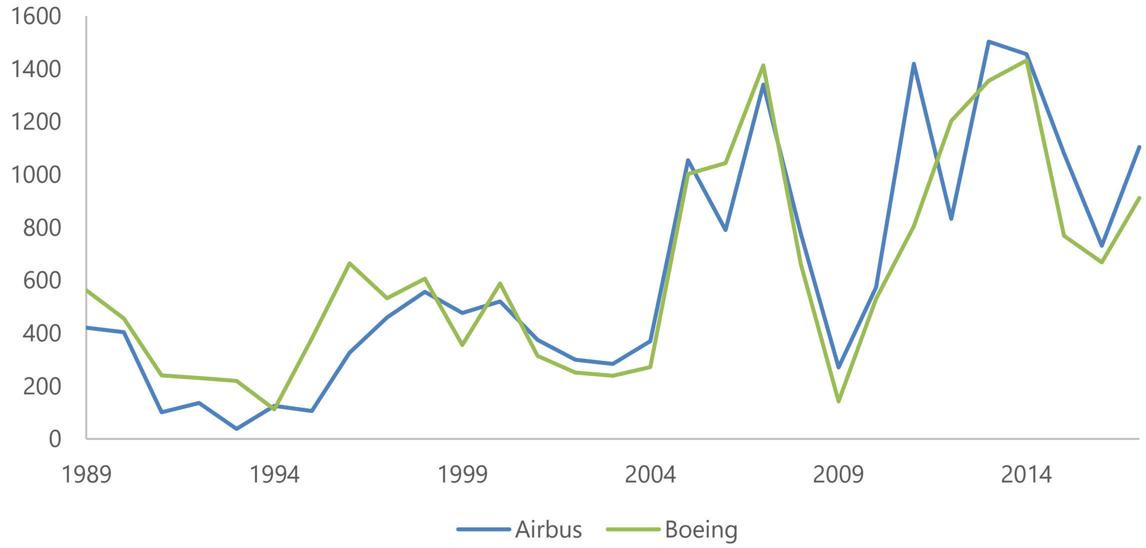

Figure 9.59 - Airbus vs. Boeing orders
Source: Wikipedia web page

In terms of orders, during the decade of 1980s and 1990s, it's clear that Boeing deliveries considerably exceeded that of Airbus. By 2000, little difference remained between both companies. However, during the last few years Airbus has received more aircraft orders than Boeing.

In terms of deliveries (Figure 9.60), Boeing has a clear lead against Airbus in the 14 years, from 1989 to 2002. After that, Airbus started to overcome Boeing during the next years.

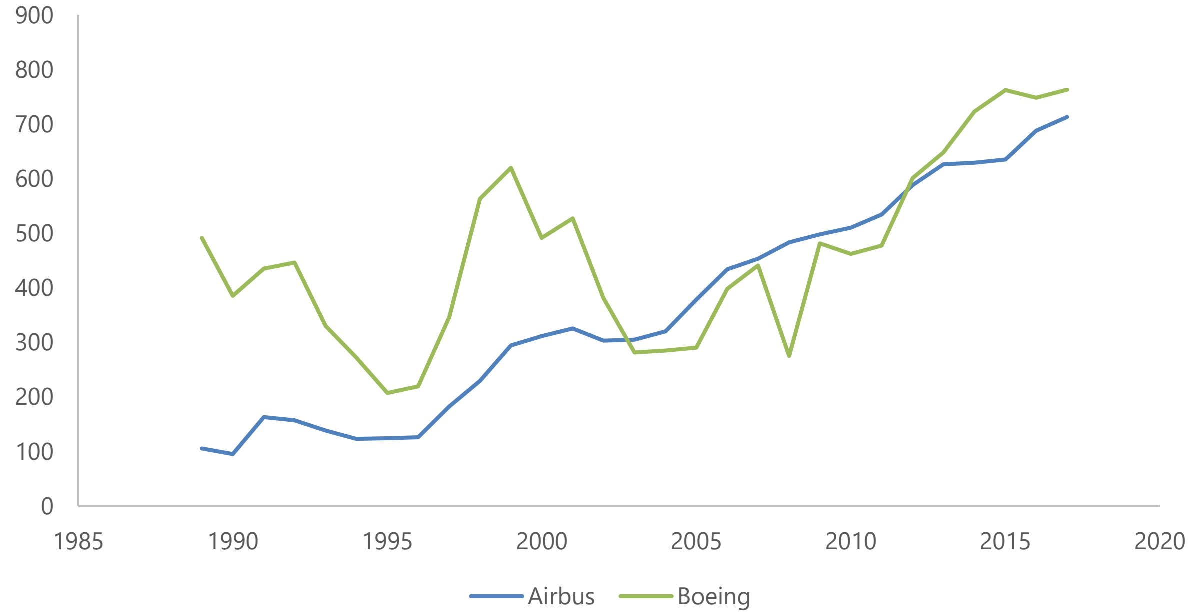

Figure 9.60 Airbus vs. Boeing deliveries
Source: Wikipedia web page

If it is compared Airbus and Boeing orders between similar aircrafts, the following results are obtained:

A320 family vs. B737 family

The Airbus A320 family consists of short-to medium-range, narrow body, commercial passenger twin-engine jet airliners manufactured by Airbus that was released in the 1980s. The family includes the A318, A319, A320 and A321. The aircraft family can accommodate up to 236 passengers and has a range of 3100 to 12000 km, depending on model. The A320 family competes directly with the Boeing 737 family, a short-to medium-range twinjet narrow-body airliner developed and manufactured by Boeing that was released in the 1960s. The B737 family is composed of several models with capacities from 85 to 215 passengers.

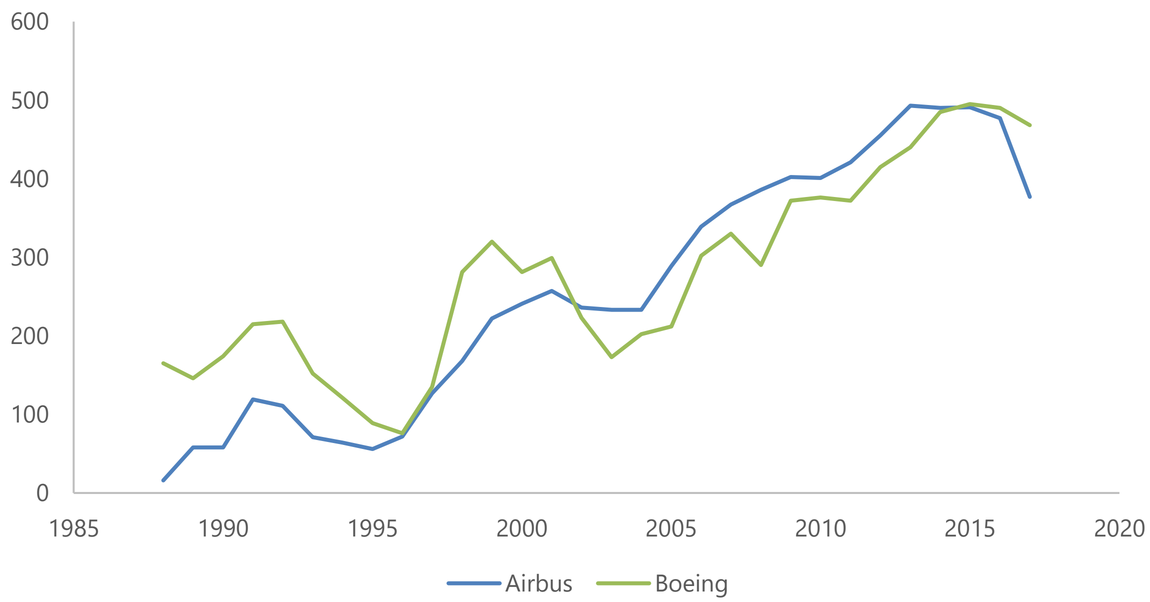

Figure 9.61 - A320 vs. B737 deliveries
Source: Wikipedia web page

In the previous image (Figure 9.61), it is compared the A320 family and the B737 family deliveries of past years. Taking into account orders and deliveries, the 737 series is the best-selling commercial jetliner in history, with a total of 14543 orders and about 9895 deliveries. In comparison, Airbus has delivered 7979 A320 series aircraft and has received 8125 orders. The B737 has been 55 years on the market and the A320 'only' 40 years.

A350 family vs. B787 family

The Airbus A350 is a family of long-range, twin-engine wide-body jet airliners developed by Airbus. The family includes the A350-800, A350-900 and A350-1000. The aircraft variants can accommodate 280 to 366 passengers and has a range of up to 9,700nm. The A350 family competes directly with the Boeing 787 family, which is a long-haul, mid-size widebody, twin-engine jet airliner made by Boeing. The family variants can seat 242 to 335 passengers and their range varies form 7,000nm to 8300nm, depending on the model.

In the following graphics, it can be seen a comparison between A350 and B787 orders (Figure 9.62) and deliveries (Figure 9.63), cumulative by year:

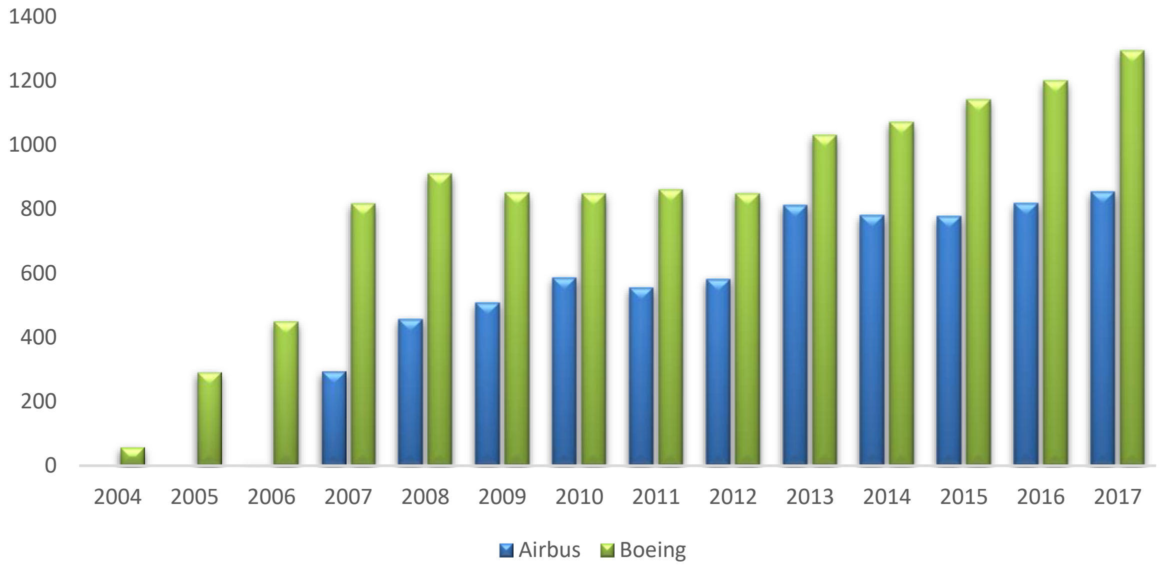

Figure 9.62 - A350 vs. B787 orders, cumulative by year
Source: Wikipedia web page

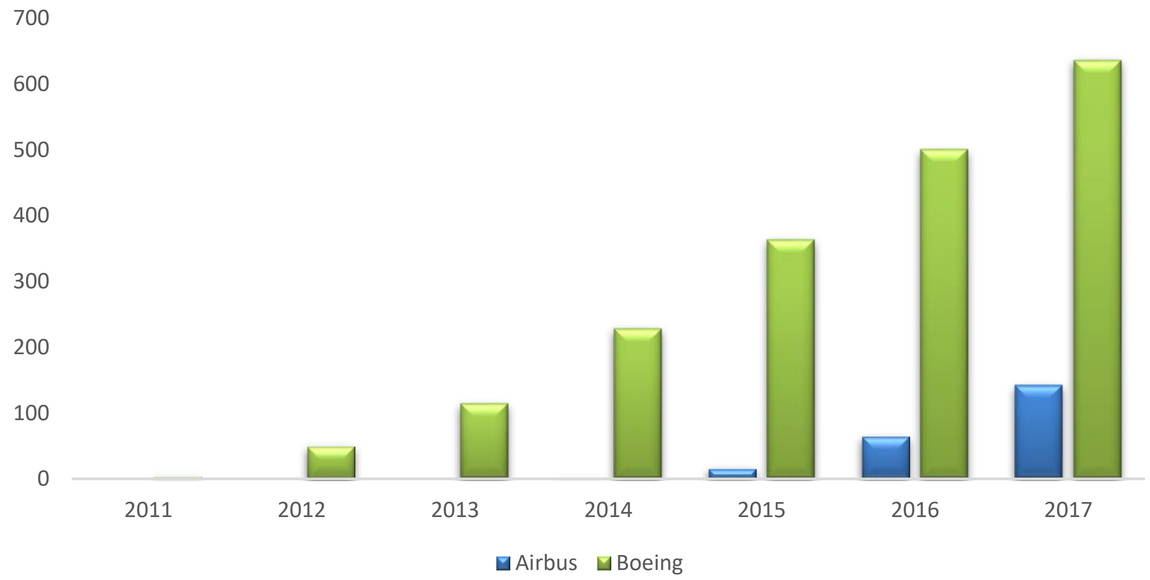

Figure 9.63 - A350 vs. B787 deliveries, cumulative by year
Source: Wikipedia web page

As it can be seen from the previous images, the B787 has a clear advantage against the A350 with respect to orders and deliveries due to the late response of Airbus to the Boeing challenge. However, it is important to note that there is an important gap in release dates, since the A350 was released in 2015 while the B787 was released in 2007.

A380 vs. B747

The Airbus A380 is a double-deck, wide-body, four-engine jet airliner manufactured by Airbus. It is the world's largest passenger airliner with a capacity to accommodate 525 to 853 passengers and with a range of 8500nm. The A380 compete with the Boeing 747, the next largest airliner. Depending on the model, the B747 can accommodate 416 passengers to 660 passengers and has a range of 7260nm.

In the following graphs, it can be seen a comparison between A380 and B747 orders (Figure 9.64) and deliveries (Figure 9.65), cumulative by year:

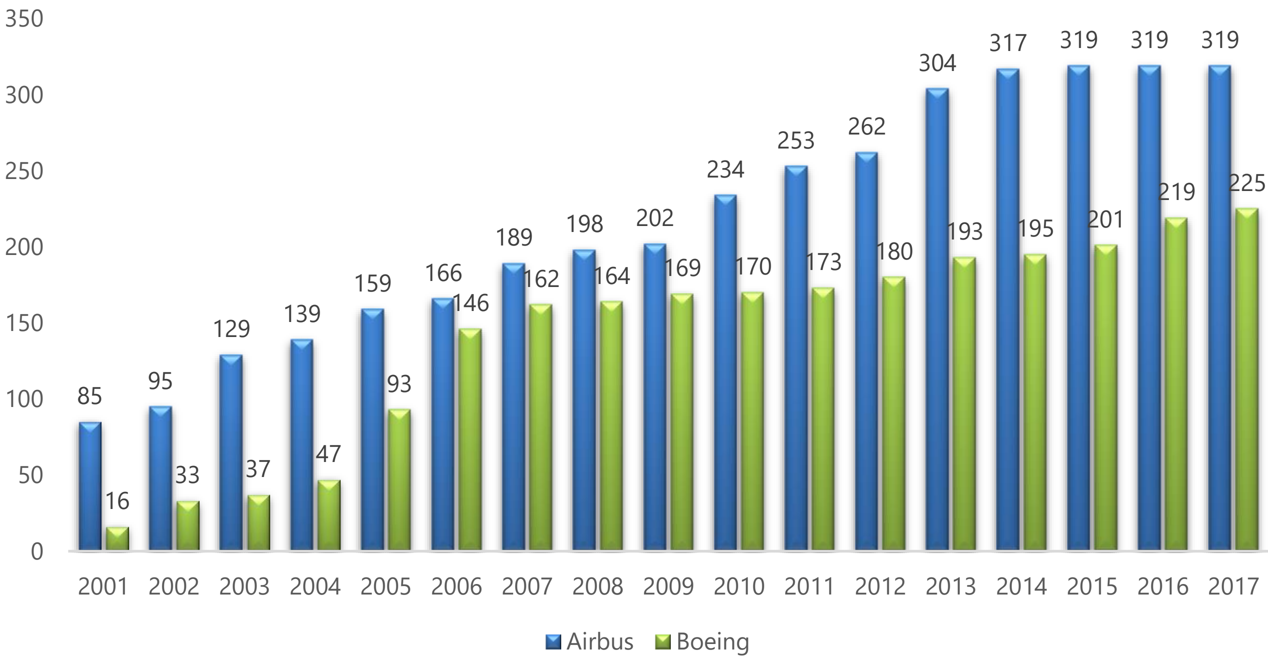

Figure 9.64 - A380 and B747 orders, cumulative by year
Source: Wikipedia web page

The previous image shows that in recent years the A380 has led the number of orders against the B747. However, it is important to note that the B747 was released in 1968, many years before the A380, accumulating in total 1568 orders.

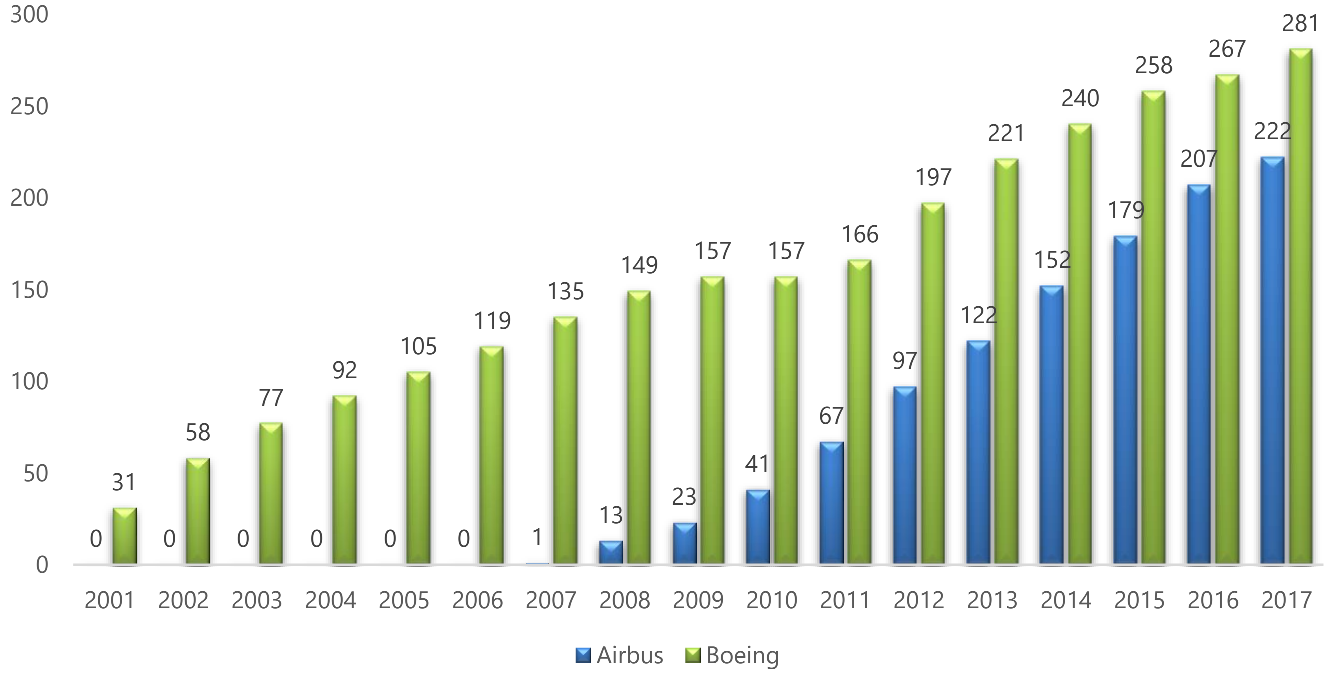

Figure 9.65 - A380 and B747 deliveries, cumulative by year
Source: Wikipedia web page

In terms of deliveries, it can be seen from the previous image that Boeing has had a clear lead in number of deliveries in past years, accumulating in total 1543 deliveries. It is reasonable since the release date of the A380 is 2005, many years after the B747. The four-engined airliner may be a dying species: the B747 is surviving on orders from freighters and the A380 on orders from airlines in the Gulf. The long-haul market is being taken over by the B738/B777 and A350.