STATE ACTION PLAN OF THE REPUBLIC OF POLAND

FOR THE AVIATION CO2 EMISSIONS REDUCTION

2021

Urząd Lotnictwa Cywilnego

CIVIL AVIATION AUTHORITY OF POLAND

IMPLEMENTATION OF ICAO RESOLUTION A40-18 ON CLIMATE CHANGE

4th Edition - August 2021

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ACTION PLAN OF THE REPUBLIC OF POLAND

INTRODUCTION:

a) The ICAO Contracting State the Republic of Poland is a member of the European Union as well the EFTA and of the European Civil Aviation Conference (ECAC). ECAC is an intergovernmental organisation covering the widest grouping of Member States[1] of any European organisation dealing with civil aviation. It is currently composed of 44 Member States, and was created in 1955.

b) ECAC States share the view that the environmental impacts of the aviation sector must be mitigated, if aviation is to continue to be successful as an important facilitator of economic growth and prosperity, being an urgent need to achieve the ICAO goal of Carbon Neutral Growth from 2020 onwards (CNG2020), and to strive for further emissions reductions. Together, they fully support ICAO's on-going efforts to address the full range of those impacts, including the key strategic challenge posed by climate change, for the sustainable development of international air transport.

c) All ECAC States, in application of their commitment in the 2016 Bratislava Declaration, support CORSIA implementation and have notified ICAO of their decision to voluntarily participate in CORSIA from the start of its pilot phase and have effectively engaged in its implementation.

d) The Republic of Poland, like all of ECAC's 44 States, is fully committed to and involved in the fight against climate change and works towards a resource-efficient, competitive and sustainable multimodal transport system.

e) The Republic of Poland recognises the value of each State preparing and submitting to ICAO an State Action Plan for CO_2 emissions reductions as an important step towards the achievement of the global collective goals agreed since the 38th Session of the ICAO Assembly in 2013.

f) In that context, it is the intention that all ECAC States submit to ICAO an action plan[2]. This is the action plan of the Republic of Poland,

g) The Republic of Poland strongly supports the ICAO basket of measures as the key means to achieve ICAO's CNG2020 target and shares the view of all ECAC States that a comprehensive approach to reducing aviation CO_2 emissions is necessary, and that this should include:

i. emission reductions at source, including European support to CAEP work in this matter (standard setting process);

ii. research and development on emission reductions technologies, including public-private partnerships;

iii. development and deployment of sustainable aviation fuels, including research and operational initiatives undertaken jointly with stakeholders;

iv. improvement and optimisation of Air Traffic Management and infrastructure use within Europe, in particular through the Single European Sky ATM Research (SESAR), and also beyond European borders through participation in international cooperation initiatives; and

v. Market Based Measures, which allow the sector to continue to grow in a sustainable and efficient manner, recognizing that the measures at (i) to (iv) above cannot, even in

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[1] Albania, Armenia, Austria, Azerbaijan, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Moldova, Monaco, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, and the United Kingdom.

[2] ICAO Assembly Resolution A40-18 also encourages States to submit an annual reporting of international aviation CO_2 emissions, which is a task different in nature and purpose to that of action plans, strategic in their nature. Also this requirement is subject to different deadlines for submission and updates as annual updates are expected. For that reason, the reporting to ICAO of international aviation CO_2 emissions referred to in paragraphs 10 & 14 of ICAO Resolution A40-18 is not necessarily part of this Action Plan, and may be provided separately, as part of routine provision of data to ICAO, or in future updates of this action plan.

aggregate, deliver in time the emissions reductions necessary to meet the ICAO 2020 CNG global goal.

h) In Europe, many of the actions which are undertaken within the framework of this comprehensive approach are in practice taken collectively, most of them led by the European Union. They are reported in Section 1 of this Action Plan, where the involvement of the Republic of Poland is described, as well as that of other stakeholders.

i) In the Republic of Poland a number of actions are undertaken at the national level, including those by stakeholders. These national actions are reported in Section 2 of this Plan.

j) In relation to European actions, it is important to note that:

- The extent of participation will vary from one State to another, reflecting the priorities and circumstances of each State (economic situation, size of its aviation market, historical and institutional context, such as EU/non EU). The ECAC States are thus involved in different degrees and on different timelines in the delivery of these common actions. When an additional State joins a collective action, including at a later stage, this broadens the effect of the measure, thus increasing the European contribution to meeting the global goals.
- Acting together, the ECAC States have undertaken measures to reduce the region's emissions through a comprehensive approach. Some of the measures, although implemented by some, but not all of ECAC's 44 States, nonetheless yield emission reduction benefits across the whole of the region (for example research, SAF promotion or ETS).

Introduction - Current state of aviation in the Republic of Poland

The outline of the policy toward sustainable transport sector in Poland

The aeronautical industry and air transportation has the extraordinary position in Poland due to historical reasons. The aviation sector constitutes a significant part of the transport sector. The state policy approach towards the sustainability and the preference of the carbon neutral economic growth paradigm was adopted in Poland in liaison with German data analysts. This attitude may be portrayed by the content of the report titled: Thomas Earl "Transport & Environment (2018) Emission Reduction Strategies for the Transport Sector in Poland." This document assumes 7% of emissions reductions from road transportation in the timeframe of 2010-2030. This general view is roughly consistent with the Carbon Neutral Growth scenario concept envisaged for the civil aviation sub-sector. If one assumes a range of 5-7% of the annual intensity increase for commercial air transport sector, we can consequently suppose the directly related increase of annual CO_2 emissions in the same proportion - as corollary of the net increase in the annual number of operations. This working assumption is consistent with short and mid-term historical data.

During the last 20 years the Polish aviation market has gone through many significant changes that influenced its pre-COVID-19 shape and contributed to its rapid expansion and development. Joining the European Union has begun a very successful period – due to various aid programmes the sector's development has accelerated, there has been a significant increase in air travel both, to and from Poland and the infrastructure has grown and has been modernized. At the moment there are 14 international airports on the territory of Poland and 28 air carriers hold the Polish Air Operator Certificate (AOC).

The positive trends, however, have been disturbed by the pending COVID-19 pandemic – like in most countries of the world, the air travel was nearly halted to stop in March 2020. Nevertheless, despite the ongoing vaccination programmes, the process of recovery is still very slow and not satisfactory. The data discussed in the analysis covers all four quarters of 2020 – it should be noted that due to the current situation, the results for this period are too unusual and therefore unreliable to give a general picture of the state of the Polish aviation market.

The Ministry of Infrastructure is working on a new program document called "Civil aviation development policy in Poland until 2030 (with an outlook until 2040)". The main objective of this document is to indicate the directions in which the potential of the aviation market in Poland should develop as an element of the common European aviation market, and thus contribute to the long-term economic growth of Poland. The main goal of the document is to be achieved, among others, by supporting activities that contribute to reducing the negative impact of air transport on the environment.

Reducing the negative impact of air transport on the environment should be one of the priorities for airports and air carriers in Poland. The aviation sector should make a significant contribution to the reduction of global emissions of pollutants. According to the document, the greatest chance for a real reduction of pollutant emissions from air transport lies in activities at the international level, in particular at the European level. Actions should also be taken both at the national and local level, taking into account the balance between the costs and benefits of reducing pollutant emissions, in order to intensify all available measures in this regard.

Actions included in the Aviation Policy aimed at reducing the level of air pollution from air transport are in line with the objectives of the European Commission's initiative entitled "Strategy for sustainable and intelligent mobility - European transport on the way to the future", as well as the assumptions of the "National plan for energy and climate for 2021-2030"

The "Civil Aviation Development Policy in Poland" emphasizes the use of alternative fuels in air transport (SAF) and the development of modern technologies that can contribute to climate neutrality. When planning a complete decarbonisation of the air transport sector, the widest possible use of vehicles powered by electricity or other zero-emission fuels, such as hydrogen, should be sought. Other activities include reducing emissions at airports and improving navigation procedures.

In addition to the "Civil Aviation Development Policy in Poland", the Ministry of Infrastructure is preparing a policy document which will address the issue of decarbonisation of all modes of transport.

General characteristics of the aviation market in Poland

The number of passengers handled at Polish airports in 2020 stood at 14.5 million passengers, i.e. around 70.3% of the air travel in the previous year and at the same time, the lowest number in the last 15 years. The average number of passengers per flight fell from 123 to 94.

The destinations and origins that were chosen most frequently in 2020 were the Great Britain, Germany and Italy for regular flights, and Greece, Turkey and Egypt – for charter flights. From the network carriers, most passengers were handled by LOT Polskie Linie Lotnicze, then by Lufthansa and KLM. The decrease in transported passengers stood at 71.4% in 2020, compared to 2019. Low cost carriers noted a drop of 67.7% for the respective periods, with Ryanair, Wizz Air and EasyJet as selected most frequently.

According to Airport Council International (ACI) Europe, the results achieved by Polish airports were 0.1 point higher than the average for the European airports associated by the organisation. Most passengers in 2020 were handled at the Warsaw Chopin Airport, Kraków John Paul II International Airport and Gdańsk Lech Wałęsa Airport.

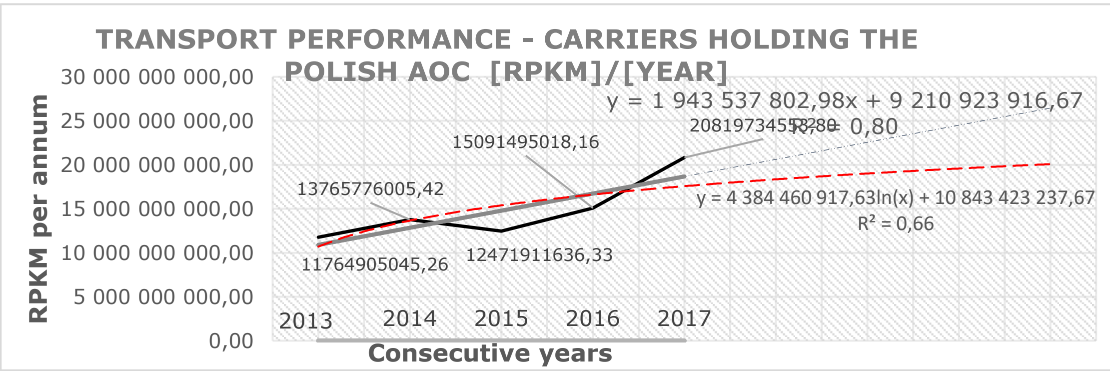
Air freight had also noted a decrease, i.e. by 18.1% in 2020, compared to 2019.
To summarize, the current state of the Polish aviation market is in a worse state than in the previous year of 2019, due to the ongoing pandemic. There has been a significant drop in the number of passengers handled at the Polish airports, although Poland achieved

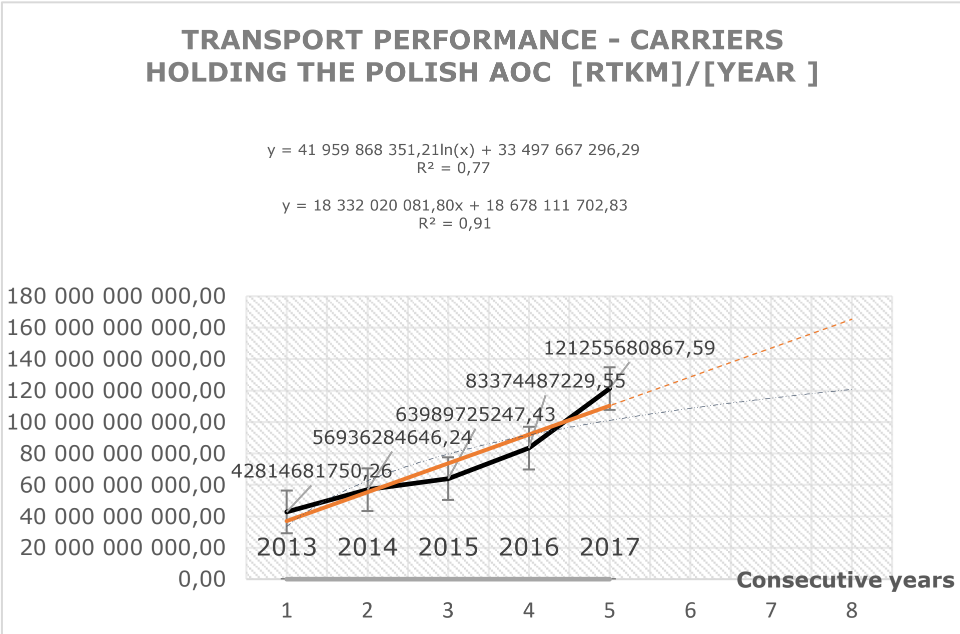
better results in air freight than the average in ACI Europe. It is possible that in the following months there will be an increase in the number of flights and transported passengers and cargo due to the on-going vaccination programmes – it depends, however, on the policy of other states towards air travel in general.

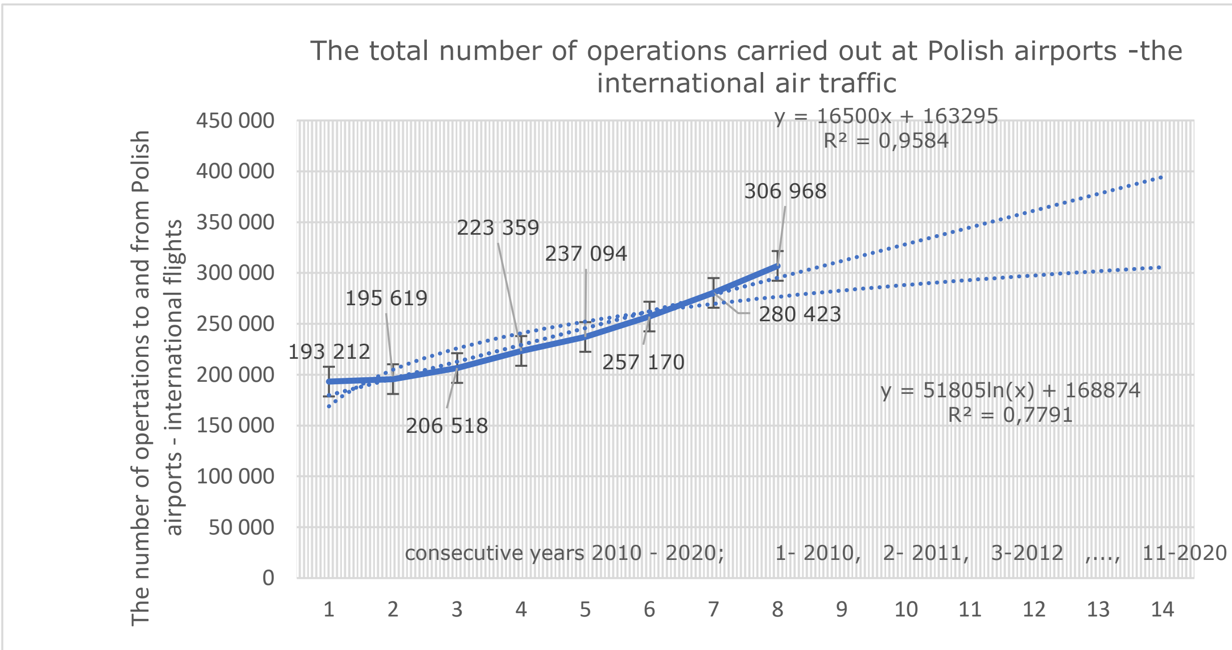
Although, the passenger travel is experiencing major problems, the part of the aviation market related to the Unmanned Aerial Vehicles (UAVs, commonly referred to as drones) is developing rapidly with new innovations and opportunities appearing even during the pandemic. Poland is the first country in Europe to develop operational drone traffic management system, PansaUTM, and is also deemed one of the most friendly environments for drone users due to complex infrastructure and enacted regulations.

Aviation as a part of the Polish GDP
The aviation market could generate from 2.4 to even 3.8% of the Polish GDP, depending on the source of the information. There have been predictions that this value could increase due to the Solidarity Transport Hub (or Central Communication/Transport Port), however, the future is difficult to determine due to the unstable conditions. The total GDP of Poland was reported to decrease by 3% due to the COVID-19 pandemic, compared to 2019 (Oxford Economics, 16 October 2020).

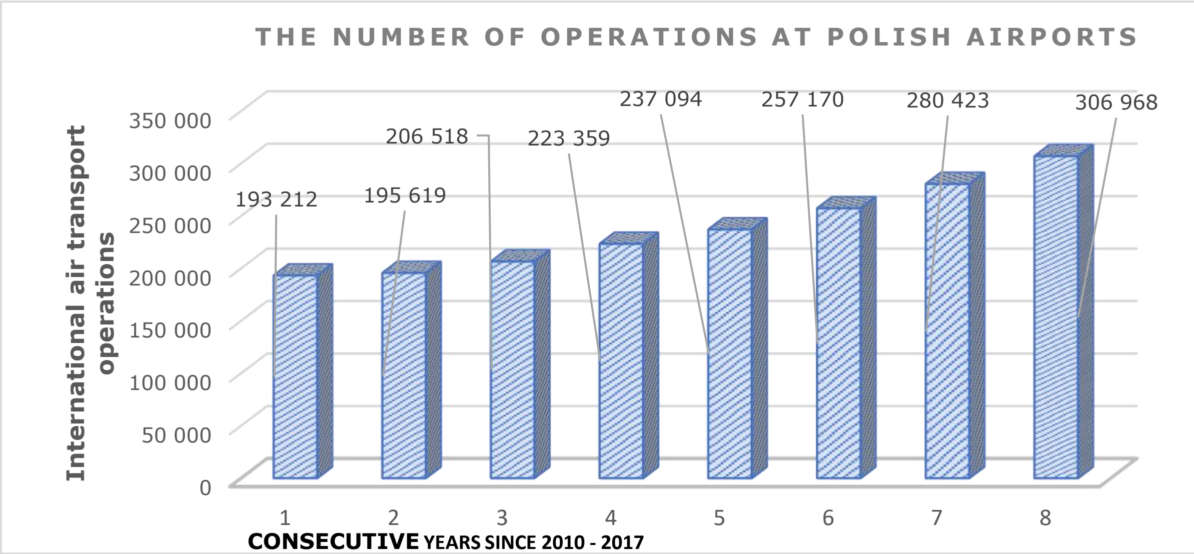
The possible recovery of the aviation market in Poland
During the last years, the Polish aviation market has been growing rapidly, having an opportunity to develop both, domestically and internationally. Forecasts for the future have predicted even more passengers, a need for higher airport capacity, more workplaces and a higher percent of GDP coming from the sector. It is hard, however, to determine whether any of these possible scenarios will actually take place due to the unstable conditions of not only this market but any other market as well. The only aspect of the aviation market that seems to be developing more and more despite the pandemic are the drones – the possible future of Polish aviation.




TRANSPORT PERFORMANCE - CARRIERS HOLDING THE POLISH AOC [RTKM]/[YEAR]
y = 41 959 868 351,21ln(x) + 33 497 667 296,29
R² = 0,77
y = 18 332 020 081,80x + 18 678 111 702,83
R² = 0,91
180 000 000 000,00
160 000 000 000,00
140 000 000 000,00
120 000 000 000,00
100 000 000 000,00
80 000 000 000,00
60 000 000 000,00
40 000 000 000,00
20 000 000 000,00
0,00
121255680867,59
83374487229,55
63989725247,43
56936284646,24
42814681750,26
2013 2014 2015 2016 2017
Consecutive years
1 2 3 4 5 6 7 8


The total number of operations carried out at Polish airports -the international air traffic
y = 16500x + 163295
R² = 0,9584
y = 51805ln(x) + 168874
R² = 0,7791
The number of operatations to and from Polish airports - international flights
450 000
400 000
350 000
300 000
250 000
200 000
150 000
100 000
50 000
0
193 212
195 619
206 518
223 359
237 094
257 170
280 423
306 968
consecutive years 2010 - 2020; 1- 2010, 2- 2011, 3-2012 ,..., 11-2020
1 2 3 4 5 6 7 8 9 10 11 12 13 14

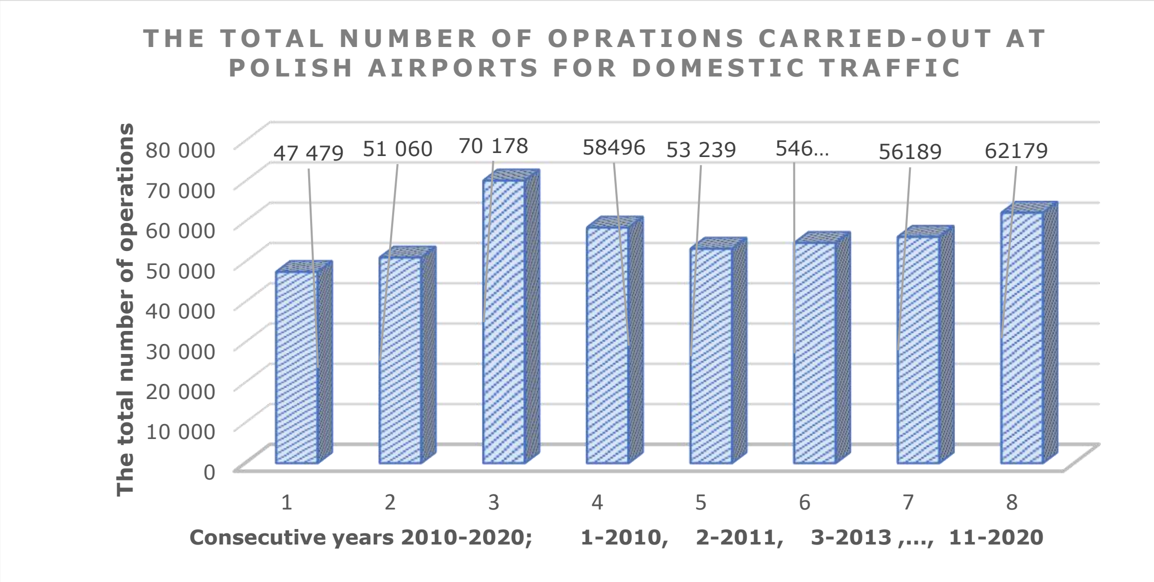
Source: PCAA



Source: PCAA 2020

TRANSPORT PERFORMANCE - CARRIERS HOLDING THE POLISH AOC [RPKM]/[YEAR]				
2013	2014	2015	2016	2017
117649 05045. 26	13765776 005.42	1247191 1636.33	15091 49501 8.16	20819 73455 3.80
Source: The Polish Civil Aviation Authority 2020.				

TRANSPORT PERFORMANCE – CARRIERS HOLDING THE POLISH AOC [RTKM]/[YEAR]				
2013	2014	2015	2016	2017
4281468175 0.26	5693628 4646.24	639897252 47.43	8337448 7229.55	121255680 867.59
Source: The Polish Civil Aviation Authority 2020.				



TRANSPORT PERFORMANCE – CARRIERS HOLDING THE POLISH AOC [RTKM]/[YEAR]				
2013	2014	2015	2016	2017
428146 81750. 26	56936 28464 6.24	63989 72524 7.43	83374 48722 9.55	1212556808 67.59
Source: The Polish Civil Aviation Authority 2020.				

Table 1-B. The number of operations to and from Polish airports for domestic traffic.

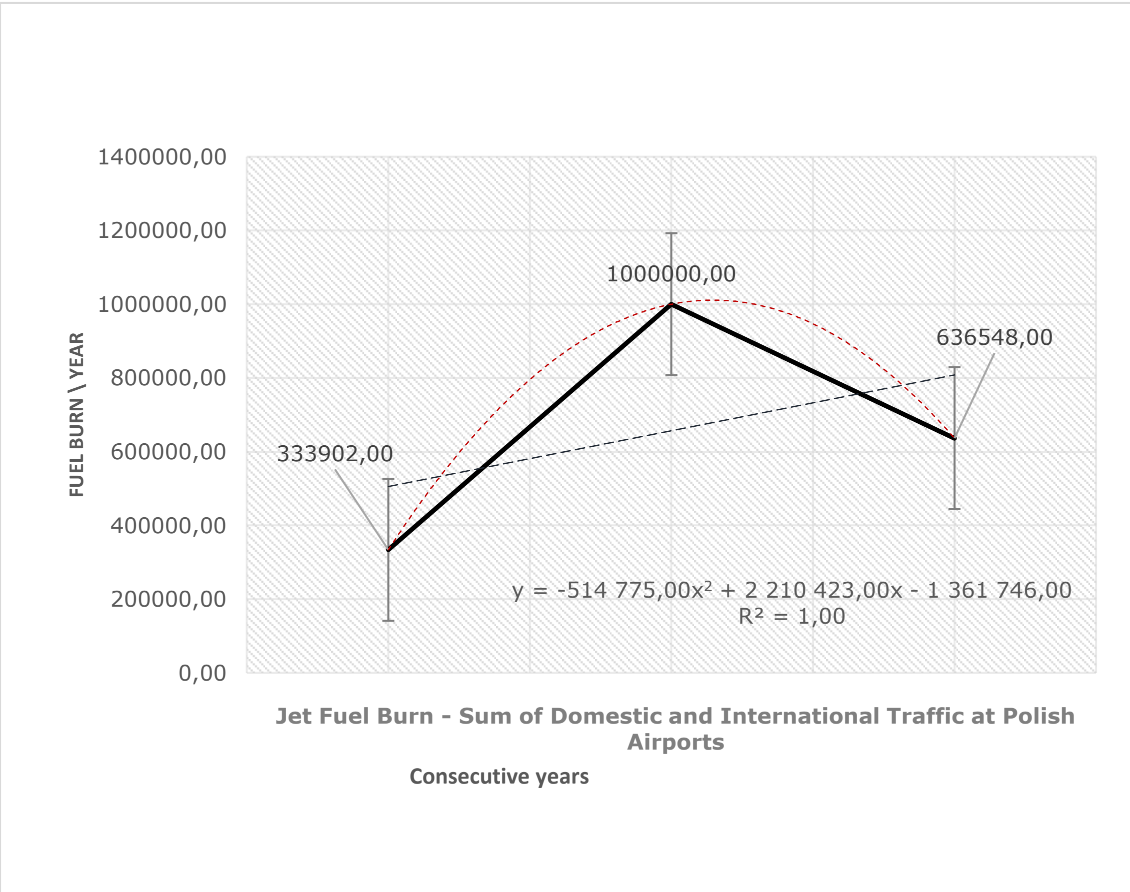
	2010	2011	2012	2013	2014	2015	2016	2017
WAW/EPWA	21975	23 159	26 938	26 067	24111	22564	23376	28135
KRK/EPKK	5934	6107	11 049	6 891	6344	6004	6539	6353
GDN/EDGD	4 917	5 233	8 148	6 945	7801	6264	7180	7536
KTW/EPKT	4 606	4 917	6 762	2663	2466	2328	2014	2456
WRO/EPWR	3 808	3 311	4 894	5400	6271	5964	6630	551
POZ/EPPO	1 969	2 302	2 719	2 727	3238	2891	2514	2936
WMI/EPMO	1 897	1 846	3 618	0	1 304	2658	2069	9
RZZ/EPRZ	1 301	2 443	3 509	3317	3147	3096	2793	2956
LCJ/EPLL	0	0	23	10	99	36	37	22
BZG/EPBY	279	1 226	1 395	1399	898	385	0	1
SZZ/EPSC	525	328	602	2256	1687	1798	1851	2476
LUZ/EPLB	0	0	2	110	479	63	0	0
IEG/EPZG	268	188	519	711	632	624	511	525
QXR/EPRA	0	0	0	0	0	0	311	221
SZY/EPSY	0	0	0	0	0	0	364	2
TOTAL	47 479	51 060	70 178	58496	58 447	54675	56189	62179

International Airport Katowice in Pyrzowice KTW / EPKT, 2. Warsaw Frideric Chopin Airport – WAW/EPWA, 3. Bydgoszcz Ignacy Jan Paderewski Airport BZG/EPBY, John Paul II International Airport Kraków-Balice KRK/EPKK, 4. Gdańsk Lech Walesa Airport GDN/EPGD, 5. Łódź-Lublinek Władysław Reymont Airport LCJ/EPLL, 6.Poznań-Ławica Henryk Wieniawski Airport POZ/EPPO, 7. Rzeszów-Jasionka Airport RZE/EPRZ, 8. "Solidarity" Szczecin-Goleniów Airport SZZ/EPSC, 9. Copernicus Airport Wrocław –Strachowice WRO/EPWR, 10. Zielona Góra-Babimost Airport IEG/EPZG, 11.Mazovian Airport Warsaw-Modlin WMI/EPMO, 12 Lublin Airport LUZ/EPLB, 13 Radom- Sadków QXR/EPRA Source: The Polish Civil Aviation Authority 2020.

Table 9.1. The ratio of ATKM per tonne of jet kerosene burned in consecutive years 2010-2017 and number of ATKM - for major market entities, for total international and total domestic flights.

Year	**2010**	**2011**	**2012**	**2013**	**2014**
Ra =ATKM /Tonne	4.29	4.37	3.97	4.46	4.92
1/(Ra)=Tonne/ATKM	0.23	0.23	0.25	0.22	0.20
ATKM	1431 008	1543422	1487477	1801744	2093426
Year	**2015**	**2016**	**2017**	**2018**	**2019**
Ra =ATKM /Tonne	**N**	**N**	**N**	**N**	**N**
1/(Ra)=Tonne/ATKM	**N**	**N**	**N**	**N**	**N**
ATKM	**N**	**N**	**N**	**N**	**N**

Source: Polish Civil Aviation Authority – 2015-2020
N-data not available



European Aviation Environmental Report (EAER), updated in 2019 and prepared by EASA, EUROCONTROL and EEA, of which the chapter "*Overview of Aviation Sector*" presents a

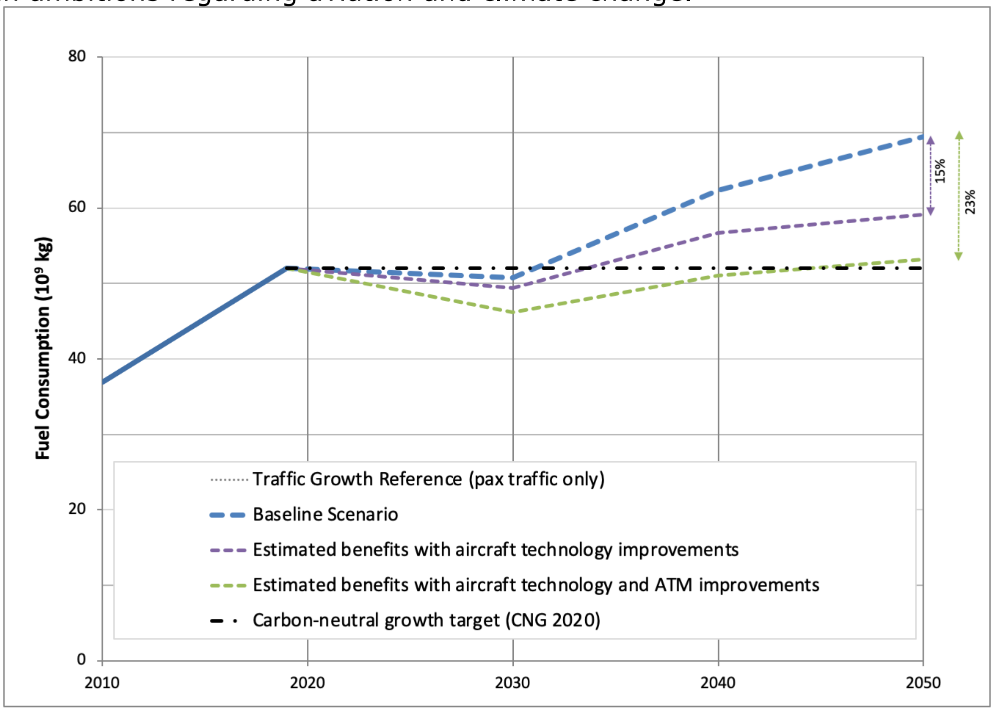
complete overview of the overall environmental performance of the European aviation system. For ease of reference, the links to the EAER website and the 2019 report are provided thereafter:
https://www.easa.europa.eu/eaer/
https://www.easa.europa.eu/eaer/system/files/usr_uploaded/219473_EASA_EAER_2019_WEB_LOW-RES_190311.pdf

Executive summary

The European section of this action plan presents a summary of the actions taken collectively throughout the 44 States of the European Civil Aviation Conference (ECAC) to reduce CO_2 emissions from the aviation system and which are relevant for each State, and provides an assessment of their benefit against an ECAC baseline. It also provides a description of future measures aimed to provide additional CO_2 savings.

Aviation is a fundamental sector for the European economy, and a very important means of connectivity, business development and leisure for European citizens and visitors. For over a century, Europe has promoted the development of new technology, and innovations to better meet societies' needs and concerns, including addressing the sectorial emissions affecting the climate.

Since 2019, the COVID-19 pandemic has generated a world-wide human tragedy, a global economic crisis and an unprecedented disruption of air traffic, significantly changing European aviation's growth and patterns and heavily impacting the aviation industry. The European air transport recovery policy is aiming at accelerating the achievement of European ambitions regarding aviation and climate change.



Aircraft related technology

European members have actively contributed to support progress in the ICAO Committee on Aviation Environmental Protection (CAEP). This contribution of resources, analytical capability and co-leadership has facilitated leaps in global certification standards that have helped drive the markets demand for technology improvements. Europe is now fully committed on the implementation of the 2017 ICAO CO_2 standard for newly built aircraft and on the need to review it on a regular basis in light of developments in aeroplane fuel efficiency.

Environmental improvements across the ECAC States are knowledge-led and at the forefront of this is the Clean Sky EU Joint Undertaking that aims to develop and mature breakthrough "clean technologies". The second joint undertaking (Clean Sky 2 – 2014-2024) has the objective to reduce aircraft emissions and noise by 20 to 30% with respect to the latest technologies entering into service in 2014. Under the Horizon Europe programme for research and innovation, the European Commission has proposed the set-up of a European Partnership for Clean Aviation (EPCA) which will follow in the footsteps of CleanSky2, recognizing and exploiting the interaction between environmental, social and competitiveness aspects of civil aviation, while maintaining sustainable economic growth. For such technology high end public-private partnerships to be successful, and thus, benefit from this and from future CO_2 action plans, securing the appropriate funding is key.

The main efforts under Clean Sky 2 include demonstrating technologies: for both large and regional passenger aircraft, improved performance and versatility of new rotorcraft concepts, innovative airframe structures and materials, radical engine architectures, systems and controls and consideration of how we manage aircraft at the end of their useful life. This represents a rich stream of ideas and concepts that, with continued support, will mature and contribute to achieving the goals on limiting global climate change. The new European Partnership for Clean Aviation (EPCA) has objectives in line with the European Green Deal goals to reach climate neutrality in 2050 and will focus on the development of disruptive technologies and maximum impact.

Sustainable Aviation Fuels (SAF)
ECAC States are embracing the introduction of sustainable aviation fuels (SAF) in line with the 2050 ICAO Vision and are taking collective actions to address the many current barriers for SAF widespread availability or use in European airports.

The European collective SAF measures included in this Action Plan focuses on its CO_2 reductions benefits. Nevertheless SAF has the additional benefit of reducing air pollutant emissions of non-volatile Particulate Matter (nvPM), which can provide important other non-CO_2 benefits on the climate which are not specifically assessed within the scope of this Plan.

At European Union (EU) level, the ReFuelEU Aviation regulatory initiative aims to boost the supply and demand for SAF at EU airports, while maintaining a level playing field in the air transport market. This initiative is expected to result in a legislative proposal in the course of 2021. The common European section of this action plan also provides an overview of the current sustainability and life cycle emissions requirements applicable to SAF in the European Union's States as well as estimates of life cycle values for a number of technological pathways and feedstock.

Collective work has also been developed through EASA on addressing barriers of SAF penetration into the market.

The European Research and Innovation programme is moreover giving impulse to innovative technologies to overcome such barriers as it is highlighted by the number of recent European research projects put in place and planned to start in the short-term.

Improved Air Traffic Management
The European Union's Single European Sky (SES) policy aims to transform Air Traffic Management (ATM) in Europe towards digital service provision, increased capacity reduced ATM costs with high level of safety and 10% less environmental impact. SES policy has several elements, one of which is developing and deploying innovative technical and operational ATM solutions.

SESAR 1 (from 2008 to 2016), SESAR 2020 (started in 2016) and SESAR 3 (starting in 2022) are the EU programmes for the development of SESAR solutions. The SESAR solutions already developed and validated are capable of providing: 21% more airspace capacity; 14% more airport capacity; a 40% reduction in accident risk; 2.8% less greenhouse emissions; and a 6% reduction in flight costs. Future ATM systems will be based on 'Trajectory-based Operations' and 'Performance-based Operations'.

Much of the research to develop these solutions is underway and published results of the many earlier demonstration actions confirm the challenge but give us confidence that the goals will be achieved in the ECAC region with widespread potential to be replicated in other regions.

Market Based Measures (MBMs)
ECAC States, in application of their commitment in the 2016 Bratislava Declaration, have notified ICAO of their decision to voluntarily participate in Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) from its pilot phase, and have effectively engaged in its implementation and they encourage other States to do likewise and join CORSIA.

ECAC States have always been strong supporters of a market-based measure scheme for international aviation to incentivise and reward good investment and operational choices, and so welcomed the agreement on CORSIA.

The 30 European Economic Area (EEA)[3] States in Europe have implemented the EU Emissions Trading System (ETS), including the aviation sector with around 500 aircraft operators participating in the cap-and-trade approach to limit CO_2 emissions. Subject to preserving the environmental integrity and effectiveness it is expected that the EU ETS legislation will continue to be adapted to implement CORSIA.

As a consequence of the linking agreement with Switzerland, from 2020 the EU ETS was extended to all departing flights from the EEA to Switzerland, and Switzerland applies its ETS to all departing flights to EEA airports, ensuring a level playing field on both directions of routes.

In accordance with the EU-UK Trade and Cooperation Agreement reached in December 2020, the EU ETS shall continue to apply to departing flights from the EEA to the UK, while a UK ETS will apply effective carbon pricing on flights departing from the UK to the EEA.
In the period 2013 to 2020, EU ETS has saved an estimated 200 million tonnes of intra-European aviation CO_2 emissions.

ECAC Scenarios for Traffic and CO_2 Emissions
The scenarios presented in this common section of State Action Plans of ECAC States take into account the impacts of the COVID-19 crisis on air transport, to the extent possible, and with some unavoidable degree of uncertainty. The best-available data used for the purposes of this action plan has been taken from EUROCONTROL's regular publication of comprehensive assessments of the latest traffic situation in Europe.

Despite the current extraordinary global decay on passengers' traffic due to the COVID-19 pandemic, hitting European economy, tourism and the sector itself, aviation is expected to continue to grow in the long-term, develop and diversify in many ways across the ECAC States. Air cargo traffic has not been impacted as the rest of the traffic and thus, whilst the focus of available data relates to passenger traffic, similar pre-COVID forecasted outcomes might be anticipated for cargo traffic both as belly hold freight or in dedicated freighters.

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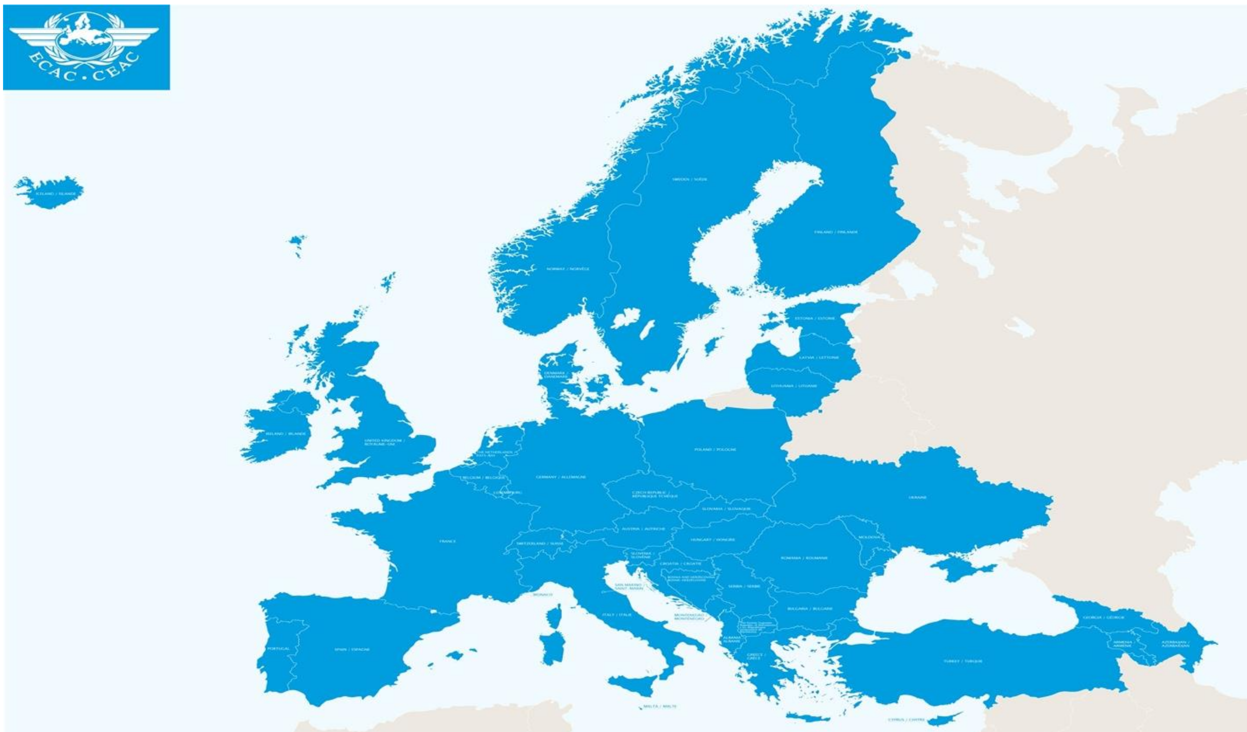
[3] The EEA includes EU countries and also Iceland, Liechtenstein and Norway.

The analysis by EUROCONTROL and EASA have identified the most likely scenario of influences on future traffic and modelled these assumptions out to future years. On the basis of this traffic forecast, fuel consumption and CO_2 emissions of aviation have been estimated for both a theoretical baseline scenario (without any additional mitigation action) and a scenario with estimated benefits from mitigation measures implemented since 2019 or provided benefits beyond 2019 that are presented in this action plan.

Under the baseline assumptions of traffic growth and fleet rollover with 2019 technology, CO_2 emissions would significantly grow in the long-term for flights departing from ECAC airports without mitigation measures. Modelling the impact of improved aircraft technology for the scenario with implemented measures indicates an overall 15% reduction of fuel consumption and CO_2 emissions in 2050 compared to the baseline. Whilst the data to model the benefits of ATM improvements may be less robust, they are nevertheless valuable contributions to reduce emissions further. Overall CO_2 emissions, including the effects of new aircraft types and ATM-related measures, are projected to improve to lead to a 23% reduction in 2050 compared to the baseline.

In the common section of this action plan the potential of sustainable aviation fuels and the effects of market-based measures have not been simulated in detail. Notably, CORSIA being a global measure, and not a European measure, the assessments of its benefits were not considered required for the purposes of the State Action Plans. But they should both help reach the ICAO carbon-neutral growth 2020 goal. As further developments in policy and technology are made, further analysis will improve the modelling of future emissions.

A. ECAC BASELINE SCENARIO AND ESTIMATED BENEFITS OF IMPLEMENTED MEASURES



ECAC BASELINE SCENARIO AND ESTIMATED BENEFITS OF IMPLEMENTED MEASURES

1. ECAC Baseline Scenario

The baseline scenario is intended to serve as a reference scenario for CO_2 emissions of European aviation in the absence of any of the mitigation actions described later in this document. The following sets of data (2010, 2019) and forecasts (for 2030, 2040 and 2050) were provided by EUROCONTROL for this purpose:

- European air traffic (includes all commercial and international flights departing from ECAC airports, in number of flights, revenue passenger kilometres (RPK) and revenue tonne-kilometres (RTK);
- its associated aggregated fuel consumption; and
- its associated CO_2 emissions.

The sets of forecasts correspond to projected traffic volumes in a scenario of "Regulation and Growth", while corresponding fuel consumption and CO_2 emissions assume the technology level of the year 2019 (i.e. without considering reductions of emissions by further aircraft related technology improvements, improved ATM and operations, sustainable aviation fuels or market based measures).

Traffic Scenario "Regulation and Growth"

As in all forecasts produced by EUROCONTROL, various scenarios are built with a specific storyline and a mix of characteristics. The aim is to improve the understanding of factors that will influence future traffic growth and the risks that lie ahead. The latest EUROCONTROL long-term forecast[4] was published in June 2018 and inspects traffic development in terms of Instrument Flight Rule (IFR) movements to 2040.

In the latter, the scenario called 'Regulation and Growth' is constructed as the 'most likely' or 'baseline' scenario for traffic, most closely following the current trends[5]. It considers a moderate economic growth, with some regulation particularly regarding the social and economic demands.

Amongst the models applied by EUROCONTROL for the forecast, the passenger traffic sub-model is the most developed and is structured around five main group of factors that are taken into account:

- **Global economy** factors represent the key economic developments driving the demand for air transport.
- Factors characterising the **passengers** and their travel preferences change patterns in travel demand and travel destinations.
- **Price of tickets** set by the airlines to cover their operating costs influences passengers' travel decisions and their choice of transport.
- More hub-and-spoke or point-to-point **networks** may alter the number of connections and flights needed to travel from origin to destination.
- **Market structure** describes size of aircraft used to satisfy the passenger demand (modelled via the Aircraft Assignment Tool).

Table 1 below presents a summary of the social, economic and air traffic related characteristics of three different scenarios developed by EUROCONTROL. The year 2016 served as the baseline year of the 20-year forecast results[Błąd! Nie zdefiniowano zakładki.] (published in 2018 by EUROCONTROL). Historical data for the year 2019 are also shown later for reference.

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[4] Challenges of Growth - Annex 1 - Flight Forecast to 2040, EUROCONTROL, September 2018.

[5] Prior to COVID-19 outbreak.

Table 1. Summary characteristics of EUROCONTROL scenarios.

	Global Growth	*Regulation and Growth*	*Fragmenting World*
2023 traffic growth	High ➚	Base ➔	Low ➘
Passenger Demographics (Population)	Ageing UN Medium-fertility variant	Ageing UN Medium-fertility variant	Ageing UN Zero-migration variant
Routes and Destinations	Long-haul ➚	No Change ➔	Long-haul ➘
Open Skies	EU enlargement later +Far & Middle East	EU enlargement Earliest	EU enlargement Latest
High-speed rail (new & improved connections)	20 city-pairs faster implementation	20 city-pairs	20 city-pairs later implementation.
Economic conditions			
GDP growth	Stronger ➚	Moderate ➔	Weaker ➘➘
EU Enlargement	+5 States, Later	+5 States, Earliest	+5 States, Latest
Free Trade	Global, faster	Limited, later	None
Price of travel			
Operating cost	Decreasing ➘➘	Decreasing ➘	No change ➔
Price of CO_2 in Emission Trading Scheme	Moderate	Lowest	Highest
Price of oil/barrel	Low	Lowest	High
Change in other charges	Noise: ➚ Security: ➘	Noise: ➚ Security: ➔	Noise: ➔ Security: ➚
Structure Network	Hubs: Mid-East ➚➚ Europe ➘ Turkey➚ Point-to-point: N-Atlantic.➚➚	Hubs: Mid-East ➚➚ Europe & Turkey ➚ Point-to-point: N-Atlantic.➚	No change ➔
Market Structure	Industry fleet forecast + STATFOR assumptions	Industry fleet forecast + STATFOR assumptions	Industry fleet forecast + STATFOR assumptions

COVID-19 impact and extension to 2050

Since the start of 2020, COVID-19 has gone from a localised outbreak in China to the most severe global pandemic in a century. No part of European aviation is untouched by the human tragedy or the business crisis. This unprecedented crisis hindered air traffic growth in 2020: flight movements declined by 55% compared to 2019 at ECAC level. It continues to disrupt the traffic growth and patterns in Europe in 2021. In Autumn 2020, EUROCONTROL published a medium-term forecast[6] to 2024, taking into account the impact of the COVID-19 outbreak. The latter is based on three different scenarios depending on how soon an effective vaccine would be made widely available to (air) travellers. Other factors have been included amongst which the economic impact of the crisis or levels of public confidence, to name a few. The Scenario 2: vaccine widely made available for travellers by Summer 2022, considered as the most likely, sees ECAC flights only reaching 92% of their 2019 levels in 2024.

In order to take into account the COVID-19 impact and to extend the horizon to 2050, the following adaptations have been brought to the original long-term forecast**Błąd! Nie zdefiniowano zakładki.**. Considering the most-likely scenarios of the long-term

6 Five-Year Forecast 2020-2024, IFR Movements, EUROCONTROL, November 2020.

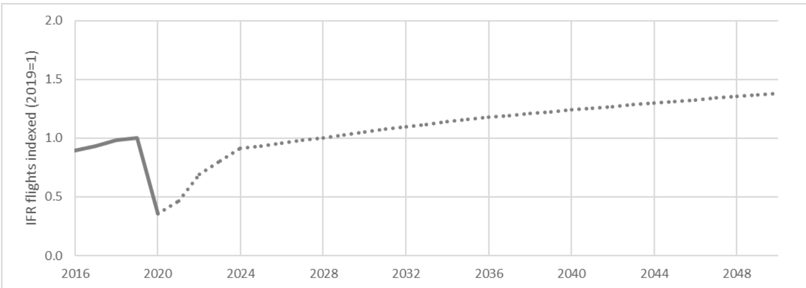
forecast**Błąd! Nie zdefiniowano zakładki.** and the medium-term forecasted version of the long-term flight forecast has been derived:

a) Replace the long-term forecast**Błąd! Nie zdefiniowano zakładki.** horizon by the most recent medium-term forecast**Błąd! Nie zdefiniowano zakładki.** to account for COVID impact;
b) Update the rest of the horizon (2025-2040) assuming that the original growth rates of the long-term forecast**Błąd! Nie zdefiniowano zakładki.**, would remain similar to those calculated pre-COVID-19; and
c) Extrapolate the final years (2040-2050) considering the same average annual growth rates as the one forecasted for the 2035-2040 period, but with a 0.9 decay[7].

The method used relies on the calculation of adjustment factors at STATFOR[8] region-pair level and have been applied to the original long-term forecast**Błąd! Nie zdefiniowano zakładki.**. Adjusting the baseline enables to further elaborate the baseline scenario as forecasted future fuel consumption and to 2030, 2040 and 2050, in the absence of action.

Figure 1 below shows the ECAC scenario of the passenger flight forecasted international departures for both historical (solid line) and future (dashed line) years.

Figure 1. Updated EUROCONTROL "Regulation and Growth" scenario of the passenger flight forecast for ECAC international departures including the COVID-19 impact in 2020 and the following 4 years.



Further assumptions and results for the baseline scenario
The ECAC baseline scenario was generated by EUROCONTROL for all ECAC States. It covers all commercial international passenger flights departing[9] from ECAC airports, as forecasted in the aforementioned traffic scenario. The number of passengers per flight is derived from Eurostat data.

EUROCONTROL also generates a number of all-cargo flights in its baseline scenario. However, no information about the freight tonnes carried is available. Hence, historical and

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[7] As the number of flights has not been directly forecasted via the system but numerically extrapolated, it does not include any fleet renewal, neither network change (airport pairs) between 2040 and 2050. This factor is aimed at adjusting the extrapolation to capture the gradual maturity of the market.

[8] STATFOR (Statistics and Forecast Service) provides statistics and forecasts on air traffic in Europe and to monitor and analyse the evolution of the Air Transport Industry.

[9] International departures only. Domestic flights are excluded. A domestic is any flight between two airports in the State, regardless of the operator or which airspaces they enter en-route. Airports located overseas are attached to the State having the sovereignty of the territory. For example, France domestic include flights to Guadeloupe, Martinique, etc.

forecasted cargo traffic have been extracted from another source (ICAO[10]). This data, which is presented below, includes both belly cargo transported on passenger flights and freight transported on dedicated all-cargo flights.

Historical fuel burn and emission calculations are based on the actual flight plans from the PRISME[11] data warehouse used by EUROCONTROL, including the actual flight distance and the cruise altitude by airport pair. These calculations were made for about 99% of the passenger flights (the remaining flights had information missing in the flight plans). Determination of the fuel burn and CO_2 emissions for historical years is built up as the aggregation of fuel burn and emissions for each aircraft of the associated traffic sample characteristics. Fuel burn and CO_2 emission results consider each aircraft's fuel burn in its ground and airborne phases of flight and are obtained by use of the EUROCONTROL IMPACT environmental model, with the aircraft technology level of each year.

Forecast years (until 2050) fuel burn and modelling calculations use the 2019 flight plan characteristics as much as possible, to replicate actual flown distances and cruise levels, by airport pairs and aircraft types. When not possible, this modelling approach uses past years traffics too, and, if needed, the ICAO CAEP forecast modelling. The forecast fuel burn and CO_2 emissions of the baseline scenario for forecast years uses the technology level of 2019.

For each reported year, the revenue per passenger kilometre (RPK) calculations use the number of passengers carried for each airport pair multiplied by the great circle distance between the associated airports and expressed in kilometres. Because of the coverage of the passenger estimation data sets (Scheduled, Low-cost, Non-Scheduled flights, available passenger information, etc.) these results are determined for about 99% of the historical passenger traffic, and 97% of the passenger flight forecasts. From the RPK values, the passenger flights RTK were calculated as the number of tonnes carried by kilometers, assuming that 1 passenger corresponds to 0.1 tonne.

The fuel efficiency represents the amount of fuel burn divided by the RPK for each available airport pair with passenger data, for the passenger traffic only. Here, the RPK and fuel efficiency results corresponds to the aggregation of these values for the whole concerned traffic years.

The following tables and figures show the results for this baseline scenario, which is intended to serve as a reference case by approximating fuel consumption and CO_2 emissions of European aviation in the absence of mitigation actions.

Table 2. Baseline forecast for international traffic departing from ECAC airports

Year	Passenger Traffic (IFR movements) (million)	Revenue Passenger Kilometres[12] RPK (billion)	All-Cargo Traffic (IFR movements) (million)	Freight Tonne Kilometres transported[13] FTKT (billion)	Total Revenue Tonne Kilometres[14] RTK (billion)
2010	4.56	1.114	0.198	45.4	156.8
2019	5.95	1.856	0.203	49.0	234.6

10 ICAO Long-Term Traffic Forecasts, Passenger and Cargo, July 2016. Cargo forecasts have not been updated as new ICAO forecast including COVID-19 effects will be made available after the end of June 2021, so those cannot be considered in this action plan common section.

11 PRISME is the name of the EUROCONTROL data warehouse hosting the flight plans, fleet and airframe data.

12 Calculated on the basis of Great Circle Distance (GCD) between airports, for 97% of the passenger traffic for forecast years.

13 Includes passenger and freight transport (on all-cargo and passenger flights).

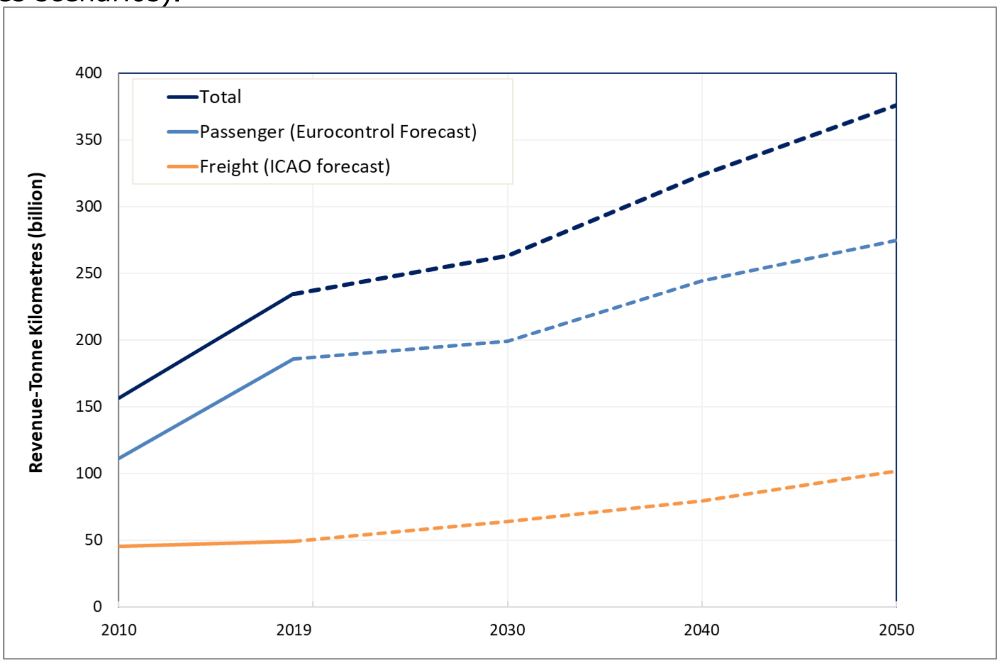
14 A value of 100 kg has been used as the average mass of a passenger incl. baggage (ref: ICAO).

2030	5.98	1,993	0.348	63.8	263.1
2040	7.22	2.446	0.450	79.4	324.0
2050	8.07	2.745	0.572	101.6	376.1

Table 3. Fuel burn and CO_2 emissions forecast for the baseline scenario

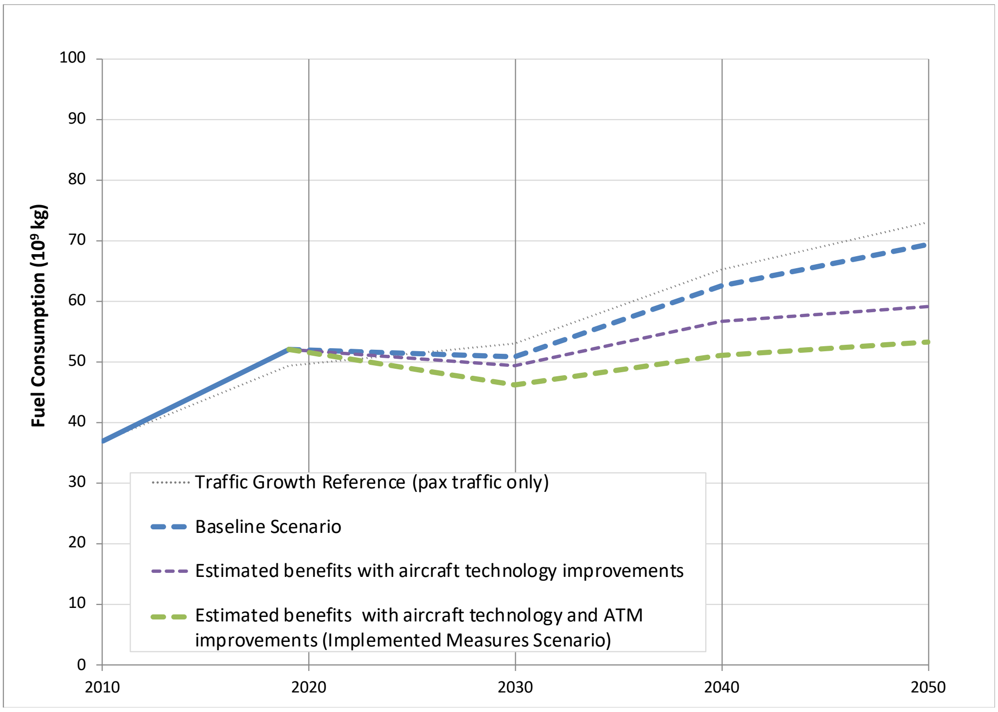
Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Fuel efficiency (kg/RPK **Błąd! Nie zdefiniowano zakładki.**)	Fuel efficiency (kg/RTK **Błąd! Nie zdefiniowano zakładki.**)
2010	36.95	116.78	0.0332	0.332
2019	52.01	164.35	0.0280	0.280
2030	50.72	160.29	0.0252	0.252
2040	62.38	197.13	0.0252	0.252
2050	69.42	219.35	0.0250	0.250
For reasons of data availability, results shown in this table do not include cargo/freight traffic.				

Figure 2. Forecasted traffic until 2050 (assumed both for the baseline and implemented measures scenarios).



The impact of the COVID-19 in 2020 is not fully reflected in Figure 2, as this representation is oversimplified through a straight line between 2019 and 2030. The same remark applies for Figure 3 and Figure 4.

Figure 3. Fuel consumption forecast for the baseline and implemented measures scenarios (international passenger flights departing from ECAC airports).



2. ECAC Scenario with Implemented Measures: Estimated Benefits

In order to improve the fuel efficiency and to reduce future air traffic emissions beyond the projections in the baseline scenario, ECAC States have taken further action. Assumptions for a top-down assessment of effects of mitigation actions are presented here, based on modelling results by EUROCONTROL and EASA. Measures to reduce aviation's fuel consumption and emissions will be described in the following chapters.

For reasons of simplicity, the scenario with implemented measures is based on the same traffic volumes as the baseline case, i.e. updated EUROCONTROL's 'Regulation and Growth' scenario described earlier. Unlike in the baseline scenario, the effects of aircraft related technology development and improvements in ATM/operations are considered here for a projection of fuel consumption and CO_2 emissions up to the year 2050.

Effects of **improved aircraft technology** are captured by simulating fleet roll-over and considering the fuel efficiency improvements of new aircraft types of the latest generation (e.g. Airbus A320NEO, Boeing 737MAX, Airbus A350XWB etc.). The simulated future fleet of aircraft has been generated using the Aircraft Assignment Tool[15] (AAT) developed collaboratively by EUROCONTROL, EASA and the European Commission. The retirement process of AAT is performed year by year, allowing the determination of the number of new aircraft required each year. In addition to the fleet rollover, a constant annual improvement of fuel efficiency of 1.16% per annum is assumed for each aircraft type with entry into service from 2020 onwards. This rate of improvement corresponds to the 'Advanced' fuel technology scenario used by CAEP to generate the fuel trends for the Assembly. This technology improvement modelling is applied to the years 2030 and 2040. For the year 2050, as the forecast traffic reuses exactly the fleet of the year 2040, the technological improvement is determined with the extrapolation of the fuel burn ratio between the baseline scenario and the technological improvement scenario results of the years 2030 to 2040.

The effects of **improved ATM efficiency** are captured in the Implemented Measures Scenario on the basis of efficiency analyses from the SESAR project. In SESAR, a value of

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15 https://www.easa.europa.eu/domains/environment/impact-assessment-tools

5,280 kg of fuel per flight for ECAC (including oceanic region) is used as a baseline[16]. Based on the information provided by the PAGAR 2019 document[17], and compared to a 2012 baseline, the benefits at the end of Wave 1 could be about 3% CO_2/fuel savings achieved by 2025 equivalent to 147.4 kg of fuel/flight. So far, the target for Wave 2 remains at about 7% more CO_2/fuel savings (352.6 kg of fuel) to reach the initial Ambition target of about 10% CO_2/fuel savings (500 kg fuel) per flight by 2035. The 2030 efficiency improvement is calculated by assuming a linear evolution between 2025 and 2035. As beyond 2035, there is no SESAR Ambition yet, it is assumed that the ATM efficiency improvements are reported extensively for years 2040 and 2050.

The as yet un-estimated benefits of Exploratory Research projects[18] are expected to increase the overall future fuel savings.

While the effects of **introduction of Sustainable Aviation Fuels (SAF)** were modelled in previous updates on the basis of the European ACARE goals[19], the expected SAF supply objectives for 2020 were not met, and in the current update the SAF benefits have not been modelled as a European common measure in the implemented measures scenario. However, numerous initiatives related to SAF (e.g. ReFuelEU Aviation) are largely described in Section B chapter 2 and it is expected that future updates will include an assessment of its benefits as a collective measure.

Effects on aviation's CO_2 emissions of **market-based measures** including the EU Emissions Trading System (ETS) with the linked Swiss ETS, the UK ETS and the ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) have not been modelled in the top-down assessment of the implemented measures scenario presented here as, at the time of the submission of this action plan, a legislative proposal for the revision of the EU ETS Directive concerning aviation, is under development to complete the implementation of CORSIA by the EU and to strengthen the ambition level of the EU ETS. CORSIA is not considered a European measure but a global one. It aims for carbon-neutral growth (CNG) of aviation as compared to the average of 2019 and 2020 levels of emissions in participating States, and an indication of a corresponding (hypothetical) target applied to Europe is shown in Figure 4[20], while recalling that this is just a reference level, given that CORSIA was designed to contribute to the CNG 2020 globally and not in individual States or regions.

Tables 4-6 and Figure 4 summarise the results for the scenario with implemented measures. It should be noted that **Table 4** show direct combustion emissions of CO_2 (assuming 3.16 kg CO_2 per kg fuel). More detailed tabulated results are found in Appendix A, including results expressed in equivalent CO_2 emissions on a well-to-wake basis (for comparison purposes of SAF benefits).

Table 4. Fuel burn and CO_2 emissions forecast for the Implemented Measures Scenario (new aircraft technology and ATM improvements only).

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[16] See SESAR ATM Master Plan – Edition 2020 (www.atmmasterplan.eu) - eATM.

[17] See SESAR Performance Assessment Gap Analysis Report (PAGAR) updated version of 2019 v00.01.04, 31-03-2021.

[18] See SESAR Exploratory Research projects - https://www.sesarju.eu/exploratoryresearch

[19] https://www.acare4europe.org/sria/flightpath-2050-goals/protecting-environment-and-energy-supply-0

[20] Note that in a strict sense the CORSIA target of CNG is aimed to be achieved globally (and hence not necessarily in each world region).

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Fuel efficiency (kg/RPK[21])	Fuel efficiency (kg/RTK[17])
2010	36.95	116.78	0.0332	0.332
2019	52.01	164.35	0.0280	0.280
2030	46.16	145.86	0.0229	0.229
2040	51.06	161.35	0.0206	0.206
2050	53.18	168.05	0.0192	0.192
2050 vs 2019			*-32%*	
For reasons of data availability, results shown in this table do not include cargo/freight traffic.				

Table 5. Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology and ATM improvements only)

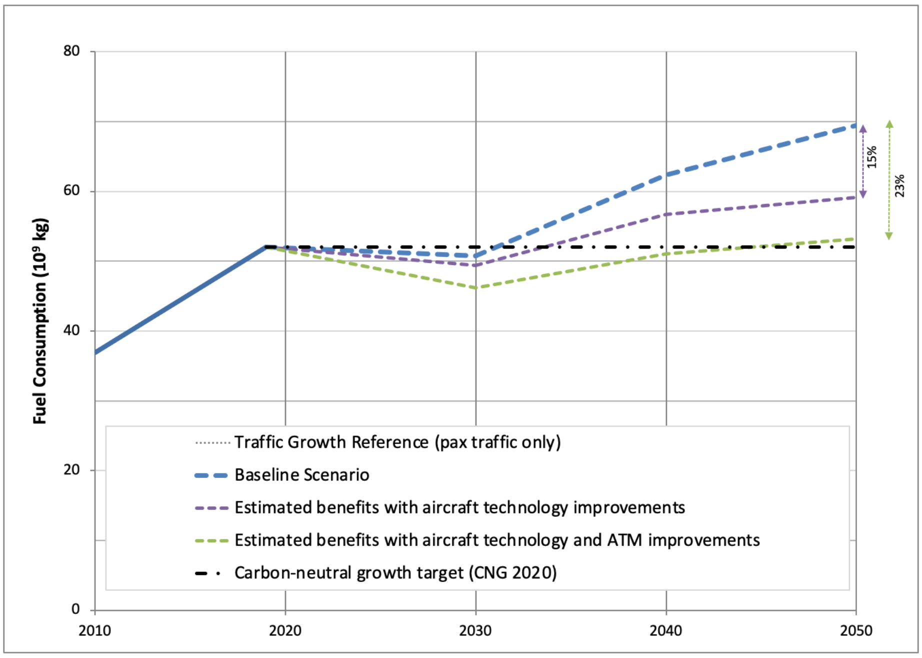
Period	Average annual fuel efficiency improvement (%)
2010-2019	-1.86%
2019-2030	-1.82%
2030-2040	-1.03%
2040-2050	-0.74%

Table 6. CO_2 emissions forecast for the scenarios described in this chapter.

Year	CO_2 emissions (10^9 kg)			% improvement by Implemented Measures (full scope)
	Baseline Scenario	Implemented Measures Scenario		
		Aircraft techn. improvements only	Aircraft techn. and ATM improvements	
2010	116.78			NA
2019	164.35			NA
2030	160.3	160.3	160.3	-9%
2040	197.1	197.1	197.1	-18%
2050	219.4	219.4	219.4	-23%
For reasons of data availability, results shown in this table do not include cargo/freight traffic. Note that fuel consumption is assumed to be unaffected by the use of sustainable aviation fuels.				

Figure 4. Fuel consumption forecast for the baseline and implemented measures scenarios.

21 Calculated on the basis of Great Circle Distance (GCD) between airports, for 97% of the passenger traffic for forecast years.



As shown in Figure 4, the impact of improved aircraft technology indicates an overall 15% reduction of fuel consumption and CO_2 emissions in 2050 compared to the baseline scenario. Overall CO_2 emissions, including the effects of new aircraft types and ATM-related measures, are projected to improve to lead to a 23% reduction in 2050 compared to the baseline.

From Table 4, under the currently assumed aircraft technology and ATM improvement scenarios, the fuel efficiency is projected to lead to a 32% reduction from 2019 to 2050. Indeed, the annual rate of fuel efficiency improvement is expected to progressively slow down from a rate of 1.82% between 2019 and 2030 to a rate of 0.74% between 2040 and 2050. Aircraft technology and ATM improvements alone will not be sufficient to meet the post-2020 carbon neutral growth objective of ICAO. This confirms that additional action, particularly market-based measures and SAF, are required to fill the gap. There are among the ECAC Member States additional ambitious climate strategies where carbon neutrality by 2050 is set as the overall objective. The aviation sector will have to contribute to this objective.

B. Actions Taken collectively in Europe

1. **TECHNOLOGY AND STANDARDS**
   1.1. Aircraft emissions standards
   1.2. Research and development: Clean Sky and the European Partnership for Clean Aviation
2. **SUSTAINABLE AVIATION FUELS (SAF)**
   2.1. ReFuelEU Aviation Initiative
   2.2. Addressing barriers of SAF penetration into the market
   2.3. Standards and requirements for SAF use
   2.4. Research and development projects
3. **OPERATIONAL IMPROVEMENTS**
   3.1. The EU's Single European Sky Initiative and SESAR
4. **MARKET-BASED MEASURES**
   4.1. The EU Emissions Trading System and its linkages with other systems (Swiss ETS and UK ETS)
   4.2. The Carbon Offsetting and Reduction Scheme for International Aviation
5. **ADDITIONAL MEASURES**
   5.1. ACI Airport Carbon Accreditation
   5.2. European industry roadmap to a net zero European aviation: Destination 2050
   5.3. Environmental Label Programme
   5.4. Multilateral capacity building projects
   5.5. Green Airports research and innovation projects
6. **SUPPLEMENTAL BENEFITS FOR DOMESTIC SECTORS**
   6.1. ACI Airport Carbon Accreditation
   6.2. ReFuelEU Aviation Initiative
   6.3. SAF Research and development projects
   6.4. The EU's Single European Sky Initiative and SESAR
   6.5. Green Airports research and innovation projects

1. TECHNOLOGY AND STANDARDS

1.1 Aircraft emissions standards

European Member States fully support ICAO's Committee on Aviation Environmental Protection (CAEP) work on the development and update of aircraft emissions standards, in particular to the **ICAO Aircraft CO_2 Standard** adopted by ICAO in 2017. Europe significantly contributed to its development, notably through the European Aviation Safety Agency (EASA). It is fully committed to its implementation in Europe and the need to review the standard on a regular basis in light of developments in aeroplane fuel efficiency. EASA has supported the process to integrate this standard into European legislation (2018/1139) with an applicability date of 1 January 2020 for new aeroplane types.

ASSESSMENT

This is a European contribution to a global measure (CO_2 standard). Its contribution to the global aspirational goals are available in CAEP.

1.2 Research and development

1.2.1 Clean Sky

Clean Sky[22] is an EU Joint Undertaking that aims to develop and mature breakthrough "clean technologies" for air transport globally. Joint Undertakings are Public Private Partnership set up by the European Union on the EU research programmes. By accelerating their deployment, the Joint Undertaking will contribute to Europe's strategic environmental and social priorities, and simultaneously promote competitiveness and sustainable economic growth. The first Clean Sky Joint Undertaking (**Clean Sky 1 -** 2011-2017) had a budget of €1.6 billion, equally shared between the European Commission and the aeronautics industry. It aimed to develop environmental-friendly technologies impacting all flying-segments of commercial aviation. The objectives were to reduce aircraft CO_2 emissions by 20-40%, NO_x by around 60% and noise by up to 10dB compared to year 2000 aircraft.

22 http://www.cleansky.eu/

This was followed up with a second Joint Undertaking (**Clean Sky 2** – 2014-2024) with the objective to reduce aircraft emissions and noise by 20 to 30% with respect to the latest technologies entering into service in 2014. The current budget for the programme is approximately €4 billion.

The two Interim Evaluations of Clean Sky in 2011 and 2013 acknowledged that the programme is successfully stimulating developments towards environmental targets. These preliminary assessments confirm the capability of achieving the overall targets at completion of the programme.

Main remaining areas for Research and Technological Development (RTD) efforts under Clean Sky 2 were:

- **Large Passenger Aircraft**: demonstration of best technologies to achieve the environmental goals whilst fulfilling future market needs and improving the competitiveness of future products.
- **Regional Aircraft:** demonstrating and validating key technologies that will enable a 90-seat class turboprop aircraft to deliver breakthrough economic and environmental performance and a superior passenger experience.
- **Fast Rotorcraft:** demonstrating new rotorcraft concepts (tilt-rotor and compound helicopters) technologies to deliver superior vehicle versatility and performance.
- **Airframe:** demonstrating the benefits of advanced and innovative airframe structures (like a more efficient wing with natural laminar flow, optimised control surfaces, control systems and embedded systems, highly integrated in metallic and advanced composites structures). In addition, novel engine integration strategies and innovative fuselage structures will be investigated and tested.
- **Engines:** validating advanced and more radical engine architectures.
- **Systems:** demonstrating the advantages of applying new technologies in major areas such as power management, cockpit, wing, landing gear, to address the needs of a future generation of aircraft in terms of maturation, demonstration and Innovation.
- **Small Air Transport:** demonstrating the advantages of applying key technologies on small aircraft demonstrators to revitalise an important segment of the aeronautics sector that can bring new key mobility solutions.
- **Eco-Design:** coordinating research geared towards high eco-compliance in air vehicles over their product life and heightening the stewardship with intelligent Re-use, Recycling and advanced services.

In addition, the **Clean Sky Technology Evaluator**[23] will continue to be upgraded to assess technological progress routinely and evaluate the performance potential of Clean Sky 2 technologies at both vehicle and aggregate levels (airports and air traffic systems).

1.2.1 Disruptive aircraft technological innovations: European Partnership for Clean Aviation

With the Horizon 2020 programme coming to a close in 2020, the Commission has adopted a proposal to set up a new Joint Undertaking under the Horizon Europe programme (2021-2027). The **European Partnership for Clean Aviation (EPCA)**[24] will follow in the footsteps of CleanSky2. The EU contribution proposed is again €1.7 billion. The stakeholder community has already formulated a Strategic Research and Innovation Agenda (SRIA), which is intended to serve as a basis of the partnership once established. Subject to the final provisions of the partnership and the EU budget allocation, industry stakeholders have proposed a commitment of €3 billion from the private side.

General objectives of EPCA:

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[23] https://www.cleansky.eu/technology-evaluator-te

[24] https://clean-aviation.eu/

(a) To contribute to reduce the ecological footprint of aviation by accelerating the development of climate neutral aviation technologies for earliest possible deployment, therefore significantly contributing to the achievement of the general goals of the European Green Deal, in particular in relation to the reduction of Union-wide net greenhouse gas emissions reduction target of at least 55% by 2030, compared to 1990 levels and a pathway towards reaching climate neutrality by 2050.
(b) To ensure that aeronautics-related research and innovation activities contribute to the global sustainable competitiveness of the Union aviation industry, and to ensure that climate-neutral aviation technologies meet the relevant aviation safety requirements, and remains a secure, reliable, cost-effective, and efficient means of passenger and freight transportation.
Specific objectives:
(a) To integrate and demonstrate disruptive aircraft technological innovations able to decrease net emissions of greenhouse gasses by no less than 30% by 2030, compared to 2020 state-of-the-art technology while paving the ground towards climate-neutral aviation by 2050.
(b) To ensure that the technological and the potential industrial readiness of innovations can support the launch of disruptive new products and services by 2035, with the aim of replacing 75% of the operating fleet by 2050 and developing an innovative, reliable, safe and cost-effective European aviation system that is able to meet the objective of climate neutrality by 2050.
(c) To expand and foster integration of the climate-neutral aviation research and innovations value chains, including academia, research organisations, industry, and SMEs, also by benefitting from exploiting synergies with other national and European related programmes.

ASSESSMENT

The quantitative assessment of the technology improvement scenario from 2020 to 2050 has been calculated by EUROCONTROL and EASA and it is included in Section A above (ECAC Baseline Scenario and Estimated Benefits of Implemented Measures) and in Appendix A.

Table 7 Fuel consumption and CO_2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology improvements after 2019 included:

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Well-to-wake CO_2e emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	36.95	116.78	143.38	0.0332	0.332
2019	52.01	164.35	201.80	0.0280	0.280
2030	49.37	156.00	191.54	0.0232	0.232
2040	56.74	179.28	220.13	0.0217	0.217
2050	59.09	186.72	229.26	0.0202	0.202
For reasons of data availability, results shown in this table do not include cargo/freight traffic.					

Table 8 Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology only):

Period	Average annual fuel efficiency improvement (%)
2010-2019	-1.86%
2019-2030	-1.22%
2030-2040	-0.65%
2040-2050	-0.74%

2. SUSTAINABLE AVIATION FUELS

Sustainable aviation fuels (SAF) including advanced biofuels and synthetic fuels, have the potential to significantly reduce aircraft emissions and ECAC States are embracing their large-scale introduction in line with the 2050 ICAO Vision.
The European collective SAF measures included in this Action Plan focuses on its CO_2 reductions benefits. Nevertheless SAF has the additional benefit of reducing air pollutant emissions of non-volatile Particulate Matter (nvPM) with up to 90% and sulphur (SO_X) with 100%, compared to fossil jet fuel[25]. As a result, the large-scale use of SAF can have important other non-CO_2 benefits on the climate which are not specifically assessed within the scope of this Plan.

2.1 ReFuelEU Aviation Initiative

On 15 January 2020, the European Parliament adopted a resolution on the European Green Deal in which it welcomed the upcoming strategy for sustainable and smart mobility and agreed with the European Commission that all modes of transport will have to contribute to the decarbonisation of the transport sector in line with the objective of reaching a climate-neutral economy. The European Parliament also called for "*a clear regulatory roadmap for the decarbonisation of aviation, based on technological solutions, infrastructure, requirements for sustainable alternative fuels and efficient operations, in combination with incentives for a modal shift*".

The Commission's work programme for 2020 listed under the policy objective on Sustainable and smart mobility, a new legislative initiative entitled "*ReFuelEU Aviation – Sustainable Aviation Fuels*".

25 ICAO 2016 Environmental Report, Chapter 4, Page 162, Figure 4.

This initiative aims to boost the supply and demand for sustainable aviation fuels (SAF) in the EU including not only advanced biofules but also synthetic fuels. This in turn will reduce aviation's environmental footprint and enable it to help achieve the EU's climate targets.

The EU aviation internal market is a key enabler of connectivity and growth but is also accountable for significant environmental impact. In line with the EU's climate goals to reduce emissions by 55% by 2030 and to achieve carbon neutrality by 2050, the aviation sector needs to decarbonise.

While several policy measures are in place, significant potential for emissions savings could come from the use of SAF, i.e. liquid drop-in fuels replacing fossil kerosene. However, currently only around 0.05% of total aviation fuels used in the EU are sustainable.
The ReFuelEU Aviation initiative aims to maintain a competitive air transport sector while increasing the share of SAF used by airlines. The European Commission aims to propose in spring 2021 a Regulation imposing increasing shares of SAF to be blended with conventional fuel. This could result in important emission savings for the sector, given that some of those fuels (e.g. synthetic fuels) have the potential to save up to 85% or more of emissions compared to fossil fuels, over their total lifecycle.

ASSESSMENT
A meaningful deployment of SAF in the aviation market will lead to a net decrease of the air transport sector's CO_2 emissions. SAF can achieve as high as 85% or more emissions savings compared to conventional jet fuel, and therefore, if deployed at a large scale, have important potential to help aviation contribute to EU reaching its climate targets.

At the time of the submission of this action plan the legislative proposal under the ReFuelEU Aviation initiative, as well as its supporting impact assessment, were not yet adopted. As a result, the assessment of the benefits provided by this collective European measure in terms of reduction in aviation emissions is expected to be included in a future update of the common section of this action plan.

2.2 Addressing barriers of SAF penetration into the market
SAF are considered to be a critical element in the basket of measures to mitigate aviation's contribution to climate change in the short-term using the existing global fleet.

However, the use of SAF has remained negligible up to now despite previous policy initiatives such as the European Advanced Biofuels Flightpath, as there are still significant barriers for its large-scale deployment.

The European Aviation Environmental Report (EAER) published in January 2019, identified a lack of information at European level on the supply and use of SAF within Europe. EASA completed two studies in 2019 to address the lack of SAF monitoring in the EU.

2.2.1 Sustainable Aviation Fuel 'Facilitation Initiative'
The first study, addressing the barriers of SAF penetration into the market, examines how to incentivise the approval and use of SAF as drop-in fuels in Europe by introducing a SAF Facilitation Initiative.

The remaining significant industrial and economic barriers limit the penetration of SAF into the aviation sector. To reduce the costs and risk that economic operators face in bringing SAF to the aviation market, this study examined how to incentivise the approval and use of SAF as drop-in fuels in Europe by introducing a SAF Facilitation Initiative.

The report begins by analysing the status of SAFs in Europe today, including both more established technologies and ones at a lower Technology Readiness Level (TRL). It reviews one of the major solutions to the obstacle of navigating the SAF approval process, namely the US Clearing House run by the University of Dayton Research Institute and funded by the Federal Aviation Administration (FAA). The issue of sustainability is also examined, via an analysis of the role of Sustainability Certification Schemes (SCS) and how they interact with regulatory sustainability requirements, particularly those in the EU's Renewable Energy Directive (RED II) and ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

Through interviews with a wide range of stakeholders the best form of European facilitation initiative has been identified. This study recommends that such an initiative be divided into two separate bodies, the first acting as an EU Clearing House and the second acting as a Stakeholder Forum.

The report is available at EASA's website: 'Sustainable Aviation Fuel 'Facilitation Initiative'.

2.2.2. Sustainable Aviation Fuel 'Monitoring System'

In response to a lack of information at the EU level on the supply and use of SAF within Europe identified by the European Aviation Environmental Report, EASA launched a second study to identify a cost effective, robust data stream to monitor the use and supply of SAF, as well as the associated emissions reductions. This included identifying and recommending performance indicators related to the use of SAF in Europe, as well as the associated aviation CO_2 emissions reductions achieved.

The study followed five steps:

1. Identification of possible performance indicators by reviewing the current 'state of the art' SAF indicators and consultation with key stakeholders.
2. Identification of regulatory reporting requirements, and other possible sources of datasets and information streams in the European context, with the potential to cover the data needs of the proposed performance indicators.
3. Examination of sustainability requirements applicable to SAF, and potential savings in greenhouse gas (GHG) emissions compared to fossil-based fuels.
4. Review of SAF use today and future expectations for SAF use within Europe.
5. Definition of a future monitoring and reporting process on SAF use in Europe and related recommendations to implement it.

The results will be used as a basis for subsequent work to include SAF performance indicators in future EAERs, which will provide insight into the market penetration of SAF over time in order to assess the success of policy measures to incentivize uptake.
The report is available at EASA's website: 'Sustainable Aviation Fuel 'Monitoring System'.

ASSESSMENT

While these studies are expected to contribute to addressing barriers of SAF penetration into the market, its inclusion is for information purposes and the assessment of its benefits in terms of reduction in aviation emissions is not provided in the present action plan.

2.3 Standards and requirements for SAF

2.3.1. European Union standards applicable to SAF supply

Within the European Union there are currently applicable standards for renewable energy supply in the transportation sector, which are included in the revised Renewable Energy Directive (RED II) that entered into force in December 2018 (Directive 2018/2001/EU).

It aims at promoting the use of energy from renewable sources, establishing mandatory targets to be achieved by 2030 for a 30% overall share of renewable energy in the EU and a minimum of 14% share for renewable energy in the transport sector, including for aviation but without mandatory SAF supply targets.

Sustainability and life cycle emissions methodologies:

Sustainability criteria and life cycle emissions methodologies have been established for all transport renewable fuels supplied within the EU to be counted towards the targets, which are fully applicable to SAF supply.

These can be found in RED´s[26] Article 17, *Sustainability criteria for biofuels and bioliquids*. Those requirements remain applicable on the revised RED II (Directive (EU) 2018/2001)38, Article 29 *Sustainability and greenhouse gas emissions saving criteria for biofuels, bioliquids and biomass fuels* paragraphs 2 to 7, although the RED II introduces some new specific criteria for forestry feedstocks.

Transport renewable fuels (thus, including SAF) produced in installations starting operation from 1 January 2021 must achieve 65% GHG emissions savings with respect to a fossil fuel comparator for transportation fuels of 94 g CO_2eq/MJ. In the case of transport renewable fuels of non-biological origin[27], the threshold is raised to 70% GHG emissions savings.

To help economic operators to declare the GHG emission savings of their products, default and typical values for a number of specific pathways are listed in the RED II Annex V (for liquid biofuels). The European Commission can revise and update the default values of GHG emissions when technological developments make it necessary.

Economic operators have the option to either use default GHG intensity values provided in RED II (Parts A & B of Annex V) so as to estimate GHG emissions savings for some or all of the steps of a specific biofuel production process, or to calculate "actual values" for their pathway in accordance with the RED methodology laid down in Part C of Annex V;

In the case of non-bio based fuels, a specific methodology is currently under development to be issued in 2021.

2.3.2. ICAO standards applicable to SAF supply

Europe is actively contributing to the development of the ICAO CORSIA Standards and Recommended Practices (SARPs), though the ICAO Committee on Aviation and Environmental Protection (CAEP), establishing global Sustainability Requirements applicable to SAF as well as to the CORSIA Methodology for Calculating Actual Life Cycle Emissions Values and to the calculation of CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels; CORSIA standards are applicable to any SAF use to be claimed under CORSIA in order to reduce offsetting obligations by aeroplane operators.

ASSESSMENT

The inclusion of European requirements for SAF respond to ICAO Guidance (Doc 9988) request (Para. 4.2.14) to provide estimates of the actual life cycle emissions of the SAF which are being used or planned to deploy and the methodology used for the life cycle analysis. It is therefore provided for information purposes only and no further assessment of its benefits in terms of reduction in aviation emissions is provided in this action plan common section.

2.4 Research and Development projects on SAF

2.4.1 European Advanced Biofuels Flightpath

[26] Directive 2009/28/EC.

[27] In the case of renewable fuels of non-biological origin, two types are considered: a) Renewable liquid and gaseous transport fuels of non-biological origin (including categories commonly referred as Power to Liquid -PtL-, Electro-fuels and Synthetic fuels). b) Waste gases, which are under the category of REcycled FUel from NOn-BIOlogical origin (also known as REFUNIOBIO).

An updated and renewed approach to the 2011 Biofuels FlightPath Initiative[28], was required to further impulse its implementation. As a result, the European Commission launched in 2016 the new Biofuels FlightPath to take into account recent evolutions and to tackle the current barriers identified for the deployment of SAF.

The Biofuels FlightPath was managed by its Core Team, which consists of representatives from Airbus, Air France, KLM, IAG, IATA, BiojetMap, SkyNRG and Lufthansa from the aviation side and Mossi Ghisolfi, Neste, Honeywell-UOP, Total and Swedish Biofuels on the biofuel producers' side.

A dedicated executive team, formed by SENASA, ONERA, Transport & Mobility Leuven and Wageningen UR, coordinated for three years the stakeholder's strategy in the field of aviation by supporting the activities of the Core Team and providing sound recommendations to the European Commission.

A number of communications and studies were delivered and are available[29].
The project was concluded with a Stakeholders conference in Brussels on 27 November 2019, and the publication of a report summarizing its outcomes.

2.4.2 Projects funded under the European Union's Horizon 2020 research and innovation programme

Since 2016, seven new projects have been funded by the Horizon 2020, which is the biggest Research and Innovation program of the EU.

BIO4A[30]: The "*Advanced Sustainable Biofuels for Aviation*» project plan to demonstrate the first large industrial-scale production and use of SAF in Europe obtained from residual lipids such as Used Cooking Oil.

The project will also investigate the supply of sustainable feedstocks produced from drought-resistant crops such as Camelina, grown on marginal land in EU Mediterranean areas. By adopting a combination of biochar and other soil amendments, it will be possible to increase the fertility of the soil and its resilience to climate change, while at the same time storing fixed carbon into the soil.

BIO4A will also test the use of SAF across the entire logistic chain at industrial scale and under market conditions, and it will finally assess the environmental and socio-economic sustainability performance of the whole value chain.
Started in May 2018, BIO4A will last until 2022, and it is carried out by a consortium of seven partners from five European countries.

KEROGREEN[31]: *Production of sustainable aircraft grade kerosene from water and air powered by renewable electricity, through the splitting of CO_2, syngas formation and Fischer-Tropsch synthesis* (KEROGREEN), is a Research and Innovation Action (RIA) carried out by six partners from four European countries aiming at the development and

28 In June 2011 the European Commission, in close coordination with Airbus, leading European airlines (Lufthansa, Air France/KLM, & British Airways) and key European biofuel producers (Choren Industries, Neste Oil, Biomass Technology Group and UOP), launched the **European Advanced Biofuels Flight-path**. This industry-wide initiative aimed to speed up the commercialisation of aviation biofuels in Europe, with an initial objective of achieving the commercialisation of 2 million tonnes of SAF by 2020, target that was not reached due to the commercial challenges of SAF large-scale supply. https://ec.europa.eu/energy/sites/ener/files/20130911_a_performing_biofuels_supply_chain.pdf

29 https://www.biofuelsflightpath.eu/ressources

30 www.bio4a.eu

31 www.kerogreen.eu

testing of an innovative conversion route for the production of SAF from water and air powered by renewable electricity.

The new approach and process of KEROGREEN reduces overall CO_2 emission by creating a closed carbon fuel cycle and at the same time creates long-term large-scale energy storage capacity which will strengthen the EU energy security and allow creation of a sustainable transportation sector.

The KEROGREEN project expected duration is from April 2018 to March 2022.

FlexJET[32]: *Sustainable Jet Fuel from Flexible Waste Biomass* (flexJET) is a four-year project targeting diversifying the feedstock for SAF beyond vegetable oils and fats to biocrude oil produced from a wide range of organic waste. This is also one of the first technologies to use green hydrogen from the processed waste feedstock for the downstream refining process thereby maximising greenhouse gas savings.

The project aims at building a demonstration plant for a 12 t/day use of food & market waste and 4000 l/day of Used Cooking Oil (UCO), produce hydrogen for refining through separation from syngas based on Pressure Swing Absorption technology, and finally deliver 1200 tons of SAF (ASTM D7566 Annex 2) for commercial flights to British Airways.

The consortium with 13 partner organisations has brought together some of the leading researchers, industrial technology providers and renewable energy experts from across Europe. The project has a total duration of 48 months from April 2018 to March 2022.

BioSFerA[33]: The *Biofuels production from Syngas Fermentation for Aviation and maritime use* (BioSFerA)project, aims to validate a combined thermochemical - biochemical pathway to develop cost-effective interdisciplinary technology to produce sustainable aviation and maritime fuels. At the end of the project next generation aviation and maritime biofuels, completely derived from second generation biomass, will be produced and validated by industrial partners at pilot scale. The project will undertake a full value chain evaluation that will result in a final analysis to define a pathway for the market introduction of the project concept. Some crosscutting evaluations carried out on all tested and validated processes will complete the results of the project from an economic, environmental and social point of view.
The project is carried out by a consortium of 11 partners from 6 European countries and its expected duration is from 1 April 2020 to 31 March 2024.

BL2F[34]: The *Black Liquor to Fuel* (BL2F) project will use "Black Liquor" to create a clean, high-quality biofuel. Black liquor is a side-stream of the chemical pulping industry that can be transformed into fuel, reducing waste and providing an alternative to fossil fuels. Launched in April 2020, BL2F will develop a first-of-its-kind Integrated "Hydrothermal Liquefaction" (HTL) process at pulp mills, decreasing carbon emissions during the creation of the fuel intermediate. This will then be further upgraded at oil refineries to bring it closer to the final products and provide a feedstock for marine and aviation fuels.

BL2F aims to contribute to a reduction of 83% CO_2 emitted compared to fossil fuels. A large deployment of the processes developed by BL2F, using a variety of biomass, could yield more than 50 billion litres of advanced biofuels by 2050.

The project brings together 12 partners from 8 countries around Europe and its expected duration is from 1 April 2020 till 31 March 2023.

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32 www.flexjetproject.eu
33 https://biosfera-project.eu
34 https://www.bl2f.eu

FLITE[35]: The *Fuel via Low Carbon Integrated Technology from Ethanol* (FLITE) consortium proposes to expand the supply of low carbon jet fuel in Europe by designing, building, and demonstrating an innovative ethanol-based Alcohol-to-Jet (ATJ) technology in an ATJ Advanced Production Unit (ATJ-APU). The ATJ-APU will produce jet blend stocks from non-food/non-feed ethanol with over 70% GHG reductions relative to conventional jet. The Project will demonstrate over 1000 hours of operations and production of over 30,000 metric tonnes of Sustainable Aviation Fuel.

The diversity of ethanol sources offers the potential to produce cost competitive SAF, accelerating uptake by commercial airlines and paving the way for implementation.
The project is carried out by a consortium of five partners from six European countries and its expected duration is from 1 December 2020 till 30 November 2024.

TAKE-OFF[36]: Is an industrially driven project aiming to be a game-changer in the cost-effective production of SAF from CO_2 and hydrogen. The unique TAKE-OFF technology is based on conversion of CO_2 and H_2 to SAF via ethylene as intermediate. Its industrial partners will team up with research groups to deliver a highly innovative process which produces SAF at lower costs, higher energy efficiency and higher carbon efficiency to the crude jet fuel product than the current benchmark Fischer-Tropsch process. TAKE-OFF's key industrial players should allow the demonstration of the full technology chain, utilising industrial captured CO_2 and electrolytically produced hydrogen. The demonstration activities will provide valuable data for comprehensive technical and economic and environmental analyses with an outlook on Chemical Factories of the Future.

The project is carried out by a consortium of nine partners from five European countries and its expected duration is from 1 January 2021 till 24 December 2024.

ASSESSMENT
This information on SAF European Research and Development projects are included in this common section of the action plan to complement the information on Sustainable Aviation Fuels measures and to inform on collective European efforts. No further quantitative assessment of the benefits of this collective European measure in terms of reduction in aviation emissions is provided in the common section of this action plan.

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35 https://cordis.europa.eu/project/id/857839
36 https://cordis.europa.eu/project/id/101006799

3. OPERATIONAL IMPROVEMENTS

3.1 The EU's Single European Sky Initiative and SESAR

3.1.1 SESAR Project

SES and SESAR

The European Union's Single European Sky (SES) policy aims to reform Air Traffic Management (ATM) in Europe in order to enhance its performance in terms of its capacity to manage variable volumes of flights in a safer, more cost-efficient and environmentally friendly manner.

The SESAR (*Single European Sky ATM Research*) programme addresses the technological dimension of the single European sky, aiming in particular to deploy a modern, interoperable and high-performing ATM infrastructure in Europe.

SESAR contributes to the Single Sky's performance targets by defining, validating and deploying innovative technological and operational solutions for managing air traffic in a more efficient manner. SESAR coordinates and concentrates all EU research and development (RTD) activities in ATM.

SESAR is fully aligned with the Union's objectives of a sustainable and digitalised mobility and is projected towards their progressive achievement over the next decade. To implement the SESAR project, the Commission has set up with the industry, an innovation cycle comprising three interrelated phases: definition, development and deployment. These phases are driven by partnerships (SESAR Joint Undertaking and SESAR Deployment Manager) involving all categories of ATM/aviation stakeholders.

Guided by the European ATM Master Plan, the SESAR Joint Undertaking (SJU) is responsible for defining, developing, validating and delivering technical and operation solutions to modernise Europe's ATM system and deliver benefits to Europe and its citizens. The SESAR JU research programme is developed over successive phases, SESAR 1 (from 2008 to

2016) and SESAR 2020 (started in 2016) and SESAR 3 (starting in 2022). It is delivering SESAR solutions in four key areas, namely airport operations, network operations, air traffic services and technology enablers.

The SESAR contribution to the SES high-level goals set by the Commission are continuously reviewed by the SESAR JU and are kept up to date in the ATM Master Plan.

SESAR and the European Green Deal objectives
The European Green Deal launched by the European Commission in December 2019 aims to create the world's first climate-neutral bloc by 2050. This ambitious target calls for deep-rooted change across the aviation sector and places significantly stronger focus on the environmental impact of flying. Multiple technology pathways are required, one of which is the digital transformation of air traffic management, where SESAR innovation comes into play. Over the past ten years the SESAR JU has worked to improve the environmental footprint of air traffic management, from CO_2 and non-CO_2 emissions, to noise and local air quality. The programme is examining every phase of flight and use of the airspace and seeing what technologies can be used to eliminate fuel inefficiencies. It is also investing in synchronised data exchange and operations on the ground and in the air to ensure maximum impact. The ambition is to reduce by 2035 average CO_2 emissions per flight by 0.8-1.6 tonnes, taking into account the entire flight from gate to gate, including the airport.

Results
To date, the SESAR JU has delivered over 90 solutions for implementation, many of which offer direct and indirect benefits for the environment, with more solutions in the pipeline in SESAR 2020. Outlined in the SESAR Solutions Catalogue, these include solutions such as wake turbulence separation (for arrivals and departure), optimised use of runway configuration for multiple runway airports, or even optimised integration of arrival and departure traffic flows for single and multiple runway airports. Looking ahead, it is anticipated that the next generation of SESAR solutions will contribute to a reduction of some 450 kg CO_2 per flight.

Considering the urgency of the situation, the SESAR JU is working to accelerate the digital transformation in order to support a swift transition to greener aviation. Large-scale demonstrators are key to bridging the industrialisation gap, bringing these innovations to scale and encouraging rapid implementation by industry. Such large-scale efforts have started now with the recently launched ALBATROSS project. They will also be the focus of the future SESAR 3 Joint Undertaking, which is expected to give further and fresh impetus to this important endeavour.

The **Performance Ambitions for 2035** compared to a **2012 baseline** for Controlled airspace for each key performance area are presented in the figure below, with the ambition for environment, expressed in CO_2 reduction, highlighted by the green dotted rectangle of **Figure 5** below:

Key performance area	SES high-level goals 2005	Key performance indicator	Performance ambition vs. baseline: Baseline value (2012)	Ambition value (2035)	Absolute improvement	Relative improvement
Capacity	Enable 3-fold increase in ATM capacity	Departure delay[4], min/dep	9.5 min	6.5-8.5 min	1-3 min	10-30%
		IFR movements at most congested airports[5], million	4 million	4.2-4.4 million	0.2-0.4 million	5-10%
		Network throughput IFR flights[5], million	9.7 million	~15.7 million	~6.0 million	~60%
		Network throughput IFR flight hours[5], million	15.2 million	~26.7 million	~11.5 million	~75%
Cost efficiency	Reduced ATM services unit costs by 50% or more	Gate-to-gate direct ANS cost per flight[1] · EUR(2012)	EUR 960	EUR 580-670	EUR 290-380	30-40%
Operational efficiency		Gate-to-gate fuel burn per flight[2], kg/flight	5280 kg	4780-5030 kg	250-500 kg	5-10%
		Additional gate-to-gate flight time per flight, min/flight	8.2 min	3.7-4.1 min	4.1-4.5 min	50-55%
		Within the: Gate-to-gate flight time per flight[3], min/flight	(111 min)	(116 min)		
Environment	Enable 10% reduction in the effects flights have on the environment	Gate-to-gate CO_2 emissions, tonnes/flight	16.6 tonnes	15-15.8 tonnes	0.8-1.6 tonnes	5-10%
Safety	Improve safety by factor 10	Accidents with direct ATM contribution[6], #/year Includes in-flight accidents as well as accidents during surface movement (during taxi and on the runway)	0.7 (long-term average)	no ATM related accidents	0.7	100%
Security		ATM related security incidents resulting in traffic disruptions	unknown	no significant disruption due to cyber-security vulnerabilities	unknown	-

1 Unit rate savings will be larger because the average number of Service Units per flight continues to increase.
2 "Additional" means the average flight time extension caused by ATM inefficiencies.
3 Average flight time increases because the number of long-distance flights is forecast to grow faster than the number of short-distance flights.
4 All primary and secondary (reactionary) delay, including ATM and non-ATM causes.
5 Includes all non-segregated unmanned traffic flying IFR, but not the drone traffic flying in airspace below 500 feet or the new entrants flying above FL 600
6 In accordance with the PRR definition: where at least one ATM event or item was judged to be DIRECTLY in the causal chain of events leading to the accident. Without that ATM event, it is considered that the accident would not have happened.

Figure 5: Performance Ambitions for 2035 for Controlled airspace (Source: European ATM Master Plan 2020 Edition).

While all SESAR solutions bring added value to ATM performance, some have a higher potential to contribute the performance of the entire European ATM network and require a coordinated and synchronised deployment. To facilitate the deployment of these SESAR solutions, the Commission establishes common projects that mandate the synchronised implementation of selected essential ATM functionalities based on SESAR solutions developed and validated by the SESAR JU.

The first common project was launched in 2014 and its implementation is currently being coordinated by the SESAR Deployment Manager throughout the entire European ATM network. It includes six ATM functionalities aiming in particular to:

- Optimise the distancing of aircraft during landing and take-off, reducing delays and fuel burn while ensuring the safest flying conditions.
- Allow aircraft to fly their preferred and usually most fuel-efficient trajectory (free route).
- Implement an initial, yet fundamental step towards digitalising communications between aircraft and controllers and between ground stakeholders allowing better planning, predictability, thus less delays and fuel optimisation and passenger experience.

The first common project[37] is planned to be completed by 2027. However, the benefits highlighted in **Figure 6** below have been measured where the functionalities have already been implemented.

37 https://ec.europa.eu/transport/modes/air/sesar/deployment_en

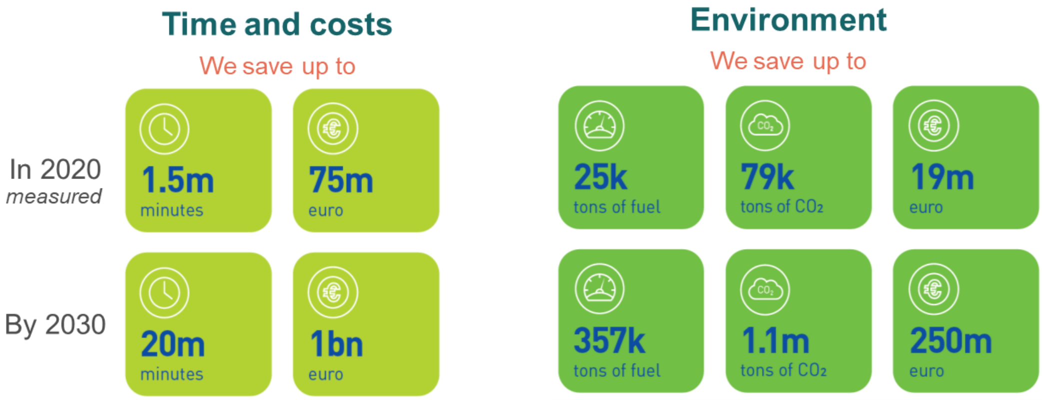

Figure 6: First results of the first common project implemented.

3.1.2 SESAR Exploratory Research (V0 to V1)

SESAR Exploratory Research projects explore new concepts beyond those identified in the European ATM Master Plan or emerging technologies and methods. The knowledge acquired can be transferred into the SESAR industrial and demonstration activities. SESAR Exploratory Research projects are not subject to performance targets but should address the performances to which they have the potential to contribute.

3.1.3 SESAR Industrial Research & Validation Projects (environmental focus)

The main outcomes of the industrial research and validation projects dedicated to the environmental impacts of aviation in SESAR 1 were:

- The initial development by EUROCONTROL of the IMPACT[38] web-based platform which allows noise impact assessments and estimates of fuel burn and resulting emissions to be made from common inputs, thus enabling trade-offs to be conducted. IMPACT has since been continuously maintained and developed by EUROCONTROL, used for ICAO Committee on Aviation Environmental Protection Modelling and Database Group (CAEP) assessments, the conduct of studies in support of the European Aviation Environment Report (EAER) editions 2016 and 2019, and has been adopted by a large range of aviation stakeholders.
- The initial development/maintenance Open-ALAQS that provides a mean to perform emissions inventory at airports, emissions concentration calculation and dispersion.
- The development of an IMPACT assessment process[39].

It should be noted that these tools and methodology were developed to cover the research and the future deployment phase of SESAR, as well as to support European states and agencies in conducting environmental impact assessments for operational or regulatory purposes. They are still in use in SESAR.

SESAR Industrial Research and Validation assesses and validates technical and operational concepts in simulated and real operational environments according to a set of key performance areas. These concepts mature through the SESAR programme from V1 to V3 to become SESAR Solutions ready for deployment.

SESAR has a wide range of solutions to improve the efficiency of air traffic management, some of which are specifically designed to improve environmental performance, by

[38] https://www.eurocontrol.int/platform/integrated-aircraft-noise-and-emissions-modelling-platform

[39] https://www.sesarju.eu/sites/default/files/documents/transversal/SESAR%202020%20-%20Environment%20Impact%20Assessment%20Guidance.pdf

reducing noise impact around airports and/or fuel consumption and emissions in all phases of flight.

A catalogue of SESAR Solutions is available[40] and those addressing environment impacts are identified by the following pictogram: 

3.1.4 SESAR2020 Industrial Research and Validation - Environmental Performance Assessment

The systematic assessment of environmental impacts of aviation are at the heart of SESAR Industrial Research and Validation activities since SESAR 1, with a very challenging target on fuel/CO_2 efficiency of 500kg of fuel savings on average per flight.

SESAR Pj19.04 Content Integration members are monitoring the progress of SESAR Solutions towards this target in a document call Performance Assessment and Gap Analysis Report (PAGAR). The Updated version of PAGAR 2019 provides the following environmental achievements:

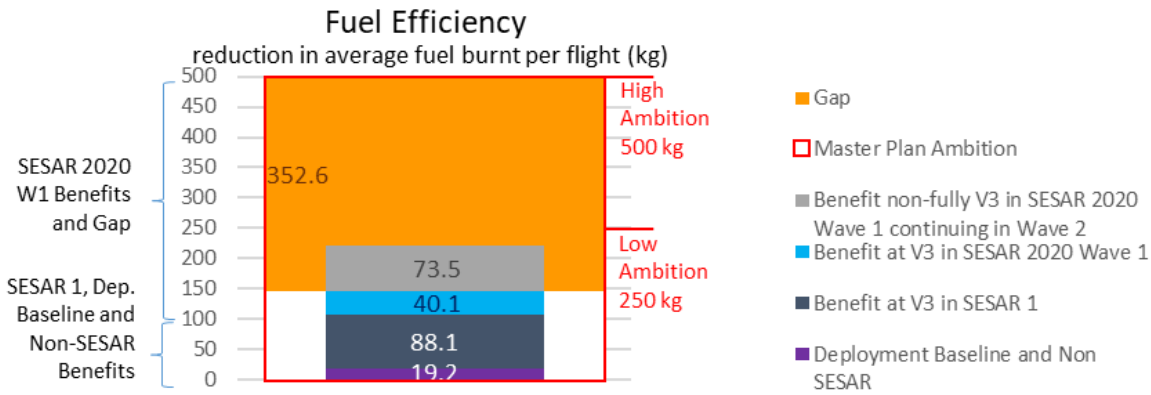

Figure 7: SESAR fuel efficiency achievement versus gap (Source: Updated version of PAGAR 2019)

The Fuel Efficiency benefits at V3 maturity level in SESAR 2020 Wave 1 represents an average of 40.1 kg of fuel savings per flight. There would therefore be a gap of 352.6 kg in fuel savings per flight to be filled by Wave 2, compared to the high fuel savings Ambition target (and a gap of 102.6 kg with respect to the low Ambition target, as the Master Plan defines a range of 5-10% as the goal). Potentially 73.5 kg might be fulfilled from Wave 1 Solutions non-fully V3 continuing in Wave 2.

A fuel saving of 40.1 kg per ECAC flight equates to about 0.76% of the 5,280kg of fuel burnt on average by an ECAC flight in 2012 (SESAR baseline). Although this might seem marginal, in 2035, ECAC-wide, it would equate to 1.9 million tonnes of CO_2 saved, equivalent to the CO_2 emitted by 165,000 Paris-Berlin flights; or a city of 258,000 European citizens; or the CO_2 captured by 95 million trees per year.

In SESAR, a value of 5,280 Kg of fuel per flight for the ECAC (including oceanic region) is used as a baseline [41]. Based on the information provided by the PAGAR 2019 document[42], the benefits at the end of Wave 1 could be about 3% CO_2/fuel savings achieved by 2025 equivalent to 147.4kg of fuel/flight. So far, the target for Wave 2 remains at about 7%

[40] https://www.sesarju.eu/news/sesar-solution-catalogue-third-edition-now-out

[41] See SESAR ATM Master Plan – Edition 2020 (www.atmmasterplan.eu) - eATM

[42] See SESAR Performance Assessment Gap Analysis Report (PAGAR) updated version of 2019 v00.01.04, 31-03-2021

more CO_2/fuel savings (352.6kg of fuel) to reach the initial Ambition target of about 10% CO_2/fuel savings (500kg fuel) per flight by 2035. Beyond 2035, there is no SESAR Ambition yet. To this could be added the as yet non-estimated benefits of Exploratory Research projects[43].

3.1.5 SESAR AIRE demonstration projects

In addition to its core activities, the SESAR JU co-financed projects where ATM stakeholders worked collaboratively to perform integrated flight trials and demonstrations of solutions. These aimed to reduce CO_2 emissions for surface, terminal, and oceanic operations and substantially accelerate the pace of change. Between 2009 and 2012, the SESAR JU co-financed a total of 33 "green" projects in collaboration with global partners, under the Atlantic Interoperability Initiative to Reduce Emissions (AIRE).

AIRE[44] is the first large-scale environmental initiative bringing together aviation players from both sides of the Atlantic. So far, three AIRE cycles have been successfully completed. A total of 15 767 flight trials were conducted, involving more than 100 stakeholders, demonstrating savings ranging from 20 to 1 000kg of fuel per flight (or 63 to 3150 kg of CO_2), and improvements in day-to-day operations. Another nine demonstration projects took place from 2012 to 2014, also focusing on the environment, and during 2015/2016 the SESAR JU co-financed fifteen additional large-scale demonstration projects, which were more ambitious in geographic scale and technology.

3.1.6 SESAR 2020 Very Large-Scale Demonstrations (VLDs)

VLDs evaluate SESAR Solutions on a much larger scale and in real operations to prove their applicability and encourage the early take-up of V3 mature solutions.

SESAR JU has recently awarded ALBATROSS[45], a consortium of major European aviation stakeholder groups to demonstrate how the technical and operational R&D achievements of the past years can transform the current fuel intensive aviation to an environment-friendly industry sector.

The ALBATROSS consortium will carry a series of demonstration flights, which the aim to implementing a "perfect flight" (in other words the most fuel-efficient flight) will be explored and extensively demonstrated in real conditions, through a series of live trials in various European operating environments. The demonstrations will span through a period of several months and will utilise over 1,000 demonstration flights.

3.1.7 Preparing SESAR

Complementing the European ATM Master Plan 2020 and the High-Level Partnership Proposal, the Strategic Research and Innovation Agenda (SRIA) details the research and innovation roadmaps to achieve the Digital European Sky, matching the ambitions of the 'European Green Deal' and the 'Europe fit for the digital age' initiative.

The SRIA[46] identifies inter-alia the need to continue working on "optimum green trajectories", on non-CO_2 impacts of aviation, and the need to accelerate decarbonisation of aviation through operational and business incentivisation.

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43 See SESAR Exploratory Research projects - https://www.sesarju.eu/exploratoryresearch

44 https://ec.europa.eu/transport/modes/air/environment/aire_en#:~:text=The%20joint%20initiative%20AIRE%20(Atlantic,NEXTGEN%20in%20the%20United%20States

45 https://www.sesarju.eu/projects/ALBATROSS

46 https://www.sesarju.eu/node/3697

ASSESSMENT

The quantitative assessment of the operational and ATM improvement scenario from 2020 to 2050 has been included in the modelled scenarios by EUROCONTROL on the basis of efficiency analyses from the SESAR project indicated in Figure 7 above and it is included in Section A above (ECAC Baseline Scenario and Estimated Benefits of Implemented Measures).

Table 9. CO_2 emissions forecast for the ATM improvements scenarios.

Year	CO_2 emissions (10^9 kg)	
	Baseline Scenario	Implemented Measures Scenario
		ATM improvements
2030	160.29	149.9
2040	197.13	177.4
2050	210.35	197.4

For reasons of data availability, results shown in this table do not include cargo/freight traffic. Note that fuel consumption is assumed to be unaffected by the use of sustainable aviation fuels.

4. MARKET-BASED MEASURES

4.1 The Carbon Offsetting and Reduction Scheme for International Aviation

ECAC Member States have always been strong supporters of a market-based measure scheme for international aviation to incentivise and reward good investment and operational choices, and so welcomed the agreement on the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

The 39th General Assembly of ICAO (2016) reaffirmed the 2013 objective of stabilising CO_2 emissions from international aviation at 2020 levels. In addition, the States adopted the introduction of a global market-based measure, namely the '*Carbon Offsetting and Reduction Scheme for International Aviation*' (CORSIA), to offset and reduce international aviation's CO_2 emissions above average 2019/2020 levels through standard international CO_2 emissions reductions units which would be put into the global market. This major achievement was most welcome by European States which have actively promoted the mitigation of international emissions from aviation at a global level.

4.1.1 Development and update of ICAO CORSIA standards

European Member States have fully supported ICAO's work on the development of Annex 16, Volume IV to the Convention on International Civil Aviation containing the Standards and Recommended Practices (SARPs) for the implementation of CORSIA, which was adopted by the ICAO Council in June 2018.

As a part of the ICAO's Committee on Aviation Environmental Protection (CAEP) work programme for the CAEP/12 cycle, CAEP's Working Group 4 (WG4) is tasked to maintain the Annex 16, Volume IV and related guidance material, and to propose revisions to improve those documents as needed.

Europe is contributing with significant resources to the work of CAEP-WG4 and EASA in particular by providing a WG4 co-Rapporteur, and by co-leading the WG4 task on maintaining the Annex 16, Volume IV and related guidance material.

4.1.2 CORSIA implementation

In application of their commitment in the 2016 "Bratislava Declaration" the 44 ECAC Member States have notified ICAO of their decision to voluntarily participate in CORSIA from the start of the pilot phase in 2021 and have effectively engaged in its implementation. This shows the full commitment of the EU, its Member States and the other Member States of ECAC to counter the expected in-sector growth of total CO_2 emissions from air transport and to achieving overall carbon neutral growth.

On June 2020, the European Council adopted COUNCIL DECISION (EU) 2020/954 on the position to be taken on behalf of the European Union within the International Civil Aviation Organization as regards the notification of voluntary participation in the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) from 1 January 2021 and the option selected for calculating aeroplane operators' offsetting requirements during the 2021-2023 period.

ASSESSMENT

CORSIA is a global measure which assessment is undertaken globally by ICAO. Thus, the assessment of the benefits provided by CORSIA in terms of reduction in European emissions is not provided in this action plan.

4.2 The EU Emissions Trading System and its linkages with other systems (Swiss ETS and UK ETS)

The EU Emissions Trading System (EU ETS) is the cornerstone of the European Union's policy to tackle climate change, and a key tool for reducing greenhouse gas emissions cost-effectively, including from the aviation sector.

The 30 EEA States in Europe have already implemented the EU Emissions Trading System (ETS), including the aviation sector with around 500 aircraft operators participating in the cap-and-trade approach to limit CO_2 emissions. It was the first and is the biggest international system capping greenhouse gas emissions. In the period 2013 to 2020 EU ETS has saved an estimated 200 million tonnes of intra-European aviation CO_2 emissions. It operates in 30 countries: the 27 EU Member States, Iceland, Liechtenstein and Norway. The EU ETS currently covers half of the EU's CO_2 emissions, encompassing those from around 11 000 power stations and industrial plants in 30 countries, and, under its current scope, around 500 commercial and non-commercial aircraft operators that fly between airports in the European Economic Area (EEA). The EU ETS Directive was revised in line with the European Council Conclusions of October 2014[47] that confirmed that the EU ETS will be the main European instrument to achieve the EU's binding 2030 target of an at least 40%[48], and will be revised to be aligned with the latest Conclusions in December 2020[49], prescribing at least 55% domestic reduction (without using international credits) of greenhouse gases compared to 1990.

The EU ETS began operation in 2005, for aviation in 2012; a series of important changes to the way it works took effect in 2013, strengthening the system. The EU ETS works on the "cap and trade" principle. This means there is a "cap", or limit, on the total amount of certain greenhouse gases that can be emitted by the factories, power plants, other installations and aircraft operators in the system. Within this cap, companies can sell to or buy emission allowances from one another. The limit on allowances available provides certainty that the environmental objective is achieved and gives allowances a market value.

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47 http://www.consilium.europa.eu/en/meetings/european-council/2014/10/23-24/

48 Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018L0410

49 1011-12-20-euco-conclusions-en.pdf (europa.eu)

For aviation, the cap is calculated based on the average emissions from the years 2004-2006, while the free allocation to aircraft operators is based on activity data from 2010. The cap for aviation activities for the 2013-2020 phase of the ETS was set to 95% of these historical aviation emissions. Starting from 2021, free allocation to aircraft operators is reduced by the linear reduction factor (currently of 2.2%) now applicable to all ETS sectors. Aircraft operators are entitled to free allocation based on a benchmark, but this does not cover the totality of emissions. The remaining allowances need to be purchased from auctions or from the secondary market. The system allows aircraft operators to use aviation allowances or general (stationary installations) allowances to cover their emissions. Currently, 82% of aviation allowances are distributed through free allocation, 3% are part of a special reserve for new entrants and fast growers, and 15% are auctioned. The legislation to include aviation in the EU ETS was adopted in 2008 by the European Parliament and the Council[50].

Following the 2013 ICAO agreement on developing CORSIA, the EU decided[51] to limit the scope of the EU ETS to flights between airports located in the European Economic Area (EEA) for the period 2013-2016, and to carry out a new revision in the light of the outcome of the 2016 ICAO Assembly. The European Commission assessed the outcome of the 39th ICAO Assembly and, in that light, a new Regulation was adopted in 2017[52].

The legislation maintains the scope of the EU ETS for aviation limited to intra-EEA flights and sets out the basis for the implementation of CORSIA. It provides for European legislation on the monitoring, reporting and verification rules through a delegated act under the EU ETS Directive of July 2019[53]. It foresees that a further assessment should take place and a report be presented to the European Parliament and to the Council considering how to implement CORSIA in Union law through a revision of the EU ETS Directive. The European Green Deal and 2030 Climate Target Plan clearly set out the Commission's intention to propose to reduce the EU ETS allowances allocated for free to airlines. This work is currently ongoing and is part of the "Fit for 55 package"[54].

The EU legislation foresees that, where a third country takes measures to reduce the climate change impact of flights departing from its airports, the EU will facilitate interaction between the EU scheme and that country's measures and flights arriving from the third country could be excluded from the scope of the EU ETS. This is the case between the EU and Switzerland[55] following the agreement to link their respective emissions trading systems, which entered into force on 1 January 2020.

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50 Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0101

51 Decision No. 377/2013/EU derogating temporarily from Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, http://eur-lex.europa.eu/LexUriServLexUriServ.do?uri=CELEX:32013D0377:EN:NOT

52 Regulation (EU) 2017/2392 of the European Parliament and of the Council of 13 December 2017 amending Directive 2003/87/EC to continue current limitations of scope for aviation activities and to prepare to implement a global market-based measure from 2021, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2017.350.01.0007.01.ENG&toc=OJ:L:2017:350:TOC

53 Commission Delegated Regulation (EU) 2019/1603 of 18 July 2019 supplementing Directive 2003/87/EC of the European Parliament and of the Council as regards measures adopted by the International Civil Aviation Organisation for the monitoring, reporting and verification of aviation emissions for the purpose of implementing a global market-based measure https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2019.250.01.0010.01.ENG

54 2021_commission_work_programme_new_policy_objectives_factsheet_en.pdf (europa.eu)

55 Commission Delegated Decision (EU) 2020/1071 of 18 May 2020 amending Directive 2003/87/EC of the European Parliament and of the Council, as regards the exclusion of incoming flights from Switzerland from the EU emissions trading system, OJ L 234, 21.7.2020, p. 16.

As a consequence of the linking agreement with Switzerland, from 2020 the EU ETS was extended to all departing flights from the EEA to Switzerland, and Switzerland applies its ETS to all departing flights to EEA airports, ensuring a level playing field on both directions of routes. In accordance with the EU-UK Trade and Cooperation Agreement reached in December 2020, the EU ETS shall continue to apply to departing flights from the EEA to the UK, while a UK ETS will apply effective carbon pricing on flights departing from the UK to the EEA.

Impact on fuel consumption and/or CO_2 emissions
The EU ETS has delivered around 200 MT of CO_2 emission reductions between 2013 and 2020[56]. While the in-sector aviation emissions for intra-EEA flights kept growing, from 53,5 million tonnes CO_2 in 2013 to 69 million in 2019, the flexibility of the EU ETS, whereby aircraft operators may use any allowances to cover their emissions, meant that the CO_2 impacts from these flights did not lead to overall greater greenhouse gas emissions. Verified emissions from aviation covered by the EU Emissions Trading System (ETS) in 2019 compared to 2018 continued to grow, albeit more modestly, with an increase of 1% compared to the previous year, or around 0.7 million tonnes CO_2 equivalent[57].

To complement the EU ETS price signal, EU ETS auctioning revenues should be used to support transition towards climate neutrality. Under the EU ETS (all sectors covered), Member States report that from 2012 until 2020, over €45 billions of ETS auction revenue has been used to tackle climate change, and additional support is available under the existing ETS Innovation Fund that is expected to deploy upwards of €12 billion in the period 2021-2030. The EU ETS' current price incentive per tonne for zero emission jet fuel, is by itself insufficient to bridge the price gap with conventional kerosene. However, by investing auctioning revenues through the Innovation Fund, the EU ETS can also support deployment of breakthrough technologies and drive the price gap down.

In terms of its contribution towards the ICAO carbon neutral growth goal from 2020, the states implementing the EU ETS have delivered, in "net" terms, the already achieved reduction of around 200 MT of aviation CO_2 emissions will continue to increase in the future under the new legislation. Other emission reduction measures taken, either collectively throughout Europe or by any of the states implementing the EU ETS, will also contribute towards the ICAO global goals. Such measures are likely to moderate the anticipated growth in aviation emissions.

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56 See the 2019 European aviation environmental report: "Between 2013 and 2020, an estimated net saving of 193.4 Mt CO_2 (twice Belgium's annual emissions) will be achieved by aviation via the EU ETS through funding of emissions reduction in other sectors.", https://www.eurocontrol.int/publication/european-aviation-environmental-report-2019

57 https://ec.europa.eu/clima/news/carbon-market-report-emissions-eu-ets-stationary-installations-fall-over-9_en

ASSESSMENT
A quantitative assessment of the EU Emissions Trading System benefits based on the current scope (intra-European flights) is shown in **Table 10**.

Table 10: Summary of estimated EU-ETS emission reductions

Estimated emissions reductions resulting from the EU-ETS[58]

Year	*Reduction in CO_2 emissions*
2013-2020	*~200 MT*[59]

Those benefits illustrate past achievements.

58 Include aggregated benefits of EU ETS and Swiss ETS for 2020.

59 See the 2019 European aviation environmental report: "Between 2013 and 2020, an estimated net saving of 193.4 Mt CO_2 (twice Belgium's annual emissions) will be achieved by aviation via the EU ETS through funding of emissions reduction in other sectors.", https://www.eurocontrol.int/publication/european-aviation-environmental-report-2019

5. ADDITIONAL MEASURES

5.1 ACI Airport Carbon Accreditation

Airport Carbon Accreditation is a certification programme for carbon management at airports, based on international carbon mapping and management standards, specifically designed for the airport industry. It was launched in 2009 by Airport Council International (ACI) EUROPE, the trade association for European airports. Since then, it has expanded globally and is today available to members of all ACI Regions.

This industry-driven initiative was officially endorsed by EUROCONTROL and the European Civil Aviation Conference (ECAC). The programme is overseen by an independent Advisory Board comprised of many distinguished, independent experts from the fields of aviation and environment, including the European Commission, ECAC, ICAO and the UNFCCC.

The underlying aim of the programme is to encourage and enable airports to implement best practice carbon and energy management processes and to gain public recognition of their achievements. It requires airports to measure their CO_2 emissions in accordance with the World Resources Institute and World Business Council for Sustainable Development GHG Protocol and to get their emissions inventory assured by an independent third party. In addition to the already existing four accreditation levels, in 2020 two new accreditation levels were introduced: Level 4 and Level 4+. The introduction of those two new levels aims on one hand to align the programme with the objectives of the Paris Agreement and on the other hand to give, especially to airports that have already reached a high level of carbon management maturity, the possibility to continue their improvements[60].

The six steps of the programme are shown in **Figure 8** and are as follows: Level 1 "Mapping", Level 2 "Reduction", Level 3 "Optimisation", Level 3+ "Neutrality", Level 4 "Transformation" and Level 4+ "Transition".

Figure 8 Six steps of *Airport Carbon Accreditation*

As of 31 March 2021, there are in total 336 airports in the programme worldwide. They represent 74 countries and 45.9% of global air passenger traffic. 112 reached a Level 1, 96 a Level 2, 63 a Level 3 and 60 a Level 3+ accreditation. Furthermore, five airports have already achieved accreditation at the newly introduced levels: 1 a Level 4 and 4 airports a Level 4+ accreditation.

One of its essential requirements is the verification by external and independent auditors of the data provided by airports. The Administrator of the programme has been collecting CO_2 data from participating airports since the programme launch. This has allowed the absolute CO_2 reduction from the participation in the programme to be quantified.

Aggregated data are included in the *Airport Carbon Accreditation* Annual Reports thus ensuring transparent and accurate carbon reporting. At Level 2 of the programme and above, airport operators are required to demonstrate CO_2 reductions associated with the activities they control.

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[60] Interim Report 2019 – 2020, *Airport Carbon Accreditation* 2020

The Annual Report, which is published in the fall of each year, typically covers the previous reporting year (i.e., mid-May to mid-May) and presents the programme's evolution and achievements. However, because of the extraordinary conditions faced in 2020 due to COVID-19 pandemic, special provisions are applied to all accredited airports, including the merge of programme years 11 and 12, which implies the extension of accreditation validity by one year. Thus, the current *Airport Carbon Accreditation* certification period covers the timespan May 2019 to May 2021. For this reason, the last published Report is considered as an Interim Report which addresses only a part of the on-going reporting period (i.e., from 16th May 2019 to 11th December 2020), and as such does not include the usual carbon Key Performance Indicators, but only valuable information regarding key achievements and developments, the most significant global and regional trends, and case studies highlighting the airports' commitment to continued climate action in spite of the current crisis. Therefore, the tables below show carbon performance metrics until the 2018/2019 regular reporting cycle.

For historical reasons European airports remain at the forefront of airport actions to voluntarily mitigate and reduce their impact on climate change. The strong growth momentum is still being maintained as there are 167 airports in the programme. These airports account for 69.7% of European air passenger traffic.

Table 11: Emissions reduction highlights for the European region

	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
Total aggregate scope 1 & 2 reduction (ktCO_2)	51.7	54.6	48.7	140	130	169	156	155	169	158
Total aggregate scope 3 reduction (ktCO_2)	360	675	366	30.2	224	551	142	899	1160	1763

Table 12: Emissions offset for the European region

	2015-2016	2016-2017	2017-2018	2018-2019
Aggregate emissions offset, Level 3+ (tCO_2)	222339	252218	321170	375146

The table above presents the aggregate emissions offset by airports accredited at Level 3+ of the programme in Europe. The programme requires airports at Levels 3+ and 4+ to offset their residual Scope 1 & 2 emissions as well as Scope 3 emissions from staff business travel.

Table 13: *Airport Carbon Accreditation* key performance indicators 2018/2019

Indicator	Unit	Time Period (2018/2019)	Absolute change compared to the 3-year rolling average	Change (%)
Aggregate scope 1 & 2 emissions from airports at Levels 1-3+	tCO_2	6,520,255	-322,297	-4.9%
Scope 1 & 2 emissions per passenger from airports at Levels 1-3+	kgs of CO_2	1.81	-0.09	-4.3%

Scope 1 & 2 emissions per traffic unit from airports at Levels 1-3+	kgs of CO_2	1.55	-0.08	-4.3%
Indicator	**Unit**	**Time Period (2018/2019)**	**Absolute change (vs. previous year)**	**Change (%)**
Offsetting of aggregate scope 1 & 2 & staff business travel emissions from airports at Level 3+	tCO_{2e}	710,673	38.673	5.8%
Indicator	**Unit**	**Time Period (2018/2019)**	**Absolute change (vs. previous year)**	**Change (%)**
Scope 3 emissions from airports at Levels 3 and 3+	tCO_2	60,253,685	6,895,954	12.9%

The programme's main immediate environmental co-benefit is the improvement of local air quality.

Costs for the design, development and implementation of *Airport Carbon Accreditation* have been borne by ACI EUROPE. *Airport Carbon Accreditation* is a non-for-profit initiative, with participation fees set at a level aimed at allowing for the recovery of the aforementioned costs.

The scope of *Airport Carbon Accreditation*, i.e. emissions that an airport operator can control, guide and influence, implies that as of Level 3, aircraft emissions are also covered. Thus, airlines can benefit from the gains made by more efficient airport operations to see a decrease in their emissions. This is consistent with the ambition of the European Green Deal, the inclusion of aviation in the EU ETS and the implementation of CORSIA and therefore can support the efforts of airlines to reduce these emissions.

ASSESSMENT
The inclusion of this collective European measure is descriptive for information purposes, and no quantitative assessment of its benefits in terms of reduction in aviation emissions is provided in the common section of this action plan.

5.2 European industry roadmap to a net zero European aviation: *Destination 2050*

DESTINATION 2050

The Destination 2050[61] is an initiative and roadmap developed by aviation industry stakeholders (A4E, ACI EUROPE, ASD, CANSO and ERA) showing an ambitious decarbonisation pathway for European aviation.

These European industry organizations commit to work together with all stakeholders and policymakers to achieve the following climate objectives:

61 www.destination2050.eu

- Reaching net zero CO_2 emissions by 2050 from all flights within and departing from the European Economic Area, Switzerland and the UK. This means that by 2050, emissions from these flights will be reduced as much as possible, with any residual emissions being removed from the atmosphere through negative emissions, achieved through natural carbon sinks (e.g., forests) or dedicated technologies (carbon capture and storage). For intra-EU flights, net zero in 2050 might be achieved with close to no market-based measures.
- Reducing net CO_2 emissions from all flights within and departing from the European Economic Area, Switzerland and the UK by 45% by 2030 compared to the baseline[62]. In 2030, net CO_2 emissions from intra-EU flights would be reduced by 55% compared to 1990 levels.
- Assessing the feasibility of making 2019 the peak year for absolute CO_2 emissions from flights within and departing from the European Economic Area, Switzerland and UK.

With the Destination 2050 roadmap and through these commitments, the European aviation sector contributes to the Paris Agreement, recognising the urgency of pursuing the goal of limiting global warming to 1.5°C.
By doing so, the European aviation sector is also effectively contributing to the collective European Green Deal and EU's climate neutrality objectives.
This roadmap is complementary to the WayPoint 2050 Air Transport Action Group (ATAG) global pathway for the decarbonization of aviation.

ASSESSMENT
The inclusion of this collective European measure is descriptive for information purposes, and no quantitative assessment of its benefits in terms of reduction in aviation emissions is provided in the common section of this action plan.

5.3 Environmental Label Programme
In response to the growing expectations of citizens to understand the environmental footprint of their flights, the European Union Member States, Switzerland, Norway, Lichtenstein, the United Kingdom and the European Commission have mandated EASA to explore voluntary environmental labelling options for aviation organisations. The proposals will be aligned with the European Green Deal, established in December 2019 and that strives to make Europe the first climate-neutral continent. The overall objective of the EASA Environmental Labelling Programme is to increase awareness and transparency, and ultimately to support passengers and other actors in making informed sustainable choices by providing harmonised, reliable and easily understandable information on their choices' environmental impacts, co-ordinated within EASA Member States. It should allow rewarding those air transport operators making efforts to reduce their environmental footprint. The label initiative covers a wide range of components of the aviation sector, including aircraft, airlines and flights.

In the proof-of-concept phase, EASA developed potential technical criteria and label prototypes for aircraft technology and design as well as airline operations, to inform European citizens on the environmental performance of aviation systems. Such information would be provided on a voluntary basis by aviation operators that have chosen to use the label. Different scenarios were developed and tested to consider how citizens could interact with labelling information, e.g. on board the aircraft and/or during the booking process as well as on a dedicated website and smartphone application. Various key environmental indicators were reviewed, including the absolute CO_2 emissions and average CO_2 emissions per passenger-kilometre of airlines.

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62 A hypothetical 'no-action' scenario whereby CO_2 emissions are estimated based on the assumption that aircraft deployed until 2050 have the same fuel efficiency as in 2018.

The pilot phase covering the period 2021-2023 will further expand the scope of indicators and take into account life-cycle considerations, e.g. to cover aspects from the extraction of raw materials to recycling and waste disposal. The pilot phase also foresees an impact assessment of the label.

While the potential CO_2 emissions reductions generated by such a label were not quantified at this stage, it is proposed to keep the ICAO updated on future developments concerning the European environmental labelling initiative, including on potential CO_2 emissions savings.

ASSESSMENT

The inclusion of this collective European measure is descriptive for information purposes, and no quantitative assessment of its benefits in terms of reduction in aviation emissions is provided in the common section of this action plan.

5.4 Multilateral capacity building projects

The European Union is highly committed to ensuring sustainable air transport in Europe and worldwide. In this endeavour, the EU is launching a number of initiatives in different areas to assist partner States in meeting the common environmental commitments.

5.4.1 EASA capacity-building partnerships

EASA has been selected as an implementing Agency for several of these initiatives, including the **EU-South East Asia Cooperation on Mitigating Climate Change impact from Civil Aviation** (EU-SEA CCCA), launched in 2019, and a **Capacity Building Project for CO_2 Emissions Mitigation in the African and Caribbean Region**, launched in 2020.

The overall objective of these projects[63] is to enhance the partnership between the EU and partner States in the areas of civil aviation environmental protection and climate change, and to achieve long-lasting results that go beyond the duration of the projects. The specific objectives of the two projects are to develop or support existing policy dialogues with partner States on mitigating GHG emissions from civil aviation, to contribute to the CORSIA readiness process of partner States, as well as to implement CORSIA in line with the agreed international schedule, including considerations of joining the voluntary offsetting phase starting in 2021 or at the earliest time possible. On top of the CORSIA-related support, these projects are assisting the partner States in the development and update of the State Action Plans to reduce CO_2 emissions from civil aviation, as well as providing support in the development of emission data management tools supporting the implementation of State Action Plans and CORSIA.

By January 2021, the EU-SEA CCCA had improved the technical readiness of all the 10 partner States in the region, as well as their aeroplane operators' capabilities to comply with CORSIA requirements. Five States had implemented emission data management solutions to generate CORSIA Emission Reports, and eight States had successfully submitted their 2019 CORSIA CO_2 Emissions Reports to ICAO. 4 CORSIA verification bodies had been accredited in the region with dedicated support to their respective National Accreditation Bodies to finalise the accreditation process.

In addition, EASA is implementing, on behalf of the Commission, technical cooperation projects in the field of aviation in Asia, Latin-America and the Caribbean, which include an environmental component aiming at cooperation and improvement of environmental standards.

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63 https://www.easa.europa.eu/domains/international-cooperation/easa-by-country/map#group-easa-extra

These projects have been successful in supporting regional capacity building technical cooperation to the partner States with regard to environmental standards. With regard to CORSIA, support is provided for the development or enhancement of State Action Plans, as well as for the implementation of the CORSIA MRV system. Projects have also been successful in engaging with key national and regional stakeholders (regulatory authorities, aeroplane operators, national accreditation bodies, verification bodies), thereby assessing the level of readiness for State Action Plan and CORSIA implementation on wider scale in the respective regions, and to identify further needs for additional support in this area.

5.4.1 ICAO - European Union Assistance Project

The assistance project *Capacity Building on CO_2 mitigation from International Aviation* was launched in 2013 with funding provided by the European Union, while implementation was carried out by ICAO Environment.

Fourteen States from Africa and the Caribbean were selected to participate in this 5-year programme, successfully implemented by ICAO from 2014 to 2019, achieving all expected results and exceeding initial targets.

The first objective of the ICAO-EU project was to create national capacities for the development of action plans. ICAO organized specific training-seminars, directed the establishment of National Action Plan Teams in the selected States, and assisted each civil aviation authority directly in the preparation of their action plans.

By June 2016, the 14 selected States had developed action plans fully compliant with ICAO's guidelines, including robust historical data and a reliable baseline scenario. A total of 218 measures to reduce fuel consumption and CO_2 emissions were proposed in the action plans, including those related to aircraft technology, operational measures, and sustainable aviation fuels.

Four pilot mitigation measures and five feasibility studies were executed with project funding in the beneficiary States. In addition to those, the beneficiary States implemented 90 mitigation measures within the project timeframe, which had been included in their action plans[64].

With the support provided by the ICAO-EU project, ICAO has succeeded in assisting the beneficiary States transform the organizational culture towards environmental protection in aviation, through the establishment of Environmental Units with dedicated staff in the Civil Aviation Authorities along with the voluntary decision of seven selected States of the project to join the ICAO Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) from its outset.

The Phase two of this project is currently being implemented by ICAO and EASA. It covers ten African States: Benin, Botswana, Cabo Verde, Comoros, Côte d'Ivoire, Madagascar, Mali, Rwanda, Senegal and Zimbabwe. The project will run between 2020 and 2023.

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64 https://www.icao.int/environmental-protection/Documents/ICAO-EU_Project_FinalReport.pdf

ASSESSMENT
The inclusion of this collective European measure is descriptive for information purposes, and no quantitative assessment of its benefits in terms of reduction in aviation emissions is provided in the common section of this action plan.

5.5. Green Airports research and innovation projects
Under the EU research and innovation actions in support of the European Green Deal and funded by the Horizon 2020 Framework Programme, the European Commission has launched in 2020 the call for tenders: ***Green airports and ports as multimodal hubs for sustainable and smart mobility***.

A clear commitment of the European Green Deal is that "transport should become drastically less polluting", highlighting in particular the urgent need to reduce greenhouse gas emissions (GHG) in aviation and waterborne transport.

In this context, airports play a major role, both as inter-connection points in the transport networks, but also as major multimodal nodes, logistics hubs and commercial sites, linking with other transport modes, hinterland connections and integrated with cities.
As such, green airports as multimodal hubs in the post COVID-19 era for sustainable and smart mobility have a great potential to immediately contribute to start driving the transition towards GHG-neutral aviation, shipping and wider multimodal mobility already by 2025.

The scope of this research program is therefore addressing innovative concepts and solutions for airports and ports, in order to urgently reduce transport GHG emissions and increase their contribution to mitigating climate change.

Expected outcomes
The projects will perform large-scale demonstrations of green airports, demonstrating low-emission energy use (electrification or sustainable aviation fuels) for aircraft, airports, other/connected and automated vehicles accessing or operating at airports (e.g. road vehicles, rolling stock, drones), as well as for public transport and carpooling, with re-charging/re-fuelling stations and use of incentives.

They will also put the focus on the development of SAF for its use at airports. The deadline to receive project proposals was closed in January 2021 and at the time of this action plan update the proposals are under revision. Future action plan updates will provide further information on the benefits of the implementation of this measure.

ASSESSMENT
The inclusion of this collective European measure is descriptive for information purposes, and no quantitative assessment of its benefits in terms of reduction in aviation emissions is provided in the common section of this action plan.

6. SUPPLEMENTAL BENEFITS FOR DOMESTIC SECTORS

Although the benefits of all the European collective measures included in this action plan are focused on international aviation, they are also applicable to domestic aviation (except CORSIA) and thus, will bring supplemental benefits in terms of CO_2 emissions reductions in the domestic European air traffic.

In addition, a number of those measures taken collectively in Europe and contained in this action plan offer as well additional supplemental benefits for domestic sectors beyond CO_2 savings. Those are summarized below.

6.1 ACI Airport Carbon Accreditation

Airport Carbon Accreditation is referred among the measures contained in this action plan aiming to encourage and enable airports to implement best practice carbon and energy management processes.

While its main objective is supporting airport actions to voluntarily mitigate and reduce their impact on climate change, the programme's main immediate environmental co-benefit is the improvement of local air quality linked to the non-CO_2 additional emissions benefits from the reduction of fuel burn that an airport operator can control, guide and influence.

6.2 ReFuelEU Aviation Initiative

Through the large-scale use of SAF, emissions of other pollutants impacting local air quality and other non-CO_2 effects on the climate can also be reduced, implying important potential supplemental benefits beyond CO_2 emissions reductions.

In addition to the reduction of CO_2 emissions, SAF has the additional benefit of reducing air pollutant emissions around airports when emitted during take-off and landing as emissions of non-volatile Particulate Matter (nvPM) with up to 90% and sulphur (SO_X) with 100%, compared to fossil jet fuel[65].

Preserving the quality of natural resources can be considered an additional benefit of any policy measure aiming to increase the sustainability of aviation by boosting the SAF market while paying particular attention to the overall environmental integrity of the SAF incentivised, as it is the case of the ReFuelEU Initiative.

Finally, the production of SAF notably from biogenic waste could contribute and be an incentive for more effective waste management in the EU.

6.3 SAF Research and development projects

One European research project funded by the Horizon 2020 Research and Innovation program of the EU, is currently assessing, among other objectives, the additional supplemental benefits for domestic sectors of the use of sustainable aviation fuels, beyond its climate benefits.

AVIATOR PROJECT[66]: The project *"Assessing aviation emission Impact on local Air quality at airports: Towards Regulation"* aim to better understand air quality impacts of aviation issues, developing new tools and regulation, and linking with the health community, providing unbiased data to society.
The project will measure, quantify and characterise airborne pollutant emissions from aircraft engines under parking (with functioning APU), taxiing, approach, take-off and climb-out conditions, with specific reference to total UFPs, NOx, SOx and VOC under different climatic conditions.

It includes among its objectives measuring emissions from aircraft engines using commercially available sustainable aviation fuels to investigate its impact on total Particulate Matter formation and evolution in the plume as well as the wider airport environment.

Will perform measurements of air quality in and around three international airports: Madrid-Barajas, Zurich and Copenhagen, to validate model developments under different operational and climatic conditions and develop a proof of concept low-cost and low-intervention sensor network to provide routine data on temporal and spatial variability of key pollutants including UFP, total PM, NO_x and SO_x.
With 17 partners from 7 countries involved, the project started in June 2019 and it is expected to finalize in 2022.

6.4 The EU's Single European Sky Initiative and SESAR

The European Union's Single European Sky (SES) initiative and its SESAR (*Single European Sky ATM Research Programme*) programme are aiming to deploy a modern, interoperable and high-performing ATM infrastructure in Europe, as has been described above in detail in this action plan, among its key operational measures to reduce CO_2 emissions.
But the environmental outcomes of SESAR implementation go far beyond reducing fuel burn, and the key deliverables from the SESAR Programme have also a significant potential to mitigate **non-CO_2 emissions and noise impacts**.
It should be noted that although no targets have yet been set for non-CO_2 emissions (at local or global level) and noise impacts, the ATM Master Plan requires that each SESAR solution with an impact on these environmental aspects assesses them to the extent possible and within available resources.

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65 ICAO 2016 Environmental Report, Chapter 4, Page 162, Figure 4.

66 https://aviatorproject.eu

In this context, for example the EUROCONTROL *Integrated aircraft noise and emissions modelling platform* IMPACT, which delivers noise contour shape files, surface and population counts based on the European Environment Agency population database, estimates of fuel burn and emissions for a wide range of pollutants, and geo-referenced inventories of emissions within the landing and take-off portion, is one of the recommended models for conducting environmental impact assessments in SESAR.

6.5. Green Airports research and innovation projects

The European Commission's Green Airports research and innovation projects referred in this action plan among the "Other measures" commonly implemented in Europe has key objectives to achieve important supplemental benefits beyond CO_2 emissions reductions, among them:

Circular Economy:

- Developing the built environment (construction/demolition) using more ecologically friendly materials and processes and incorporating these improvements in the procurement processes to sustainably decrease the ecological footprint.
- Promoting the conversion of waste to sustainable fuels.
- Addressing the sustainable evolution of airports, also in the context of circular economy (e.g. activities linked to aircraft decommissioning and collection/sorting of recyclable waste), considering institutional and governance aspects, ownership, regulation, performance indicators and balance of force between regulators, airlines and airport operators.
- Addressing the feasibility of a market-based instrument to prevent/reduce Food Loss and Waste (FLW) and to valorise a business case of transformation of FLW into new bio-based products. This includes FLW measurement and monitoring methodologies and the subsequent mapping of FLW total volume at stake in the considered airport.

Biodiversity:

- Enhancing biodiversity, green land planning and use, as well as circular economy (e.g. repair, reuse and recycling of buildings and waste, in the context of zero-waste concepts).

Non-CO_2 impacts:

- Addressing air quality (indoor, outdoor, including decontamination from microbiological pathogens) and noise trade-off.
- Assessing non-technological framework conditions, such as market mechanisms and potential regulatory actions in the short and medium term, which can provide financial/operational incentives and legal certainty for implementing low emission solutions.
- Developing and promoting new multi-actor governance arrangements that address the interactions between all airport-related stakeholders, including authorities, aircraft owners and operators, local communities, civil society organisations and city, regional or national planning departments.

APPENDIX A
DETAILED RESULTS FOR ECAC SCENARIOS FROM SECTION A

1. BASELINE SCENARIO

a) Baseline forecast for international traffic departing from ECAC airports

Year	Passenger Traffic (IFR movements) (million)	Revenue Passenger Kilometres[67] RPK (billion)	All-Cargo Traffic (IFR movements) (million)	Freight Tonne Kilometres transported[68] FTKT (billion)	Total Revenue Tonne Kilometres[69] RTK (billion)
2010	4.56	1,114	0.198	45.4	156.8
2019	5.95	1,856	0.203	49.0	234.6
2030	5.98	1,993	0.348	63.8	263.1
2040	7.22	2,446	0.450	79.4	324.0
2050	8.07	2,745	0.572	101.6	376.1

Note that the traffic scenario shown in the table is assumed for both the baseline and implemented measures scenarios.

b) Fuel burn and CO_2 emissions forecast for the baseline scenario

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	36.95	116.78	0.0332	0.332
2019	52.01	164.35	0.0280	0.280
2030	50.72	160.29	0.0252	0.252
2040	62.38	197.13	0.0252	0.252
2050	69.42	219.35	0.0250	0.250
For reasons of data availability, results shown in this table do not include cargo/freight traffic.				

2. IMPLEMENTED MEASURES SCENARIO
2A) EFFECTS OF AIRCRAFT TECHNOLOGY IMPROVEMENTS AFTER 2019

a) Fuel consumption and CO_2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology improvements after 2019 included:

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Well-to-wake CO_2e emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	36.95	116.78	143.38	0.0332	0.332
2019	52.01	164.35	201.80	0.0280	0.280

67 Calculated on the basis of Great Circle Distance (GCD) between airports, for 97% of the passenger traffic for forecast years.

68 Includes passenger and freight transport (on all-cargo and passenger flights).

69 A value of 100 kg has been used as the average mass of a passenger incl. baggage (ref: ICAO).

2030	49.37	156.00	191.54	0.0232	0.232
2040	56.74	179.28	220.13	0.0217	0.217
2050	59.09	186.72	229.26	0.0202	0.202
For reasons of data availability, results shown in this table do not include cargo/freight traffic.					

b) Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology only)

Period	Average annual fuel efficiency improvement (%)
2010-2019	-1.86%
2019-2030	-1.22%
2030-2040	-0.65%
2040-2050	-0.74%

2B) EFFECTS OF AIRCRAFT TECHNOLOGY AND ATM IMPROVEMENTS AFTER 2019

a) Fuel consumption and CO_2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology and ATM improvements after 2019:

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Well-to-wake CO_2e emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	36.95	116.78	143.38	0.0332	0.332
2019	52.01	164.35	201.80	0.0280	0.280
2030	46.16	145.86	179.09	0.0217	0.217
2040	51.06	161.35	198.12	0.0196	0.196
2050	53.18	168.05	206.33	0.0182	0.182
For reasons of data availability, results shown in this table do not include cargo/freight traffic.					

b) Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology and ATM improvements)

Period	Average annual fuel efficiency improvement (%)
2010-2019	-1.86%
2019-2030	-1.82%
2030-2040	-1.03%
2040-2050	-0.74%

c) Equivalent (well-to-wake) CO_2e emissions forecasts for the scenarios described in this common section

Year	Well-to-wake CO_2e emissions (10^9 kg)			% improvement by Implemented Measures (full scope)
	Baseline Scenario	Implemented Measures Scenario		
		Aircraft techn. improvements only	Aircraft techn. and ATM improvements	
2010	143.38			NA
2019	201.80			NA
2030	196.8	191.5	179.1	-9%
2040	242.0	220.1	198.1	-18%
2050	269.3	229.3	206.3	-23%
For reasons of data availability, results shown in this table do not include cargo/freight traffic. Note that fuel consumption is assumed to be unaffected by the use of sustainable aviation fuels.				

APPENDIX B: NOTE ON THE METHODS TO ACCOUNT FOR THE CO_2 EMISSIONS ATTRIBUTED TO INTERNATIONAL FLIGHTS

1. Background

The present note addresses recommendations on the methodologies to account the CO_2 emissions, for the guidance on the development of the common European approach for ECAC States to follow, in view of the submission to ICAO of their updated State Action Plans for CO_2 Emissions Reduction (APER).

The ECAC APER guidance shall be established on the basis of the ICAO 9988 Guidance on the Development of States' Action Plans on CO_2 Emissions Reduction Activities document (3rd edition). One of its objectives is to define a common approach for accounting CO_2 emissions of international flights: two different methods are proposed for CO_2 accounting, namely ICAO and IPCC. Because of their intrinsic definitions, it is expected that these two different approaches induce both accounting differences, and practical issues, and furthermore, two ways to target the CO_2 Emissions Reduction Activities, and to define the action plans, de facto.

As the objective of the definition of the common section of the ECAC APER guidance consists into determining a common approach for all the foreseen activities, including CO_2 accounting and monitoring, the ECAC APER Task Group required to assess the details of each methods and to propose recommendations in this present note.

2. Accounting methods

The ICAO Doc 9988 document 3rd edition defines the two CO_2 accounting methods (§3.2):

a) ICAO: each State reports the CO_2 emissions from the international flights operated by aircraft registered in the State (State of Registry).
b) IPCC: each State reports the CO_2 emissions from the international flights departing from all aerodromes located in the State or its territories (State of Origin).

The international flights concern aircraft movements from a country to another country. Each method determines the country assignment of the movement.

Method	ICAO	IPCC
Definition	The ICAO methodology is based on the State of nationality of the airline, and defines an "international" flight as one undertaken to or from an airport located in a State other than the airline's home State, i.e. each State reports only on the international activity of its own commercial air-carriers.	The IPCC methodology defines international aviation as flights departing from one country and arriving in another, i.e. each State report to IPCCs in respect of all flights departing from their territory, irrespective of the nationality of the operator.
Use in projects	CORSIA/ETS (partially)	IPCC EAER UNFCCC

2.1 Comparisons: flown distance and number of operations

The comparison of the number of operations and flown distance of 2019, aggregated at ECAC or State levels provide a good indication of the possible differences for CO_2 accounting.

At the ECAC area level, the relative difference between the ICAO and IPCC methods, is -0.66% for operations number and + 0.26% on flown distance (Source EUROCONTROL/CRCO). This is explained by the fact that movements of the operators registered outside the ECAC area member states are not counted in.

The table hereafter lists the countries for which the relative differences of counting the number of operations or flown distance is more than 50% or less than -50% (Source EUROCONTROL/CRCO).

DEPARTURE COUNTRY	(ICAO – IPCC) % difference number of operations	(ICAO – IPCC) % difference number of flown distance
ALBANIA	-71.04%	-75.34%
ARMENIA	-80.76%	-84.64%
AUSTRIA	114.51%	104.81%
BOSNIA AND HERZEGOVINA	-83.45%	-80.73%
CROATIA	-52.08%	-65.54%
CYPRUS	-84.06%	-92.75%
DENMARK	-68.07%	-53.81%
ESTONIA	-67.93%	-53.48%
FAROE ISLANDS	*-100.00%*	*-100.00%*
GEORGIA	-68.62%	-66.45%
GREECE	-58.26%	-65.83%
HUNGARY	213.95%	245.36%
IRELAND	509.31%	478.00%
ITALY	-71.45%	-63.90%
LIECHTENSTEIN	2100.00%	8572.91%
LITHUANIA	-78.83%	-65.95%
LUXEMBOURG	55.29%	54.05%
NORTH MACEDONIA	-98.69%	-98.90%
MALTA	97.00%	125.78%
MONACO	100.17%	708.97%
SLOVAKIA	-73.46%	-72.30%

The previous table highlights the possible relative differences for a country-by-country approach:

- High differences for low-cost origin countries (Ireland, Austria, Hungary) as all the movements exceed the departures capacity: nb operations ICAO >> nb operations IPCC
    - Example: Ireland (Ryanair), Austria (EasyJet), Hungary (Wizzair)
- High differences for business jet country locations: nb operations ICAO > nb operations IPCC
    - Example: Monaco, Malta, Liechtenstein
- Difference for countries with lot of low-cost departures: nb operations ICAO < nb operations IPCC
    - Example: Greece, Italy

3 Impact on the action plan definitions

The choice of the method entails two significantly different approaches. The ICAO approach would bring the focus on the capability of a State to manage the emissions evolution of only its own "flag carriers". A State having a significant aviation activity operated by non-flag carriers would therefore not be able to reflect in the plan its possible policy on the evolution of its overall aviation activity. Also, if the State flag carriers have an important aviation activity between third countries, this would become a "responsibility" of the State in terms of emissions reduction plans.

The IPCC method, on the contrary, brings the focus on the management of the emissions reductions for the State related aviation activity, integrating the State's policy in terms of evolution and importance of the aviation business for it and national plans to reduce emissions (e.g., promotion of operations with more fuel-efficient aircraft).

Allowing States to use the ICAO or the IPCC method has the risk of under estimation for some as well as double counting for others if consolidating the States action plans.

It is also worth noting that the IPCC method actually allows consolidating and correlating the data with the CORSIA reporting. Indeed, under CORSIA emissions are reported by States aggregated at country pair level with no info on the operator. If all States were reporting action plans based on the IPCC approach aggregating at country pair level, this info can be consolidated and correlated with the CORSIA reported one. The ICAO method for the action plans would not allow this.

3.1 Impact on the baseline definition (ECAC)

The selection of the ICAO/IPCC method also affects the definition and estimation of the CO_2 emissions of the international flights at the ECAC level.

The Base year dataset and the forecasts dataset that EUROCONTROL shall define and assess (at the ECAC level), are based on the IPCC. The ICAO method cannot be used for such assessments.

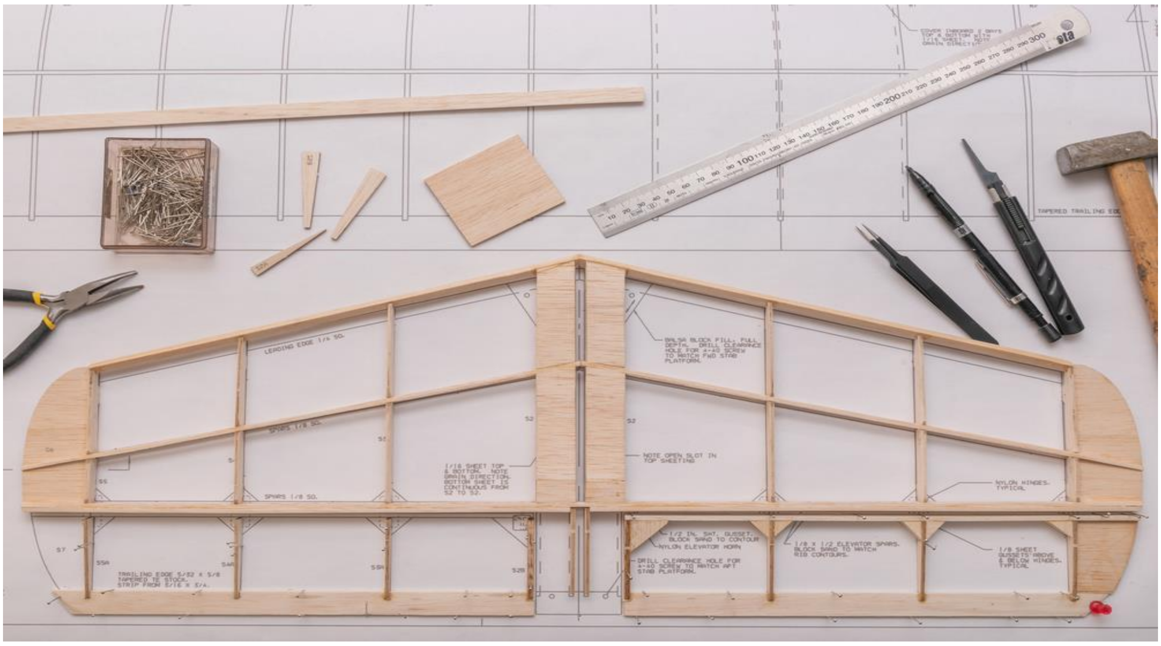
LIST OF ABBREVIATIONS

AAT - Aircraft Assignment Tool
ACARE – Advisory Council for Research and Innovation in Europe
ACA – Airport Carbon Accreditation
ACI – Airports Council International
AIRE – The Atlantic Interoperability Initiative to Reduce Emissions
APER TG - Action Plans for Emissions Reduction Task Group of the ECAC/EU Aviation and Environment Working Group (EAEG)
ATM – Air Traffic Management
CAEP – Committee on Aviation Environmental Protection
CNG – Carbon neutral growth
CORSIA - Carbon Offsetting and Reduction Scheme for International Aviation
EAER – European Aviation Environmental Report
EASA – European Aviation Safety Agency
EC – European Commission
ECAC – European Civil Aviation Conference
EEA – European Economic Area
EFTA – European Free Trade Association
EU – European Union
EU ETS – the EU Emissions Trading System
GHG – Greenhouse Gas
ICAO – International Civil Aviation Organisation
IFR – Instrumental Flight Rules
IPCC – Intergovernmental Panel on Climate Change
IPR – Intellectual Property Right
JU – Joint Undertaking
MBM – Market-based Measure
MT – Million tonnes
PRISME - Pan European Repository of Information Supporting the Management of EATM
RED – Renewable Energy Directive
RPK – Revenue Passenger Kilometre
RTK – Revenue Tonne Kilometre
RTD – Research and Technological Development
SAF – Sustainable Aviation Fuels
SES – Single European Sky
SESAR – Single European Sky ATM Research
SESAR JU – Single European Sky ATM Research Joint Undertaking
SESAR R&D – SESAR Research and Development
SMEs - Small and Medium Enterprises

SECTION 2 - National Actions in the Republic of Poland

This section includes supplemental information on the participation of the Republic of Poland in EU aviation research and development programs towards the carbon neutral civil aviation, including complementary measures.

All these National Actions in the Republic of Poland are contributions to the European measures taken collectively, so its quantification is already included in Section 1 of this Action Plan.



TECHNOLOGY AND STANDARDS

Overview

The aviation industry in the Republic Poland and especially pronounced in the countries forming the industrial core of the European Community is research oriented, with particular emphasis on technology and innovation processes, aiming at targets which have been coordinated at the Pan-European level. They were formulated for the first time in the European strategy paper "Vision 2020" and were last updated in "Flightpath 2050". The aviation industry enterprises in the Republic of Poland are substantially involved in cooperation with European and global supply chains. The gains in efficiency of newly available aircraft stem from the overall and partial system architecture and from the synergy of many innovations in technical detail along the supply chain. Investments into research, technology and innovation with the purpose of improving the ecological balance of the aviation product for the enterprises at the same time mean investments into their own competitiveness, since ecological benefit in aviation in most cases also entails economic benefits for the aircraft operator. A quantification of the contributions to ecological efficiency of the systems and components from the Republic of Poland is not possible because of the large numbers of influence factors, for example the individual success of the technologies in the market and the fleet policy of the airlines. This success is clearly reflected in the positive developments of the number of jobs and the turnover in the civil aviation industry. Further growth in global aviation is only possible if innovative and internationally competitive technologies can be offered which allow a further optimization of civil aircraft. The focus is placed especially on improvements and increases in efficiency in the research and technology fields listed below. This also includes aspects of an efficient and resource-saving manufacture and production of sustainable technologies.

2.1 THE RESEARCH WORK COMPONENTS PROVIDED BY THE INSTITUTE OF AERODYNAMICS AND APPLIED MECHANICS (FPAE / IAAM).

Field/Division	Climate relevant statutory research aims	Projects	Remarks on the program scope	Relevance to Carbon Neutrality Goals
Composite and smart materials	1.nanocomposites, 2.failure and fatigue of materials monitoring	FP 5, EP6, FP 8	Programs as a whole.	The increased potential for improvements regarding the structural efficiency of aircraft minimizes fuel burn.
Division of Aerodynamics	1. Computational research (Highly efficient CFD tools /numerical codes), 2. Wind tunnel tests 3. Passive and active flow control methods, 4. Grid generation and adaptation techniques, 5. Adjoint methods of optimization and uncertainty, quantification, 6. Lattice Boltzmann methods	"The program of The Polish-French cooperation in fluid dynamics."-" Sphere Maniacs"	Critical parts of the research involving variables influencing the flight energy efficiency both in direct and indirect manner.	The increased room for practical applications of aerodynamical improvements, supports the energy efficiency component of aero plane flight, and hence the advances of the general fuel economy of air transport.
Division of Mechanics	1. Aircraft control.	Cooperation with the Deutsches Zentrum für Luft- und Raumfahrt (DLR), and with the Technical University of Denmark (DTU),	Partial influence on energy efficiency of the aircraft flight.	Advances in the domain of aircraft control exerts indirect positive influence on the domain of the energy efficiency of flight.
The crucial excerpt from the WUT website supplementary info: "For the last few years, European programs, especially the FP5 and FP6, have offered a unique opportunity for finding new sources of funds. The Institute has involved a considerable part of its capacity into the process of preparing projects, which brought over 8 projects we are now engaged in. It should be noted, moreover, that the 8 projects have been successfully completed over the last two years. Undoubtedly, from the viewpoint of the achieved result, the Institute has a leading position, compared not only to the achievements of other WUT institutes but also in the view of Polish contribution to European Programs as a whole."				
Source: Faculty of Power and Aeronautical Engineering FPAE / Institute of Aerodynamics and Applied Mechanics IAAM, Warsaw University of Technology, April 2021 - Politechnika Warszawska, Wydział Mechaniczny Energetyki i Lotnictwa, ul. Nowowiejska 24, 00-665 Warszawa, [https://www.meil.pw.edu.pl/iaam], [https://www.meil.pw.edu.pl/eng/PAE2/Institutes/IAAM]				

2.2 THE RESEARCH PROVIDED BY THE INSTITUTE OF AVIATION IN WARSAW (IAW).

Scientific Entity	Climate relevant statutory research aims	Projects	Remarks on the program scope	Relevance to Carbon Neutrality Goals
IAW	High speed civil tilt rotor wind tunnel project (HIGHTRIP)	CLEAN SKY 2 (program wide integrated CO_2 reduction goals)	Wind tunnel tests outcomes allow for both aerodynamic improvements as well as flight mechanics fine tuning, influencing energy efficiency domain and fuel burn reduction	The increased potential for improvements regarding the aerodynamics and aeromechanical advances leading to improved efficiency of aircraft and fuel burn minimization.
IAW	Design, manufacture and deliver a high performance, low cost, low weight Nacelle Structure for Next Generation Tilt-Rotor (TRAIL)	CLEAN SKY 2	Critical parts of the research involving variables influencing the flight energy efficiency both in a direct and indirect manner.	The increased room for practical applications of both aeromechanical as well aerodynamical improvements, supports the energy efficiency improvement of aero plane flight, and hence the advances of the general fuel economy of air transport.
IAW	Projects interconnected with RACER helicopter development.	CLEAN SKY 2	Partial influence on energy efficiency of the aircraft flight, whitening the available design space.	Involvement in aircraft design always assume weight minimization and aerodynamic improvements. Combined advances in the aforementioned domains exerts direct and indirect positive influence on the aspect of the energy efficiency of flight, and reduction of fuel burn.
IAW	Full Fairing for Main Rotor Head of the Lifer Craft demonstrator (LATTE)	CLEAN SKY 2	Partial influence on energy efficiency to the aircraft in flight.	Combined effect of aerodynamic and structural efficiency on fuel burn reduction.
IAW	Design and Realization of equipped engine compartments including cowling for a fast compound rotorcraft (DREAM)	CLEAN SKY 2	Partial influence on energy efficiency to the aircraft in flight.	Combined effect of aerodynamic and structural efficiency on fuel burn reduction.
IAW	Optimization of APU Exhaust Muffler Thermal Barrier and Air Intakes construction Technologies (CHRZASZCZ)	CLEAN SKY 2	Partial effects of air intake dimensioning optimizing air inlet aerodynamic efficiency and exhaust dimensioning, taking into account the aerodynamic drag reduction.	Combined effect of aerodynamic and structural efficiency on fuel burn reduction.
IAW	Investigation and Maturation of Technologies for Hybrid	HORIZON 2020	Direct however limited in scale, synergy with carbon	Creation of technical basis for potential and conditional

	Electric Propulsion (IMOTHEP)		neutral growth assuming abundance of green electricity.	CO_2 emissions eradication in aviation.
IAW	Turbomachinery Retrofits enabling Flexible back-up capacity for the transition of the European energy system (TURBO-REFLEX)	HORIZON 2020	Synergic and complementary effects to electric / hybrid propulsion systems in aviation.	Creation of supplemental technical basis for potential and conditional CO_2 emissions eradication in aviation.
Source: Dr Eng. Sylvester Wyka, Deputy Director for Research and Scientific Affairs, Sieć badawcza Łukasiewicz – Instytut Lotnictwa, Al. Krakowska 110/114, 02-256 Warszawa NIP: 107 004 63 38, REGON: 387193275, [ilot.lukasiewicz.gov.pl]				

2.2.1 THE RESEARCH PROVIDED BY THE INSTITUTE OF AVIATION IN WARSAW (IAW) RESEARCH BASED ON GRANTS OR STATUTORY FUNDS.

Scientific Entity	Climate relevant statutory research aims	Projects	Remarks on the program scope	Relevance to Carbon Neutrality Goals
IAW	Adaptation of the piston / reciprocal engines rig /test stand/ to the needs of the laboratory of the aeronautical hybrid propulsion systems (ADAPT)	Grants or Statutory Funds	Potential and indirect synergic and complementary effects with the electric / hybrid propulsion systems in aviation.	Creation of technical capabilities for the technical basis for the potential and conditional CO_2 emissions eradication in aviation.
IAW	Development and test of fan design methodology, for non-uniform disturbed aerodynamic flow at the inlet-able to suckle boundary layer. (BLI Fan)	Grants or Statutory Funds	Potential at source reduction of emission by improved engine propulsive efficiency.	Potential reduced emission intensity and fuel efficiency driven emission reductions effects
IAW	Development and investigation of combustor chamber with swirling/rotating detonation, working on combustible air – Jet Kerosene (Jet – A) vapors mixture.	Grants or Statutory Funds	Potential at source reduction of emission by improved engine propulsive efficiency.	Potential reduced emission intensity and fuel efficiency driven emission reductions effects
IAW	The design and construction of the hybrid propulsion system for an airplane.	Grants or Statutory Funds	Direct however limited in scale, synergy with carbon neutral growth assuming abundance of green electricity.	Creation of technical basis for potential and conditional CO_2 emissions eradication in aviation.
IAW	Multirotor UAV of high payload capability and powered by hybrid propulsion.	Grants or Statutory Funds	Direct however limited in scale, synergy with carbon neutral growth assuming abundance of green electricity.	Creation of technical basis for potential and conditional CO_2 emissions eradication in aviation.
IAW	The development of competencies within the realm of numerical simulations of the aeroacoustics problems [NOISE]	Grants or Statutory Funds	The indirect impact justified on the basis of the noise CO_2 emissions interactions.	Intricacies of Noise-Pollutant Emissions Level or interdependencies. Due to the noise operational restrictions, aeroplanes are forced to omit the residential areas in the airport vicinity, in consequence their routes usually are subjected to significant elongation causing substantial CO_2

				emissions increases. So less noisy aircraft might also emit less CO_2 - in the circumstances of accessible operational efficiency.
The crucial excerpt from the IAW website supplementary info: "The information undrescores the liason of The Engineering Design Center- EDC, established in April 2000 under the agreement between the General Electric Aircraft Engines, and the Institute of Aviation. In course of the intense development Polish engineers support with their work both GE's aviation engines department improving parts and components of aviation engines, and among others an environmental protection equipment for ground application such as filters and electrofilters. The design processes comprise the domains of vanes and blade airfoils design, engine rotating parts design, structures design, combustion processes, as well mechanical systems design. The Engineering Design Center allows the utilisation of the intellectual potential of the best graduates of Polish universities of technology to work in Poland and participate in ambitious international projects comprising the design of the latest jet engines. The center employs approximately 800 engineers Source: PhD Eng., Rafał Kajka, Director of Engineering Design Cente, [www.edcpolska.pl]				
Source: Dr Eng. Sylwester Wyka, Deputy Director for Research and Scientific Affairs, Sieć badawcza Łukasiewicz – Instytut Lotnictwa, Al. Krakowska 110/114, 02-256 Warszawa NIP: 107 004 63 38, REGON: 387193275, [ilot.lukasiewicz.gov.pl]				

OPERATIONAL IMPROVEMENTS

2.3 THE CO_2 MITIGATION MEASURES IMPLEMENTED BY THE POLISH AIR NAVIGATIONAL SERVICES PROVIDER PANSA – SHOWING GENERAL CONSISTENCY WITH THE EFFORT EXERCISED AT THE LEVEL OF THE EUROPEAN UNION.

Entity	Climate relevant statutory research aims	Projects	Remarks on the program scope	Relevance to Carbon Neutrality Goals
PANSA	Optimization of en-route portion of the flight, shortening the expected flight duration.	Application of the concept Free Route Airspace (implemented in February 2019) in order to optimize en-route portion of the flight trajectories, adjusted to the needs of airspace users, as well as to the characteristics of the Warszawa FIR (EPWW FIR) airspace. It is foreseen that between 2020 and 2024 the further optimisation of Polish Free Route Airspace (POLFRA) concept will be carried out with the aim to further increase airspace user's benefits which could also reduce the negative impact on environment such as reduction of CO2 emission stemming from increased horizontal flight efficiency. However, adopted solutions have to include air traffic flow and capacity management aspects in order not to decrease capacity of a given ACC sectors and the whole airspace throughput taking into account complexity of EPWW FIR airspace. In parallel the POLFRA project will be gradually expanded in order to include cross-border FRA operations with neighbouring FIRs with first step being the implementation of common cross-border FRA area (Baltic FRA) within Baltic FAB.	Polish Free Rout Airspace FL95, H24	The shortened flight distance and time lowers the levels of fuel burn, and hence associated emissions levels including CO_2, NOx PM etc., influencing both climate change as well ambient air quality issues.
PANSA	Optimization of en-route portion of the flight, shortening the expected flight duration	*Phase 2 – Regional Cross-Border FRA Implementation: Baltic FRA (implementation of common cross-border FRA area within Baltic FAB and implementation of cross-border FRA operations between Poland and Slovakia (Baltic FRA and SEE FRA)) – FEB 2022	Cross-border FRA operations amid Poland, Slovakia and Lithuania - H24.	The shortened flight distance and time lowers the levels of fuel burn, and hence associated emissions levels including CO_2, NOx PM etc., influencing both climate change as well ambient air quality issues
Source: Maciej Kurowski Director of Bureau of Administration, Polish Air Navigational Services Provider, PANSA - Polska Agencja Żeglugi Powietrznej, PAŻP , ul. Wieżowa 8, 02-147 Warszawa, REGON:140886771, NIP:52222838321, 2021.,[info@pansa.pl], (Operational Bureau Data). *)[https://www.pansa.pl/inc/uploads/2019/12/Conops.pdf]				

Projects	Remarks on program scope of European	Relevance to Carbon Neutrality Goals	Remarks on the program scope	Relevance to Carbon Neutrality Goals
PANSA	Optimization of en-route flights, shortening the expected flight duration, and an improvement of TMA (Terminal	The CDM demand driven TMA structure optimization 2015-2021. Implementation and maintaining work flow mode and procedures of Air Traffic Control Services enabling aircraft crews to apply the CDO (Continuous Descent Operations) approach regime as well as enabling the regime	TMA structure optimization customized to regime allow to conduct CDM operations gradual implementation in the 2019-2021 years interval	The shortened flight distance and time lowers the levels of fuel burn, and hence associated emissions levels including CO_2, NOx PM etc., influencing both climate change as well local air quality.

	Maneuvering Area) adjacent route segments flight efficiency.	of the CCO (Continuous Climb Operations) for the regime take-offs.		
PANSA	Optimization of en-route portion of the flight, shortening the expected flight duration.	Cross-Border FRA operations between FIR Warszawa and Sweden FIR, operational H24. Starting in 2023	Cross-border FRA operations between Baltic FAB (Poland) and the FAB DK-SE (Sweden)	Minimization of the associated emissions levels including CO_2, NOx PM etc., influencing both climate change as well general improvement the air quality.
Source: Maciej Kurowski Director of Bureau of Administration, Polish Air Navigational Services Provider, PANSA - Polska Agencja Żeglugi Powietrznej, PAŻP, ul. Wieżowa 8, 02-147 Warszawa, REGON:140886771, NIP:52222838321, 2021.,[info@pansa.pl], (Operational Bureau Data). *)[https://www.pansa.pl/inc/uploads/2019/12/Conops.pdf]				

Projects	Remarks on program scope of European	Relevance to Carbon Neutrality Goals	Remarks on the program scope	Relevance to Carbon Neutrality Goals
PANSA	Optimization of en-route portion of the flight , shortening the expected flight duration	Optimization of the lower en-route airspace configuration/management after year 2025	The cooperation with the adjacent FIRs on flight trajectories optimization	Minimization the associated emissions levels including CO_2, NOx PM etc., influencing both climate change as well general improvement the air quality.
Source: Maciej Kurowski Director of Bureau of Administration, Polish Air Navigational Services Provider, PANSA - Polska Agencja Żeglugi Powietrznej, PAŻP, ul. Wieżowa 8, 02-147 Warszawa, REGON:140886771, NIP:52222838321, 2021.,[info@pansa.pl], (Operational Bureau Data), *)[https://www.pansa.pl/inc/uploads/2019/12/Conops.pdf]				

Entity	Climate relevant statutory research aims	Projects	Remarks on the program scope	Relevance to Carbon Neutrality Goals
PANSA/ Operational Bureau/Design of operations and Aeronautical Obstacles Analysis Division	Optimization of en-route portion of the flight , shortening the expected flight duration.	Shortening of SID (Standard Instrumental Departures /STARS (Standard Terminal Arrival Routes)) procedures, implementing of RNAV (area Navigation)/GNSS (Global navigational Satellite System) procedures.		The minimization of the associated emissions levels including CO_2, NOx PM etc., influencing both climate change as well general improvement the air quality
PANSA/ Division of Air Traffic Flow and Capacity Management	Ensuring proper airspace capacity ensuring durability of en-route optimization effects, even in case of excessive aerospace load contingency.	Optimization of Area Control Sectors (ACC) sectorization, Reduction of Air Traffic Flow and Capacity Management (ATFCM) regulations,	Improved effectivity of Air Traffic Flow and Capacity Management (ATFCM) services to Air Traffic Control (ATC) and Aircraft Operators (AOs).	Further minimization of the associated emissions levels including CO_2, NOx PM etc., influencing both climate change as well general improvement the air.
PANSA /AMC Poland	Further progress on optimization of en-route portion of the flight , shortening the expected flight duration.	Implementing of Advanced Flexible Use of Airspace AFUA at the levels of ASM2 I ASM3 and promote closer cooperation (strengthening cooperation) with Military – the reduction of activity time of temporary airspace structures - minimization of the civil aircraft route-trajectories elongation, development of support tools, AMC (CAT - Commmon Airspace Tool)* and integration of these tools under cooperation among AMC and FMP (Flow Management Position); implementation of new procedures between FMP and I AMC; the development of the AFUA (Advanced Flexible Use of Airspace), improvement of the airspace management at Network and at the national level (FIR Warsaw), by the means of extension CDM (Collaborative Decision Making) concept, and using functional connection ASM /ATFCM.	The effort towards implementation of the interoperability Thorough European Cooperation (iTEC) linked to SESAR and the sense of the operational improvements outlined in this program.	Further minimization of the associated emissions levels including CO_2, NOx PM etc., influencing both climate change as well general improvement the air quality

Source: Maciej Kurowski Director of Bureau of Administration, Polish Air Navigational Services Provider, PANSA – Polska Agencja Żeglugi Powietrznej, PAŻP, ul. Wieżowa 8, 02-147 Warszawa, REGON:140886771, NIP:52222838321, 2021.,[info@pansa.pl], (Operational Bureau Data).
*)[https://www.pansa.pl/inc/uploads/2019/12/Conops.pdf]

Table # 3.1. The CO_2 mitigation measures implemented by the Polish Air Navigational Services Provider PANSA – showing general consistency with the effort exercised at the level of European Union. (Sequel)

Entity	Climate relevant statutory research aims	Projects	Remarks on the program scope	Relevance to Carbon Neutrality Goals
PANSA	Further progress on optimization of en-route flights, shortening the expected flight duration.	The use of A-CDM (Airport – Collaborative Decision Making) procedure at the Chopin Warsaw Airport in order to minimize both, noise nuisances as well to lower the levels of the minimized aircraft fuel burn, ensuring both the CO_2 levels as well the levels of common air pollutants emissions reduction, due to more precise timing of aircraft airport operations. The iTEC v3 project is created on the basis of innovative solutions within a virtual domain using the cloud concept. The project uses digital automatic tools for aeronautical data processing. The implementation of this	The effort towards implementation of the interoperability Thorough European Cooperation (iTEC) linked to SESAR and the sense of the	Further minimization of the associated emissions levels including CO_2, NOx PM etc., influencing both climate

		solution will accelerate progress and allow the development of an efficient Pan European cross-border ATMS. The fast flow of data and virtual centers will allow Airspace Supervision on the opposite continent side by each of the iTEC partners. The iTEC system of data processing of a/c trajectories uses four dimensions. This 4D data processing approach allows ATC controllers to precisely position the a/c, and also to optimize the ATM depending on current operational circumstances. Due to the aforementioned improvements the progress is ongoing in the efficiency and punctuality of aeronautical operations, and both, the amount of emitted air pollutants and the operational costs are reduced. The iTEC (Interoperability Thorough European Cooperation) are co-financed by EU financial assistance means of CEF (The Connecting Europe Facility) and INEA funds (Innovation and Networks Executive Agency (INEA))within the framework of the CEF 2016 as well CEF 2017.	operational improvements outlined in this program.	change as well general improvement the air quality
*) Cat category 1, 2 and 3. Where CAT 1 means a precision instrument approach and landing with a decision height not lower than 200 feet (60 meters) and with either an RVR not less than 550 m and visibility of not less than 800 m. CAT 2 **Category II** (**CAT II**) operation" means a precision instrument approach and landing with a decision height lower than 200 feet (60 meters) but not lower than 100 feet (30 meters) and an RVR of not less than 350 meters; CAT IIIA lower than 30 m (100ft) or no DH, RVR not less than 200 m, CAT IIB lower than 15 m (50ft) or no DH, Rurales's than 200 m but not less than 50 m, CAT III C no DH (Decision Height) no RVR limitation.				
Source: Maciej Kurowski Director of Bureau of Administration, Polish Air Navigational Services Provider, PANSA - Polska Agencja Żeglugi Powietrznej, PAŻP, ul. Wieżowa 8, 02-147 Warszawa, REGON:140886771, NIP:52222838321, 2021.,[info@pansa.pl], (Operational Bureau Data). *)[https://www.pansa.pl/inc/uploads/2019/12/Conops.pdf]				

Table # 3.1. The CO_2 mitigation measures implemented by the Polish Air Navigational Services Provider PANSA – showing general consistency with the effort exercised at the level of the European Union. (Sequel)

Entity	Climate relevant statutory research aims	Projects	Remarks on the program scope	Relevance to Carbon Neutrality Goals
	Ensuring proper airspace capacity ensuring durability of en-route optimization effects, even in case of excessive airspace load contingency.	1. Processes comprised in a contract between PANSA and Indra Sistema's Inc. on project operational implementation till 2024 – realized n the Center of Air Traffic Control (CATC) located in the vicinity of the Airport. The contractual tasks include the implementation of the operational air traffic management system iTEC v3. The CATC center complex is aimed to perform an alternate function for Warsaw Cater for Air Traffic Management (WCATC). In need, this center will ensure the takeover of ATC services of the other extant PANSA regional centers. 2. The joint undertaking of PANSA, Poznan Supercomputer-Network Center, and Poznan Technical University (NAVIHUB) in the form of plane combining knowledge, competences and expertise of research institutes, universities, companies, entrepreneurial entities, and broadly understood aviation sector infrastructure managerial circles. The aim of NAVIHUB is to create and to test modern solutions within the realm of aeronautical navigation and aeronautics, which in the forthcoming future will be used at airports, i.e., both on the already existing and operating airports as well those airports barely conceived or designed within the planning space in Poland. The jointly undertaken research and development projects within the framework of NAVIHUB concerns among many other issues, the aspects of aeronautical data analysis and aeronautical data processing, utilization of advanced algorithms which will allow for the aircraft routes optimization processes. In effect, the aircraft movement will occur along optimized trajectories which subsequently causes the shortening of expected arrival times and will bring the reduction of fuel burn along with reduced CO_2 emissions. This will also reduce the other common air pollutants emissions levels.		Further minimization of the associated emissions levels including CO_2, NOx PM etc., influencing both climate change as well general improvement the air.
	Early environment protective actions in reaction to the fast development of UAV aviation market segment	The realization of the "Digital Services for Unmanned Aerial Vehicles projectwithin the framework of the Operational Program 'Digital Poland', financed by the European Union financial means. This project assumes joint effort of three institutional entities namely: the Ministry of Infrastructure, the Polish Civil Aviation Authority and the Polish Air Navigational Services Provider, aimed at the development of new digital solutions for the entire civil aviation sector. The immediate beneficiaries of that project will be all UAV users. This project will allow to improve and broaden the use of unmanned aerial vehicles and make both, the training and administration within this domain more efficient. The program also firmly emphasizes the importance of the sustainability component by minimizing the use of resources including downsizing streams of materials and energy.		Both UAV – manned aircraft substitution effects and direct environment protection measures within the UAV segment.

Source: Maciej Kurowski Director of Bureau of Administration, Polish Air Navigational Services Provider, PANSA - Polska Agencja Żeglugi Powietrznej, PAŻP, ul. Wieżowa 8, 02-147 Warszawa, REGON:140886771, NIP:52222838321, 2021.,[info@pansa.pl], (Operational Bureau Data), *)[https://www.pansa.pl/inc/uploads/2019/12/Conops.pdf].
Remark: The PANSA innovative projects are largely comprised in the framework of the SESAR R&D program. The expected outcomes of research works associated with the outlined projects are understood as the creation of technical possibilities of practical optimization of airplanes routes, leading to the reduction of the aircraft CO_2 emissions levels.

The are some easily accessible website data sources [1-CS], (2020) providing the corroborative evidence on the participation of the Polish entities in the Clean Sky programme supported both, by the central government at the national level as well as the local administration of the Province level.
Poland Opolskie – Advanced manufacturing systems.
Poland Pomorskie - Electrical engineering.

Poland Śląskie - Microelectronics, Advanced manufacturing systems.
Poland National Level (NCRB) - Advanced manufacturing systems.
Poland Podkarpacke Aviation - Aeronautics & Space.
Poland Lublin Mechatronics, possible RIS3 evolution toward aeronautics, Microelectronics.

Gardner [2-CS], (2021) provides also some complementary corroborative data on R&D activities undertaken jointly by the Polish and European aviation oriented entities representing the small and medium enterprises market segment (SMEs), which are focused on developing the technologies and which have established the consortium including: the Institute of Aviation in Warsaw, Italian Research Entity - CIRA, the Polish Aviation Plants, EUROTECH, SZEL-TECH Szeliga Grzegorz; P.W. „Metrol" Dariusz Dąbkowski, ULTRATECH, AVITION PLANTS Margański & Myslowski. The project coordinator responsible for the realization of the SAT-AM project, and the head of the Aviation Structures and Design Department at the Institute of Aviation Mr. Paweł Guła, stated that the obvious, however challenging way for minimizing the fuel consumption is aerodynamic optimisation of aircraft elements as well as weight reduction. The Energy consumption related to the manufacturing process can also be addressed by interrelated production process and product optimisation, manufacturing time optimisation, including the use of the more energy efficient manufacturing equipment.

According to the Clean Sky project officer Antonello Marino, from the Clean Sky perspective, some results of the aforementioned R&D project are already available and are very promising. They were able to reduce the number of parts by more than 37%, to reduce weight by up to 10% and to reduce manufacturing costs by 26% by substituting joints and mechanical fasteners such as bolts and screws with new technologies in composites and additive manufacturing.

Sources:
[1-CS]"Clean Sky working together with the member States, and Regions. Synergies with European Structural and Investments Funds (ESIF)." Clean Sky 2 - Joint undertaking 2020, Horizon 2020, European Union Funding for Research & Innovation, Brochure pp.9-10, [https://www.cleansky.eu/sites/default/files/inline-files/Clean%20Sky%20Region%20Brochure%20%281%29.pdf],
[2-CS] Ginger Gardner „Composites and 3D printing could boost Europe's SAT manufacturing capabilities for the 2030s" 2021, [https://www.compositesworld.com/news/composites-and-3d-printing-could-boost-europes-sat-manufacturing-capabilities-for-the-2030s].

3.1 REDUCTION OF EMISSION AT SOURCE I.E., FROM AN EXISTING FLEET OF AIRFRAMES – POWERPLANT COMBINATIONS.

1. Fleet replacement coordinated with fleet growth, focused on Specific Air range SAR maximization, associated with the supplemental specific airline requirements for the new aircraft orders, focused on aircraft lightweight internal equipment and finishing (first order approximation of the attainable levelized fuel burn reduction effect is expected at the level of 0.4% - 0.8% per year, depending on the initial fleet age and structure, as well as the states of the nature for airline business affecting the financial aspect of the possible pace of the fleet replacement process).

(i) Sub-option of partial fleet reengineering if needed or /and if feasible.

2. Block of commercial aircraft Maintenance, Repair and Overhaul (MRO) measures.
The fleet-wide maintenance measures focused on increase of the flight energy efficiency and fuel burn minimization:

i) aircraft interior cleaning focused on weight reduction, maintaining the lowest weight possible by removing paint of excessive thickness, dust and dirt removal, water vapor condensate elimination from internal-fuselage space, applying in optimal time intervals the thermal insulation drying (after consumption of initial effects the residual potential is estimated at the level of 0.25-0.5%),
ii) maintaining lowest drag possible by precise positioning of the aircraft inspection hatch covers, doors, landing gear fairing and engine cowls, reducing miss-alignment or miss-rigging on any doors (including main landing gear doors, nose landing gear door),
iii) the monitoring of paint condition and the level of the aircraft's exterior surface deterioration and the polishing of the aerodynamic surfaces with particular focus on wings and empennages leading edges, polishing engines inlets and engine nose lips to reduce lip loss (after consumption of initial effects the residual potential is estimated at the level of 0.5-1%),

iv) regular cleaning of the aircraft exterior, i.e. applying aerodynamic wetted surface wash in appropriate time intervals using innovative approaches with antistatic and/or superhydrophobic additives,
v) engine dust deposits removal (0.1-0.3%),
vi) technical internal engines wash, (0.3-0.6%)
vii) cabin and aircraft careful dirt removal (0.1-0.2%),
viii) aircraft empty weight periodic control (0.05-0.10%).

3.2 OPERATIONAL DOMAIN - FROM THE AIRLINE'S AND/OR AIRPORT PERSPECTIVE.

1) On ground/on-airport component of the emissions CO_2 reduction.
   i) replacement of aircraft APU by the GPU fueled by non-expensive sustainable alternative fuel like bio-diesel manufactured in LCAF like regime - effect (at the level of 1-2%) so there is no need to apply Sustainable Aviation Fuel in this segment,
   ii) Ensuring maximization of the use of the pushback tugs fueled by bio-diesel*(the remaining potential at the level 0.5-2.8 %) (manufactured in sustainable lean energy regime) or equivalent robots. Again the underlying idea is to avoid costly SAF or LCAF fuels. (*As long as the fuel mix structure of the electricity generation sector in Poland remains dominated by fossil fuels the electric tugs and electric vehicles will not ensure the expected CO_2 reduction effects.)
   iii) Externally supported engine warm-up during winter season and initial leading edges and engine lips deicing procedures (0.4-1.2%) (applying on-ground cheap but still alternative energy carriers),
   iv) External air conditioning systems for aircraft if technically applicable (0.05- 0.1%).
   v) Optimization /shortening of taxing routes (0.1 - 0.25%).

2) Operational efficiency in flight including both ETOPS limitations management as well as ANSP dependent route optimization and navigation procedures optimization, including also fuel reserve optimization (residual expected potential at the level 1%-2.2% fuel savings per flight).
3) Center of gravity location management (0.15% – 0.6%),
4) Wind and altitude trade-off measures,
5) In some cases, the room for the major reengineering of the entire connection networks of the specific operator should be predicted. This assumption may include directional network optimization and the fine-tuning of the short-haul / long haul flights ratio.
6) The fleet wide/or the network wide Cost Index optimization effects.
   i) The Cost Index influence considerations.
   Regardless of the trends assuming the rise of jet kerosene prices, and rational expectation of the increase in CO_2 equivalent allowances, the fuel burn costs having the following structure are expected to grow:

FBC=Fuel Mass*(Fuel Cost/Mass Unit) +3.16*(Fuel Mass*Allowance Cost/Mass Unit)
Hence:
FBC= Fuel Mass*{Fuel Cost+3.16 Allowance Cost},
Therefore, the corrected fuel burn cost per Mass Unit:
FBC/MU=Fuel Cost+3.16*Allowance Cost.

In consequence:
Cost Index = [Cost of time ($/minute)]/ [Cost of fuel*3.16 Allowance Cost ($/kg)]

Both the allowances price component and the fuel price component are expected to grow. Moreover, the ratio of (3.16*Allowances Cost) / (Cost of Fuel) may also show propensity to moderate but systematic growth along the timeline. On the other hand, the increased maintenance requirements, will raise the overall maintenance costs in a substantial manner, and hence also the noticeable increase in the cost of time may also ensue.

Due to the forecasted magnitude of aggregated fuel burn costs, it is expected, that the cruise speed will be lowered by shift toward the maximum range speed as long as the cruise route segments are considered, including minor correction toward the maximum endurance speed for loitering segments. It has been initially assumed that CI driven fuel burn minimization effects may account for approximately 1.5%-3% fuel saving depending on existing room for further improvements.

4 LOT Polskie Linie Lotnicze (Polish Airlines) – Destination ECO

Taking into account the growing importance of the environmental attitudes in the society and the ongoing discourse on environmental impact of human-being related to the abatement of the negative anthropologic effects on environment, LOT Polskie Linie Lotnicze decided to adopt a more systematic approach to the environmental protection domain and to launch a relevant long term project - Destination ECO.

The overarching purpose of the Destination ECO program is defined as the apt and responsible management of the environmental impacts and undertaking of the long run environmental initiatives, directed towards the limitation of the influence of the number of factors exerting collectively substantial climate change impact. To achieve that, strategic actions are taken such as: investment in new fleet, operational optimization in order to improve the fuel consumption economy, or seeking for alternative fuels. Various initiatives are also undertaken at the level of everyday entrepreneurial operations including actions within the domain of passenger services, as well routine works conducted in the headquarters of the company. The environmental activities are implemented jointly with contractors, suppliers and due to a newly adopted carbon footprint compensation program also with passengers.

The environmental actions taken by LOT Polskie Linie Lotnicze are centered on four major components, namely:

- Reduction of CO_2 emissions largely due to further fleet replacement to increase the share of more environmentally friendly aircraft in the fleet structure, and by introducing operational improvements,
- The solid waste management by the elimination of the use of the products or elements made of non-biodegradable, non-recyclable materials, and intensifying the selective waste collection and recycling,
- Searching for Sustainable Alternative aviation Fuels and their use, combined with the natural resources and sustainability protection measures by limiting the use of water, energy, fertilizers, and avoiding the harmful land use changes and more.
- The Offsetting Projects assuming the quantifiable, verifiable, durable and well documented CO_2 emissions, and CO_2 equivalent emission compensation effects.

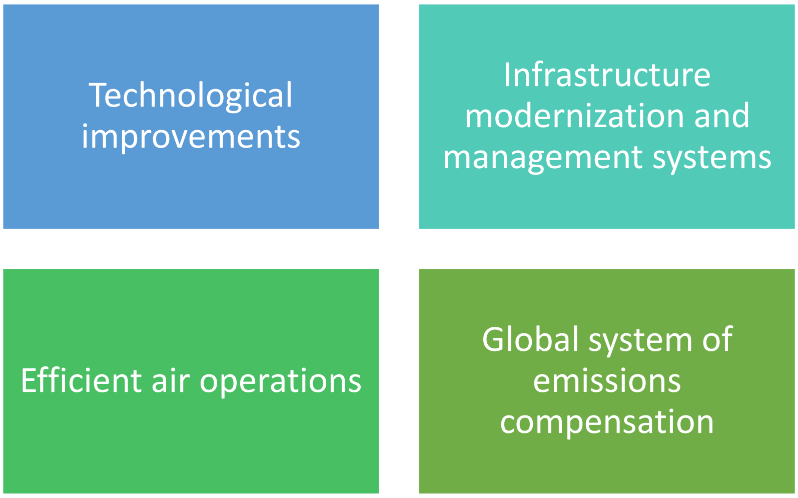
Within the aforementioned components LOT Polskie Linie Lotnicze develops and plans to carry out the training of employees and to undertake the educational effort addressed to its contractors, partners, and passengers.
Each step towards an environment of improved quality is important, and each solution may change a lot, if we really use it. Theretofore, LOT Polskie Linie Lotnicze has a careful look at its environment and ensures appropriate reactions in order to create a better future for the next generations.

4.1 The activities of the LOT Polskie Linie Lotnicze in the domain of environmental protection.

The unexpected outbreak of the pandemic of the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS–CoV-2) changed the civil air transport market causing widespread, high magnitude and far-reaching consequences influencing a majority of the global civil aviation transport system. The sharp drop in the number of operations, have encouraged air carriers to withdraw the oldest airplanes types from their fleets. Hence, after the end of the pandemic, the fleet structure will be more effective and environmentally friendly.

The most modern airplanes types safeguard a better fuel economy and generally improved environmental performance largely due to the weight reduction achieved by the application of new lightweight composite materials, ensuring increased structural efficiency and in consequence influencing the rag polar curve in a beneficial manner. These modern airplanes powered by new advanced powerplants types of improved fuel economy, both due to general aerodynamic advancements combined with the application of new generation of winglets, are incomparably more environmentally friendly, than their predeceasing counterparts.

The strategy of four IATAs' pillars of emission reduction in aviation



LOT Polskie Linie Lotnicze actively participate in activities aimed at the limitation of emissions in aviation consistently with the IATA Four Pillars Strategy.

The implementation of the aforementioned Four Pillars strategy in practical approach means among other things fleet replacement, redesign of flight operations and/or procedures and participation in emission compensation programs. LOT Polskie Linie Lotnicze are engaged in the activities aimed at the Pan-European airspace throughput improvement and airports. These actions have the expected emission reduction potential at the level of 16 million tons of CO_2 per annum at a European scale. For that reason LOT Polskie Linie Lotnicze actively support the activities towards the deployment of the Single European Space Management System program.

4.1.1 Fleet Structural Changes

Boeing 787 Dreamliner

The lower mass of Boeing B-787 aircraft combined with its new fuel efficient and lightweight Rolls-Royce engines shows significantly improved fuel economy with incremental fuel burn savings (20-25% less than their predecessors). In addition, the noise emissions levels of those engines are approximately by 60% smaller and a majority of their parts can be recycled after the engine's exploitation.

Boeing 737 MAX 8

The Boeing B-737 MAX 8 are about 7% lighter than their predecessor and their wings have a new winglet type and the new engines are more fuel efficient. The wing of that aircraft is equipped with the Split Scimitars ensuring 1.8% fuel saving effect. The new engines LEAP-1B ensure CO_2 emission level reduction by 14% and by 40% smaller noise emission level.

4.1.2. Aeronautical Operations

In recent years the procedure consisting in one engine taxiing after landing and flight routes optimization program, supplemented by other measures allowed to achieve a 7% emission reduction effect.

- **The Single Engine Taxi-in** procedure was conceived for Embraer, Boeing 737 and Bombardier Q400 aircraft, however, the application of this procedure depends on the characteristics of the aerodrome concerned, the location and shape of taxiways and the specificity of the aircraft
- **Technical engine wash** and the so-called wet aircraft surface washing every 3-6 months on average. The frequency of this measure is the function of aircraft flying hours, aircraft age and engine type.
- **Aircraft trim** – optimization of the center of mass positioning, as well empennage angles to minimize aerodynamic drag.
- **Zero fuel weight** – the fuel reserve optimization and hence the aircraft in flight weight minimization resulting in fuel saving effects. The fuel reserve optimization, however, is a data driven process which requires estimated Zero Fuel Weight (ZZFW) figures. This is improved via the flow of the relevant EZFW data telegrams improvement from the aircraft to the flight planning system, including the aircraft weight devoid of fuel, but including passenger mass, baggage weight as well as mail and cargo weight. The improved access to the up to date data allow to optimize the fuel reserve as well as the fuel needed for a particular flight which positively influences its consumption during the flight.

- **APU Monitoring** (Auxiliary Power Unit) – One hour of on ground APU operation causes a fuel use which amounts to 220 kg for an average aircraft of the Boeing B 787 fleet, 140 kg for an average aircraft of the EMB fleet, 110 kg for an average aircraft of the B 737 fleet and 90 kg for an average aircraft of the Q400 fleet. In order to limit the use of an aircraft fuel by APU a recommendation was issued on using GPU everywhere (if possible). The second step aimed at APU use reduction was introduced in November 2019 and named "quick current procedure" at the Warsaw Frederic Chopin Airport for the Boeing B 787 fleet. This procedural solution consists in restraining of APU start after landing while considering current weather conditions, and relaying on the handling agent providing the GPU electricity supply at the aircraft parking stand, before taxiing to the Gate. The current procedure is applied in the case of about 40% of landings at the Warsaw Frederic Chopin Airport, and its implementation results in halving the average time of the APU work during taxi-in (from 8 to 4 minutes).

- **Cost Index (CI) –** a cyclical update of the data used to calculate the cost index, which is used to determine such flight speeds in all phases of the flight that will result in the most efficient fuel consumption.

The cost of time means all aggregated costs of aircraft and its airworthiness maintenance, including systematic calendar overhauls costs and non-calendar overhauls, insurance, cost of navigational services, etc., however, they are incurred independently of aircraft use, they are necessary to maintain aircraft airworthiness as well as ensure the continuous aircraft operability.

The more precise and accurate the Cost Index values are, the better informed are the decisions on the airline economy improvements using the cruise speed optimization.
In other words the Cost Index is intended to improve the airline profitability, by efficient operational cost minimization, depending on which of the costs components prevail namely: the cost of time or the cost of fuel.

If the fuel cost is increased by the sum of CO_2 emissions compensation cost, and the cost of the CO_2 allowances, than the shift toward greater relative scale of fuel savings will ensue. Hence the more environmentally friendly Cost Index values will be adopted and the decision to decrease the en route speed will be the airline choice.

However, in general in the probabilistic sense the use of the most current data to calculate the CI values seems to be environmentally neutral, the current precise and accurate CI values allow to lover the overall operational costs by optimization of the cruise speed against two conflicting requirements including the cost of time and the cost of fuel (the increase in cost of time encourages the increase of speed at the expense of fuel burn increment, and vice versa: the increase in the fuel price ceteris paribus encourages the optimisation of speed, i.e. lowering it to moving closer toward the so called economic speed).

- **NADP2 (Noise Abatement Departure Procedure 2)** – the implementation of the NADP2 as a basic departure procedure. This solution aims at ensuring of the adoption of a proper climbing trajectory profile, leading to the lowered fuel consumption and in the case of the Boeing B787 aircraft type the NADP2 procedure allows to save about 200 kg of the aviation fuel.
- Continuous Descent Approach (CDA) – a smooth approach to landing.
- The optimization of the gravity centre position of an aircraft.
- Optimization of the air operations planning, inclusive of the flight paths.

Moreover, LOT Polskie Linie Lotnicze applies procedures allowing a quick identification of malfunctions which might cause the increase of fuel consumption. These procedures allow to optimize the amount of water taken on-board for the needs of individual flights or the introduction of an electric system instead of paper flight plans.

4.1.3 The Pro-Environmental Changes in "on board" and "on ground" Products.

As one of the most necessary changes, the passengers indicated to those relating to the use of plastic and other materials harmful for the environment in on-board and ground products. LOT Polskie Linie Lotnicze, addressing the expectations of its clients, introduced a whole range of changes.

Their introduction aimed not only at the implementation of ecological materials and the reduction of other ones but also a decrease of their weight which causes a decrease in fuel consumption.

Thus, LOT Polskie Linie Lotnicze resigned from using plastic straws, packing foils or the lamination of passenger seats manuals. Plastic earphones packages have been replaced by biodegradable ones made of corn starch, crayons for children are packed in paper and the slippers are now packed only in a paper banderole.

Also plastic garbage bags were withdrawn, just like bleached napkins which have been replaced by recycled ones.

In addition, LOT Polskie Linie Lotnicze introduced a healthy food offer and decided to reduce the orders of products using palm oil or harmful preservatives. These changes cover also the sub-suppliers who bulk pack their products which further reduces the use of plastic on board.

Moreover, the approach to travel sets for passengers has been changed aimed, *inter alia*, at the reduction of materials harmful for the environment.

One of the most significant changes was the introduction of electronic newspapers instead of traditional ones due to which the passengers have access to over a thousand newspapers. This allowed to reduce the number of garbage left after each flight and the weight of on-board products which reduces the fuel consumption. Along with a lack of foils protecting the newspaper packets it allowed to reduce the paper use by 135 tons per year and the CO_2 emissions were reduced by approximately 424 tons per year.

It is worth noting that changes have been introduced not only on board but also on the ground. In business lounges of LOT Polskie Linie Lotnicze all traditional bulbs have been exchanged to LEDs, the plastic stirrer sticks have been withdrawn and some products (like sugar or spices) are not served in single-use packages anymore.

4.1.4 Educational Activities

The pro-ecological activities introduced by LOT Polskie Linie Lotnicze require a proper training for the employees. It is a very time-consuming process and in a traditional form also environment unfriendly. Therefore, the company introduced an e-learning platform due to which the training can be performed remotely. E-learning allows to repeat the training and revise the training materials. Pilots have a crucial influence on fuel efficiency and it is them and their actions which impact the flight effectiveness. An ability to reach out to the crews through e-learning and the introduction of eco modules will cause the reduction of emissions by at least 1%, which constitutes a huge potential if one takes into consideration all flight operations.
Some of the activities cover:

- Fuel Bulletin – it includes information for the crews on how to perform operations aimed at fuel efficiency.
- Airport Briefing Sheet – provides the pilots with the most up-to date information allowing them to better prepare for the flight and to better plan an appropriate amount of fuel.
- Fleet Chief Fuel Report – fuel reports for Fleet Chiefs including information on how a given fleet applies the fuel policy, on progress of a given fleet and potential areas for improvement.
- Personalized Fuel Statistics – statistics for pilots including selected fuel policy initiatives showing their performance against their fleet.
- Regular meetings of the instructors' council with pilots – the meetings cover issues related to fuels and their purpose is to discuss selected fuel initiatives, the level of their applicability in each fleet and to indicate possible areas for improvement.
- Fuel Committee – the establishment and regular meetings of the committee whose purpose is to identify and introduce fuel initiatives and solutions aimed at the increase of fuel efficiency.
- Cooperation with aircraft producers within the scope of activities and solutions aimed at efficient fuel consumption.

4.1.5 The Emissions Compensations Payments and Cooperation with the Polish State Forests.

Since 2019 a voluntary CO_2 emission compensation program is offered to passengers and financial means are accumulated in the Environmental earmarked budget.

At the Destination Eco program website there is an interactive carbon footprint calculator available with a map. Due to this functionality each passenger may check the individual trip carbon footprint and subsequently may provide a compensatory payment to a dedicated account at the last stage of the ticket reservation procedure. [www.lot.com]. The passenger may accept the amount suggested by the calculator or he/she may decide to pay a bigger amount. The financial means collected on the aforementioned account allow a cooperation with the Polish State Forests aimed at the enhancement of the absorption of CO_2 from the atmosphere by forest ecosystems.

The CO_2 Sequestration project in Swarożyn.

For the last two years LOT Polskie Linie Lotnicze has been participating in the auctioning of the CO_2 Emission Removal Units organized by States Forests. The financial means gathered during the auction are invested in the biodiversity preservation project named "The protection of the habitat of cranes by revitalization of the wetland bird habitats and improvement of the retention capacity of the rosary on the territory of the Swarożyn Forest Inspectorate".

The project scope assumes that the seven dried-up ponds with a total area of 10 ha will be revitalized and filled with fresh water improving the retention capacity of afforested land and increasing the water resources. This will significantly improve the condition of the local forests – the trees around the ponds will be healthier and the microclimate will stabilize. The project will also create conditions necessary to assure proper nesting and rearing of offspring by the common crane (Lat. Grus grus), and many others birds species of the wetland - marsh habitat, encountered at the terrains belonging to the Starogard Forest Inspectorate. The project implementation will increase the CO_2 absorption by the nearby forests by approximately 220 tons per year.

SUSTAINABLE AVIATION FUELS

5. SAF

PKN Orlen runs an HVO project which will enable the production of BIOJET biofuel. The product will be made of lipid raw materials with the application of the hydrogenation process (*inter alia*, used cooking oils will be utilized). The BIOJET biocomponent as well as the target JET fuel will fulfill the requirements of the ASTM D7566 standard. The target capacity of the new HVO installation will amount up to 240 kt/per annum of the BIOJET biocomponent and the production should start in 2024.

ADDITIONAL MEASURES

6. MODERNISATION OF THE POLISH AIRPORT NETWORK IN TERMS OF REDUCING CO_2 EMISSIONS.

Poland will be supported by the European Commission with the project of *Modernisation of the Polish airport network in terms of reducing CO_2 emissions*. The support concerns the preparation for joining the "Airport Carbon Accreditation" program by Polish airports. It is a program developed by Airport Council International (ACI) which aims to identify energy management techniques and the carbon footprint of each airport.

The project, which would be financed by the Technical Support Instrument, is devoted to the first phase of the program, i.e. mapping, and paves the way for further actions. The aim of the activities connected with the mapping phase is to facilitate identification of the needs of the airports with respect to green investments, and help them prepare for the subsequent implementation of the investment plan associated with decarbonisation of their operations by means of appropriate carbon footprint measurements and other relevant analyses. It is also a contribution to the development of policy actions at the administration level.

Sources:

[1] [https://apps.lot.com/destinationeco],
[2] [www.lot.com.],
[3] [https://businessinsider.com.pl/firmy/zarzadzanie/lot-wprowadza-mozliwosc-kompensacji-emisji-co2-destinationeco/jr0rkbe]

7. INVESTMENTS THAT WILL SUPPORT ENVIRONMENTAL IMPACT MITIGATION MEASURES

Poland is preparing a proposal for an investment program, aimed at modernizing the infrastructure of airports in the TEN-T network in terms of reducing emissions.

The implementation of an investment is a long-term process. Acquiring knowledge about similar investments made by other airports in Europe, and drawing on best practices will enable the efficient execution of the investment program aimed at implementing EU climate ambitions, focusing e.g. on improving the energy efficiency of airports and aiming at achieving the highest possible level of decarbonisation of all airports included in the European TEN-T transport network.

The program shall focus on the following types of investments:

- Sustainable Aviation Fuels,
- Renewable energy sources,
- Electromobility,
- Modernisation of systems.

CONCLUSION

"Section 2 of this action plan was finalised on August 10, 2021, and shall be considered as subject to update after that date".

This Action Plan provided an overview of measures taken by the Republic of Poland and its aviation sector in order to limit the aviation's CO_2 emissions. Both national actions and the measures initiated on the European level are covered by this document. The measures described in the previous chapters cover a broad range of subjects, including aircraft-related technology development, support for alternative fuels, improved Air Traffic Management.

List of abbreviations and definitions

AFTK (Available Freight Tonne[70] Kilometers) - the measure of flight's freight carrying capacity calculated by multiplying the number of seats of an aircraft by distance travelled in kilometers.

ASM (Available Seat Mile)[71] - the measure of flight's freight carrying capacity calculated by multiplying the number of seats an aircraft has by the distance travelled in miles.

ATK - Available Tonne Kilometer.

ATC - Additional Centre Tanks.

AUW (All–Up Weight Aircraft Gross Weight) – is the total aircraft weight at any moment during the flight or ground operation.

BOW (Basic Operating Weight) – total weight of the aircraft ready for flight, including crew, fixed ballast, unusable fuel, normal operating level of oil and total quantity of hydraulic fluid but without payload or fuel (sometimes excludes the crew).

Break Even Load Factor - the percentage of available seats the airline has in service that have to be sold at a given yield, or price level, to cover its costs; in recent years overall the Break Even Load Factor, industry average is assumed at the levels around of 66%.

Carriage - transportation or carriage of cargo by air.

Carrier - Industry term for 'airline'[72].

CASK - Cost per Available Seat Kilometers used to compare financial effectiveness of different airlines.

CASM - Cost per Available Seat Mile used to compare financial effectiveness of different airlines.

CGO (Cargo) - goods and property carried or to be carried on an aircraft, other than mail or property carried under terms of an international postal convention, baggage or property of the carrier, provided that baggage transported under an air waybill or shipment records is cargo.

City Pair - a term used for cities of departure and destination, e.g.,[73] from Warsaw to New York.

Destination - the ultimate stopping place according to the contract of carriage.

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70 The international settlements need special caution regarding the non-metric mass units. We distinguish mass-based metric tonne (1000 kg or 1 Mega gram) and other units like avoirdupois or imperial weight system units commonly called 'ton'. The absolute difference between Long ton and Short ton is 240 pounds or 108. 81526 kg, and relative difference constitutes about 12% referring to the short ton basis. Assuming a mistake of admitting the long ton in place of the metric tonne, the total error might be estimated at the level of (+) 1.6%. On the other hand, assuming that one has admitted the short ton in place of the metric tonne, the absolute error would be at the level of 92.81526 kg, and the relative error might be estimated at the level of (-) 9.281526 % - referring to the metric tonne datum.

However, there is the so called short ton, a weight unit equal to 2 000 pounds ≈ 907, 18474 kg used in the USA and Canada and is referred to as 'ton'. There is also the long ton defined as 2240 pounds corresponding to the 1016 kilograms or 1. 016 metric tonnes.

71 The U.S. statute mile or statutory mile or survey mile measures 1 609. 3472 metres, formally abbreviated to 'mi' to avoid confusion with 'm' for meter of SI unit's system, however, at present the abbreviation 'm.' is commonly used, namely mph, mpg - mile per gallon etc. The conversion facto for the 1 Nautical Mile = 1,508 Statute Miles. There is also the international mile distinguished (aka. The International Statute Mile, or English mile, by international agreement in 1959), which measures 1 609. 344 meters so per each mile there is 3,2 mm difference.

72 However, frequently encountered default understanding of this term encompasses collectively: airports, airframes assemblers, powerplant manufacturing entities as well systems, avionics and other OEM manufacturers.

EW (Empty Weight) - the sum of Manufacturer Empty Weight, Standard Items weight, Operators Items weight, where Standard Items encompass engine oil, engine coolant, water, hydraulic fluid and unusable fuel.
Fleet - the number of aircraft operated by an airline, but also depending on the level of analytical tasks or statistical assignment, the general population of all aircraft attributable to the jurisdiction of an area specific Civil Aviation Authority, or global population of all aircraft types under supervision of ICAO.
FTK (Freight Tonne Kilometers) – i.e. 1 FTK = one metric tonne of revenue load carried at a distance of one kilometer.
Fuel Jettison / Fuel Dumping – a procedure allowing an emergency landing after take-off to adjust actual Gross Aircraft Weight to the mass the aircraft is certified and allowed for landing namely, Maximum Landing Weight.
Layover - a long, usually overnight, stop between flights usually involving change of flight number and/or aircraft.
LF (Load Factor) - a share of airline throughput actually utilized, expressed as dimensionless ratio of passenger-kilometers travelled to seat-kilometers available namely RPKs/RPMs or ASKs/ASMs, for practical reasons averaged for the certain number of flights, also the term PLF (Passenger Load Factor) is applied as an explicit reminder on the existence of FLF - Freight Load Factor - (AFTK actually utilized)/(AFTK) *100%.
Long haul - a long-distance international flight frequently intercontinental lasting at least 6 hours.
Maximum Structural Landing Weight / Maximum Landing Weight - the maximum Aircraft Gross Weight due to design or operational limitations at which the aircraft is permitted to land.
MFW (Minimum Flight Weight) – minimum certified weight for a flight as limited by aircraft and airworthiness requirements.
MLW - Maximum Landing Weight.
MRW - Maximum Ramp Weight.
MZFW - Maximum Zero Fuel Weight.
Operating Empty Weight - a sum of the EW and crew plus their baggage.
OWV - Operational Weight Variants as included in TCDS Type Certificate Data Sheet.
RASK - Revenue per Available Seat Kilometer, can be computed by getting the Load Factor multiplied by the Yield to get the revenue per increment capacity; to make calculations for system wide Load Factor, simply divide the Revenue Passenger Kilometer by the Available Seat per Kilometer to get the Load Factor for individual flight; to get the quotient of the revenue passengers on board divide it by the aircraft capacity,[74]
RASM - Revenue per Available Seat Mile.
RASM / **RASK** - Revenue per Available Seat Mile / Kilometer, are commonly used similar terms,
Route - consecutive links in a network served by single flight numbers as a single route.
RPKM - Revenue Passenger Kilometer.
RTKM - Revenue Tonne Kilometer.
Segment - a clearly identified part of a journey, usually between two cities and involving one departure and one arrival; distinction from 'flight' should be emphasized, which may involve stop-overs where only one flight number is used. Flight Sector / Segment means also a non-stop operation of an aircraft between points A and B with corresponding departure and arrival times.

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74 Revenue per Available Seat Mile (RASM) constitutes metrics applied to compare the financial efficiency of airlines. The RASM is calculated by dividing the airline operating income by the number of Available Seat Miles (ASM) of airline, obviously the higher the RASM the more efficient the airline under consideration.