REPORT
TSL 2016-5592
August 2016

ICAO State Action Plan on

CO_2 Emissions Reduction Activities

Sweden

August 2016

Maritime and civil Aviation Department
Market, Environment and Analysis Unit

The report is available on the Swedish Transport Agency's website
www.transportstyrelsen.se

Designation TSL 2016-5592

Author Section for environment, Annika Lindell
Month Year August 2016

Table of contents

1 Introdution

a. Sweden is a member of the European Union 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 environmental concerns represent a potential constraint on the future development of the international aviation sector, and together they fully support ICAO's on-going efforts to address the full range of these concerns, including the key strategic challenge posed by climate change, for the sustainable development of international air transport.
c. Sweden, like all of ECAC's forty-four 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.
d. Sweden recognises the value of each State preparing and submitting to ICAO an updated State action plan for emissions reductions, as an important step towards the achievement of the global collective goals agreed at the 38th Session of the ICAO Assembly in 2013.
e. In that context, it is the intention that all ECAC States submit to ICAO an Action plan [2]. This is the action plan of Sweden.
f. Sweden shares the view of all ECAC States that a comprehensive approach to reducing aviation emissions is necessary, and that this should include:
   i. emission reductions at source, including European support to CAEP work
   ii. research and development on emission reductions technologies, including public-private partnerships
   iii. the development and deployment of low-carbon sustainable alternative fuels, including research and operational initiatives undertaken jointly with stakeholders
   iv. the optimisation and improvement 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 the

[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, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, The former Yugoslav Republic of Macedonia, Turkey, Ukraine, and the United Kingdom.
[2] ICAO Assembly Resolution A38-18 also encourages States to submit an annual reporting on international aviation CO2 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 on international aviation CO2 emissions referred to at paragraph 11 of ICAO Resolution A38/18 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.

Atlantic Initiative for the Reduction of Emissions (AIRE) in cooperation with the US FAA.

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 aggregate, deliver in time the emissions reductions necessary to meet the global goals. This growth becomes possible through the purchase of carbon units that foster emission reductions in other sectors of the economy, where abatement costs are lower than within the aviation sector.

g. In Europe, many of the actions which are undertaken within the framework of this comprehensive approach are in practice taken at a supra-national level, most of them led by the European Union. They are reported in Section 5 of this Action Plan, where Swedens involvement in them is described, as well as that of stakeholders.

h. In Sweden a number of actions are undertaken at the national level, including by stakeholders, in addition to those of a supra-national nature. These national actions are reported in Section 6 of this Plan.

i. In relation to actions which are taken at a supranational level, it is important to note that:

- The extent of participation will vary from one State and 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 to 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.
- Nonetheless, acting together, the ECAC States have undertaken to reduce the region’s emissions through a comprehensive approach which uses each of the pillars of that approach. Some of the component measures, although implemented by some but not all of ECAC’s 44 States, nonetheless yield emission reduction benefits across the whole of the region (thus for example research, ETS).

2 Current state of aviation in Sweden

Geographical and Demographical Characteristics

Sweden is located in the north of Europe and is the third largest country in Western Europe with an area of 450 000 km². More than half of the area consists of forests, 10 percent consists of mountains and approximately 8 percent is cultivated land, lakes and rivers. The longest distance from north to south is 1 574 km and the longest east-west distance is 499 km[3]. In size Sweden is almost comparable to e.g. Spain and France.

Sweden has 9.7 million inhabitants, 21 percent of the population in Sweden are younger than 18 years old and about 19 percent have passed the retirement age of 65[4].

Sweden has a population density of almost 24 inhabitants per square kilometers with the population mostly concentrated to the southern half of the country[4]. Approximately 85 percent of the Swedish population lives in urban areas and the population live on 1.3 percent of the land area[5].

Airports

Today there are 46 IFR aerodromes in Sweden, and 39 of these are operated with commercial air traffic. Of the 39 with commercial air traffic there are 27 owned by municipalities, 10 are state-owned (by Swedavia) and two have other ownership structures e.g. limited liabilities. Swedavia AB[6] was established in 2010 as a state owned company for airport operations.

[3] www.sweden.se
[4] www.scb.se
[5] http://www.scb.se/statistik/_publikationer/BO0801_2012A01_BR_BO01BR1201.pdf
[6] www.swedavia.se

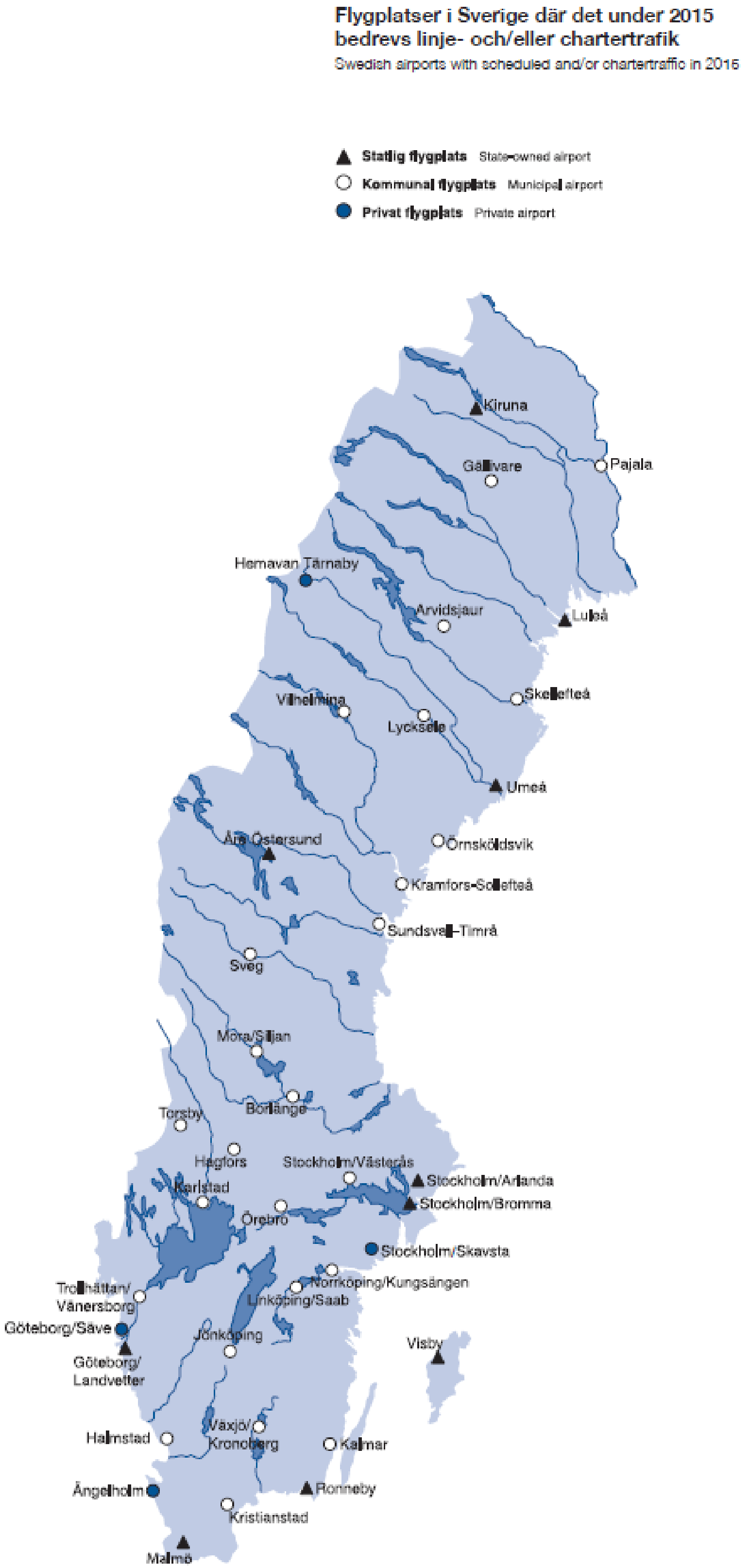


Figure 1. Swedish Airports 2015.

Top 10 airports regarding passengers

The largest aerodromes based upon departing and arriving passengers can be seen in figure 2. Approximately 23.1 million passengers travelled to or from Stockholm/Arlanda in 2015 and approximately 6.2 million to or from Göteborg/Landvetter. Eight of the airports among the "top 10 airports" are owned by Swedavia and two are private airports (Stockholm/Skavsta and Ängelholm).

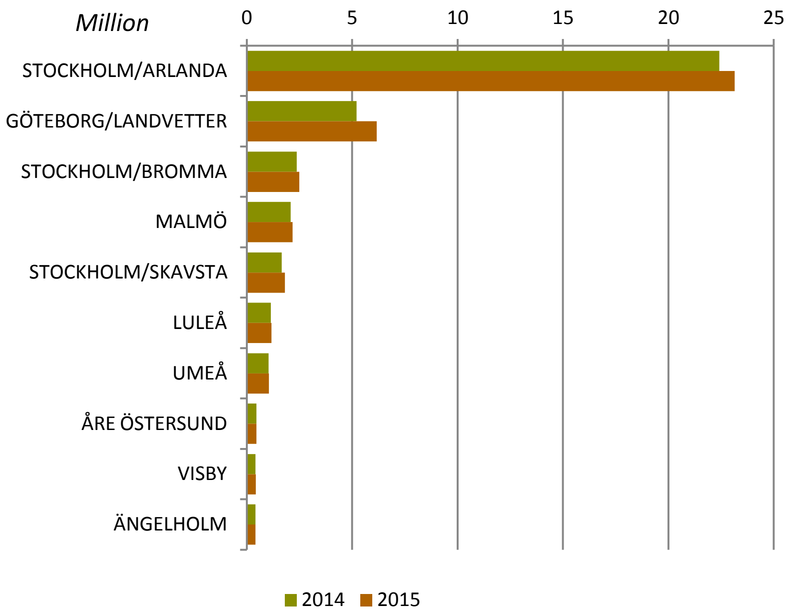


Figure 2. Number of scheduled and non-scheduled passengers at the top 10 airports 2014 and 2015

Top 10 airports regarding movements

The top 10 airports in terms of movements can be seen in figure 3. At e.g. Stockholm/Arlanda were almost 226 000 movements registered and at Göteborg/Landvetter were almost 68 000 movements registered in 2015. Among the top 10 airports in relation to movements are eight owned by Swedavia, one is a private airport (Stockholm/Skavsta) and one is a municipal airport (Stockholm/Västerås).

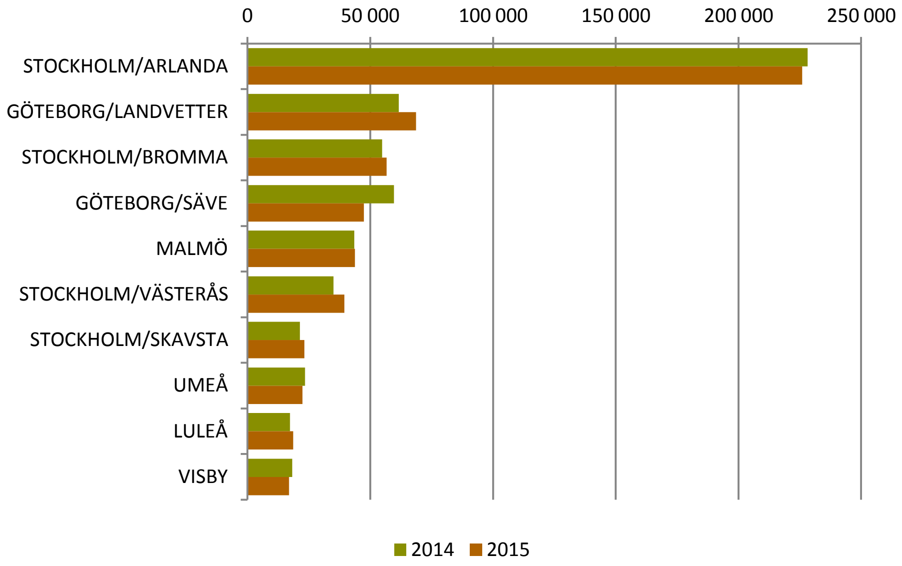


Figure 3. Number of movements at the top 10 airports 2014 and 2015

In 2015, 93.7 percent of the passengers arrived or departed at one of the top 10 Swedish airports (figure 4). Most passengers arrived or departed at Stockholm/Arlanda (55 percent), Göteborg/Landvetter (15 percent) and Stockholm/Bromma (6 percent). 88.4 percent of all passengers arrived or departed at the Swedavia airports in 2015.

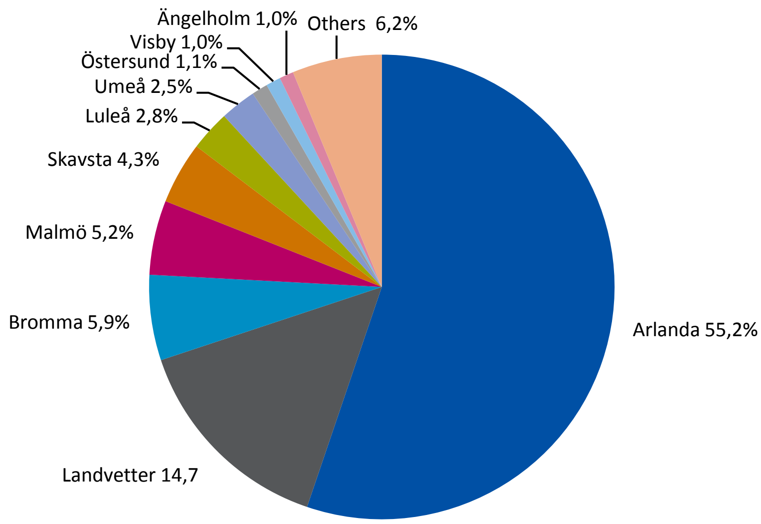


Figure 4. Airport's market shares 2015

Air Navigation Services

LFV (a public enterprise) has 1 200 employees that operate air navigation services for civil and military customers at 26 locations in Sweden[7]. Until September 2010, LFV was the only provider of air navigation services in Sweden but today the air traffic services market is partially exposed to competition. The company Aviation Capacity Resources AB (ACR) operate air navigation services at 12 locations in Sweden[8]. The state owned airports are exempt from competition for air navigation services after a decision from the Swedish parliament mid June 2014.

Another provider is NUAC HB[9]. NUAC HB started to provide operational support, to the ATCCs in Copenhagen, Stockholm and Malmö in January 2011. The company administrates the Danish/Swedish Functional Airspace Block (FAB) and from mid 2012, NUAC HB manages the en route operations from Naviair and LFV and acts as an ANS provider delivering Air Traffic Management (ATM) in the Danish/Swedish FAB[10].

Passengers

In 2015, almost 23.1 million passengers departed from the Swedish airports, all time high figures. Departing passengers increased by 3.2 percent between 2014 and 2015.

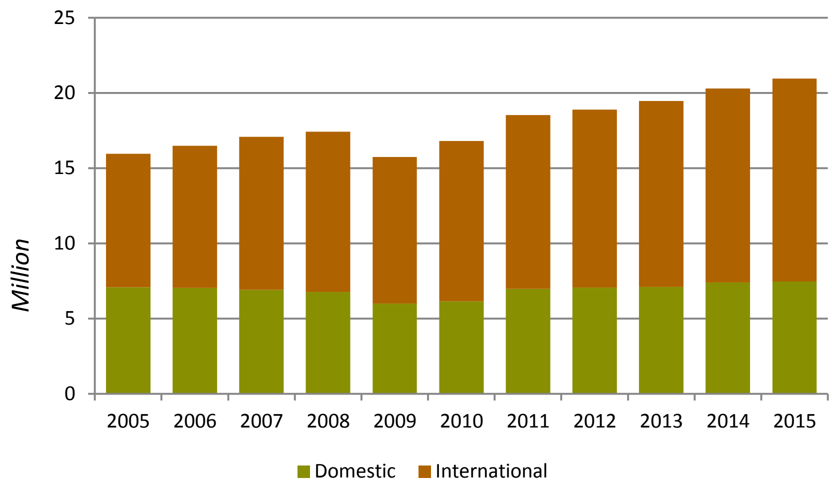


Figure 5. Number of international and domestic departing passengers in scheduled and non-scheduled traffic at Swedish airports 2005-2015

[7] www.lfv.se
[8] www.acr-sweden.se
[9] NUAC HB is a joint subsidiary owned by Danish Naviair and Swedish LFV
[10] www.nuac.eu

Movements

In 2015 were 712 000 IFR-movements (international and domestic) recorded in Swedish airspace. It is almost 14 000 fewer than the all time high level in 2008. The growth was about 1 percent in 2015 compared to 2014. Overflights amount to about 42 per cent of the movements 2015, a proportion that have not changed during the last ten years, see figure 6.

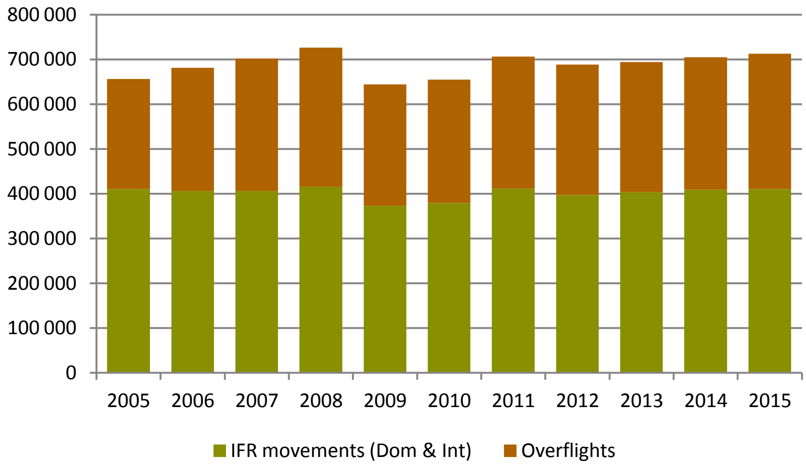


Figure 6. Number of international and domestic IFT-movements at Swedish airports 2005-2015

Freight and mail

In total 149 tonnes freight and mail arrived or departed at the Swedish airports in 2015. This is an increase of almost 3 percent compared to 2014. See figure 7.

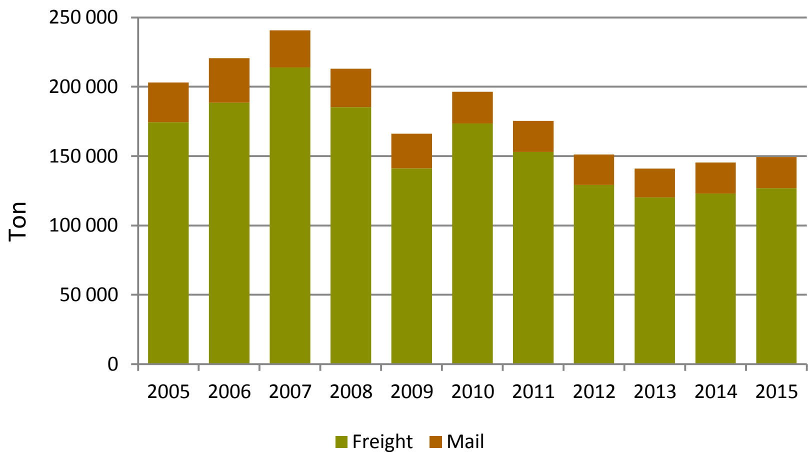


Figure 7. Freight and mail in tonnes loaded and unloaded at Swedish airports 2005- 2015

Air operators /Aircrafts - operating licenses

Operating licenses are categorized in category A and B. Category A includes aircraft carriers with aircraft maximum take-off weight of 10 tonnes or more and/or 20 seats or more. Within category A there are 13 operating licenses granted in Sweden.

Aircraft carriers with aircraft with maximum take-off weight of less than 10 tonnes and/or less than 20 seats are included in category B. Within category B there are 18 operating licenses granted in Sweden. Among these are 6 corporations operating with airplanes, 12 operating with helicopters.

In 2015 Sweden had 3 057 Swedish registered aircraft (compared to 3 068 in 2014. Of these were 1 725 airworthy (1 802 in 2014)[11].

Airlines operating in Sweden and market shares based on number of passengers

Concerning domestic air traffic, SAS, obtained more than 45 percent of the market shares in 2015 and Malmö Aviation and Norwegian obtained about 18 percent each of the passengers in the domestic market. See figure 8.

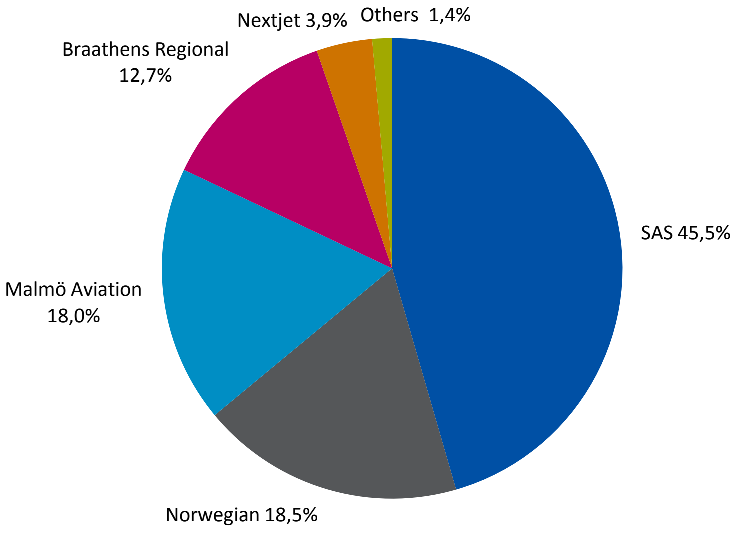


Figure 8. Domestic market shares related to passengers, 2015

Regarding international air traffic, SAS, obtained 24 percent of the market shares in 2015, Norwegian obtained 15 percent and Ryanair about 8 percent, see figure 9.

[11] http://www.trafa.se/globalassets/statistik/flygtrafik/luftfart-2015.pdf

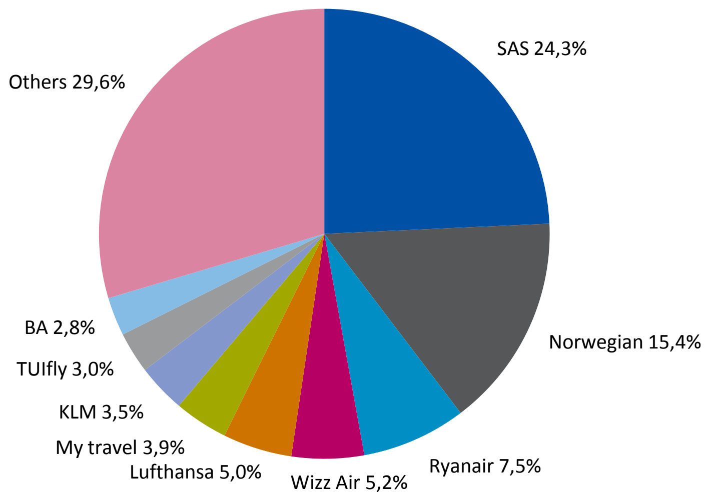


Figure 9. International market shares related to passengers, 2015

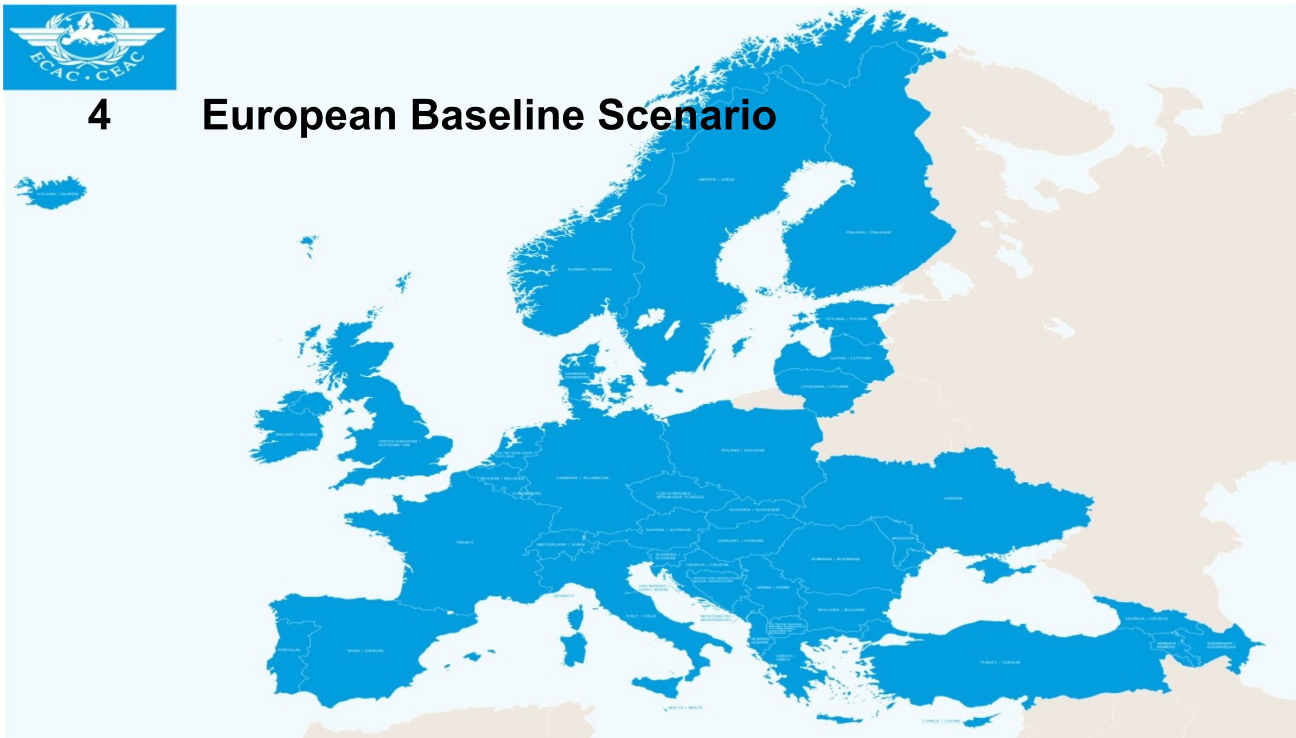
3 Emissions Data

The Swedish emissions data are taken from Sweden´s National Inventory Report 2014, submitted under the United Nations Framework Convention Climate Change (Source Swedish EPA).

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Domestic Aviation	659	620	603	589	492	476	524	515	517	515
International Aviation	1927	1996	2187	2453	2083	2105	2269	2163	2237	2266

Figure 10. CO_2 emissions (1000 metric ton) reported by Sweden

Emissions of CO_2 from domestic aviation in Sweden have declined with 22 percent in 2014 compared to 2005. For flights from Sweden to the first destination in another country (in accordance with IPCC definition of International Flights) the emissions of CO_2 between 2005 and 2014 have risen with 17.6 percent.



4 European Baseline Scenario

The baseline scenario of ECAC States presents the following sets of data (in 2010) and forecast (in 2020 and 2035), which were provided by EUROCONTROL:

- European air traffic (includes all international and national passenger flight departures from ECAC airports, in number of flights, and RPK calculated purely from passenger numbers, which are based on EUROSTAT figures. Belly freight and dedicated cargo flights are not included),
- its associated aggregated fuel consumption (in million tonnes)
- its associated emissions (in million tonnes of CO2), and
- average fuel efficiency (in kg/10RPK).

The sets of forecasts correspond to projected traffic volumes and emissions, in a scenario of "regulated growth".

4.1 Scenario "Regulated Growth", Most-likely/Baseline scenario

As in all 20-year 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. In the 20-year forecast published in 2013 by EUROCONTROL, the scenario called 'Regulated Growth' was constructed as the 'most-likely' or 'baseline' scenario, most closely following the current trends. It considers a moderate economic growth, with regulation reconciling the environmental, social and economic demands.

	A: Global Growth	C: Regulated Growth	D: Fragmenting World	C': Happy Localism
2019 traffic growth	High ↗	Base →	Low ↘	Base →
Passenger				
Demographics (Population)	Aging UN Medium-fertility variant	Aging UN Medium-fertility variant	Aging UN Zero-migration variant	Aging UN Medium-fertility variant
Routes and Destinations	Long-haul ↗	No Change →	Long-haul ↘	Long-haul ↘
Open Skies	EU enlargement later +Far & Middle-East	EU enlargement earliest	EU enlargement latest	EU enlargement earliest
High-speed rail (new & improved connections)	54 city-pairs faster implementation	54 city-pairs	42 city-pairs later implementation	54 city-pairs faster implementation
Economic conditions				
GDP growth	Stronger ↗	Moderate →	Weaker ↘↘	Weaker ↘
EU Enlargement	Later	Earliest	Latest	Earliest
Free Trade	Global, faster	Limited, later	None	More limited, even later
Price of travel				
Operating cost	Decreasing ↘↘	Decreasing ↘	No change →	Decreasing ↘
Cost of CO_2	Lowest	Lower	Highest	Lower
Price of oil	Lower	Low	High	High
Other charges	Noise: ↗ Security: ↘	Noise: ↗ Security: →	Noise: → Security: ↗	Noise: ↗ Security: →
Structure				
Network	Middle-East hubs ↗↗ Europe ↘ Turkey ↗	Middle-East hubs ↗↗ Europe and Turkey ↗	No change →	Middle-East hubs ↗↗ Europe and Turkey ↘
Market Structure	Medium ↗↗ Large - Very Large ↗	Medium to Very Large ↗	Large ↗ Very Large ↗	Large ↗ Very Large ↗

Table 1. Summary characteristics of EUROCONTROL scenarios

The table above presents a summary of the social, economic and air traffic-related characteristics of the different scenarios developed by EUROCONTROL for the purposes of EUROCONTROL 20-year forecast of IFR movements[12].

4.2 ECAC baseline scenario

The ECAC baseline scenario presented in the following tables was generated by EUROCONTROL for all ECAC States including the Canary Islands. Over-flights of the ECAC area have not been included.

The baseline scenario, which is presented in the following tables, does not include business and dedicated cargo traffic. It covers only commercial passenger flight movements for the area of scope outlined in the previous paragraph, using data for airport pairs, which allows for the generation of fuel efficiency data (in kg/RPK). Historical fuel burn (2010) and emission calculations are based on the actual flight plans from the PRISME data warehouse, including the actual flight distance and the cruise altitude by airport pair. Future year fuel burn and emissions (2020, 2035) are modelled

[12] The characteristics of the different scenarios can be found in Task 4: European Air Traffic in 2035, Challenges of Growth 2013, EUROCONTROL, June 2013 available at ECAC website

based on actual flight distances and cruise altitudes by airport pair in 2014. Taxi times are not included. The baseline is presented along a scenario of engine-technology freeze, as of 2014, so aircraft not in service at that date are modelled with the fuel efficiency of comparable-role in-service aircraft (but with their own seating capacities).

The future fleet has been generated using the Aircraft Assignment Tool (AAT) developed collaboratively by EUROCONTROL, the European Aviation Safety Agency and the European Commission. The retirement process of the Aircraft Assignment Tool is performed year by year, allowing the determination of the amount of new aircraft required each year. This way, the entry into service year (EISY) can be derived for the replacement aircraft. The Growth and Replacement (G&R) Database used is largely based on the Flightglobal Fleet Forecast - Deliveries by Region 2014 to 2033. This forecast provides the number of deliveries for each type in each of the future years, which are re-scaled to match the EUROCONTROL forecast.

The data and forecasts for Europe show two distinct phases, of rapid improvement followed by continuing, but much slower improvement after 2020. The optimism behind the forecast for the first decade is partly driven by statistics: in the 4 years 2010-2014, the average annual improvement in fuel efficiency for domestic and international flights was around 2%, [Source: EUROCONTROL] so this is already achieved. Underlying reasons for this include gains through improvements in load factors (e.g. more than 3% in total between 2010 and 2014), and use of slimmer seats allowing more seats on the same aircraft. However, neither of these can be projected indefinitely into the future as a continuing benefit, since they will hit diminishing returns. In their place we have technology transitions to A320neo, B737max, C-series, B787 and A350 for example, especially over the next 5 years or so. Here this affects seat capacity, but in addition, as we exit from the long economic downturn, we see an acceleration of retirement of old, fuel-inefficient aircraft, as airline finances improve, and new models become available. After that, Europe believes that the rate of improvement would be much slower, and this is reflected in the ‘technology freeze’ scenario, which is presented here.

Year	Traffic (millions of departing flights)	Total Fuel burn (in million tonnes)
2010	7,12	40,34
2020	8,48	48,33
2035	11,51	73,10

Table 2. Total fuel burn for passenger domestic and international flights (ECAC)

Year	CO_2 emissions (in million tonnes)
2010	127,47
2020	152,72
2035	231,00

Table 3. CO_2 emissions forecast

Year	Traffic (in billion RPK)
2010	1 329,6
2020	1 958,7
2035	3 128,2

Table 4. Traffic in RPK (domestic and international departing flights from ECAC airports, PAX only, no freight and dedicated cargo flights)

Year	Fuel efficiency (in kg/10 RPK)
2010	0,3034
2020	0,2468
2035	0,2337

Table 5. Fuel efficiency (kg/10RPK)

Period	Fuel efficiency improvement
2020 - 2010	-2,05%
2035 - 2020	-0,36%
2035 - 2010	-1,04%

Table 6. Average annual fuel efficiency improvement

In order to further improve fuel efficiency and to reduce future air traffic emissions beyond the projections in the baseline scenario, ECAC States have taken further action. Supranational measures in order to achieve such additional improvement will be described in the following sections.

It should be noted, however, that a quantification of the effects of many measures is difficult. As a consequence, no aggregated quantification of potential effects of the supranational measures can be presented in this action plan.

5 Supra-national actions, including those led by the EU

5.1 AIRCRAFT-RELATED TECHNOLOGY DEVELOPMENT

5.1.1 Aircraft emissions standards (Europe's contribution to the development of the aeroplane CO_2 standard in CAEP)

European Member States fully supported the work achieved in ICAO’s Committee on Aviation Environmental Protection (CAEP), which resulted in an agreement on the new aeroplane CO_2 Standard at CAEP/10 meeting in February 2016, applicable to new aeroplane type designs from 2020 and to aeroplane type designs that are already in-production in 2023. Europe significantly contributed to this task, notably through the European Aviation Safety Agency (EASA) which co-led the CO_2 Task Group within CAEP’s Working Group 3, and which provided extensive technical and analytical support.

The assessment of the benefits provided by this measure in terms of reduction in European emissions is not provided in this action plan. Nonetheless, elements of assessment of the overall contribution of the CO_2 standard towards the global aspirational goals are available in CAEP.

5.1.2 Research and development

Clean Sky is an EU Joint Technology Initiative (JTI) that aims to develop and mature breakthrough “clean technologies” for air transport. By accelerating their deployment, the JTI will contribute to Europe's strategic environmental and social priorities, and simultaneously promote competitiveness and sustainable economic growth.

Joint Technology Initiatives are specific large-scale EU research projects created by the European Commission within the 7th Framework Programme (FP7) and continued within the Horizon 2020 Framework Programme. Set up as a Public Private Partnership between the European Commission and the European aeronautical industry, Clean Sky pulls together the research and technology resources of the European Union in a coherent programme, and contribute significantly to the 'greening' of aviation.

The first Clean Sky programme (**Clean Sky 1** - 2011-2017) has a budget of € 1,6 billion, equally shared between the European Commission and the aeronautics industry. It aims to develop environmental friendly technologies impacting all flying-segments of commercial aviation. The objectives are to reduce CO2 aircraft emissions by 20-40%, NO_x by around 60% and noise by up to 10dB compared to year 2000 aircraft.

What has the current JTI achieved so far?
It is estimated that Clean Sky resulted in a reduction of aviation CO_2 emissions by more than 20% with respect to baseline levels (in 2000), which represents an ***aggregate reduction of 2 to 3 billion tonnes of CO_2 over the next 35 years***

This was followed up by a second programme (**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.

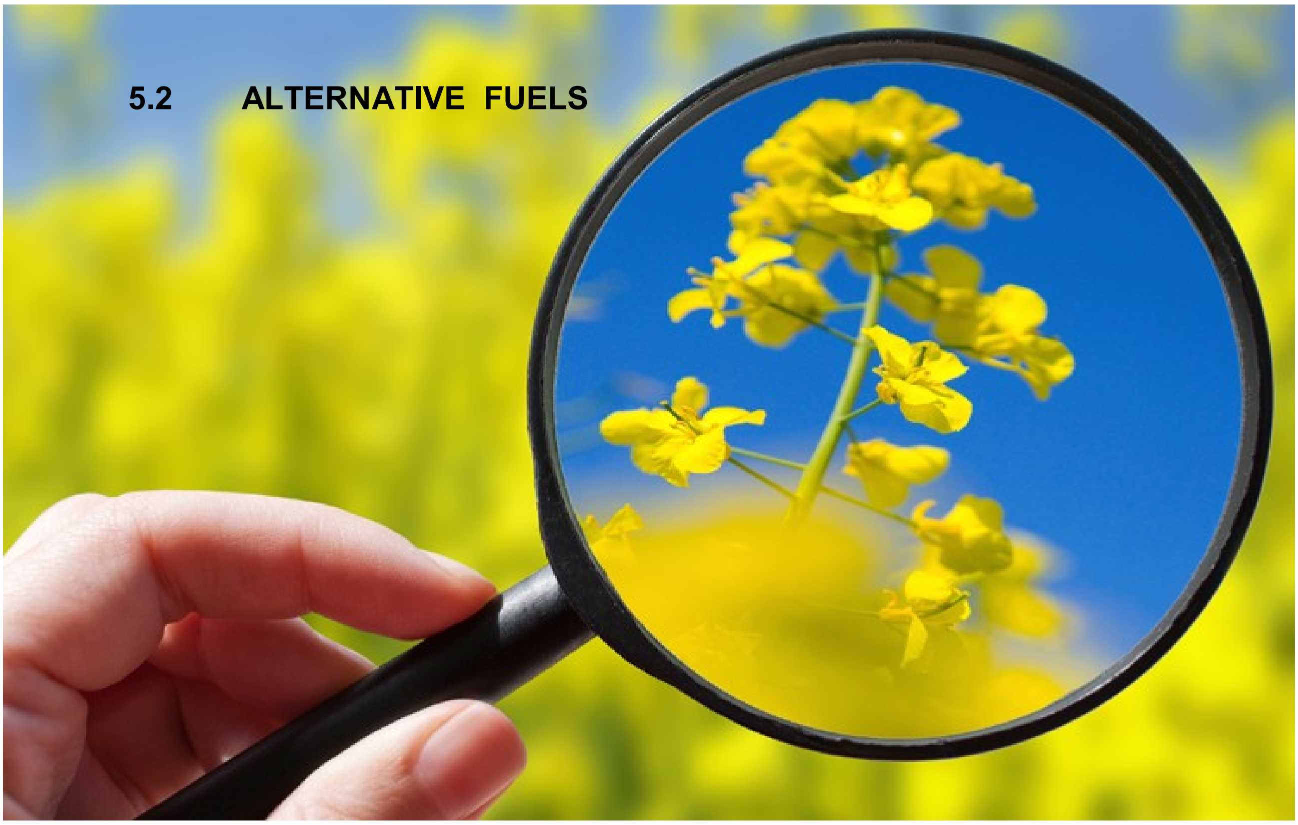
Main remaining areas for RTD efforts under Clean Sky 2 are:

- **Large Passenger Aircraft**: demonstration of best technologies to achieve the environmental goals while 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 superior passenger experience.
- **Fast Rotorcraft**: demonstrating new rotorcraft concepts (tilt-rotor and FastCraft compound helicopter) 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 investigate innovative fuselage structures will be 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 future generation aircraft in terms of maturation, demonstration and Innovation.
- **Small Air Transport**: demonstrating the advantages of applying key technologies on small aircraft demonstrators and to revitalise an important segment of the aeronautics sector that can bring key new mobility solutions.
- **Eco-Design**: coordinating research geared towards high eco-compliance in air vehicles over their product life and heightening the stewardship in intelligent Re-use, Recycling and advanced services.

In addition, the **Technology Evaluator** will continue and 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). More details on Clean Sky can be found at the following link: http://www.cleansky.eu/

5.2 ALTERNATIVE FUELS



5.2.1 European Advanced Biofuels Flightpath

Within the European Union, Directive 2009/28/EC on the promotion of the use of energy from renewable sources ("the Renewable Energy Directive" – RED) established mandatory targets to be achieved by 2020 for a 20% overall share of renewable energy in the EU and a 10% share for renewable energy in the transport sector. Furthermore, sustainability criteria for biofuels to be counted towards that target were established.[13]

In February 2009, the European Commission's Directorate General for Energy and Transport initiated the SWAFEA (Sustainable Ways for Alternative Fuels and Energy for Aviation) study to investigate the feasibility and the impact of the use of alternative fuels in aviation.

The SWAFEA final report was published in July 2011[14]. It provides a comprehensive analysis on the prospects for alternative fuels in aviation, including an integrated analysis of technical feasibility, environmental sustainability (based on the sustainability criteria of the EU Directive on

[13] Directive 2009/28/EC of the European Parliament and of the Council of 23/04/2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, Article 17 Sustainability criteria for biofuels and bioliquids, at pp. EU Official Journal L140/36-L140/38.

[14] http://www.icao.int/environmental-protection/GFAAF/Documents/SW_WP9_D.9.1%20Final%20report_released%20July2011.pdf.

renewable energy[15]) and economic aspects. It includes a number of recommendations on the steps that should be taken to promote the take-up of sustainable biofuels for aviation in Europe.

In March 2011, the European Commission published a White Paper on transport[16]. In the context of an overall goal of achieving a reduction of at least 60% in greenhouse gas emissions from transport by 2050 with respect to 1990, **the White Paper established a goal of low-carbon sustainable fuels in aviation reaching 40% by 2050**.

> ACARE *Roadmap targets regarding share alternative sustainable fuels:*
> *Aviation to use:*
> *- **at minimum 2%** sustainable alternative fuels in 2020;*
> *- **at minimum 25%** sustainable alternative fuels in 2035;*
> *- **at minimum 40%** sustainable alternative fuels **in 2050***

Source: ACARE Strategic Research and Innovation Agenda, Volume 2

As a first step towards delivering this goal, 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 aims to speed up the commercialisation of aviation biofuels in Europe, with the **objective of achieving the commercialisation of sustainably produced paraffinic biofuels in the aviation sector by reaching a 2 million tonnes consumption by 2020**.

This initiative is a shared and voluntary commitment by its members to support and promote the production, storage and distribution of sustainably produced drop-in biofuels for use in aviation. It also targets establishing appropriate financial mechanisms to support the construction of industrial "first of a kind" advanced biofuel production plants. The Biofuels Flight path is explained in a technical paper, which sets out in more detail the challenges and required actions[17].

More specifically, the initiative focuses on the following:

1. Facilitate the development of standards for drop-in biofuels and their certification for use in commercial aircraft;
2. Work together with the full supply chain to further develop worldwide accepted sustainability certification frameworks
3. Agree on biofuel take-off arrangements over a defined period of time and at a reasonable cost;

[15] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.
[16] Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, COM (2011) 144 final
[17] http://ec.europa.eu/energy/technology/initiatives/doc/20110622_biofuels_flight_path_technical_paper.pdf.

4. Promote appropriate public and private actions to ensure the market uptake of paraffinic biofuels by the aviation sector;
5. Establish financing structures to facilitate the realisation of 2nd Generation biofuel projects;
6. Accelerate targeted research and innovation for advanced biofuel technologies, and especially algae.
7. Take concrete actions to inform the European citizen of the benefits of replacing kerosene by certified sustainable biofuels.

The following “Flight Path” provides an overview about the objectives, tasks, and milestones of the initiative.

Time horizons (Base year - 2011)	Action	Aim/Result
Short-term (next 0-3 years)	Announcement of action at International Paris Air Show	To mobilise all stakeholders including Member States.
	High-level workshop with financial institutions to address funding mechanisms.	To agree on a "Biofuel in Aviation Fund".
	> 1 000 tonnes of Fisher-Tropsch biofuel become available.	Verification of Fisher-Tropsch product quality. Significant volumes of synthetic biofuel become available for flight testing.
	Production of aviation class biofuels in the hydro-treated vegetable oil (HVO) plants from sustainable feedstock	Regular testing and eventually few regular flights with HVO biofuels from sustainable feedstock.
	Secure public and private financial and legislative mechanisms for industrial second generation biofuel plants.	To provide the financial means for investing in first of a kind plants and to permit use of aviation biofuel at economically acceptable conditions.
	Biofuel purchase agreement signed between aviation sector and biofuel producers.	To ensure a market for aviation biofuel production and facilitate investment in industrial 2G plants.
	Start construction of the first series of 2G plants.	Plants are operational by 2015-16.
	Identification of refineries & blenders which will take part in the first phase of the action.	Mobilise fuel suppliers and logistics along the supply chain.
Mid-term (4-7 years)	2000 tonnes of algal oils are becoming available.	First quantities of algal oils are used to produce aviation fuels.
	Supply of 1,0 M tonnes of hydrotreated sustainable oils and 0,2 tonnes of synthetic aviation biofuels in the aviation market.	1,2 M tonnes of biofuels are blended with kerosene.
	Start construction of the second series of 2G plants including algal biofuels and pyrolytic oils from residues.	Operational by 2020.
Long-term (up to 2020)	Supply of an additional 0,8 M tons of aviation biofuels based on synthetic biofuels, pyrolytic oils and algal biofuels.	2,0 M tonnes of biofuels are blended with kerosene.
	Further supply of biofuels for aviation, biofuels are used in most EU airports.	Commercialisation of aviation biofuels is achieved.

When the Flight-path 2020 initiative began in 2010, only one production pathway was approved for aviation use; no renewable kerosene had actually been produced except at very small scale, and only a handful of test and demonstration flights had been conducted using it. Since then, worldwide technical and operational progress of the industry has been remarkable. Four different pathways for the production of renewable kerosene are now approved and several more are expected to be certified. A significant number of flights using renewable kerosene have been conducted, most of them revenue flights carrying passengers. Production has been demonstrated at demonstration and even industrial scale for some of the pathways. Use of renewable kerosene within an airport hydrant system was demonstrated in Oslo in 2015.

Production (EU)
Neste *(Finland): by batches*
- Frankfurt-Hamburg (6 months) 1189 flights operated by Lufthansa: 800 tonnes of bio-kerosene
- Itaka: €10m EU funding (2012-2015): > 1 000 tonnes
Biorefly*: €13,7m EU funding: 2000 tonnes per year – second generation (2015) – BioChemtex (Italy)*

BSFJ Swedish Biofuels*: €27,8m EU funding (2014-2019)*

Performed flights using bio-kerosene
IATA: 2000 flights worldwide using bio-kerosene blends performed by 22 airlines between June 2011 and December 2015
Lufthansa: 1189 flights Frankfurt-Hamburg using 800 tonnes of bio-kerosene (during 6 months – June/December 2011)
KLM: a series of 200 flights Amsterdam-Paris from September 2011 to December 2014, 26 flights New York-Amsterdam in 2013, and 20 flights Amsterdam-Aruba in 2014 using bio-kerosene

5.2.2 Research and Development projects on alternative fuels in aviation

In the time frame 2011-2016, 3 projects have been funded by the FP7 Research and Innovation program of the EU.

ITAKA: €10m EU funding (2012-2015) with the aim of assessing the potential of a specific crop (camelina) for providing jet fuel. The project aims entail the testing of the whole chain from field to fly, assessing the potential beyond the data gathered in lab experiments, gathering experiences on related certification, distribution and on economical aspects. As feedstock, ITAKA targets European camelina oil and used cooking oil, **in order to meet a minimum of 60% GHG emissions savings compared to the fossil fuel jetA1**.

SOLAR-JET: this project has demonstrated the possibility of producing jet-fuel from CO2 and water. This was done by coupling a two-step solar thermochemical cycle based on non-stoichiometric ceria redox reactions with the Fischer-Tropsch process. This successful demonstration is further complemented by assessments of the chemical suitability of the solar kerosene, identification of technological gaps, and determination of the technological and economical potentials.

Core-JetFuel: €1,2m EU funding (2013-2017) this action evaluates the research and innovation "landscape" in order to develop and implement a strategy for sharing information, for coordinating initiatives, projects and results and to identify needs in research, standardisation, innovation/ deployment, and policy measures at European level. Bottlenecks of research and innovation will be identified and, where appropriate, recommendations for the European Commission will be elaborated with respect to re-orientation and re-definition of priorities in the funding strategy. The consortium covers the entire alternative fuel production chain in four domains: Feedstock and sustainability; conversion technologies and radical concepts; technical compatibility, certification and deployment; policies, incentives and regulation. CORE-JetFuel ensures cooperation with other European, international and national initiatives and with the key stakeholders in the field. The expected benefits are enhanced knowledge of decision makers, support for maintaining coherent research policies and the promotion of a better understanding of future investments in aviation fuel research and innovation.

In 2015, the European Commission launched projects under the Horizon 2020 research programme with capacities of the order of several 1000 tonnes per year.

5.3 IMPROVED AIR TRAFFIC MANAGEMENT AND INFRASTRUCTURE USE

5.3.1 The EU's Single European Sky Initiative and SESAR

SESAR Project

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 larger volume of flights in a safer, more cost-efficient and environmental friendly manner.

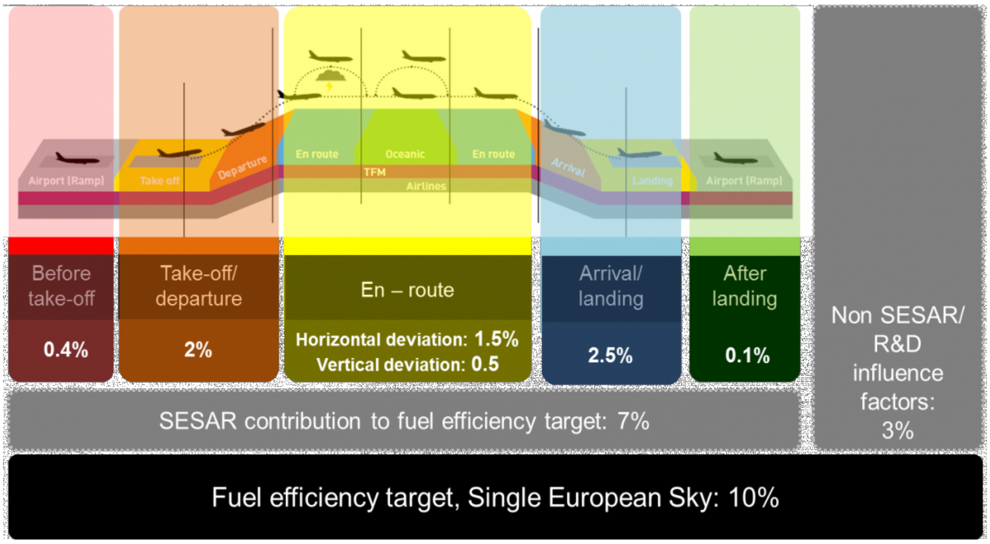
The SES aims at achieving 4 high level performance objectives (referred to 2005 context):

- Triple capacity of ATM systems
- Reduce ATM costs by 50%
- Increase safety by a factor of 10
- **Reduce the environmental impact by 10% per flight**

SESAR, the technological pillar of the Single European Sky, contributes to the Single Sky's performance targets by defining, developing, validating and deploying innovative technological and operational solutions for managing air traffic in a more efficient manner.

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

The estimated potential fuel emission savings per flight segment is depicted below:



SESAR's contribution to the SES performance objectives is now targeting for 2016, as compared to 2005 performance:

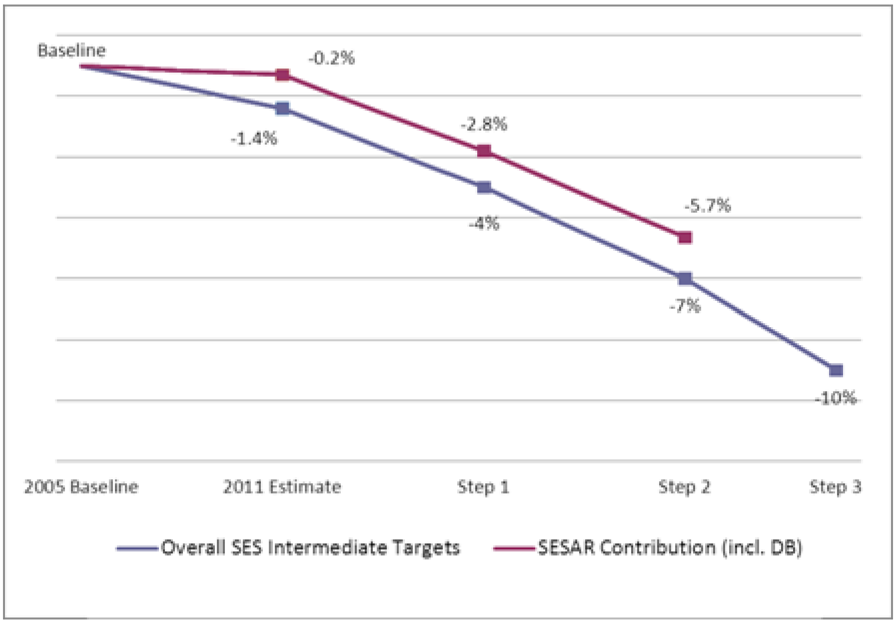
1) 27% increase in airspace capacity and 14% increase in airport capacity;
2) Associated improvement in safety, i.e. in an absolute term, 40% of reduction in accident risk per flight hour.
3) **2,8 % reduction per flight in gate to gate greenhouse gas emissions;**
4) 6 % reduction in cost per flight.

The projection of SESAR target fuel efficiency beyond 2016 (Step 1[18]) is depicted in the following graph:

[18] **Step 1**, "Time-based Operations" is the building block for the implementation of the SESAR Concept and is focused on flight efficiency, predictability and the environment. The goal is a synchronised and predictable European ATM system, where partners are aware of the business and operational situations and collaborate to optimise the network. In this first Step, time prioritisation for arrivals at airports is initiated together with wider use of datalink and the deployment of initial trajectory-based operations through the use of airborne trajectories by the ground systems and a controlled time of arrival to sequence traffic and manage queues.

Step 2, "Trajectory-based Operations" is focused on flight efficiency, predictability, environment and capacity, which becomes an important target. The goal is a trajectory-based ATM system where partners optimise "business and mission trajectories" through common 4D trajectory information and users define priorities in the network. "Trajectory-based Operations" initiates 4D based business/mission trajectory management using System Wide Information Management (SWIM) and air/ground trajectory exchange to enable tactical planning and conflict free route segments.

Step 3, "Performance-based Operations" will achieve the high performance required to satisfy the SESAR target concept. The goal is the implementation of a European high performance, integrated, network-centric, collaborative and seamless air/ground ATM system. "Performance-based Operations" is realised through the achievement of SWIM and collaboratively planned network operations with User Driven Prioritisation Processes (UDPP).



It is expected that there will be an ongoing performance contribution from non-R&D initiatives through the Step 1 and Step 2 developments, e.g. from improvements related to FABs and Network Management: the intermediate allocation to Step 1 development has been set at -4%, with the ultimate capability enhancement (Step 3) being -10%. 30% of Step 1 target will be provided through non-R&D improvements (-1,2% out of -4%) and therefore -2,8% will come from SESAR improvements. Step 2 target is still under discussion in the range of 4,5% to 6%.

The SESAR concept of operations is defined in the European ATM Master Plan and translated into SESAR solutions that are developed, validated and demonstrated by the SESAR Joint Undertaking and then pushed towards deployment through the SESAR deployment framework established by the Commission.

SESAR Research Projects (environmental focus)

Within the SESAR R&D activities, environmental aspects have mainly been addressed under two types of projects: Environmental research projects which are considered as a transversal activity and therefore primarily contribute to the validation of the SESAR solutions and SESAR demonstration projects, which are pre-implementation activities. Environment aspects, in particular fuel efficiency, are also a core objective of approximately 80% of SESAR's primary projects.

Environmental Research Projects:

Four Environmental research projects are now completed:

- Project 16.03.01 dealing with Development of the Environment validation framework (Models and Tools);

- Project 16.03.02 dealing with the Development of environmental metrics;
- Project 16.03.03 dealing with the Development of a framework to establish interdependencies and trade-off with other performance areas;
- Project 16.03.07 dealing with Future regulatory scenarios and risks.

In the context of Project 16.03.01 the IMPACT tool was developed providing SESAR primary projects with the means to conduct fuel efficiency, aircraft emissions and noise assessments at the same time, from a web based platform, using the same aircraft performance assumptions. IMPACT successfully passed the CAEP MDG V&V process (Modelling and Database Group Verification and Validation process). Project 16.06.03 has also ensured the continuous development/maintenance of other tools covering aircraft GHG assessment (AEM), and local air quality issues (Open-ALAQS). It should be noted that these tools have been developed for covering the research and the future deployment phase of SESAR.

In the context of Project 16.03.02 a set of metrics for assessing GHG emissions, noise and airport local air quality has been documented. The metrics identified by Project 16.03.02 and not subject of specific IPRs will be gradually implemented into IMPACT.

Project 16.03.03 has produced a comprehensive analysis on the issues related to environmental interdependencies and trade-offs.

Project 16.03.07 has conducted a review of current environmental regulatory measures as applicable to ATM and SESAR deployment, and another report presenting an analysis of environmental regulatory and physical risk scenarios in the form of user guidance. It identifies both those Operation Focus Areas (OFA) and Key Performance Areas which are most affected by these risks and those OFAs which can contribute to mitigating them. It also provides a gap analysis identifying knowledge gaps or uncertainties which require further monitoring, research or analysis.

The only Environmental Research project that is still on-going in the current SESAR project is the SESAR Environment support and coordination project which ensures the coordination and facilitation of all the Environmental research projects activities while supporting the SESAR/AIRE/DEMO projects in the application of the material produced by the research projects. In particular, this project delivered an Environment Impact Assessment methodology providing guidance on how to conduct an assessment, which metrics to use and do and don’ts for each type of validation exercise with specific emphasis on flight trials.

New environmental research projects will be defined in the scope of SESAR 2020 work programme to meet the SESAR environmental targets in accordance to the ATM Master Plan.

Other Research Projects which contribute to SESAR's environmental target:

A large number of SESAR research concepts and projects from exploratory research to preindustrial phase can bring environmental benefits. Full 4D trajectory taking due account of meteorological conditions, integrated departure, surface and arrival manager, airport optimised green taxiing trajectories, combined xLS RNAV operations in particular should bring significant reduction in fuel consumption. Also to be further investigated the potential for remote control towers to contribute positively to the aviation environmental footprint.

Remotely Piloted Aircraft (RPAS) systems integration in control airspace will be an important area of SESAR 2020 work programme and although the safety aspects are considered to be the most challenging ones and will therefore mobilise most of research effort, the environmental aspects of these new operations operating from and to non-airport locations would also deserve specific attention in terms of emissions, noise and potentially visual annoyance.

SESAR demonstration projects:

In addition to its core activities, the SESAR JU co-finances projects where ATM stakeholders work collaboratively to perform integrated flight trials and demonstrations validating solutions for the reduction of CO_2 emissions for surface, terminal and oceanic operations to substantially accelerate the pace of change. Since 2009, the SJU has co-financed a total 33 “green” projects in collaboration with global partners, under the Atlantic Interoperability Initiative to Reduce Emissions (AIRE), demonstrating solutions on commercial flights.

A total of 15767 flight trials were conducted under the AIRE initiative involving more than 100 stakeholders, demonstrating savings ranging from 20 to 1000kg fuel per flight (or 63 to 3150 kg of CO_2), and improvements to day-to-day operations. Other 9 demonstration projects took place from 2012 to 2014 focusing also on environment and during 2015 and 2016 the SESAR JU is co-financing 15 additional large-scale demonstrations projects more ambitious in geographic scale and technology. More information can be found at http://www.sesarju.eu

AIRE – Achieving environmental benefits in real operations

AIRE was designed specifically to improve energy efficiency and lower engine emissions and aircraft noise in cooperation with the US FAA, using existing technologies by the European Commission in 2007. SESAR JU has been managing the programme from an European perspective since 2008. 3 AIRE demonstration campaigns took place between 2009 and 2014.

A key feature leading to the success of AIRE is that it focused strongly on operational and procedural techniques rather than new technologies. AIRE trials have almost entirely used technology which is already in place, but until the relevant AIRE project came along, air traffic controllers and other users hadn't necessarily thought deeply about how to make the best use operationally of that technology. In New York and St Maria oceanic airspace lateral separation optimisation is given for any flight that requests it because of the AIRE initiative and the specific good cooperation between NAV Portugal and FAA.

Specific trials have been carried for the following improvement areas/solutions as part of the AIRE initiative:

a. Use of GDL/DMAN systems (pre departure sequencing system / Departure Manager) in Amsterdam, Paris and Zurich;
b. Issue of Target-Off Block time (TOBT), calculation of variable taxi out time and issue of Target-Start-up Arrival Time (TSAT) in Vienna;
c. Continuous Descent Operations (CDOs or CDAs) in Amsterdam, Brussels, Cologne, Madrid, New York, Paris, Prague, Pointe a Pitre, Toulouse, and Zurich;
d. CDOs in Stockholm, Gothenburg, Riga, La Palma; Budapest and Palma de Majorca airports using RNP-AR procedures;
e. Lateral and vertical flight profile changes in the NAT taking benefit of the implementation of Automatic Dependent Surveillance-Broadcast (ADS-B) surveillance in the North Atlantic;
f. Calculation of Estimated Times of Arrival (ETA) allowing time based operations in Amsterdam;
g. Precision Area Navigation - Global Navigation Satellite System (PRNAV GNSS) Approaches in Sweden;
h. Free route in Lisbon and Casablanca, over Germany, Belgium, Luxembourg, Netherlands in the EURO-SAM corridor, France, and Italy;
i. Global information sharing and exchange of actual position and updated meteorological data between the ATM system and Airline AOCs for the vertical and lateral optimisation of oceanic flights using a new interface;

The **AIRE 1** campaign (2008-2009) has demonstrated, with 1152 trials performed, that significant savings can already be achieved using existing technology. **CO_2 savings per flight ranged from 90kg to 1250kg and the accumulated savings during trials were equivalent to 400 tonnes of CO_2.** This first set of trials represented not only substantial improvements for the greening of air transport, but high motivation and commitment of the teams involved creating momentum to continue to make progress on reducing aviation emissions.

Domain	Location	Trials performed	CO_2 benefit/flight
Surface	Paris, France	353	190-1200 kg
Terminal	Paris, France	82	100-1250 kg
	Stockholm, Sweden	11	450-950 kg
	Madrid, Spain	620	250-800 kg
Oceanic	Santa Maria, Portugal	48	90-650 kg
	Reykjavik, Iceland	48	250-1050 kg
	Total	1152	

The **AIRE 2** campaign (2010-2011) showed a doubling in demand for projects and a high transition rate from R&D to day-to-day operations. 18 projects involving 40 airlines, airports, ANSPs and industry partners were conducted in which surface, terminal, oceanic and gate-to-gate operations were tackled. 9416 flight trials took place. In the table below the AIRE 2 projects operational aims and results are summerised.

Table: Summary of AIRE 2 projects

Project name	Location	Operation	Objective	CO_2 and Noise benefits per flight (kg)	Nb of flights
CDM at Vienna Airport	Austria	CDM notably pre-departure sequence	CO_2 & Ground Operational efficiency	54	208
Greener airport operations under adverse conditions	France	CDM notably pre-departure sequence	CO_2 & Ground Operational efficiency	79	1800
B3	Belgium	CDO in a complex radar vectoring environment	Noise & CO_2	160-315; -2dB (between 10 to 25 Nm from touchdown)	3094
DoWo - Down Wind Optimisation	France	Green STAR & Green IA in busy TMA	CO_2	158-315	219
REACT-CR	Czech republic	CDO	CO_2	205-302	204
Flight Trials for less CO_2 emission during transition from en-route to final approach	Germany	Arrival vertical profile optimisation in high density traffic	CO_2	110-650	362
RETA-CDA2	Spain	CDO from ToD	CO_2	250-800	210

Project name	Location	Operation	Objective	CO_2 and Noise benefits per flight (kg)	Nb of flights
DORIS	Spain	Oceanic: Flight optimisation with ATC coordination & Data link (ACARS, FANS CPDLC)	CO_2	3134	110
ONATAP	Portugal	Free and Direct Routes	CO_2	526	999
ENGAGE	UK	Optimisation of cruise altitude and/or Mach number	CO_2	1310	23
RlongSM (Reduced longitudinal Separation Minima)	UK	Optimisation of cruise altitude profiles	CO_2	441	533
Gate to gate Green Shuttle	France	Optimisation of cruise altitude profile & CDO from ToD	CO_2	788	221
Transatlantic green flight PPTP	France	Optimisation of oceanic trajectory (vertical and lateral) & approach	CO_2	2090+1050	93
Greener Wave	Switzerland	Optimisation of holding time through 4D slot allocation	CO_2	504	1700
VINGA	Sweden	CDO from ToD with RNP STAR and RNP AR.	CO_2 & noise	70-285; negligible change to noise contours	189
AIRE Green Connections	Sweden	Optimised arrivals and approaches based on RNP AR & Data link. 4D trajectory exercise	CO_2 & noise	220	25
Trajectory based night time	The Netherlands	CDO with pre-planning	CO_2 + noise	TBC	124
A380 Transatlantic Green Flights	France	Optimisation of taxiing and cruise altitude profile	CO_2	1200+1900	19
				Total	9416

CDOs were demonstrated in busy and complex TMAs although some operational measures to maintain safety, efficiency and capacity at an acceptable level had to developed.

The **AIRE 3** campaign comprised 9 projects (2012-2014) and 5199 trials summarised in the table below.

Project name	Location	Operation	Number of Trials	Benefits per flight
AMBER	Riga International Airport	turboprop aircraft to fly tailored Required Navigation Performance – Authorisation Required (RNP-AR) approaches together with Continuous Descent Operations (CDO),	124	230 kg reduction in CO_2 emissions per approach; A reduction in noise impact of 0.6 decibels (dBA)
CANARIAS	La Palma and Lanzarote airports	CCDs and CDOs	8	Area Navigation-Standard Terminal Arrival Route (RNAV STAR) and RNP-AR approaches 34-38 NM and 292-313 kg of fuel for La Palma and 14 NM and 100 kg of fuel for Lanzarote saved.
OPTA-IN	Palma de Mallorca Airport	CDOs	101	Potential reduction of 7-12% in fuel burn and related CO_2 emissions
REACT plus	Budapest Airport	CDOs and CCOs	4113	102 kg of fuel conserved during each CDO
ENGAGE Phase II	North Atlantic – between Canada & Europe	Optimisation of cruise altitude and/or Mach number	210	200-400 litres of fuel savings; An average of 1-2% of fuel conserved
SATISFIED	EUR-SAM Oceanic corridor	Free routing	165	1578 kg in CO_2 emissions
SMART	Lisbon flight information region (FIR), New York Oceanic and Santa Maria FIR	Oceanic: Flight optimisation	250	3134 kg CO_2 per flight
WE-FREE	Paris CDG, Venice, Verona, Milano Linate, Pisa, Bologna, Torino, Genoa airports	free routing	128	693 Kg of CO_2 for CDG-Roma Fiumicino ; 504 kg of CO_2 for CDG Milano Linate
MAGGO*	Santa Maria FIR and TMA	Several enablers	100*	*

*The MAGGO project couldn’t be concluded

SESAR solutions and Common Projects for deployment

SESAR Solutions are operational and technological improvements that aim to contribute to the modernisation of the European and global ATM system. These solutions are systematically validated in real operational environments, which allow demonstrating clear business benefits for the ATM sector when they are deployed including **the reduction by up to 500 kg of fuel burned per flight by 2035 which corresponds to up to 1,6 tonnes of CO_2 emissions per flight, split across operating environments.**

By end of 2015 twenty-five SESAR Solutions were validated targeting the full range of ATM operational environments including airports. These solutions are made public on the SESAR JU website in a datapack form including all necessary technical documents to allow implementation. One such solution is the integration of pre-departure management within departure management (DMAN) at Paris Charles de Gaulle, resulting in a 10% reduction of taxi time, 4 000-tonne fuel savings annually and a 10% increase of Calculated Take Off Time (CTOT) adherence and the Implementation. Another solution is Time Based Separation at London Heathrow, allowing up to five more aircraft per hour to land in strong wind conditions and thus reduces holding times by up to 10 minutes, and fuel consumption by 10% per flight. By the end of SESAR1 fifty-seven solutions will be produced.

The deployment of the SESAR solutions which are expected to bring the most benefits, sufficiently mature and which require a synchronised deployment is mandated by the Commission through legally binding instruments called Common Projects.

The first Common Projects identify six ATM functionalities, namely Extended Arrival Management and Performance Based Navigation in the High Density Terminal Manoeuvring Areas; Airport Integration and Throughput; Flexible Airspace Management and Free Route; Network Collaborative Management; Initial System Wide Information Management; and Initial Trajectory Information Sharing. The deployment of those six ATM functionalities should be made mandatory.

- The Extended Arrival Management and Performance Based Navigation in the High Density Terminal Manoeuvring Areas functionality is expected to improve the precision of approach trajectory as well as facilitate traffic sequencing at an earlier stage, **thus allowing reducing fuel consumption and environmental impact in descent/arrival phases.**
- The Airport Integration and Throughput functionality is expected to improve runway safety and throughput, **ensuring benefits in terms of fuel consumption** and delay reduction as well as airport capacity.

- The Flexible Airspace Management and Free Route functionality is expected to enable a more efficient use of airspace, thus providing significant **benefits linked to fuel consumption** and delay reduction.
- The Network Collaborative Management functionality is expected to improve the quality and the timeliness of the network information shared by all ATM stakeholders, thus ensuring significant benefits in terms of Air Navigation Services productivity gains and delay cost savings.
- The Initial System Wide Information Management functionality, consisting of a set of services that are delivered and consumed through an internet protocol-based network by System Wide Information Management (SWIM) enabled systems, is expected to bring significant benefits in terms of ANS productivity.
- The Initial Trajectory Information Sharing functionality with enhanced flight data processing performances is expected to improve predictability of aircraft trajectory for the benefit of airspace users, the network manager and ANS providers, implying less tactical interventions and improved de-confliction situation. This is expected to have a positive impact on ANS productivity, **fuel saving** and delay variability.

SESAR 2020 programme
SESAR next programme (SESAR 2020) includes in addition to exploratory and industrial research, very large scale demonstrations which should include more environmental flight demonstrations and goes one step further demonstrating the environmental benefits of the new SESAR solutions.

5.4 ECONOMIC/MARKET-BASED MEASURES

5.4.1 The EU Emissions Trading System

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. It operates in 31 countries: the 28 EU Member States, Iceland, Liechtenstein and Norway. The EU ETS is the first and so far the biggest international system capping greenhouse gas emissions; it currently covers half of the EU's CO_2 emissions, encompassing those from around 12 000 power stations and industrial plants in 31 countries, and, under its current scope, around 640 commercial and non-commercial aircraft operators that have flown between airports in the European Economic Area (EEA).

The EU ETS began operation in 2005; 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.

By the 30th April each year, companies, including aircraft operators, have to surrender allowances to cover their emissions from the previous calendar year. If a company reduces its emissions, it can keep the spare allowances to cover its future needs or sell them to another company that is short of allowances. The flexibility that trading brings ensures that emissions are cut where it costs least to do so. The number of allowances reduces over time so that total emissions fall.

As regards aviation, legislation to include aviation in the EU ETS was adopted in 2008 by the European Parliament and the Council[19]. The 2006 proposal to include aviation in the EU ETS was accompanied by detailed impact assessment[20]. After careful analysis of the different options, it was concluded that this was the most cost-efficient and environmentally effective option for addressing aviation emissions.

In October 2013, the Assembly of the International Civil Aviation Organization (ICAO) decided to develop a global market-based mechanism (MBM) for international aviation emissions. The global MBM design is to be decided at the next ICAO Assembly in 2016, including the mechanisms for the implementation of the scheme from 2020. In order to sustain momentum towards the establishment of the global MBM, the European Parliament and Council have decided to temporarily limit the scope of the aviation activities covered by the EU ETS, to intra-European flights[21]. The temporary limitation applies for 2013-2016, following on from the April 2013 'stop the clock' Decision[22] adopted to promote progress on global action at the 2013 ICAO Assembly.

The legislation requires the European Commission to report to the European Parliament and Council regularly on the progress of ICAO discussions as well as of its efforts to promote the international acceptance of market-based mechanisms among third countries. Following the 2016 ICAO Assembly, the Commission shall report to the European Parliament and to the Council on actions to implement an international agreement on a global market-based measure from 2020, that will reduce greenhouse gas emissions from aviation in a non-discriminatory manner. In its report, the Commission shall consider, and, if appropriate, include proposals on the appropriate scope for coverage of aviation within the EU ETS from 2017 onwards.

Between 2013 and 2016, the EU ETS only covers emissions from flights between airports which are both in the EEA. Some flight routes within the EEA are also exempted, notably flights involving outermost regions.

---

[19] 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.

[20] http://ec.europa.eu/clima/policies/transport/aviation/documentation_en.htm.

[21] Regulation (EU) No 421/2014 of the European Parliament and of the Council of 16 April 2014 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in view of the implementation by 2020 of an international agreement applying a single global market-based measure to international aviation emissions http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32014R0421.

[22] 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/LexUriServ/LexUriServ.do?uri=CELEX:32013D0377:EN:NOT.

The complete, consistent, transparent and accurate monitoring, reporting and verification of greenhouse gas emissions remain fundamental for the effective operation of the EU ETS. Aviation operators, verifiers and competent authorities have already gained experience with monitoring and reporting during the first aviation trading period; detailed rules are prescribed by Regulations (EU) N°600/2012[23] and 601/2012.[24]

The EU legislation establishes exemptions and simplifications to avoid excessive administrative burden for the smallest aircraft operators. Since the EU ETS for aviation took effect in 2012 a de minimis exemption for commercial operators – with either fewer than 243 flights per period for three consecutive four-month periods or flights with total annual emissions lower than 10 000 tonnes CO_2 per year –applies, which means that many aircraft operators from developing countries are exempted from the EU ETS. Indeed, over 90 States have no commercial aircraft operators included in the scope of the EU ETS. From 2013 also flights by non-commercial aircraft operators with total annual emissions lower than 1 000 tonnes CO_2 per year are excluded from the EU ETS up to 2020. A further administrative simplification applies to small aircraft operators emitting less than 25 000 tonnes of CO_2 per year, who can choose to use the small emitter`s tool rather than independent verification of their emissions. In addition, small emitter aircraft operators can use the simplified reporting procedures under the existing legislation.

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 consider options available in order to provide for optimal interaction between the EU scheme and that country's measures. In such a case, flights arriving from the third country could be excluded from the scope of the EU ETS. The EU therefore encourages other countries to adopt measures of their own and is ready to engage in bilateral discussions with any country that has done so. The legislation also makes it clear that if there is agreement on global measures, the EU shall consider whether amendments to the EU legislation regarding aviation under the EU ETS are necessary.

Impact on fuel consumption and/or CO_2 emissions

The environmental outcome of an emissions trading system is determined by the emissions cap. Aircraft operators are able to use allowances from outside the aviation sector to cover their emissions. The absolute level of CO_2 emissions from the aviation sector itself can exceed the number of

[23] Commission Regulation (EU) No 600/2012 of 21 June 2012 on the verification of greenhouse gas emission reports and tonne-kilometre reports and the accreditation of verifiers pursuant to Directive 2003/87/EC of the European Parliament and of the Council, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R0600&from=EN

[24] Regulation (EU) No 601/2012 of the European Parliament and of the Council of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council, http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32012R0601.

allowances allocated to it, as the increase is offset by CO_2 emissions reductions in other sectors of the economy covered by the EU ETS.

Over 2013-16, with the inclusion of only intra-European flights in the EU ETS, the total amount of annual allowances to be issued will be around 39 million. Verified CO_2 emissions from aviation activities carried out between aerodromes located in the EEA amounted to 56,9 million tonnes of CO_2 in 2015. This means that the EU ETS will contribute to achieve more than 17 million tonnes of emission reductions annually, or around 68 million over 2013-2016, partly within the sector (airlines reduce their emissions to avoid paying for additional units) or in other sectors (airlines purchase units from other ETS sectors, which would have to reduce their emissions consistently). While some reductions are likely to be within the aviation sector, encouraged by the EU ETS's economic incentive for limiting emissions or use of aviation biofuels[25], the majority of reductions are expected to occur in other sectors.

Putting a price on greenhouse gas emissions is important to harness market forces and achieve cost-effective emission reductions. In parallel to providing a carbon price which incentivises emission reductions, the EU ETS also supports the reduction of greenhouse gas emissions through €2,1 billion funding for the deployment of innovative renewables and carbon capture and storage. This funding has been raised from the sale of 300 million emission allowances from the New Entrants' Reserve of the third phase of the EU ETS. This includes over €900 million for supporting bioenergy projects, including advanced biofuels[26].

In addition, through Member States' use of EU ETS auction revenue in 2013, over €3 billion has been reported by them as being used to address climate change[27]. The purposes for which revenues from allowances should be used encompass mitigation of greenhouse gas emissions and adaptation to the inevitable impacts of climate change in the EU and third countries, to reduce emissions through low-emission transport, to fund research and development, including in particular in the fields of aeronautics and air transport, to fund contributions to the Global Energy Efficiency and Renewable Energy Fund, and measures to avoid deforestation.

In terms of contribution towards the ICAO global goals, the States implementing the EU ETS will together deliver, in “net” terms, a reduction of at least 5% below 2005 levels of aviation CO_2 emissions for the scope that is covered. Other emissions reduction measures taken, either at supra-national level in Europe or by any of the 31 individual states implementing the EU ETS, will also contribute towards the ICAO global goals. Such

[25] The actual amount of CO2 emissions savings from biofuels reported under the EU ETS from 2012 to 2014 was 2 tonnes.
[26] For further information, see http://ec.europa.eu/clima/policies/lowcarbon/ner300/index_en.htm.
[27] For further information, see http://ec.europa.eu/clima/news/articles/news_2014102801_en.htm.

measures are likely to moderate the anticipated growth in aviation emissions.

Estimated emissions reductions resulting from the EU-ETS

Year	*Reduction in CO_2 emissions*
2013-2016	*65 million tonnes*

The table presents projected benefits of the EU-ETS based on the current scope (intra-European flights).

5.5 EU INITIATIVES IN THIRD COUNTRIES

5.5.1 Multilateral projects

At the end of 2013 the European Commission launched a project of a total budget of €6,5 million under the name *"Capacity building for CO_2 mitigation from international aviation"*. The 42-month project, implemented by the ICAO, boosts less developed countries' ability to track, manage and reduce their aviation emissions. In line with the call from the 2013 ICAO Assembly, beneficiary countries will submit meaningful State action plans for reducing aviation emissions, and also receive assistance for establishing emissions inventories and piloting new ways of reducing fuel consumption. Through the wide range of activities in these countries, the project contributes to international, regional and national efforts to address growing emissions from international aviation. The beneficiary countries are the following:

Africa: Burkina Faso, Kenya and Economic Community of Central African States (ECCAS) Member States: Angola, Burundi, Cameroon, Central African Republic, Chad, Republic of Congo, Democratic Republic of Congo, Equatorial Guinea, Gabon, Sao Tome and Principe.

Caribbean: Dominican Republic and Trinidad and Tobago.

5.6 SUPPORT TO VOLUNTARY ACTIONS

5.6.1 ACI Airport Carbon Accreditation

Airport Carbon Accreditation is a certification programme for carbon management at airports, based on carbon mapping and management standard specifically designed for the airport industry. It was launched in 2009 by ACI EUROPE, the trade association for European airports.

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.

This industry-driven initiative was officially endorsed by EUROCONTROL and the European Civil Aviation Conference (ECAC). It is also officially supported by the United Nations Environmental Programme (UNEP). The programme is overseen by an independent Advisory Board.

In 2014 the programme reached global status with the extension of the programme to the ACI North American and Latin American & Caribbean regions, participation has increased to 125 airports, in over 40 countries across the world – an increase of 23% from the previous year, growing from 17 airports in Year 1 (2009-2010). These airports welcome 1,7 billion passengers a year, or 27,5% of the global air passenger traffic.

Airport Carbon Accreditation is a four-step programme, from carbon mapping to carbon neutrality. The four steps of certification are: Level 1 “Mapping”, Level 2 “Reduction”, Level 3 “Optimisation”, and Level 3+ “Carbon Neutrality”.

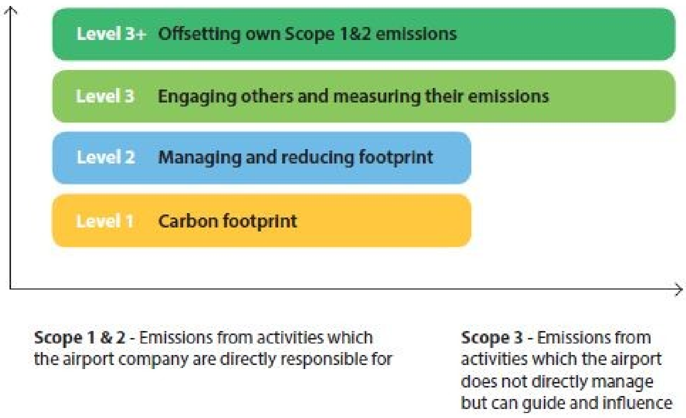


Figure: Levels of certification (ACA Annual Report 2014-2015)

One of its essential requirements is the verification by external and independent auditors of the data provided by airports. Aggregated data are included in the *Airport Carbon Accreditation Annual Report* thus ensuring transparent and accurate carbon reporting. At level 2 of the programme and above (Reduction, Optimisation and Carbon Neutrality), airport operators are required to demonstrate CO_2 reduction associated with the activities they control.

In Europe, participation in the programme has increased from 17 airports to 92 in 2015, an increase of 75 airports or 441% since May 2010. 92 airports mapped their carbon footprints, 71 of them actively reduced their CO_2 emissions, 36 reduced their CO_2 emissions and engaged others to do so, and 20 became carbon neutral. European airports participating in the programme now represent 63,9% of European air passenger traffic.

Anticipated benefits:
The Administrator of the programme has been collecting CO_2 data from participating airports over the past five years. This has allowed the absolute CO_2 reduction from the participation in the programme to be quantified.

Emissions reduction highlights

	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Total aggregate scope 1 & 2 reduction (tCO_2)	51 657	54 565	48 676	140 009	129 937	168 779
Total aggregate scope 3 reduction (tCO_2)	359 733	675 124	365 528	30 155	223 905	550 884

Emissions performance summary

Variable	2013 -2014		2014-2015	
	Emissions	**Number of airports**	**Emissions**	**Number of airports**
Aggregate carbon footprint for 'year 0'[28] for emissions under airports' direct control (all airports)	22 044 683 tonnes CO_2	85	2 089 358 tonnes CO_2	92
Carbon footprint per passenger	2,01 kg CO_2		1,89 kg CO_2	
Aggregate reduction in emissions from sources under airports' direct control (Level 2 and above)[29]	87 449 tonnes CO_2	56	139 022 tonnes CO_2	71
Carbon footprint reduction per passenger	0,11 kg CO_2		0,15 kg CO_2	
Total carbon footprint for 'year 0' for emissions sources which an airport may guide or influence (level 3 and above)[30]	12 777 994 tonnes CO_2	31	14 037 537 tonnes CO_2	36
Aggregate reductions from emissions sources which an airport may guide or influence	223 905 tonnes CO_2		550 884 tonnes CO_2	
Total emissions offset (Level 3+)	181 496 tonnes CO_2	16	294 385 tonnes CO_2	20

Its main immediate environmental co-benefit is the improvement of local air quality.

Costs for 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 aircraft emissions in the LTO cycle are also covered. Thus, airlines can benefit from the gains made by more efficient airport operations to see a decrease in their emissions during the LTO cycle. This is coherent with the objectives pursued with the inclusion of aviation in the EU ETS as of 1 January 2012 (Directive 2008/101/EC) and can support the efforts of airlines to reduce these emissions.

[28] 'Year 0' refers to the 12 month period for which an individual airport's carbon footprint refers to, which according to the Airport Carbon Accreditation requirements must have been within 12 months of the application date.

[29] This figure includes increases in emissions at airports that have used a relative emissions benchmark in order to demonstrate a reduction.

[30] These emissions sources are those detailed in the guidance document, plus any other sources that an airport may wish to include.

6 National actions in Sweden

This section is complementary to the Supra-national actions described in section 5 above. In many cases national activities and actions in Sweden that are described in this section are illustrations of how supra-national actions are implemented in Sweden. Many activities and projects that are intended to limit the emission of carbon dioxide from civil aviation in Sweden are based on extensive cooperation. The stakeholders involved are airports, air navigation services (ANS) providers, aircraft operators, research institutes and universities as well as central government and regional authorities.

6.1 Aircraft related technology

Reference is made to Aircraft emissions standards and the development of an aircraft CO_2 standard described in the previous section "Supra-national actions". The Swedish Transport Agency has provided an expert for the development of the new CO_2 standard in the CO_2 task group within CAEP´s Working Group 3 and the expert will continue to participate in the finalisation of the work.

6.2 Improved air traffic management and infrastructure use

Please note that more information about LFV (a public enterprise that manages air navigation services) as well as Swedavia AB (a state owned company for airport operations) both mentioned below, can be found in the section "Current State of Aviation in Sweden".

Free Route Airspace in DK-SE FAB

In 2009, Swedish and Danish airspace became one joint Danish-Swedish Functional Airspace Block (DK-SE FAB). Also in 2009 a joint company, NUAC (Nordic Unified Air traffic Control) was established by LFV and Danish Naviair, operating the traffic control across national airspaces.

In 2011 Free Route Airspace (FRA) was introduced in the DK-SE FAB to enable airlines to plan direct flight routes through the Danish-Swedish airspace. FRA in the DK-SE FAB reduces CO_2 emissions with 40.000 tonnes annually according to simulations executed by Eurocontrol.

Extended Free Route Airspace – NEFRA and Borealis

LFV and Naviair have agreed on developing the NEFRA Programme started in May 2013. NEFRA aims to connect the existing FRA in the DK-SE FAB with the planned FRA in NEFAB states (Estonia, Finland, Latvia and Norway) seamlessly from late 2015. The Programme will benefit customers to plan their flights through NEFAB and DK-SE FAB in the most cost-efficient way of their preference, without any requirements to cross the state or FAB borders at predefined points as it is today.

Also, LFV is part of the Borealis Alliance (including Norway, Estonia, Finland, Iceland, Ireland, Sweden, Latvia, UK and Denmark). It is planned to extend NEFRA to cover the full Borealis Alliance airspace from 2018.

Structured environmental co-operation between stakeholders

LFV, NUAC and Swedavia quarterly meet representatives from six airlines (SAS, Norwegian, Malmö Aviation, Nextjet, Ryanair and Novair) in order to continuously analyse airspace, procedures and working methods for Pilots and Air Traffic Controllers to find common areas of improvements and environmental gains.

This co-operation is a very important forum to gather knowledge and enhance the understanding between airlines, pilots, airports and LFV. The co-operation has also resulted in a lot of modifications to working methods at LFV, such as enhanced methods for providing predictability for approach planning, enabling CDO, providing distance-to-go during approach vectoring, more fuel efficient ways to use speed control etc.

The stakeholders are currently working on reducing fuel consuming speed restrictions on SIDs, better predictability for ToD-planning for approaches into Stockholm-Arlanda etc.

Reduced and harmonised descent speeds

By reducing descent speed and descent angle, arriving flights can leave the cruise level somewhat earlier and thereby save fuel and reduce emissions. This can also make the descent- and speed profiles of the arriving traffic flow more harmonised, which in turn can make ATC sequencing more efficient. Actual fuel data and model calculations for both Airbus321 and Boeing737 show that a reduction of descent speed by 20 knots will save approximately 20 kg of fuel. In turn the flight will extended by 45 seconds, but an increasing number of airlines want to make this trade-off between fuel and time by getting their pilots to use lower descent speed.

During 2013 trials with a published common descent speed (EcoDescend) of 260 knots or less was evaluated into the Gothenburg area. If needed, pilots could request higher speed, and this was also permitted as long as it was suitable for the current traffic situation. The average descent speed was reduced by almost 10 knots, and a total of 800 tonnes of CO_2 were saved annually for the arrivals into the two commercial airports in Gothenburg. In 2014 these speed regulations where permanently implemented into Gothenburg, and LFV are currently examining if similar trials can be conducted in the more traffic dense Stockholm airspace.

Measuring and enabling Vertical Flight Efficiency

Since many years LFV is measuring and actively working in different ways to enhance the Vertical Flight Efficiency for both departing and arriving flights in Swedish Airspace. With the newly developed tool GAIA (Green ATM Interactive Analysis) LFV is able to measure the vertical and horizontal performance of the air traffic in Swedish airspace in detail. In 2014 55% of all arrivals into the twelve largest airports in Sweden conducted a Continuous Descent Operation (CDO) from 28.500 feet, and the average time in level flight during approach was 73 seconds. Also 92% of all departures were able to make a Continuous Climb Operation (CCO) with no level flight at all, and the average time in level flight during climb was just 8 seconds.

GAIA is also used to visualize the radar tracks and performance of the air traffic in order to find ´bottlenecks´ and areas of improvement in Swedish airspace.

The number of approaches using closed STARs and short RNP-approaches are also continuously measured since this is considered to be the most fuel efficient way of conducting an approach.

Training Air Traffic Controllers in fuel management

LFV has accumulated the knowledge gained in the environmental co-operation between stakeholders over the years and transformed it into an environmental workshop for Air Traffic Controllers to raise awareness of how different ATC-behaviours can impact fuel consumption. Roughly 300 of LFVs 500 controllers have so far attended the workshop.

New working position in Stockholm TMA

In 2014 a new working position for departing traffic in Stockholm TMA was implemented. This enabled shorter intervals between departures in some conditions, and reduced taxi waiting times by at least 3.000 minutes/year saving 30 tonnes of fuel and 95 tonnes of CO_2.

The time in holding for arriving traffic was also reduced by this new working position, but it was difficult to measure and calculate the amount of fuel saved in a reliable way.

Structured co-operation on Swedavia's environmental processes

To build and/or operate an airport of a certain size in Sweden a permit by the Land and Environment Court is required in accordance with the Swedish Environmental Code. For civil airports, the Land and Environmental Court's decision can be appealed. An application for permit must contain an environmental impact assessment (EIA). Before an EIA can be prepared, the operator must consult with the county administrative board and the individuals that are likely to be particularly affected by the airport operations. As the airport operations are likely to have significant environmental effects, the airport operator must also consult with other state agencies, the municipalities, the public and organizations likely to be affected by the operations. Aircraft noise influences people in large areas, so the consultation circuit is often large. The ruling from the court normally consists of an environmental permit with conditions. The environmental conditions can for example govern departure and arrival routes (with the purpose of e.g. avoiding noise sensitive areas, enable dispersion of air traffic, shortening of routes to minimize emissions) and departure and arrival procedures (to decrease noise exposure and/or emissions).

LFV assists Swedavia with Environmental Impact Assessments (EIA) and in the legal processes regarding new environmental permits for some of the major airports in Sweden. These processes comprise analysis on improvements and how leading edge technology can be used to reduce the environmental impact. As a result of this co-operation, Swedavia will introduce fuel optimized RNP-procedures as well as changed conditions for handling of take-offs along the SID in order to reduce fuel consumption. Both Stockholm/Arlanda and Malmö/Sturup Airports have implemented new environmental permissions during 2015, and there are potential in the new environmental conditions for shortening departure tracks for low noise aircrafts to reduced fuel/emissions.

In the environmental impact assessment (EIA) for Stockholm/Arlanda Airport, Göteborg/Landvetter Airport and for Malmö Airport Swedavia has launched a suggestion on how to phase out the traffic from the airport which would benefit the least noisy aircraft types and will reduce fuel consumption.

The new environmental permit for Stockholm/Arlanda Airport has a condition stating that aircraft should follow SID until they reach 2000 meters, but the condition also allow aircraft to leave SID when the noise level is below 65 dB(A) on the ground, which means that a large number of aircraft will leave the SID at much lower heights than 2000 m. Consequently, the aircraft can approach their destinations directly and thus shorten their actual flight path. A shortening of just 1 nautical mile reduces the CO_2-emissions by approximately 20 kg per individual flight.

However, with this condition neighbours living close to the airport may find it less predictable to know where the aircraft will be. More people may be affected, although by noise levels much below the recommended standard (70 dB). Also Malmö Airport and Göteborg/Landvetter Airport has the same type of conditions.

Ongoing and recently completed collaborative projects in order to reduce the environmental impact from aviation

The SESAR Joint Undertaking collaborates with the US Federal Aviation Administration (FAA) and a number of European and North American partners in an international programme for the reduction of aircraft emissions (AIRE - Atlantic Interoperability Initiative to Reduce Emissions). On the European side alone, this project has since 2009 realised more than 6.000 trials in real operational conditions. Most of the solutions validated in AIRE are in operations today or will be shortly. During 2010 -2012 two AIRE projects has been conducted in Sweden and led by LFV. One project, VINGA, has been focusing on fuel optimization for a smaller airport, Göteborg Landvetter Airport and one, Green Connection, has been focusing on a larger airport, Stockholm Arlanda Airport.

6.3 Alternative fuels

Biofuels outlook

The production and use of renewable biofuels have grown fast in Sweden during the last years. The development has been focused to the road sector and is highly dependent on policy instruments. With increasing volumes of biofuels in road and with technology moving forward the likeliness of renewables in other means of transport increases.

The goal of ten percent renewable energy in the transport sector to 2020 according to the Renewable Energy Directive (2009/28/EC) has been, and is still, an important policy to create incentives to increase the share of renewables. In Sweden there is a political will to prioritize a fossil fuels independent vehicle fleet to 2030 and a vision of a climate neutral energy system to 2050, but so far no binding targets are set for renewables in the transport sector after 2020. Most ambitions for the transport sector exclude aviation and there are no binding national goals for renewables in aviation specifically.

However, the development of second generation biofuels can also be beneficial for the use of renewables in aviation. In Sweden focus is on using lingo-cellulose feedstock as wooden biomass is an important national resource and Sweden has a long industrial record to utilize such feedstock for various purposes and a high R&D competence. So far, flights have been made with various types of low-blended vegetable oils. With second generation biofuels the hope is to create renewable aviation fuels in commercial scale, using forest industry rest products.

In June 2015 the Swedish Energy Agency announced two new research programmes amounting to 180 million SEK (€19.5 m). The programmes will fund more efficient and inexpensive processes for the production of biofuels. The focus is on biofuels that according to the Swedish Energy Agency are most relevant to contribute to the conversion to renewables in the transport sector. In the short run, the need is for biofuels that can be used in current vehicles, where biofuels from lignin is the most prioritized area. In the long run focus is on ethanol and biofuels from gasification.

Swedish biofuels

Reference is made to previous section 5.2.1 where Swedish Biofuels is mentioned. Swedish Biofuels AB is a Stockholm based company with a focus on high-performance sustainable products for the transport and chemical industry. The company has developed a diverse range of patented technology and products to serve the green aviation and ground transportation market.

Swedish Biofuels produces aviation fuel, as well as diesel and gasoline, at its Pilot Plant located at the Royal Institute of Technology, KTH, Stockholm, Sweden. The plant has been in continuous operation since 2011, successfully confirming the reproducibility of the fuel quality. Swedish Biofuels supplies quantities of aviation fuel from its Pilot Plant to USAF/FAA under the program of Sweden US cooperation in matters of alternative fuels. The program has the goal of completing certification of its technology for military use in aviation. Swedish Biofuels participates in the ASTM standards group that certifies alternative aviation fuels, and has provided test fuel data to complete certification of its technology for civil use in aviation. Diesel and gasoline produced by Swedish Biofuels technology do not require any certification and will be available on the market as soon as they can be produced in commercial volumes.

To accelerate the commercialization of the technology, and with the financial support of the European Commission, Swedish Biofuels will coordinate an international consortium over the next five years with the goal of producing biofuels for use in aviation.

A pre-commercial industrial scale plant will be constructed during the period of 2015-2019. The plant will use Swedish Biofuels technology. The capacity of the plant will be 10,000 tonnes per year, of which half will be aviation fuel with the rest being ground transportation fuels. The aviation fuel produced will be compatible, without blending, with in-service and envisaged jet engines for both civil and military applications. It will consume a variety of sustainable raw materials, as defined in article 21.2 of the Renewable Energy Directive 8, focusing on, wood residues and municipal solid waste.

The demonstration plant forms part of the path to full size plant construction and operation. The full scale commercial plant size is estimated to be 200,000 tonnes per annum of motor fuel, of which jet fuel would make up half. Swedish Biofuels business plan is to deploy, through production licences, 3 commercial units in the 10 years following the project; an estimate based on considerations of market acceptance, safety and financial risks. In the best scenario of a good political and economic environment, up to 600,000 t/y of advanced biofuels can be produced in Sweden and neighbouring countries.

IATA estimates that a 3 % volume blend-in of sustainable biojet globally would reduce aviation CO2 emissions by about 2% - a reduction of over 10 million tonnes of CO2 each year. Each commercial plant producing 200,000 tonnes of Swedish Biofuels technology will save 468,000 tonnes of CO2 per year from Jet A-1, with comparable savings expected in the diesel and gasoline pools. If Swedish Biofuels meets its commercial deployment goals in the first 10 post-project years, the resulting 3 plants would be estimated to save 1,404,000 tonnes of CO_2 per year in the global transport fuels sector.

Nordic Initiative for Sustainable Aviation (NISA)

NISA is a Nordic association working to promote and develop a more sustainable aviation industry, with a specific focus on alternative sustainable fuels for the aviation sector. The goal of NISA is to accelerate the development and the commercialization of sustainable aviation fuels. This is achieved by organizing activities, strengthening the cooperation across the value chain and by focusing on opportunities in the Nordic region. The actors behind the initiative are the Nordic airports, Nordic airlines and their organizations, and the aviation authorities. The initiative is also supported by aircraft manufacturers Airbus and Boeing.

Fly Green Fund

In summer 2014 Karlstad Airport in Sweden was the first airport in the world to provide a stationary supply of biofuel for aviation. To promote the use and production of sustainable alternative fuels for aviation Karlstad Airport, together with SkyNRG and NISA (Nordic Initiative on Sustainable Alternative Fuels) has started a cooperation called Fly Green Fund. The fund is an initiative that gives companies and organisations the opportunity to decrease their environmental impact by flying on bio jet fuel and has the aim to kick-start the market for bio jet fuel flights in the Nordic countries. The idea behind the fund is to offer the customers to pay an additional amount on top of the flight ticket, called a “bio-ticket”. Of the additional amount, 75 percent will go to cover the costs of conducting the flight with a biofuel blend, and 25 percent will go to support the development of a Nordic biofuel production plant using forestry residue as bio source. The aim is to extend the fund to the whole Nordic region. Up to now the Swedish airport provider Swedavia and the regional airports have joined the initiative, together with SAS, KLM, EFS and Braathens Aviation. There are also companies connected to the fund as custumers. The goal is to have biofuel representing 25 percent of the total fuel for domestic aviation in Sweden by 2025.

6.4 More efficient operations

SAS goal towards 2020 is to reduce its flight emissions per produced unit by 20 % compared with 2010.

The main driver to reduce flight emissions is fleet renewal:

- As of the end of 2014 all previous generation short haul aircraft (MD80's and B737 Classics) were replaced with current generation A320's and B737NG's.
- Between 2016 and 2020 SAS plans to introduce 30 A320neo's. They will replace existing aircrafts in the fleet. Approximately a 15% increase in fuel efficiency is expected.
- Between mid-2015 and the end of 2016 SAS plans to introduce 4 A330E (242t). They will replace existing aircrafts in the fleet and an fuel efficiency increase per passenger kilometre at approximately 2 and 15% is expected compared to A330 and A340 respectively.
- From mid-2018 and a couple of years onwards SAS plans to introduce 8 A350. They will replace existing aircrafts in the fleet and an fuel efficiency increase per passenger kilometre at approximately 30% is expected compared to A340.
- The last couple of year SAS has introduced 10 new ATR72-600 turboprops on wet lease basis. As of mid-2016 SAS expects to have approximately 16 aircraft in its operations. To replace a half-full larger aircraft (141 seats) with a full ATR72-600 (70 seats) enables considerable reduction in fuel consumption and emissions.

Furthermore SAS is working actively with a fuel saving-program which includes almost all operations. Other elements in the emission reduction program is modification of existing aircraft, lighter products onboard, green flights, landing and starts, and future access to alternative sustainable jet fuels.

The fuel saving activities within SAS own control and with existing aircraft is expected to increase SAS fuel efficiency with 0,3-1% annually. Please note that fleet renewal is excluded in this figure.

Please note that this information about SAS is valid for the whole of SAS and is submitted in the Action Plans for Denmark and Norway as well.

Novair is a charter operator and operates three A321 aircraft, typically flying to the Canary Islands in the winter and various destinations in Greece and Turkey during the summer period. Novair will renew its fleet in the spring of 2017 with A321 Neo. The fuel consumption is expected to be lowered by 15 percent due to implementation of new technology.

Novair has an internal ongoing project with the high level objective to continuously improve cost effectiveness in the daily flight operation, and fuel conservation is the main driver in that work since 2007. However, this work is done together with external actors as well, such as Air Navigation

Service Providers and Airports. This is done both on a national basis together with local partners as well as being involved in the European Air Traffic Management modernization program SESAR as an Airspace User expert.

The Standard Operating Procedures in Novair are based on the Airbus Green Operating Procedures. Investment in new technologies such as capabilities to fly Performance Based Navigation (PBN) procedures is vital to minimize the environmental footprint of aviation. Novair has been involved in pioneering PBN activities in Sweden as well as other European States. An example of such activities is the implementation of RNP AR (Required Navigation Performance - Authorization Required) approaches in Gothenburg Airport. One of these RNP AR approaches is 11 NM shorter than the normal approach with ILS. The emissions reduction is 300 kg CO2 each time being flown. In addition, a neighbouring community is relieved by overflying aircraft.

The fuel conservation activities in 2014 corresponded to 1 429 000 kg less emissions of CO_2 compared to a nominal scenario and the fuel consumption in 2014 corresponded to 0,026 litres/RPK (Revenue Passenger Kilometre).

Braathens Aviation has a continued ambition to lower the CO_2 emissions. Since 2007 the emissions has been lowered by 10% per hour flown and the ambition is to continue to reduce the emissions.

Green descents is an important way to reduce the emissions and in order to facilitate for conducting green descents when it is possible, the timetable has been adjusted and the flighttime prolonged with five minutes for certain flights.

Another way for Braathens Aviation to reduce the emissions is to use ground electricity instead of the onboard Auxilary Power Unit (APU).

6.5 Economic/Market-based measures

NO_x charges

Since 1998 the Swedish State owned airports apply charges on aircraft NO_x emissions. Aircraft that emit more NO_x in the LTO cycle are charged more than aircraft with less NO_x emissions. The charge is based on certified emission values of NO_x and is applied in accordance with ICAO guidance. The charge is SEK 50 per kg NO_x.

The NO_x emissions charges were introduced to improve local air quality. However, ICAO/CAEP has concluded that altitude NO_x emissions performance for current engines is controlled by LTO NO_x emission certification. As altitude NOx emissions have a climate warming effect, the airport NO_x charges should be regarded as a tool for the reduction of climate impact from aviation as well.

6.6 Other measures

European airport carbon accreditation

The Airport Carbon Accreditation Scheme is described in section 5.6.1. The scheme was launched in June 2009. Stockholm/ Arlanda Airport was the first airport accredited at the highest level in the European Airport Carbon Accreditation (ACA) program 2009. Since then all the Swedavia airports have been certified. That means that as of June 2015 the Swedish airport operator Swedavia owns and operates ten of the total of twenty airports in Europe/World with the highest level of certification.

Swedavia has a long term commitment to decrease fossil CO_2 emissions and environmental impact from its own operations and to support aviation's transition from fossil to renewable fuels. Swedavia therefore actively supports the development of renewable jet fuels in the Nordic countries and the access to bio jet fuels at Swedavia's airports in Sweden. Swedavia is a member of both Fly Green Fund and NISA.

7 Conclusion

This action plan was finalised on the 5th of August 2016 and shall be considered as subject to update after this date.