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Cooperation in aviation beyond Europe's Borders

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Abstract
Europe is entering a new age of development that raises new challenges resulting from technical development, increased mobility of people and globalization of changes. The effect of these changes are the chances, but also the risks accompanying these changes. One of the most important sectors of the market and community is transport, which in a particularly meaningful way concentrates all the effects of the currently occurring changes. Air transport, due to its specificity resulting from the most advanced level of technical development and very high importance in the market, is particularly sensitive and vulnerable to the impact of development conditions. Air transport and cooperating industry is of great social and political importance, ensuring global domination of the most developed countries. Due to the global nature of air transport and the other aviation sectors, worldwide cooperation must be considered in order to achieve the expected effects in terms of efficiency and safety. This cooperation must take into account the specificity of the European transport market related to the location of a large number of airports in a relatively small area and high density of air traffic, as well as the specificity of the market, which affects the condition of the aviation industry in Europe. The paper analyses the state of European cooperation with other countries of the world in the most important areas of air transport (ATM, certification, environmental impact, safety and security) in achieving common goals, in the view of the vision of the development of air transport and aviation industry in Europe, formulated in the Flightpath 2050 Report.

1. Background and motivation

Air transport plays an essential role in stimulating sustainable economic and social development around the world. About 65.5 million people in the world work in various sectors of the economy, directly and indirectly, related to air transport. Companies working for air transport generate over USD 2.7 billion of global Gross Domestic Product (GDP), which is 3.6% of global GDP. The productivity of jobs in the field of air transport is on average, 4.4 higher than in other sectors of the economy. In 2017, the airlines of the world transported over 4.1 billion passengers and cargo with a value exceeding 6 billion USD [1], [8].

In 2018, every day, air transport globally transported around 12 million passengers, carried out 120 000 flights and carried goods worth 18.8 billion dollars [1], [8].

In addition to a positive impact on the global market, air transport has a negative impact on the whole planet's environment. In 2017, due to its activities, air transport consumed 341 billion litres of aviation fuel, while emitting 859 million tonnes of carbon dioxide to the atmosphere. Consumed fuel accounted for 10% of the global consumption of liquid fuels by the entire global market [1], [8].

The global air transport system consists of around 1 300 airlines using a combined fleet of over 31 000 aircraft. Aeroplanes make flights from almost 4 000 airports, through a network of several million kilometres of air connections, managed by 170 air navigation service providers [1], [8].

Due to its characteristics, air transport is a global activity. Aviation provides the only fast global transport network, which makes it an essential element supporting the development of worldwide business and tourism. Air transport plays a vital role in facilitating economic growth, especially in developing countries. Air transport facilitates world trade, helping countries to contribute to the global market by increasing access to international markets and enabling globalisation of production.

Except to the benefits mentioned above, there are other economic benefits associated with aviation, such as additional jobs or business, whose occurrence is related to the existence of companies or industries, because air travel allows it.

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Including them in the analysis would increase the number of employees and global economic effects resulting from the existence of the worldwide air transport network several times.
But even if the speed and efficiency of air transport significantly facilitate economic progress, its growth under certain conditions may also have negative effects. Although undoubtedly, on the one hand, the development of air transport is associated with the improvement of living comfort, improvement of social mobility and an increase in general prosperity, unmanaged traffic growth can also lead to increased safety risks in these conditions, when it overtake the development of regulations and requirements regarding the infrastructure necessary to support it. The management of regulations and requirements consists mainly of adopting similar and consistent standards regarding aircraft design and production as well as their operational use. Furthermore, only coordinated and coherent actions aimed at reducing the negative impact of air transport on the natural environment can bring the desired results.
Due to the global nature of air transport and all entities working on its needs, there are several areas of aviation that are of common interest to the world community, and also governments and national and international institutions representing them, including: education, research, industry, airlines, airports, service providers, air traffic management (ATM). Some of the areas that justify cooperation outside individual countries and continents are ATM, harmonised rules for the certification, minimisation of environmental impact, as well as safety and security requirements.
The most crucial organisation dealing with the development and implementation of international regulations codifying the safety of international air transport and supporting its progress to ensure its safe and orderly development is the International Civil Aviation Organization (ICAO). ICAO coordinates activities at the global level in five areas of comprehensive Strategic Objectives [9]:
- enhancement of global civil aviation safety,
- increasing the capacity and improvement of the efficiency of the global civil aviation system,
- enhancement of global civil aviation security and facilitation,
- fostering the development of a sound and economically-viable civil aviation system,
- minimisation of the adverse environmental effects of civil aviation activities.

At the lower level, ICAO objectives are implemented by national and transnational organisations. In Europe, the transnational organisation is the European Union Aviation Safety Agency (EASA). The most important goals performed by EASA are [6]:
- ensuring the highest common level of safety protection for EU citizens,
- guaranteeing the highest common level of environmental protection,
- ensuring single regulatory and certification process among the Member States,
- facilitation the internal aviation single market & create a level playing field,
- work with other international aviation organisations & regulators.

In particular, the last goal relates to international cooperation aimed at achieving ICAO objectives in a harmonised way for the whole world.
Because the European air transport system is part of the global network, its development must take into account cooperation with others, beyond European countries, to achieve sustainable development in areas defined by ICAO. Also a vision of the development of the aviation sector in Europe, which was developed as part of the work a High Level Group on Aviation Research, with a central role of ACARE, complies with the objectives of ICAO, taking into account the ambitions and development plans of the largest actors in the European aviation sector.
Flightpath 2050 Report was published in 2011. In this report, 23 goals were formulated, which should ensure the achievement of sustainable and competitive development of the aviation sector in Europe. PARE - Perspectives for Aeronautical Research in Europe, is the European initiative funded by the Horizon 2020 programme, aimed at triggering active collaboration between various European stakeholders to support the achievement of the Flightpath 2050 goals. PARE create a group of yearly reports on the perspectives for aeronautical research in Europe, covering the progress of the 23 Flightpath 2050 goals (and related issues), and making the recommendations appropriate to the conclusions reached. One of PARE's goals is the analysis of cooperation beyond Europe´s borders to:
- promote the seamless compatibility of Air Traffic Management (ATM) systems worldwide, across continents and oceans,
- promote harmonised certification standards worldwide as already exist in other sectors to ensure the growth of aviation as the safest mode of transport,
- minimise the effects of aviation on the environment on a global scale,
- promote aviation safety worldwide including for European and other passengers flying with non-European airlines,
- promote aviation security worldwide, including at airports and destinations frequently used for European business and holiday travel.

The paper analyses all these areas with particular attention to international cooperation in order to define common and harmonized standards and requirements as well as good practices.

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2. Air Traffic Management

Historically, Europe consisted of a number of countries that did not create uniform political, economic or demographic systems. Along with the development of closer political and economic cooperation within the European Union, the efforts have been made to harmonize the rules of Air Traffic Control (ATC) and Air Traffic Management (ATM), which has led to creation of a Single European Sky (SES) over Europe. Despite those activities, the ATC and ATM systems in Europe are fragmented and dominated by local ANSP (Air Navigation Service Providers) that have a monopoly for the running the ATC and ATM services. The border division of the airspace has made the European ATC and ATM system a kind of a mosaic of national ATC and ATM systems [2], [3], [4], [13].
Europe is a unique region on Earth because of to the very high population density and high intensity of flights performed on its territory. In 2015, more than 9.9 million IFR operations were carried out in Europe and forecasts predict their growth by 16 percent by 2022 (Figure 1) [3]. Currently, around 27,000 con-trolled flights take place in the European airspace every day. Europe is facing an airspace capacity crisis, as it is predicted that the number of flights will increase by as much as 50% in the next 10–20 years [3], [4], [13].

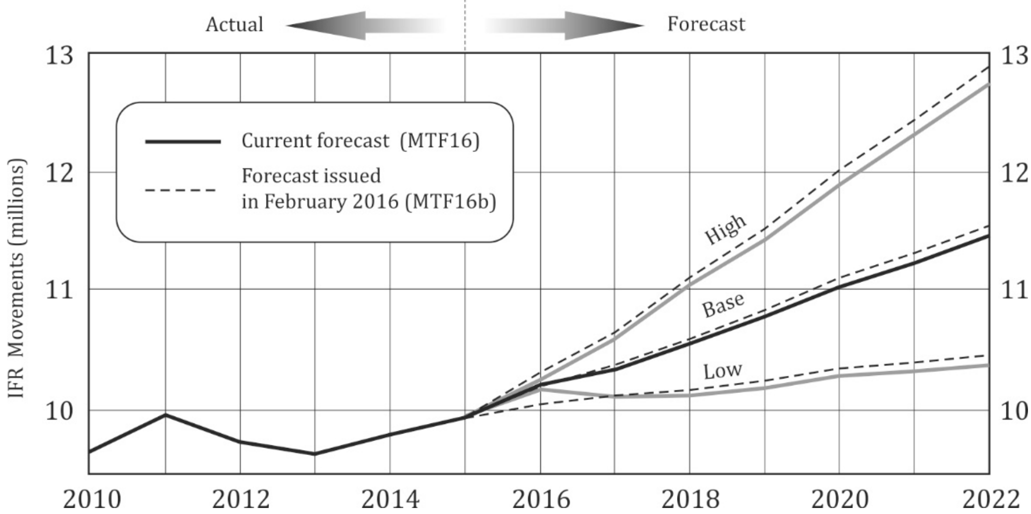

Figure 1: A seven-year forecast for total Europe flight movements [3].

Each year, over 1.6 billion passengers in Europe take one of 10 million flights. Passengers expecting a safe and trouble-free journey, without any delays or cancellations and arriving on time with luggage in hand. Meeting these expectations is the task of the European ATM system, which has so far managed safely and effectively the flow, traffic and density of traffic in the sky over Europe. However, with a forecasted increase in the number of flights to 16.9 million by 2030, the current ATM system needs to be improved using the latest technologies and revised operational procedures to avoid fragmentation and to meet the need for more flights in an efficient, safe and environmentally friendly manner. The modernized air transport system, characterized by innovative technology and the timely delivery of competitive products and services, will be of key importance to Europe's economy, society and cohesion [8].
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 19th 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. 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” [4], [13].
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. 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 2) 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 [2].

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Figure 2: SES implementation five pillars [7].

The answer to some of the problems was the launch of the SESAR program (Single European Sky ATM Research), which is a technological pillar of the SES [13]. The aim of this program is to improve ATM system performance by its modernising and harmonising in order to increase the capacity of the ATM network to cope with the ever-increasing number of flight operations while improving economic and security indicators [4], [13]. At present, the second stage of this undertaking, SESAR 2020, is being implemented. SESAR 2020 introduces new ideas to the market and increases the pace of changes in ATM. Like its predecessor, the SESAR 2020 program is a technological pillar of the European Single European Sky (SES). In this respect, it contributes to the creation of a SES that aims to [13]:

- triple the capacity of airspace in order to reduce delays,
- improve safety performance by a factor of 10,
- reduce the environmental impact by 10% and
- reduce the cost of ATM services for airspace users by 50%.

Ultimately, this means:

- greater mobility and choice for passengers in Europe,
- a more collaborative and better performing network, and
- an airspace in which all aircraft, from regular to civil Remotely Piloted Aircraft Systems (RPAS), will be safely integrated.

European activities resulted from ICAO efforts to address the needs of the air transport industry and international civil aviation aimed at coordinating the worldwide planning processes in support of a global air traffic management (ATM) system. Because a plan of action was needed to advance implementation of CNS/ATM systems the Global Air Navigation Plan (GANP) for CNS/ATM Systems was developed by ICAO. The Global Plan was developed in consideration of the operational concept and the Strategic Objectives of ICAO on the basis of an industry roadmap which was developed in follow-up to the Eleventh Air Navigation Conference [9]. On this basis, the ongoing Air Navigation improvement programmes being undertaken by a number of ICAO Member States (SESAR in Europe; NextGen in the United States; CARATS in Japan; SIRIUS in Brazil, and others in Canada, China, India and the Russian Federation) are therefore in line with the main objectives of the Global Plan. These countries have mapped out their plans for appropriate Block Upgrade Modules to ensure the global interoperability of their air navigation solutions in the near and long term [11].

As two of the world's most significant aviation modernisation programmes, NextGen and SESAR have a shared interest in harmonisation as a means of ensuring interoperability. Both initiatives have identified common challenges and have adopted a performance driven approach to modernisation. It is widely understood and accepted that the systems cannot be completely identical. However, harmonisation is necessary to:

- ensure that flights or aircraft can operate seamlessly between systems,
- ensure that common standards are available where needed,
- minimise costs and identify synergies by sharing results and efforts.

2.1. Comparison of SESAR with NextGen

Within SES framework, particularly on the technology side, 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 SES. 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.

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 [12].

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

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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 [12].

Figure 3: SESAR main pillars [13].

Globally, each one of these development programs (SESAR and NextGen) are focused on the specific problems of each region. 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 [3], [4] (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 [4], [12].
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 (Figure 4), 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 [3]) 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).

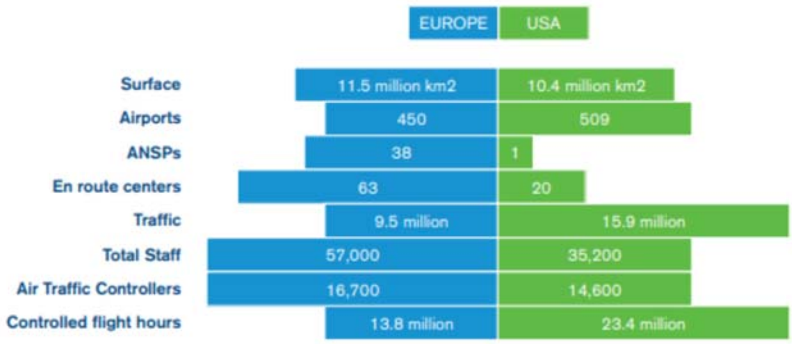

Figure 4: 2010 U.S./Europe Comparison of ATM-Related Operational Performance [7].

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 [12].

2.2. NextGen – SESAR collaboration

In 2011, the U.S. and the EU signed a Memorandum of Cooperation (MoC) on Civil Aviation Research and Development (R&D). In December 2017, the MoC was amended to cover the full lifecycle of SESAR and NextGen programmes, including deployment under a new Annex 1 for ATM modernisation containing three appendices on:

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R&D, performance measurement and deployment coordination. The aim of the cooperation is to ensure the necessary harmonisation of the two programmes and to secure global interoperability, in particular for airspace users. Each appendix is implemented through coordination plans detailing terms of reference, goals and the activities to be undertaken under the MoC. These coordination plans also help to mitigate identified risks and allow for the engagement of stakeholders as part of the process [12].

NextGen and SESAR have together made significant progress in several critical areas. The principal areas in which progress has been achieved are as follows:

- Coordination in support of ICAO - The U.S. and Europe are supporting ICAO in developing the next edition of the GANP in preparation for the 40th ICAO Assembly in 2019;
- Harmonisation risk management - A new joint harmonisation risk issue opportunity management (HRIOM) framework has been established, to provide a strategically-aligned view of organisational, institutional and structural challenges to achieving NextGen and SESAR goals with respect to global harmonisation and interoperability;
- Air/ground data communications - The first joint U.S.-EU air/ground data communication strategy supported by industry from both sides of the Atlantic was delivered, clearly identifying targets, risks, and concrete actions on mitigating divergence and enabling the transition;
- SWIM (System-Wide Information Management) - An initial joint U.S.-EU SWIM strategy has been developed;
- Navigation - A joint U.S.-EU navigation systems roadmap is being developed;
- UAS/Drones - Collaborative has been established on the harmonisation and interoperability aspects related to the integration of unmanned aerial systems, or drones.
- Cybersecurity - Harmonisation activities on cybersecurity have been initiated, aimed in particular at the development of a common trust framework enabling secure interoperability for the exchange of information.

2.3. 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.

3. Harmonised certification standards

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 main way to reduce costs and certification time is to properly plan this process in order to elimination of duplicate activities. 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.

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

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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 sets the standard for these processes essential for the safety of air transport.

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 [6].
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.
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.

3.3. Conclusion

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.
Currently, aircraft manufacturers are working on innovative projects that go beyond currently developed technical solutions. However, these revolutionary solutions can be a challenge in the certification process because they represent a huge change compared to current configurations. 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.

4. Aviation Effects on the Environment

All transport, including air transport, causes deterioration of natural environment and has a negative impact on people. The effects of aviation on the environment can be considered at two levels: locally as the emission and noise near airports; globally as in-flight emissions worldwide. Aviation contributes a small percentage (about 3.5%) to global

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pollution of the environment caused by human activity, but its influence is extremely unfavourable locally, in the areas of airports. The most important dangers which follow from the functioning of an airport are: noise emission and air pollution, including unfavourable climate changes, both globally and locally. The aims of reduction of environmental impact can be either compatible or contrasting at the local or global level 7], [8] [10], [11].
Impact of air transport on the environment analysed on the local level is mainly connected with the noise generated by taking-off and landing aircraft. On regional level, harmful influence of aviation is connected with polluting the air with reactive chemicals occurring close to the place of their emission. In global scale, due to an increasing number of air flights there occur climate changes in the whole globe connected with migration of pollution with compounds of small reactivity introduced to the environment at cruise altitudes, which is on the border of troposphere and stratosphere.
Emission of aviation pollution is a result of combustion of fuel used to power the aircraft, and its level depends on the fuel quality and the process of combustion. Basic fuel used in modern civil aircraft is aviation kerosene. This is a cheap product of the distillation of crude oil, it does not require refining, thanks to which it has gained popularity in aviation. This type of fuel has the lowest freezing point of all the fuels (below minus 50°C) and properties facilitating start of the cold engine, thanks to which it is safe for using in cold climate. Typical exhaust gases from aviation engines contain 4 components: nitrogen (N2), oxygen (O2), carbon dioxide (CO2) and water vapour. Moreover, a small volume of exhaust consists of a mixture of carbon monoxide (CO) and unburned hydrocarbons (UHC). As a result, there occur nitrogen oxides (N2O, NO, NO2 – further referred to as NyOx) which cause the occurrence of ozone and photochemical smog. Emissions of NyOx and other pollutions can be limited maintaining stoichiometric conditions of combustion in respectively low temperature, below 800°C. However, it is not possible regarding often changes of power level of the engine, especially in the initial and final phases of the flight and providing high temperature which is necessary for steady combustion [14].
Taking-off and landing aircraft are a source of noise which is considered to be environmental pollution in accordance to applicable legislation. Similar to chemical pollution, exceeding permissible standards of noise level has a negative impact of the surroundings and their inhabitants. A taking-off aircraft produces noise of about 120 dB, close to the threshold of pain (130 dB). There have been attempts to limit the noise emission by imposing decrease of aviation engines thrust during flights over populated areas and by introducing no flight zone (for example, over national parks). However, the obtained environmental effect would not balance the increasing number of flights.
Noise has a negative impact on health of the people who live close to airports. This impact on human health can be divided into auditory health effects and non-auditory health effects. Auditory health effects include ongoing hearing loss connected with damages of the inner ear. However, non-auditory health effects include, first of all, cardiovascular diseases (such as high blood pressure, coronary heart disease). Long-term expose of inhabitants to permanent noise leads to occurrence of neuroses, sleep disorders and low effective intellectual activities. It has been proved that people who live near airports bear health consequences recalculated at hundreds of USD per capita a year. For a sample airport with more than 400,000 operations a year, at the airport boundary, total yearly environmental damages range from $290 per person to $1200 per person ($860 mean) [15].
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.
Modern solutions directed to reduce aircraft impact for the environment was the subject of two biggest programs concerning aviation implemented by the European Union. One of them was SESAR JU (SESAR, 2006; WWW. SESAR JU) which supposed development of the solutions of a 10-time-increase of the safety level, a 3-time-increase of airspace capacity, reduction of costs connected with air traffic by 50% and decreasing of air transport impact on natural environment by 10 per cent. The other program was Clean Sky 2 (WWW. Clean Sky), a continuation of the Clean Sky program, in the frames of which there would be developed new technological solutions which would be more environmentally friendly (new aircrafts, new power units, airborne systems and so on) [13].

4.1. Joint activities for the environment protection

The 39th Session of the ICAO Assembly, held from 27 September to 7 October 2016, adopted Resolution A39-2: Consolidated statement of continuing ICAO policies and practices related to environmental protection — Climate change. Resolution A39-2 reflects the determination of ICAO’s Member States to provide continuous leadership to international civil aviation in limiting or reducing its emissions that contribute to global climate change [9].
The 39th Assembly also recognized that the aspirational goal of 2 per cent annual fuel efficiency improvement is unlikely to deliver the level of reduction necessary to stabilize and then reduce aviation’s absolute emissions contribution to climate change, and that goals of more ambition are needed to deliver a sustainable path for aviation.

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To achieve international aviation's global aspirational goals, a comprehensive approach, consisting of a basket of measures has been identified, namely [1], [9]:

- Aircraft-related technology development – purchase of new aircraft and new equipment to retrofit existing aircraft with more fuel-efficient technology;
- Alternative fuels – investments in the development and deployment of sustainable aviation fuels;
- Improved air traffic management and infrastructure use – improved use of communication, navigation and surveillance/air transport management (CNS/ATM) to reduce fuel burn;
- Economic/market-based measures – researching and building awareness of low cost, market-based measures to reducing emissions such as emission trading, levies, and off-setting.

Aviation has always had a focus on efficiency. Fuel makes up the main operating cost for airlines, so in this sense economic and environmental motivations are intertwined. Thanks to new aircraft, absolute emissions from US airlines dropped 3% between 2000 and 2016, while traffic rose 24%. In Europe, several factors, including new technology and air traffic management efficiency, contributed to holding aviation emissions in 2014 at around the same as 2005 levels, despite 25% growth in passenger traffic. On average, each new generation of aircraft is roughly 15% to 20% more efficient than the previous generation [10].

The last decade has seen the development or introduction of entirely new aircraft types, such as the Airbus A380, A350 XWB and A220 family and the Boeing 787 Dreamliner. These were joined by new versions of existing aircraft, such as the Embraer E2, 737MAX, A320neo, A330neo and Boeing 747-8. These are powered by next-generation jet engines made by manufacturers such as CFM International, Pratt & Whitney, GE Aviation and Rolls-Royce, and all have produced impressive fuel savings. By 2020, it is expected that other fuel-efficient aircraft will enter service, including Boeing's 777X [10].

In addition to the latest propulsion technology, additional technological features have been included to maximise fuel efficiency. Improved aerodynamics, new manufacturing techniques and composite materials play a prominent role in determining how much fuel is burned on any given flight.

Another direction is to increase the use of sustainable aviation fuels (SAF), which will reduce the use of non-renewable fuel resources of the planet. The development of SAF represents considerable potential for securing the sustainable development of air travel. Sustainable aviation fuels (sometimes referred to as 'biofuels') are almost chemically identical to traditional jet fuel and meet the rigid jet fuel specifications. But rather than being made from fossil fuels, they are synthesised from other, sustainable 'feedstocks'. These feedstocks can take the form of plant matter, municipal waste or even used cooking oil.

The potential of SAF to reduce aviation greenhouse gas (GHG) emissions has been recognized by ICAO, Member States and the aviation industry, such that SAF are included amongst the "basket of measures" put forward to assist States in designing their action plans on CO2 emissions reductions. According to the ICAO 2016 trends assessment, a 100 per cent substitution of CAF with SAF could reduce 63 per cent of the baseline CO2 emissions from international flights in 2050. This would be aviation's most significant contribution towards achieving carbon neutral growth.

5. Safety and security

The air transport industry plays a significant role in the global economy. Secure air transport service enhances connectivity in trade, tourism, political and cultural links between States. Annual international air passenger traffic is expected to reach 6 billion by 2030 from about 3.3 billion today, while air cargo transported is expected to increase to 125 million tonnes from 50 million. With air traffic projected to increase significantly in the future, there is a need for a planning framework at the international, regional and national levels to manage growth in a safe, secure and efficient manner [1], [11].

5.1. 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

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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.

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 [11].

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.

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.

The last decade saw continued improvements in overall safety performance. Industry measures have resulted in a 70% reduction in the accident rate, from 3.60 per million flights in 2008 to 1.08 per million flights in 2017. IATA's developed a Six-Point Safety Strategy which is a comprehensive, data-driven approach to identifying organizational, operational, and emerging safety issues. Its six points are as follows [8]:

- reducing operational risk,
- enhancing quality and compliance through audit programs,
- advocating for improved aviation infrastructure, such as the implementation of performance-based navigation (PBN) approaches,
- supporting the consistent implementation of safety management systems,
- supporting effective recruitment and training to enhance quality and compliance,
- identifying and addressing emerging safety issues.

In the past 15 years a rapid increase in the development of Unmanned Aircraft Systems (UAS) has been noticed. UAS represent a potential hazard to civil aviation, particularly through their irresponsible use in the vicinity of airports and manned aircraft. Many UAS are being flown by people unfamiliar with the safety risks and with civil aviation and its regulations. Many governmental and non-governmental organizations and business representatives work together to identify and implement UAS regulations. These include ICAO, IATA, key air transport industry stakeholders, and national civil aviation authorities (CAAs). In addition, ICAO issued a letter on 20 March 2017 emphasizing national responsibilities to protect civil aircraft from pilotless aircraft [8], [9], [11].

The transition from prescriptive- to performance-based regulations for UAS and the establishment of target levels for safety will set the foundation for the implementation of further safety initiatives. Many organizations participates in developing policies and operational technology concepts to enhance safety. Priorities include the following [8]:

- dynamic geofencing that provides adaptable virtual barriers using a combination of global positioning system (GPS) and radio frequency connections, such as Wi-Fi or Bluetooth, to keep UAS from entering dangerous, restricted, or sensitive airspace
- detect and avoid (DAA) technology
- analyses of UAS incidents and accidents to identify trends and support safety management systems (SMS) and state safety programs (SSP).

It is becoming increasingly important for UAS to be safely integrated into overall airspace. Developing UAS traffic management (UTM) architecture will require new technologies and safety and security standards and safeguards.

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5.2. 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.
The 2016 United Nations Security Council Resolution 2309 on Aviation Security reaffirmed the obligation of countries to ensure the security of their citizens and of other nationals against terrorist attacks on air services operating within their territories. It likewise reaffirmed the responsibility of nations to safeguard their citizens and other nationals against terrorist attacks on international civil aviation wherever these may occur. Resolution 2309 also urged nations to implement ICAO Annex 17 standards at every airport within their jurisdictions and to urgently address any gaps or vulnerabilities [11].
In September 2016, delegates at the 39th Session of the International Civil Aviation Organization (ICAO) Assembly agreed that there was a need for the accelerated development of a Global Aviation Security Plan (GASeP) as a future aviation security policy and programming framework. The GASeP, which replaces the ICAO Comprehensive Aviation Security Strategy (ICASS), addresses the needs of States and industry in guiding all aviation security enhancement efforts through a set of internationally agreed priority actions, tasks and targets [11].
The Plan calls for action at the global, regional and national levels, as well by industry and all other stakeholders, in raising the level of implementation of Annex 17 – Security; intensified efforts are also required for ICAO to enhance its capacity to support States in this regard [11].
Central to the Plan is a Roadmap that outlines 94 tasks, accompanying 32 actions under 5 key priority outcomes, which set out objectives until the 40th Session of the ICAO Assembly in 2019. A set of indicators and target dates also accompanies each individual task. This Roadmap is a “living” document and shall be periodically reviewed and adjusted as necessary, taking into account new and emerging aviation security threats [8], [11].

Figure 5: GASeP’s five priorities [8].

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.
Currently, the security problem concerns the airports, their infrastructure and the organizational system. 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.

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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.
The increasing digitization of aviation necessitates a robust cybersecurity strategy. IATA proposed and launched a task force to address cybersecurity in 2017. The Aviation Cyber Security Task Force (ACSTF) of industry experts in this emerging area of risk to air transport will report to the IATA Security Group (SEG). The aim is to gather information, determine the scope of the threat, and identify best practice for airlines regarding the increasing probability of a cyber breach of aircraft systems [8].

6. Conclusion

The global nature of air transport and aviation industry requires cooperation between countries to achieve a comparable level of safety in all areas of aviation. The coordinating role in all activities has ICAO supported by various international organizations (IATA, EASA, EUROCONTROL, etc.), national organizations (Aviation Authorities, Service Providers etc.) and industry stakeholders. Under these conditions, Europe develops air transport and aviation industry, according global goals and individual goals and aims resulting from Europe's needs and ambitions. Continuous cooperation between countries and groups of countries is required to adapt requirements and goals to the changing environment. The European Union, working with other countries of the world, is building own dominant market position in such complex economic conditions. Some of the initiatives undertaken by the European Union are carried out successfully, in accordance with the adopted development plans, and some require corrective actions, which are a response to the changing conditions, social, economic and technological. This requires continuous monitoring of progress using a variety of tools that support the achievement of strategic objectives formulated in the vision of aviation development in Europe Flightpath 2050. One of them is the initiative funded by the Horizon 2020 programme, named Perspectives for Aeronautical Research in Europe (PARE). The assessment of the rate of progress relative to these goals and respective provision of recommendations, particularly focusing on significant issues which include long-distance travelling, the participation of women in aerospace and educating and attracting young talents will contribute to better effectiveness in achieving the goals of the Flightpath 2050.

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