ICAO State Action Plan on CO₂ Emissions Reduction Activities

Sweden

30\textsuperscript{th} of June 2015
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1 Introduction

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 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. 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

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1 Albania, Armenia, Austria, Azerbaijan, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Moldova, Monaco, Montenegro, Netherlands, 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. For that reason, the reporting to ICAO on international aviation CO2 emissions referred to at paragraph 11 of ICAO Resolution A38/18 is not part of this Action Plan. This information will be provided to ICAO separately, as this is already part of the existing routine provision of data by ECAC States.
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 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 6 of this Action Plan, where Sweden’s 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 7 of this Plan.

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

i.) 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.

ii.) 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 List of abbreviations used

ACARE – Advisory Council for Research and Innovation in Europe
ACARS – Aircraft Communications Addressing and Reporting System
ACI – Airports Council International
ALPS – Advanced Low Pressure System
ANS – Air Navigation Service
BAU – Business as Usual
CDM – Collaborative Decision Making
CDO – Continuous Descent Operations
CPDLC – Controller-Pilot Data Link Communications
EASA – European Aviation Safety Agency
ECAC – European Civil Aviation Conference
EEA – European Economic Area
EFTA – European Free Trade Association
EU – European Union
FAB – Functional Airspace Block
FANS – Future Air Navigation System
GHG – Greenhouse Gas
IADP – Innovative Aircraft Demonstrator Platform
ILUC – Indirect Land Use Change
ITD – Integrated Technology Demonstrator
JTI – Joint Technology Initiative
LSHX – Liquid Skin Heat Exchanger
LTO cycle – Landing/Take-off Cycle
OFA – Operational Focus Area
RNP AR – Required Navigation Performance Authorization Required
RNP STAR – Required Navigation Performance Standard Arrival
SES – Single European Sky
SESAR – Single European Sky ATM Research
SESAR JU – Single European Sky ATM Research Joint Undertaking
SME – Small and Medium-sized Enterprises
SWAFEA - Sustainable Ways for Alternative Fuels and Energy for Aviation
TA – Transverse Activities
TE – Technology Evaluator
TMA – Terminal Manoeuvring Area
ToD – Top of Descent
TRL – Technology Readiness Level
3 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. 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.

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

Airports

Today there are 46 IFR aerodromes in Sweden, and 40 of these are operated with commercial air traffic. Of the 40 with commercial air traffic there are 27 owned by municipalities, 11 are state-owned (by Swedavia) and two have other ownership structures e.g. limited liabilities. Swedavia AB was established in 2010 as a state owned company for airport operations.

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3 [www.sweden.se](http://www.sweden.se)
4 [www.scb.se](http://www.scb.se)
6 [www.swedavia.se](http://www.swedavia.se)
Figure 1. Swedish Airports 2014.\(^7\)

\(^7\) Göteborg/Säve is now owned by Swedavia
Top 10 airports regarding passengers

The largest aerodromes based upon departing and arriving passengers can be seen in figure 2. Approximately 22.4 million passengers travelled to or from Stockholm/Arlanda in 2014 and approximately 5.2 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).

![Bar chart showing number of scheduled and non-scheduled passengers at the top 10 airports 2013 and 2014](image)

Figure 2. Number of scheduled and non-scheduled passengers at the top 10 airports 2013 and 2014

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 more than 228 000 movements registered and at Göteborg/Landvetter were almost 62 000 movements registered in 2014. 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).
In 2014, 92.5 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 (13 percent) and Stockholm/Bromma (6 percent). 88 per cent of all passengers arrived or departed at the Swedavia airports in 2014.\(^8\)

\(^8\) The number of passengers at Göteborg/Save is not included as the airport was not owned by Swedavia in 2014.
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. 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. 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. 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 Navaiair and LFV and acts as an ANS provider delivering Air Traffic Management (ATM) in the Danish/Swedish FAB.

Figure 4. Airport’s market shares 2014

9 www.lfv.se
10 www.acr-sweden.se
11 NUAC HB is a joint subsidiary owned by Danish Navaiair and Swedish LFV
12 www.nuac.eu
Passengers

In 2014, almost 22.3 million passengers departed from the Swedish airports, all time high figures. Departing passengers increased by 4 percent between 2013 and 2014.

![Figure 5. Number of international and domestic departing passengers in scheduled and non-scheduled traffic at Swedish airports 2005-2014](image)

Movements

In 2014 were 705,000 IFR-movements (international and domestic) recorded in Swedish airspace. It is 21,000 fewer than the all time high level in 2008. The growth was about 1.5 per cent in 2014 compared to 2013. Overflights amount to about 42 per cent of the movements 2014, a proportion that have not changed during the last nine years, see figure 6.

Freight and mail

In total 145 tonnes freight and mail arrived or departed at the Swedish airports in 2014. This is an increase of 3 percent compared to 2013. See figure 7.

Figure 6. Number of international and domestic IFT-movements at Swedish airports 2005-2014

Figure 7. Freight and mail in tonnes loaded and unloaded at Swedish airports 2005-2014
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 12 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 20 operating licenses granted in Sweden. Among these are 7 corporations operating with airplanes, 12 operating with helicopters and one is operating with both airplanes and helicopters.

In 2014 Sweden had 3 068 Swedish registered aircraft (compared to 3 077 in 2013). Of these were 1 801 airworthy (1 795 in 2013)\(^\text{13}\).

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

Concerning domestic air traffic, SAS, obtained 45 percent of the market shares in 2014 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, 2014](http://www.transportstyrelsen.se/globalassets/om_oss/finansiering/ar-2014.pdf)
Regarding international air traffic, SAS, obtained 25 percent of the market shares in 2014, Norwegian obtained 16 percent and Ryanair about 8 percent, see figure 9.

Figure 9. International market shares related to passengers, 2014
4 Emissions Data

The Swedish emissions data are taken from Sweden’s National Inventory Report 2013, submitted under the United Nations Framework Convention Climate Change (Source Swedish EPA).

<table>
<thead>
<tr>
<th>Year</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Aviation</td>
<td>659</td>
<td>620</td>
<td>603</td>
<td>589</td>
<td>492</td>
<td>476</td>
<td>524</td>
<td>515</td>
<td>517</td>
</tr>
<tr>
<td>International Aviation</td>
<td>1927</td>
<td>1996</td>
<td>2187</td>
<td>2453</td>
<td>2083</td>
<td>2105</td>
<td>2269</td>
<td>2163</td>
<td>2237</td>
</tr>
</tbody>
</table>

Emissions of CO₂ from domestic aviation in Sweden have declined with 78 percent in 2013 compared to 2005. For flights from Sweden to the first destination in another country (in accordance with IPCC definition of International Flights) CO₂ between 2005 and 2013 have risen with 16 percent.
5 European Baseline Scenario

Placeholder for text describing the baseline scenario, which will be summarized in the table underneath. To be completed during the autumn 2015.

European Baseline Scenario

<table>
<thead>
<tr>
<th></th>
<th>CO₂ emissions, tons</th>
<th>Traffic in RTK**</th>
<th>Fuel consumption, in tons</th>
<th>Fuel efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td></td>
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</tr>
<tr>
<td>2020</td>
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<td></td>
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<tr>
<td>2030 or 2035 or 2050</td>
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6 Actions taken at the supranational level

6.1 Aircraft related technology development

6.1.1 Aircraft emissions standards - Europe's contribution to the development of the CO\textsubscript{2} standard in CAEP

European Member States fully support the ongoing work in ICAO’s Committee on Aviation Environmental Protection (CAEP), and welcomed the agreement of certification requirements for a global aeroplane CO\textsubscript{2} Standard at CAEP/9 in 2013. Assembly Resolution A38-18 requests the Council to develop a global CO\textsubscript{2} standard for aircraft aiming to finalize analyses by late 2015 and adoption by the Council in 2016. Europe continues to make a significant contribution to this task notably through the European Aviation Safety Agency (EASA) which co-leads the CO\textsubscript{2} Task Group within CAEP’s Working Group 3, and which provides extensive technical and analytical support.

In the event that a standard, comprising of certification requirements and regulatory level, is adopted in 2016, it is expected to have an applicability date set at 2020 or beyond. In addition to being applicable to new aeroplane types, CAEP is discussing potential applicability options for in-production types. The contribution that such a standard will make towards the global aspirational goals will of course depend on the final applicability requirements and associated regulatory level that is set.

6.1.2 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 7\textsuperscript{th} Framework Programme (FP7) and continued within the Horizon 2020 Framework Programme in order to allow the achievement of ambitious and complex research goals. 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.

**Clean Sky 1 (2011 to 2017)**

**Budget:** €1.6 billion  
**CO₂ emissions reduction:** -20% to -40% (programme objective)  
**Fuel burn CO₂ target 2020 (2000 baseline):** -50% per pax.km or tonne.km

The first Clean Sky programme was set up in 2011 for a period up to 31 December 2017, with a budget of €1.6 billion, equally shared between the European Commission and the aeronautics industry, and the aim to develop environmental friendly technologies impacting all flying segments of commercial aviation. Clean Sky objectives for the whole programme at aircraft level are to reduce CO₂ aircraft emission between 20-40%, NOₓ by around 60% and noise by up to 10dB compared to year 2000 aircraft.

**Clean Sky 2 (2014-2024)**

**Budget:** €4 billion  
**Fuel burn CO₂ target 2025 (baseline: state of the art 2014):** -20%  
**Fuel burn CO₂ target 2035 (baseline: state of the art 2014):** -30%

A new programme – **Clean Sky 2** – was set up in 2014 for a period up to 31 December 2024 in order to make further advancements towards more ambitious environmental targets and to secure the competitiveness of the European aeronautical industry in the face of growing competition. The new Clean Sky 2 Joint Technology Initiative objectives are to increase the aircraft fuel efficiency and 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 with more than €2 billion industrial commitment matched by a similar contribution from the Horizon 2020 transport budget.
Technologies, Concept Aircraft and Demonstration Programmes form the three complementary instruments used by Clean Sky in meeting its goals:

- **Technologies** are selected, developed and monitored in terms of maturity or ‘Technology Readiness Level’ (TRL). A detailed list of more than one hundred key technologies has been set. The technologies developed by Clean Sky will cover all major segments of commercial and general aviation aircraft. The technologies are developed in Clean Sky by each Integrated Technology Demonstrators (ITD), and subject to TRL roadmaps. Some technologies may not directly provide an environmental outcome, being ‘enabling technologies’ without which the global achievements would not be feasible.

- **Concept Aircraft** are design studies dedicated to integrating technologies into a viable conceptual configuration. They cover a broad range of aircraft: business jets, regional and large commercial aircraft, as well as rotorcraft. They are categorized in order to represent the major future aircraft families. Clean Sky environmental results will be measured and reported mainly by comparing Concept Aircraft to existing aircraft and aircraft incorporating ‘business as usual’ technology in the world fleet.

- **Demonstration Programmes** include physical demonstrators that integrate several technologies at a larger ‘system’ or aircraft level, and validate their feasibility in operating conditions. This helps determine the true potential of the technologies and enables a realistic environmental assessment. Demonstrations in a relevant operating environment enable technologies to reach the maturity level of 6, according to the scale of levels of technology maturity developed by NASA in 1995 and called Technology Readiness Level (TRL).

It is estimated that the technology developments already made or in progress could reduce aviation CO₂ emissions by more than 20% with respect to baseline levels (in 2000), which represents an **aggregate reduction of 2 to 3 billion tonnes of CO₂ over the next 35 years**.
domains to address the common environmental objectives and to demonstrate and validate the required technology breakthroughs in a commonly defined programme. All those technology domains have been integrated into 6 Integrated Technology Demonstrators (ITD) that cover the broad range of R&D work and able to deliver together more environmental friendly aircraft manufacturing and operations:

- **Smart Fixed Wing Aircraft** - delivers active wing technologies together with new aircraft configurations, covering large aircraft and business jets. Key enabling technologies from the transversal ITDs, for instance Contra Rotating Open Rotor, are being integrated into the demonstration programmes and concept aircraft.

- **Green Regional Aircraft** - develops new technologies for the reduction of noise and emissions, in particular advanced low-weight & high performance structures, incorporation of all-electric systems, bleed-less engine architecture, low noise/high efficiency aerodynamics, and finally environmentally optimised mission and trajectory management.

- **Green Rotorcraft** - delivers innovative rotor blade technologies for reduction in rotor noise and power consumption, technologies for lower airframe drag, environmentally friendly flight paths, the integration of diesel engine technology, and advanced electrical systems for elimination of hydraulic fluids and for improved fuel consumption.

- **Sustainable and Green Engines** - designs and builds five engine demonstrators to integrate technologies for low fuel consumption, whilst reducing noise levels and nitrous oxides. The ‘Open Rotor’ is the target of two demonstrators. The others address geared turbofan technology, low pressure stages of a threeshaft engine and a new turboshaft engine for helicopters.

- **Systems for Green Operations** - focuses on all electrical aircraft equipment and system architectures, thermal management, capabilities for environmentally-friendly trajectories and missions, and improved ground operations to give any aircraft the capability to fully exploit the benefits of the “Single European Sky”.

- **Eco-Design** - supports the ITDs with environmental impact analysis of the product life-cycle. Eco-Design focuses on environmentally-friendly design and production, withdrawal, and recycling of aircraft, by optimal use of raw materials and energies, thus improving the environmental impact of the entire aircraft life-cycle.
In addition, the Technology Evaluator programme, co-led by DLR and Thales, is a set of numerical models predicting the local and global environmental impact of developed technologies and allows independent analysis of the projects Part of the Clean Sky programme is performed by partners selected through open calls for proposals addressing specific tasks which fit into the overall technical Work Programme and time schedule.

By 2014 most down-selections of key technologies have been completed for integration in demonstrators that will enter the phase of detailed design, manufacturing and testing. Several demonstrators have passed the design phase and have started testing successfully. An Advanced Lip Extended Acoustic Panel, the technology to reduce the Fan noise of large turbofan engine was flown and validated in operational conditions in 2010 with an Airbus A380-800 aircraft. A flight test with Falcon F7X, which validated the technology to visualize laminar flow structure in flight by an infrared camera, was already performed in 2010. Two flight tests started in the last quarter of 2014, namely in the Sustainable and Green Engines ITD with SAGE 3 flight testing on Advanced Low Pressure System (ALPS) configuration and the flight tests of an experimental Liquid Skin Heat Exchanger (LSHX) in the System for Green Operations ITD.

The two Interim Evaluations of Clean Sky in 2011 and 2013 acknowledged that the programme is successfully stimulating developments towards environmental targets and that it was highly successful in attracting a high level and wide participation from all EU key industries and a large number of SMEs. The preliminary assessments of the environmental benefits confirm the capability of achieving the overall targets at completion of the programme.

**Clean Sky: First Assessment (2011)**

The first assessment of the Technology Evaluator performed in 2011 demonstrated that short/medium range aircraft equipped with open rotor engines and laminar-flow wing technology could deliver up to 30% better fuel efficiency and related CO2 emissions and important reductions in noise nuisance are foreseen.

**Clean Sky: Second Assessment (2012)**

The second assessment performed in 2012 showed similar results and demonstrated that CO2 emission reduction is in the range of 20 to 30% depending on the type of aircrafts. Reduction in NOx emissions is up to 70% and in noise footprint up to 68% depending on the concept aircraft.
Based on this success, the Clean Sky 2 programme builds upon contents and achievements of the Clean Sky programme and makes further advancements towards more ambitious environmental targets.

In terms of programme structure, Clean Sky 2 continues to use the Integrated Technology Demonstrators (ITDs) mechanism but also involves demonstrations and simulations of several systems jointly at the full vehicle level through Innovative Aircraft Demonstrator Platforms (IADPs). A number of key areas are coordinated across the ITDs and IADPs through Transverse Activities (TA) where additional benefit can be brought to the Programme through increased coherence, common tools and methods, and shared know-how in areas of common interest. As in Clean Sky, a dedicated monitoring function - the Technology Evaluator (TE) - is incorporated in Clean Sky 2.

- **Large Passenger Aircraft IADP** - TRL demonstration of the best technologies to accomplish the combined key ACARE goals with respect to the environment, fulfilling future market needs and improving the competitiveness of future products.

- **Regional Aircraft IADP** - focuses on 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 IADP** - consists of two separate demonstrators, the NextGenCTR tilt-rotor and the FastCraft compound helicopter. These two fast rotorcraft concepts aim to deliver superior vehicle versatility and performance.

- **Airframe ITD** - demonstrates, as one of the key contributors to the different IADPs flight demonstrators, 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. It will also test novel engine integration strategies and investigate innovative fuselage structures.

- **Engines ITD** - focuses on activities to validate advanced and more radical engine architectures.

- **Systems ITD** - develops and builds highly integrated, high TRL demonstrators 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 TA** - aims at developing, validating and integrating key technologies on small aircraft demonstrators up to TRL6 and to revitalise an important segment of the aeronautics sector that can bring key new mobility solutions.

• **Eco-Design TA** - 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).

### 6.2 Alternative fuels

#### 6.2.1 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.14

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 201115. 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 renewable energy16) and economic aspects. It includes a number of

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15 http://www.swafea.eu/LinkClick.aspx?fileticket=llSmYPFnxY%3D&tabid=38
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. 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.

<table>
<thead>
<tr>
<th>ACARE Roadmap targets to share alternative sustainable fuels:</th>
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<tbody>
<tr>
<td>- 2% in 2020</td>
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<tr>
<td>- 25% in 2035</td>
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<tr>
<td>- at least 40% by 2050</td>
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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 Flightpath. 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 tons 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 Flightpath is explained in a technical paper, which sets out in more detail the challenges and required actions.

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;

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17 Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, COM(2011) 144 final
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;

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.

<table>
<thead>
<tr>
<th>Time horizons (Base year - 2011)</th>
<th>Action</th>
<th>Aim/Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-term (next 0-3 years)</td>
<td>Announcement of action at International Paris Air Show</td>
<td>To mobilise all stakeholders including Member States.</td>
</tr>
<tr>
<td></td>
<td>High level workshop with financial institutions to address funding mechanisms.</td>
<td>To agree on a &quot;Biofuel in Aviation Fund&quot;.</td>
</tr>
<tr>
<td></td>
<td>&gt; 1,000 tons of Fisher-Tropsch biofuel become available.</td>
<td>Verification of Fisher-Tropsch product quality. Significant volumes of synthetic biofuel become available for flight testing.</td>
</tr>
<tr>
<td></td>
<td>Production of aviation class biofuels in the hydrotreated vegetable oil (HVO) plants from sustainable feedstock</td>
<td>Regular testing and eventually few regular flights with HVO biofuels from sustainable feedstock.</td>
</tr>
</tbody>
</table>
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 tons of algal oils are becoming available.

First quantities of algal oils are used to produce aviation fuels.

Supply of 1.0 M tons of hydrotreated sustainable oils and 0.2 tons of synthetic aviation biofuels in the aviation market.

1.2 M tons 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 tons 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 Flightpath 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. During the four years since then, worldwide technical and operational progress of the industry has been remarkable. Three different pathways for the production of renewable
kerosene are now approved and several more are expected to be certified. More than 1,600 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 will be demonstrated in Oslo in 2015.

### Flights

**IATA:** 1600 flights worldwide using bio-kerosene blends

**Lufthansa:** 1189 flights Frankfurt-Hamburg using 800 tons of bio-kerosene

**KLM:** 18 flights Amsterdam-Aruba-Bonaire using 200 tons of bio-kerosene

### Production (EU)

- **Neste** (Finland): by batches

- **Frankfurt-Hamburg (6 months)** 1189 flights operated by Lufthansa: 800 tons of bio-kerosene

- **Itaka:** €10m EU funding (2012-2015): > 1 000 tons

- **Biorefly:** €13.7m EU funding: 2000 tons per year – second generation (2015) – BioChemtex (Italy)

- **BSFJ Swedish Biofuels:** €27.8m EU funding (2014-2019)
6.2.2 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 is launching projects under the Horizon 2020 research programme with capacities of the order of several 1000 tons per year.**
6.3 Improved air traffic management and infrastructure use

6.3.1 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:

- 27% increase in airspace capacity and 14% increase in airport capacity;
- Associated improvement in safety, i.e. in an absolute term, 40% of reduction in accident risk per flight hour.
- 2.8% reduction per flight in gate to gate greenhouse gas emissions;
- 6% reduction in cost per flight.

The projection of SESAR target fuel efficiency beyond 2016 (Step 1\(^{19}\)) is depicted in the following graph:

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\(^{19}\) 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
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. 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).
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:

4 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 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 16.03.02 a set of metrics for assessing GHG emissions, noise and airport local air quality has been documented. The metrics identified by 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 ongoing 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:

AIRE

The Atlantic Interoperability Initiative to Reduce Emissions (AIRE) is a programme designed to improve energy efficiency and lower engine emissions and aircraft noise in cooperation with the US FAA based on existing technologies. The SESAR JU is responsible for its management from a European perspective.

Under this initiative ATM stakeholders work collaboratively to perform integrated flight trials and demonstrations validating solutions for the reduction of CO2 emissions for surface, terminal and oceanic operations to substantially accelerate the pace of change.

3 AIRE demonstration campaigns took place between 2007 and 2014.

The AIRE 1 campaign (2008-2009), has demonstrated, with 1,152 trials performed, that significant savings can already be achieved using existing technology. CO2 savings per flight ranged from 90kg to 1250kg and the accumulated savings during trials were equivalent to 400 tons of CO2.

Another positive aspect of such pre implementation demonstrations is the human dimension. Indeed the demonstration flight strategy established in AIRE is to produce constant step-based improvements, to be implemented by each partner in order to contribute to reaching the common objective. Hence the AIRE projects boost crew and controller’s motivation to pioneer new ways of working together focusing on environmental aspects, and enables cooperative decision making towards a common goal.

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. 9416 flight trials took place. Table 2 summarises AIRE 2 projects operational aims and results.

<table>
<thead>
<tr>
<th>Project Location</th>
<th>Operation</th>
<th>Objective</th>
<th>CO2 and Noise benefits per flight (kg)</th>
<th>Nb of flights</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDM at Vienna Airport</td>
<td>CDM notably pre-departure sequence</td>
<td>CO2 &amp; Ground Operational efficiency</td>
<td>54</td>
<td>208</td>
</tr>
</tbody>
</table>

Table 2: Summary of AIRE 2 projects
<table>
<thead>
<tr>
<th>Category</th>
<th>Country</th>
<th>Description</th>
<th>CO2</th>
<th>CO2 Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greener airport operations under adverse conditions</td>
<td>France</td>
<td>CDM notably pre-departure sequence</td>
<td>79</td>
<td>1800</td>
</tr>
<tr>
<td>B3</td>
<td>Belgium</td>
<td>CDO in a complex radar vectoring environment</td>
<td>160-315; -2dB (between 10 to 25 Nm from touchdown)</td>
<td>3094</td>
</tr>
<tr>
<td>DoWo - Down Wind Optimisation</td>
<td>France</td>
<td>Green STAR &amp; Green IA in busy TMA</td>
<td>158-315</td>
<td>219</td>
</tr>
<tr>
<td>REACT-CR</td>
<td>Czech Republic</td>
<td>CDO</td>
<td>205-302</td>
<td>204</td>
</tr>
<tr>
<td>Flight Trials for less CO2 emission during transition from en-routeto final approach</td>
<td>Germany</td>
<td>Arrival vertical profile optimisation in high density traffic</td>
<td>110-650</td>
<td>362</td>
</tr>
<tr>
<td>RETA-CDA2</td>
<td>Spain</td>
<td>CDO from ToD</td>
<td>250-800</td>
<td>210</td>
</tr>
<tr>
<td>DORIS</td>
<td>Spain</td>
<td>Oceanic : Flight optimisation with ATC coordination &amp; Data link (ACARS, FANS CPDLC)</td>
<td>3134</td>
<td>110</td>
</tr>
<tr>
<td>ONATAP</td>
<td>Portugal</td>
<td>Free and Direct Routes</td>
<td>526</td>
<td>999</td>
</tr>
<tr>
<td>ENGAGE</td>
<td>UK</td>
<td>Optimisation of cruise altitude and/or Mach number</td>
<td>1310</td>
<td>23</td>
</tr>
<tr>
<td>RlongSM (Reduced longitudinal Separation Minima)</td>
<td>UK</td>
<td>Optimisation of cruise altitude profiles</td>
<td>441</td>
<td>533</td>
</tr>
<tr>
<td>Gate to gate Green Shuttle</td>
<td>France</td>
<td>Optimisation of cruise altitude profile &amp; CDO</td>
<td>788</td>
<td>221</td>
</tr>
</tbody>
</table>
CDOs were demonstrated in busy and complex TMAs although some operational measures to maintain safety, efficiency and capacity at an acceptable level had to be developed.

The AIRE 3 campaign (2012-2014)

Table 3 below summarises the nine projects of the third AIRE campaign. Seven of them are completed. A detailed analysis of the results is on-going.
<table>
<thead>
<tr>
<th>Project name</th>
<th>Objectives</th>
<th>Expected results</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>CANARIAS</td>
<td>Reduction of track miles, fuel consumption (and therefore CO₂) through optimised vertical and horizontal paths compared with existing arrival procedures.</td>
<td>Reduction of:  - 90-180 kg of fuel burn per flight.  - 285-570 kg of CO₂ emissions per flight.</td>
<td>La Palma, Lanzarote</td>
</tr>
<tr>
<td>AMBER</td>
<td>Design, validation and test RNAV STARS and RNP-AR arrivals, in order to reduce CO₂ emissions and noise in the airport’s vicinity.</td>
<td>Reduction of:  - 70-120 kg of fuel burn per flight.  - 220-380 CO₂ emissions per flight.</td>
<td>Riga Airport</td>
</tr>
<tr>
<td>REACT-PLUS</td>
<td>Introduction of more efficient flight profiles by identifying and implementing Continuous Descent Approaches (CDA) and Continuous Climb Departures (CCD).</td>
<td>Reduction of:  - 70-120 kg of fuel burn per flight.  - 220-380 CO₂ emissions per flight.</td>
<td>Budapest Airport</td>
</tr>
<tr>
<td>OPTA-IN</td>
<td>Achieve optimised descent procedures (with current systems) using the OPTA speed control concept and an ad-hoc air traffic control tool.</td>
<td>Reduction of:  - 22-30% of fuel burn per flight.  - 126-228 CO₂ per flight.</td>
<td>Palma de Mallorca Airport</td>
</tr>
<tr>
<td>SMART</td>
<td>Optimisation of oceanic flights by seeking the most economical route under actual meteorological conditions. It involves integration</td>
<td>Reduction of:  - 2% fuel burn per flight.  - 2% CO₂ emissions per flight.</td>
<td>Lisbon FIR, Santa Maria FIR, New York Oceanic</td>
</tr>
</tbody>
</table>
of various flight plans, position and meteorological data between the ATM system and Airline Operations Centre.

<table>
<thead>
<tr>
<th>SATISFIED</th>
<th>Trial and assess the feasibility of implementing flexible optimised oceanic routes.</th>
<th>Reduction of CO₂ emissions per flight.</th>
<th>EUR-SAM corridor</th>
</tr>
</thead>
</table>
| ENGAGE PHASE II | Expands on the work of ENGAGE (AIRE II) and aims at demonstrating safety and viability of progressive step climb or continuous altitude change. | Reduction of:  
• 416 kg of fuel per flight.  
• 1310 kg of CO₂ emissions per flight. | North Atlantic |
| WE FREE | Flight trials for free route optimisation during weekends using flights between Paris CDG and airports in Italian cities. | Reduction of CO₂ emissions per flight. | France  
Switzerland  
Italy |
| MAGGO | Foster quick implementation of enhancements in the Area Control Centres (ACC) and Tower (TWR) communications and surveillance. | Fuel savings of 0.5% per flight. | Santa Maria FIR  
Santa Maria TMA |

Everyone sees the “AIRE way of working together” as an absolute win-win to implement change before the implementation of SESAR solutions.

SESAR next programme (SESAR 2020) includes very large scale demonstrations which should include more environmental flight demonstrations and go one step further demonstrating the environmental benefits of the new SESAR solutions.
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. 17 solutions have already been identified in the key areas of the ATM Master Plan. SESAR Solutions according to a study conducted by the SJU will help saving 50 million tons of CO₂ emissions. However to fully achieve SESAR benefits the SESAR solutions must be deployed in a synchronised and timely manner.

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.

1. 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.

2. 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.

3. 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.

4. 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.
5. 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.

6. 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.

The fuel efficiency expected benefits from the deployment of these solutions is 66% reduction of fuel burn resulting in EUR 0.8 billion (6%) CO₂ credit savings.

6.4 Economic/market-based measures

6.4.1 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 CO₂ emissions, encompassing those from around 12,000 power stations and industrial plants in 31 countries, and, under its current scope, around 600 commercial and non-commercial aircraft operators that have flown between airports in the European Economic Area (EEA)²⁰.

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

²⁰ Estimate from Eurocontrol, to be updated following reporting of 2013 and 2014 emissions by 31 March 2015.
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, following more than a decade of inaction with respect to the introduction of a global market based measure aiming at reducing the impact of aviation on climate change on the level of the International Civil Aviation Organization (ICAO), legislation to include aviation in the EU ETS was adopted in 2008 by the European Parliament and the Council. The 2006 proposal to include aviation in the EU ETS was accompanied by detailed impact assessment. 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. This is an important step and follows years of pressure from the EU for advancing global action. 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. The temporary limitation applies for 2013-2016, following on from the April 2013 'stop the clock' Decision adopted to promote progress on global action at the 2013 ICAO Assembly.

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22 http://ec.europa.eu/clima/policies/transport/aviation/documentation_en.htm
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.

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) No 600/2012 and 601/2012.

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 CO₂ 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 CO₂ 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 CO₂ 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 CO₂ 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 CO₂ emissions from the aviation sector itself can exceed the number of allowances allocated to it, as the increase is offset by CO₂ emissions reductions in other sectors of the economy.

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 CO₂ emissions from aviation activities carried out between aerodromes located in the EEA amounted to 54.9 million tonnes of CO₂ in 2014. This means that the EU ETS will contribute to achieve around 16 million tonnes of emission reductions annually, or almost 65 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 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, 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.\textsuperscript{27}

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.\textsuperscript{28} 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\textsubscript{2} emissions for the scope that is covered. Other emissions reduction measures taken, either at supranational level in Europe or by any of the 31 individual states implementing the EU ETS, will also contribute towards the ICAO global goals. Such measures are likely to moderate the anticipated growth in aviation emissions.

### 6.5 EU initiatives in third countries

#### 6.5.1 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\textsubscript{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 2010 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:

\footnote{For further information, see http://ec.europa.eu/clima/policies/lowcarbon/ner300/index_en.htm}

\footnote{For further information, see http://ec.europa.eu/clima/news/articles/news_2014102801_en.htm}

Caribbean: Dominican Republic and Trinidad and Tobago.

6.5.2 Support to voluntary actions: 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 CO2 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.

Now covering ACI member airports in three ACI regions, Europe, Asia-Pacific, Africa, it is poised to move to Latin America and North America in the coming years. The number of airports participating in the programme has grown from 17 in Year 1 (2009-2010) to 102 at the end of Year 5 – an increase of 85 airports or 500% in participation. Airport participation in the programme now covers 23.2% of world 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”.

Levels of certification (ACA Annual Report 2013-2014)

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 CO2 reduction associated with the activities they control.

In 2014, 5 years after the launch of the programme, 85 European airports were accredited, representing 62.8% of European passenger traffic.

**Anticipated benefits:**

The Administrator of the programme has been collecting CO2 data from participating airports over the past five years. This has allowed the absolute CO2 reduction from the participation in the programme to be quantified.

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<tr>
<td>Total aggregate scope 1 &amp; 2 reduction (tCO2)</td>
<td>51,657</td>
<td>54,565</td>
<td>48,676</td>
<td>140,009</td>
<td>129,937</td>
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<tr>
<td>Total aggregate scope 3 reduction (tCO2)</td>
<td>359,733</td>
<td>675,124</td>
<td>365,528</td>
<td>30,155</td>
<td>223,905</td>
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<tr>
<th>Variable</th>
<th>Year 4</th>
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<tr>
<td>Emissions</td>
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Aggregate carbon footprint for ‘year 0’\textsuperscript{29} for emissions under airports’ direct control (all airports) & 2,553,869 tonnes CO2 & 75 & 2,044,683 tonnes CO2 & 85 \\
Carbon footprint per passenger & 2.75 kg CO2 & & 2.01 kg CO2 & \\
Aggregate reduction in emissions from sources under airports’ direct control (Level 2 and above)\textsuperscript{30} & 158,544 tonnes CO2 & 43 & 87,449 tonnes CO2 & 56 \\
Carbon footprint reduction per passenger & 0.22 kg CO2 & & 0.11 kg CO2 & \\
Total carbon footprint for ‘year 0’ for emissions sources which an airport may guide or influence (level 3 and above)\textsuperscript{31} & 12,176,083 tonnes CO2 & 26 & 6,643,266 tonnes CO2\textsuperscript{32} & 31 \\
Aggregate reductions from emissions sources which an airport may guide or influence & 30,155 tonnes CO2 & & 223,905 tonnes CO2 & \\
Total emissions offset (Level 3+) & 66,724 tonnes CO2 & 15 & 181,496 tonnes CO2 & 16 \\

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.

\textsuperscript{29} ‘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.

\textsuperscript{30} This figure includes increases in emissions at airports that have used a relative emissions benchmark in order to demonstrate a reduction.

\textsuperscript{31} These emissions sources are those detailed in the guidance document, plus any other sources that an airport may wish to include.
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.
7 NATIONAL ACTIONS IN SWEDEN

This section is complementary to the Supra-national actions described in section 6 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.

7.1 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 is providing an expert for the development of a new CO$_2$ standard in the CO$_2$ task group within CAEP’s Working Group 3.

7.2 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.

EcoFly - structured environmental co-operation between stakeholders

In EcoFly, LFV 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.

EcoFly 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.

EcoFly 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 CO2 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 EcoFly co-operation 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 CO2.
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 are implementing 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 CO2-emissions by 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). Swedavia suggest this type of condition in all applications. Regarding Göteborg/Landvetter Airport a new condition for departing traffic would lead to a yearly carbon dioxide reduction of 450 tonnes, based on the existing traffic volume of approximately 30 000 take-offs. Also Malmö Airport has the same type of condition, but here the aircraft can leave SID when the noise level is below 70 dB(A) on the ground.

**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.

**7.3 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 6.2.1 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 CO\textsubscript{2} emissions by about 2% - a reduction of over 10 million tonnes of CO\textsubscript{2} each year. Each commercial plant producing 200,000 tonnes of Swedish Biofuels technology will save 468,000 tonnes of CO\textsubscript{2} 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\textsubscript{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 Nordic

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 Nordic. 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 has joined the initiative, together with SAS, KLM and Braathens Aviation. The goal is to have biofuel representing 25 percent of the total fuel for domestic aviation in Sweden by 2025.

7.4 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 CO₂ compared to a nominal scenario and the fuel consumption in 2014 corresponded to 0,026 litres/RPK (Revenue Passenger Kilometre).

Braathens Aviation has a continues ambition to lower the CO₂ 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 Auxiliary Power Unit (APU).

### 7.5 Economic/Market-based measures

#### NOx charges

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

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

7.6 Other measures

European airport carbon accreditation

The Airport Carbon Accreditation Scheme is described in section 6.5.2. 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 CO2 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 Nordic and NISA.