

ACTION PLAN OF SWEDEN

With reference to Resolution A37-19 – Climate change

June 2012

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INTRODUCTION

- a) Sweden is a member of the European Union (EU) and of the European Civil Aviation Conference (ECAC). ECAC is an intergovernmental organisation covering the widest grouping of Member States¹ 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 ongoing 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 a State Action Plan on emissions reductions, as an important step towards the achievement of the global collective goals agreed at the 37th Session of the ICAO Assembly in 2010.
- e) In that context, it is the intention that all ECAC States submit to ICAO an Action Plan, regardless of whether or not the 1% de minimis threshold is met, thus going beyond the agreement of ICAO Assembly Resolution A/37-19. 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

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.

- ii. research and development on emission reductions technologies, including public-private partnerships
 - iii. the development and deployment of low-carbon sustainable alternative fuels, including research and operational initiatives undertaken jointly with stakeholders
 - iv. the optimisation and improvement of Air Traffic Management, and infrastructure use within Europe, in particular through the Single European Sky ATM Research (SESAR), and also beyond European borders, through the Atlantic Initiative for the Reduction of Emissions (AIRE) in cooperation with the US FAA.
 - v. Market-based measures, such as open emission trading schemes (ETS), which allow the sector to continue to grow in a sustainable and efficient manner, recognising 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 under an ETS of CO₂ allowances from 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 EU. They are reported in Section 1 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 2 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).

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. ² In size Sweden is almost comparable to e.g. Spain and France.

Sweden has almost 9.5 million inhabitants, with 21 percent of the population in Sweden are younger than 18 years old and about 18 percent have passed the retirement age of 65³.

Sweden has a population density of 21 inhabitants per square kilometers with the population mostly concentrated to the southern half of the country. Approximately 84 percent of the Swedish population lives in urban areas and the population live on 1.3 percent of the land area. ⁴

Airports

After a split of the former Civil Aviation Administration, a state owned company for airport operations, *Swedavia AB*⁵ was established in 2009 as well as a public enterprise that manages air navigation services for civil and military customers, *LFV*⁶.

The plan to create a limited company for airport operations date back almost 20 years and the idea was to achieve clear-cut rules and regulations regarding division of responsibility between owners, board and management.

Today there are 51 IFR aerodromes in Sweden, and 40 of these are operated with commercial air traffic. Of the 40 with commercial air traffic there are 24 owned by municipalities, 11 are state-owned (by Swedavia) and five have other ownership structures e.g. limited liabilities.

² www.sweden.se

³ www.scb.se

⁴ http://www.scb.se/statistik/publikationer/BO0801_2007A01_BR_BO01SA0701.pdf

⁵ www.swedavia.se

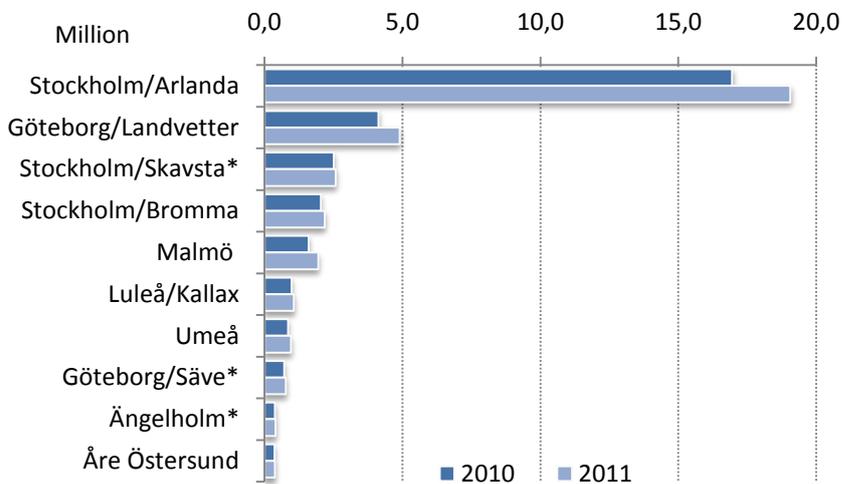
⁶ www.lfv.se



Figure 1. Swedish Airports 2012.

Top 10 airports regarding passengers

The largest aerodromes based upon departing and arriving passengers can be seen in figure 2. Approximately 19 million passengers travelled to or from Stockholm -Arlanda in 2011 and approximately 5 million to or from Göteborg-Landvetter. Seven of the airports among the “top 10 airports” are owned by Swedavia and three are private airports (notated * in figure 2).

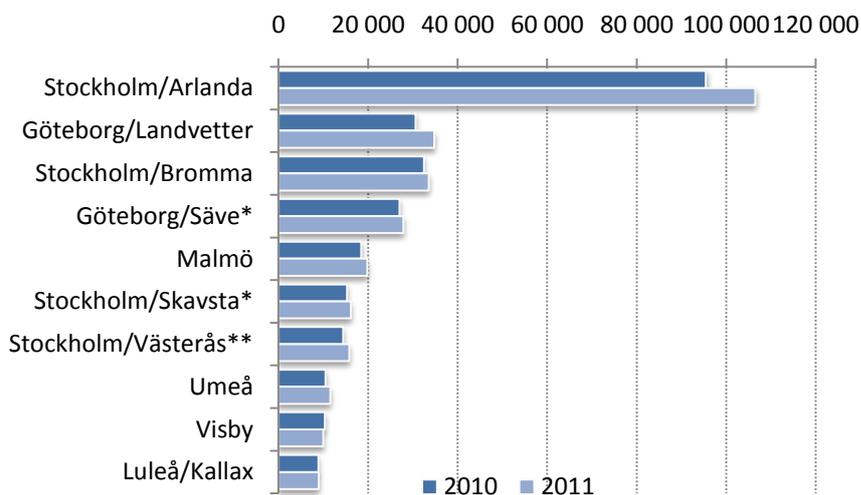


* Private airport

Figure 2. Number of scheduled and non-scheduled passengers at the top 10 airports 2010 and 2011

Top 10 airports regarding landings

The top 10 airports in terms of landings can be seen in figure 3. At e.g. Stockholm/Arlanda were almost 110 000 landings registered and at Göteborg/Landvetter were approximately 35 000 landings registered in 2011. Among the top 10 airports in relation to landings are seven owned by Swedavia, two are private airports and one is a municipal airport (notated * and ** respectively in figure 3).



* Private airport, ** Municipal airport

Figure 3. Number of landings at the top 10 airports 2010 and 2011

In 2011, 92 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 (51 percent), Göteborg/Landvetter (13 percent) and Stockholm/Skavsta (7 percent). Of the top 10 airports are

seven owned by Swedavia. 85 per cent of all passengers arrived or departed at the eleven Swedavia airports in 2011.

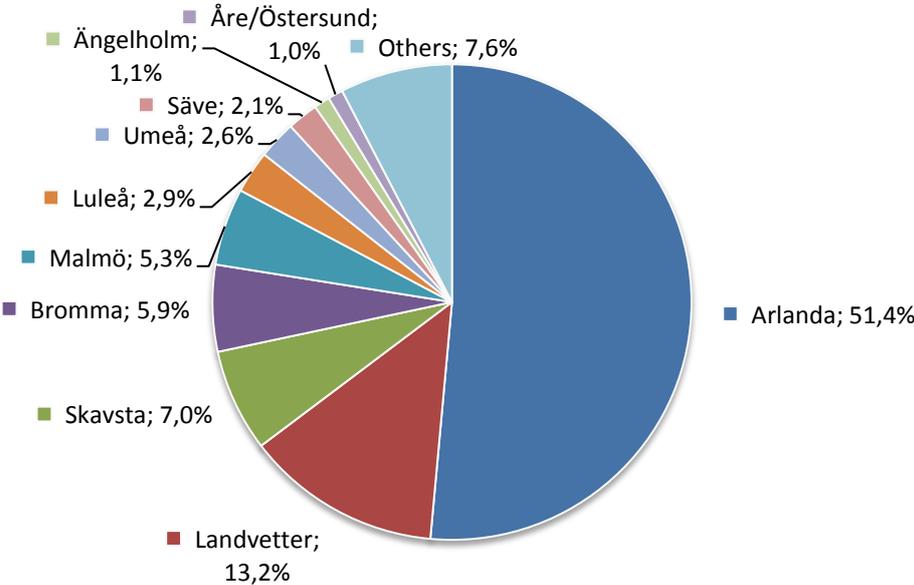


Figure 4. Airport's market shares 2011

Air Navigation Services

LFV (a public enterprise) has 1,300 employees that operate air navigation services for civil and military customers at 35 locations in Sweden⁷. Until September 2010, LFV was the only provider of air navigation services in Sweden but today the air traffic services market is exposed to competition. The air traffic services at Västerås, Växjö, Örebro and Trollhättan airports are managed by Aviation Capacity Resources AB (ACR). Another provider is NUAC HB⁸. 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 will take over the en route operations from Naviair and LFV and will as an ANS provider deliver Air Traffic Management (ATM) in the Danish/Swedish FAB⁹.

Passengers

In 2011, 18.5 million passengers departed from the Swedish airports, all time high figures. Departing passengers increased with almost 12 per cent between 2010 and 2011. With an adjustment for the volcanic ash impact on aviation in April 2010, the growth in 2011 is estimated to about 9 percent.

⁷ www.lfv.se

⁸ NUAC HB is a joint subsidiary owned by Danish Naviair and Swedish LFV

⁹ www.nuac.eu

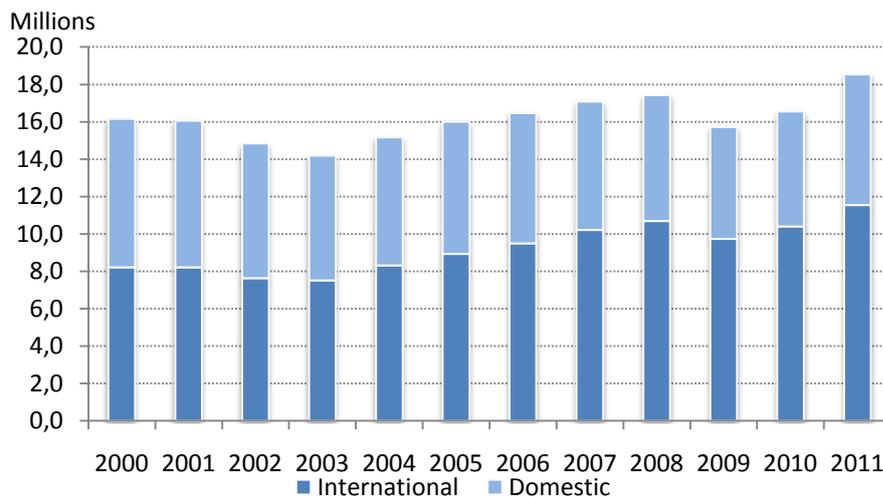


Figure 5. Number of international and domestic departing passengers in scheduled and non-scheduled traffic at Swedish airports 2000-2011

Movements

In 2011 were 706 000 IFR-movements (international and domestic) recorded in Swedish airspace. It is 20 000 fewer than the all time high level in 2008. The growth was about 8 per cent in 2011 compared to 2010. Overflights amount to about 42 per cent of the movements 2011, a proportion that have not changed during the last five years, see figure 6.

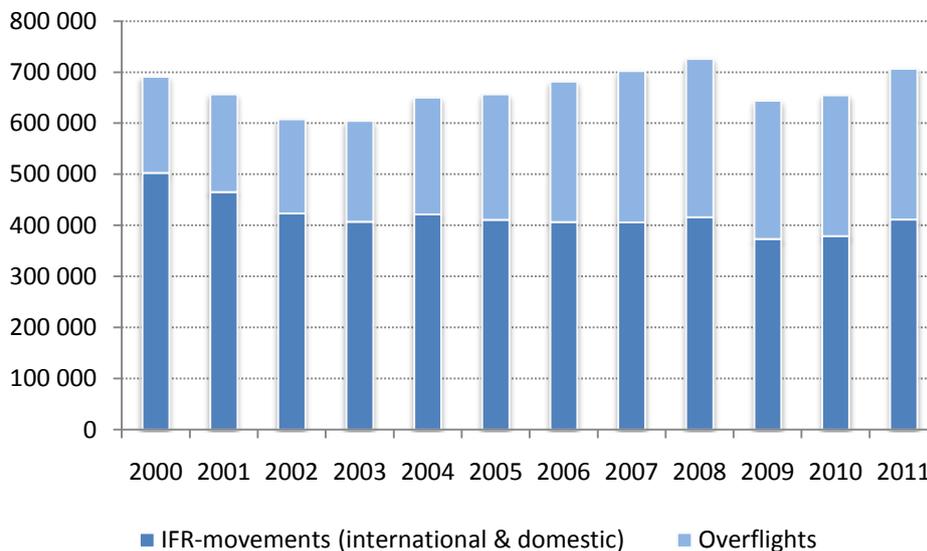


Figure 6. Number of international and domestic IFR-movements at Swedish airports and over flights in Swedish airspace 2000-2011

Freight and mail

In total 175 tonnes freight and mail arrived or departed at the Swedish airports in 2011. This is a decrease of about 11 per cent compared to 2010. See figure 7

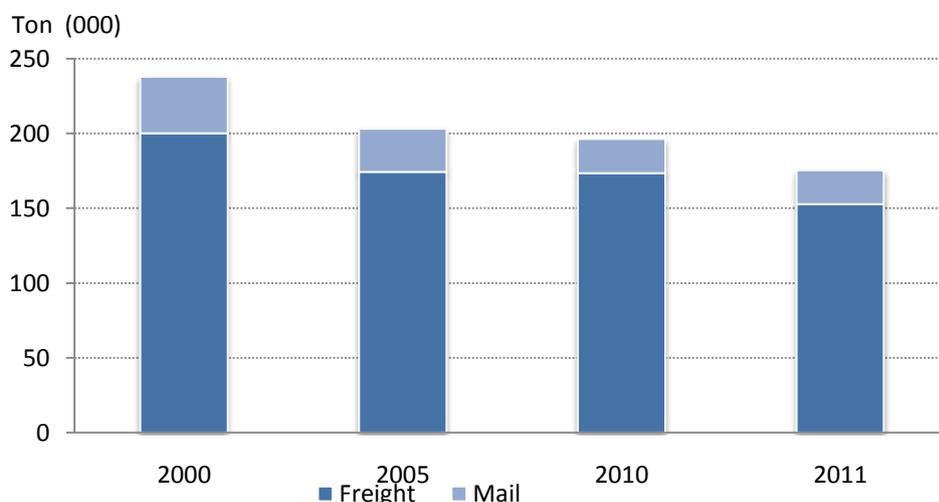


Figure 7. Freight and mail in tonnes loaded and unloaded at Swedish airports 2000, 2005, 2010 and 2011

Air operators /Aircrafts- operating licenses

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

Aircraft carriers with aircraft with maximum take-off weight of less than 10 tonnes and/or less than 20 seats are included in *category B*. Within category B there are 28 operating licenses granted in Sweden. Among these are 11 corporations operating with airplanes, 16 operating with helicopters and one is operating with both airplanes and helicopters.

Among these, in total 41 operators, are 26 operators EU-OPS licensed. In 2011 Sweden had 3 089 Swedish registered aircraft (compared to 3 153 in 2010). Of these were 1 676 airworthy (1 993 in 2010)¹⁰ and almost 76 percent of the aircraft weighing less than 5 700 kg.

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

Concerning domestic air traffic, SAS, obtained 42 percent of the market shares in 2011 and Malmö Aviation obtained 19 percent of the passengers in the domestic market. See figure 8.

¹⁰

http://www.transportstyrelsen.se/Global/Om_oss/Transportstyrelsens%20%C3%A5rsredovisning%202011.pdf

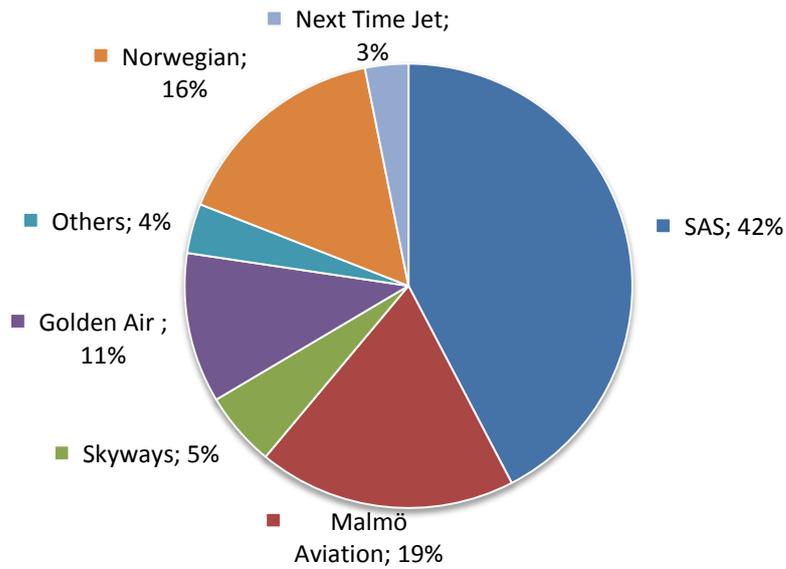


Figure 8. Domestic market shares related to passengers, 2011

Regarding international air traffic, SAS, obtained 21 percent of the market shares in 2011, Ryanair obtained 13 percent and Norwegian 10 percent. Note that the category “Others” is considerably larger, compared to domestic traffic regarding international traffic (39 and 4 percent respectively) see figure 9.

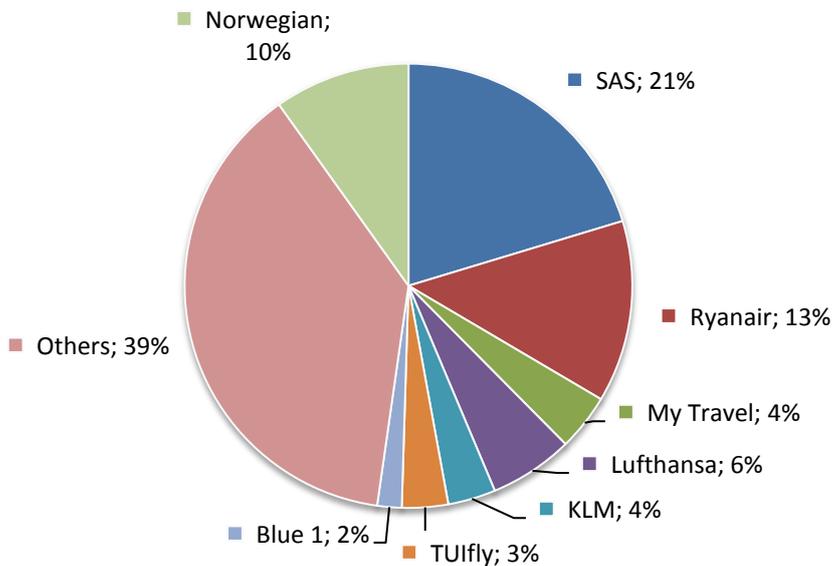


Figure 9. International market shares related to passengers, 2011

CO2 emissions reported by Sweden for 2005-2010 based on the IPCC guidelines

Year	2005	2006	2007	2008	2009	2010
Domestic Aviation	663	623	605	634	517	465
International Aviation	1 936	2 006	2 195	2 354	2 008	2 066

Figure 10. CO2 emissions (1000 metric tons) reported by Sweden. From Sweden's National Inventory Report 2012, submitted under the United Nations Framework Convention on Climate Change (Source: Swedish EPA)

SECTION 1- Supra-national actions

1. AIRCRAFT RELATED TECHNOLOGY DEVELOPMENT

Aircraft emissions standards

European states fully support the ongoing work in ICAO's Committee on Aviation Environmental Protection (CAEP) to develop an aircraft CO₂ standard. Assembly Resolution A37-19 requests the Council to develop a global CO₂ standard for aircraft aiming for 2013. It is recognised that this is an ambitious timeframe for the development of a completely new ICAO standard. Europe is contributing to this task notably through the European Aviation Safety Agency providing the co-rapporteurship of the CO₂ task group within CAEP's Working Group 3.

In the event that a standard, comprising certification requirement and regulatory level, is adopted in 2013, it is likely to have an applicability date set some years in the future. The contribution that such a standard will make towards the global aspirational goals will of course depend on the regulatory level that is set, but it seems unlikely that an aircraft CO₂ standard could have any significant effect on the fuel efficiency of the global in-service fleet until well after 2020.

Research and development

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

Joint Technology Initiatives are specific large scale EU research projects created by the European Commission within the 7th Framework Programme (FP7) 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 will pull together the research and technology resources of the European Union in a coherent, 7-year, €1.6bn programme, and contribute significantly to the 'greening' of aviation.

The Clean Sky goal is to identify, develop and validate the key technologies necessary to achieve major steps towards the Advisory Council for Aeronautics Research in Europe (ACARE) environmental goals for 2020 when compared to 2000 levels:

- Fuel consumption and carbon dioxide (CO₂) emissions reduced by 50%

- Nitrous oxides (NO_x) emissions reduced by 80%
- Perceived external noise reduction of 50%
- Improved environmental impact of the lifecycle of aircraft and related products.

Three complementary instruments are used by Clean Sky in meeting these goals:

Technologies.

These 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 aircraft.

Concept Aircraft.

These are design studies dedicated to integrating technologies into a viable conceptual configuration, and assessing their potential and relevance. They cover a broad range of aircraft: business jets, regional and large commercial aircraft, as well as rotorcraft. They have been grouped and categorised in order to represent the major future aircraft families. Clean Sky's environmental results will be measured and reported upon principally by Concept Aircraft.

Demonstration Programmes.

Some technologies can be assessed during their development phase, but many key technologies need to be validated at an integrated vehicle or system level via dedicated demonstrators. These demonstrators pull together several technologies at a larger "system" or aircraft level. Airframe, Engine and Systems technologies are monitored through in-flight or large scale ground demonstrations. The aim is to validate the feasibility of these technologies in relevant (in-flight or operating) conditions. Their performance can then be predicted in areas such as mechanical or in-flight behaviour. This in turn will help determine the true potential of the technologies and enable a realistic environmental assessment. Demonstrations enable technologies to reach a higher level of maturity (or TRL: technology readiness level), which is the "raison d'être" of Clean Sky.

The environmental objectives of the programme are determined by evaluating the performance of concept aircraft in the global air transport system (when compared to 2000 level technology and to a "business as usual" evolution of technology). The ranges of environmental improvements result from the sum of technologies which are expected to reach TRL5-6 within the programme timeframe. While not all of these technologies will be developed directly through the Clean Sky programme, it is neither feasible nor relevant at this stage to isolate the benefits derived purely from Clean Sky technologies, as Clean Sky will achieve a significant synergy effect in European Aeronautics Research by maturing closely linked technologies to a materially higher TRL through demonstration and integration.

Clean Sky activities are performed within six "**Integrated Technology Demonstrators**" (ITDs) and a "**Technology Evaluator**".

The three vehicle-based ITDs will develop, deliver and integrate technologies into concrete aircraft configurations. The two "transversal" ITDs are focused on propulsion and systems, and will deliver technologies, which will be integrated in various aircraft configurations by the vehicle ITDs. A further ITD will focus specifically on the life cycle assessment and 'eco-design' philosophy.

Smart Fixed Wing Aircraft (SFWA) – co-led by Airbus and SAAB - will deliver innovative 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, will be integrated into the demonstration programmes and concept aircraft.

Green Regional Aircraft (GRA) – co-led by Alenia and EADS CASA - will develop 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 (GRC) – co-led by Agusta Westland and Eurocopter - will deliver 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 (SAGE) - co-led by Rolls-Royce and Safran - will design and build 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 turboprop technology, low pressure stages of a three-shaft engine and a new turboshaft engine for helicopters.

Systems for Green Operations (SGO) - co-led by Liebherr and Thales - will focus 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 - co-led by Dassault and Fraunhofer Gesellschaft - will support the ITDs with environmental impact analysis of the product life-cycle. Eco-Design will focus 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.

Complementing these six ITDs, the **Technology Evaluator (TE)** is a dedicated evaluation platform cross-positioned within the Clean Sky project structure. The TE is co-led by DLR and Thales, and includes the major European aeronautical research organisations. It will assess the environmental impact of the technologies developed by the ITDs and integrated into the Concept Aircraft. By doing this, the TE will enable Clean Sky to measure and report the level of success in achieving the environmental objectives, and in contributing towards

the ACARE environmental goals. Besides a mission level analysis (aircraft level), the positive impact of the Clean Sky technologies will be shown at a relevant hub airport environment and across the global air transport system.

The first assessment by the Technology Evaluator on the way to meeting Clean Sky's environmental objectives is planned for the end of 2011. The ranges of potential performance improvement (reduction in CO₂, NO_x and Noise) will be narrowed or evolved during the life of the programme based on the results from the key technologies developed and validated through the demonstrations performed.

Clean Sky is a 'living' programme: each year, Annual Implementation Plans are produced and agreed, and research priorities are (re-)calibrated based on results achieved. The best approach to progressing the technologies is pursued. The Clean Sky JU uses regular Calls for Proposals to engage with the wider aeronautical industry, research organisations and universities in order to bring the best talent on board and enable broad collaborative participation. A very significant share of the Clean Sky research programme is already being taken on by Europe's aerospace related SMEs, and by September 2011 nine Calls for Proposals will have been completed, demonstrating the JU's commitment to involving all competent organisations in the European aeronautics research arena. In June 2011, a major and exciting milestone was reached with the 400th partner joining the Clean Sky programme.

2. ALTERNATIVE FUELS

European Advanced Biofuels Flightpath

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 goal was to provide the European Commission with information and decision elements to support its future air transport policy, in the framework of the European commitment to promote renewable energy for the mitigation of climate change, security of supply and also to contribute to Europe's competitiveness and economic growth.

The study team involved 20 European and international organisations, representing all players in alternative aviation fuels: aircraft and engine manufacturing, air transport, oil industry, research and consulting organisations covering a large spectrum of expertise in the fields of fuel, combustion, environment as well as agriculture.

The SWAFEA final report was published in July 2011¹¹. 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 energy¹²) and economic aspects. It includes a number of

¹¹ <http://www.swafea.eu/LinkClick.aspx?fileticket=IIISmYPFNxY%3D&tabid=38>

¹² Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC

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 transport¹³. 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.

As a first step towards delivering this goal, in June 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 Flight path is explained in a technical paper, which sets out in more detail the challenges and required actions¹⁴.

More specifically, the initiative focuses on the following:

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

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.

¹³ Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, COM(2011) 144 final

¹⁴ http://ec.europa.eu/energy/technology/initiatives/doc/20110622_biofuels_flight_path_technical_paper.pdf

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

	biofuels and pyrolytic oils from residues.	
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.

3. IMPROVED AIR TRAFFIC MANAGEMENT AND INFRASTRUCTURE USE

The EU's Single European Sky initiative and SESAR

The EU's Single European Sky initiative was originally launched by the European Commission in 1999. Its fundamental aim is to reform the architecture of European air traffic control to meet future capacity and safety needs. Its main principles are to reduce fragmentation in European air traffic management, between states, between civil and military, and between systems; to introduce new technology; and to establish a new regulatory framework built on closer synergy between the EU and Eurocontrol.

The first package of EU Single European Sky legislation was adopted by the Council and European Parliament in 2004. This was followed in 2009 by the Single European Sky II package of measures, which comprises five main pillars: performance, safety, technology, airport capacity and the human factor. The aim is to improve the performance of air navigation services by reducing the cost of flights, while improving the capacity and better preserving the environment, all having regard to the overriding safety objectives.

Reducing fragmentation in European air traffic management is expected to result in significant efficiency and environmental improvements. A core starting point is the reduction of the current surplus length of flights in Europe, estimated on average to be almost 50 km. The defragmentation of European airspace with new possibilities for more direct routing, and efforts to define a true pan European network of routes and to implement flexible use of airspace are expected to result in emission reductions of 2% per year.

SESAR

SESAR (Single European Sky ATM Research) is the technological component of the Single European Sky (SES). It is a €2.1bn Joint Undertaking, funded equally by the EU, Eurocontrol and industry (€700m EU, €700m Eurocontrol, €700m industry). Fifteen companies are members of the SESAR JU: AENA, Airbus, Alenia Aeronautica, the DFS, the DSNA, ENAV, Frequentis, Honeywell, INDRA, NATMIG, NATS (En Route) Limited, NORACON, SEAC, SELEX Sistemi Integrati and Thales. The SESAR SJU includes an additional thirteen

associate partners including non-European companies with different profiles and expertise.

SESAR aims to help create a "paradigm shift" by putting performance-based operations at the core of air traffic management's objectives, and will be supported by state-of-the-art and innovative technology capable of ensuring the safety, sustainability and fluidity of air transport worldwide over the next 30 years. It is composed of three phases:

- The Definition phase (2004-2008) delivered the ATM master plan defining the content, the development and deployment plans of the next generation of ATM systems. This definition phase was led by Eurocontrol, and co-funded by the European Commission under the Trans European Network-Transport programme and executed by a large consortium of all air transport stakeholders.
- The Development phase (2008-2013) will produce the required new generation of technological systems, components and operational procedures as defined in the SESAR ATM Master Plan and Work Programme.
- The Deployment phase (2014-2020) will see the large scale production and implementation of the new air traffic management infrastructure, composed of fully harmonised and interoperable components guaranteeing high performance air transport activities in Europe.

Implementation of SESAR in general will facilitate the following:

- Moving from airspace to trajectory based operations, so that each aircraft achieves its agreed route and time of arrival and air and ground systems share a common system view.
- Collaborative planning so that all parties involved in flight management from departure gate to arrival gate can strategically and tactically plan their business activities based on the performance the system will deliver.
- An information rich ATM environment where partners share information through system wide information management.
- A globally agreed 4D trajectory definition and exchange format at the core of the ATM system where time is the 4th dimension providing a synchronised "time" reference for all partners.
- Airspace users and aircraft fully integrated as essential constituents and nodes of the ATM system.
- Dynamic airspace management and integrated co-ordination between civil and military authorities optimising the available airspace.
- Network planning focused on the arrival time as opposed to today's departure based system with Airport airside and turn-around fully integrated into ATM.
- New Communication, Navigation & Surveillance (CNS) technologies providing for more accurate airborne navigation and spacing between aircraft to maximise airspace and airport efficiency, improve communication and surveillance.
- Central role for the human widely supported by automation and advanced tools ensuring safe working without undue pressure.

Within the SESAR programme most of the almost 300 projects include environmental aspects of aviation. They concern aircraft noise management and mitigation, aircraft fuel use and emissions management etc. throughout all of SESAR's 16 work packages. The Joint Undertaking's role is to establish environmental sustainability as an integral aspect of broader ATM development and operating processes.

SESAR aims at reducing the environmental impact per flight by 10% without compromising on safety but with clear capacity and cost efficiency targets in mind. More specifically, in addressing environmental issues, SESAR will:

1. Achieve emission improvements through the optimisation of air traffic management services. The SESAR target for 2020 is to enable 10% fuel savings per flight as a result of ATM improvements alone, leading to a 10% reduction of CO₂ emissions per flight;
2. Improve the management of noise emissions and their impacts through better flight paths, or optimised climb and descent solutions;
3. Improve the role of ATM in enforcing local environmental rules by ensuring that flight operations fully comply with aircraft type restrictions, night movement bans, noise routes, noise quotas, etc.;
4. Improve the role of ATM in developing environmental rules by assessing the ecological impact of ATM constraints, and, following this assessment, adopting the best alternative solutions from a European sustainability perspective.
5. Accompany the development of new procedures and targets with an effective regulatory framework in close cooperation with the European Commission;
6. Implement more effective two-way community relations and communications capabilities at local and regional levels including a commonly agreed environmental strategy and vision.

By 2012 SESAR is expected to deliver fuel burn reductions of approximately 2% (compared with a baseline 2010), to demonstrate environmental benefits on city pairs connecting 8 European airports, and to have airspace users signing up to the SESAR business case (including the environment case) for time-based operations.

Operational improvements: 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. 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.

AIRE has demonstrated in 2009, with 1,152 trials performed, that significant savings can 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 is the human dimension - the AIRE projects boost crew and controller motivation to pioneer new ways of working together focusing on environmental aspects, and enabled cooperative decision-making towards a common goal.

The strategy is to produce constant step-based improvements, to be implemented by each partner in order to contribute to reaching the common objective. In 2010 demand for projects has more than doubled and a high transition rate from R&D to day-to-day operations, estimated at 80%, from AIRE 2009 projects was observed (expected to further increase with time). Everyone sees the "AIRE way of working together" as an absolute win-win to implement change before the implementation of more technology intensive ATM advancements expected for the period 2013 onward. A concrete example of the progress achieved is that, due to AIRE, both FAA and NAV Portugal offer lateral optimisation over the transatlantic routes to any user upon request. In July 2010, the SESAR JU launched a new call for tender and had an excellent response - 18 projects were selected involving 40 airlines, airport, air navigation service providers and industry partners. More than 5,000 trials are expected to take place.

4. ECONOMIC / MARKET-BASED MEASURES

The EU Emissions Trading System

The EU Emissions Trading System (EU ETS) is a cornerstone of the European Union's policy to combat climate change and its key tool for reducing industrial greenhouse gas emissions cost-effectively. Being the first and biggest international scheme for the trading of greenhouse gas emission allowances, the EU ETS currently covers some 11,000 power stations and industrial plants in 30 countries.

Launched in 2005, 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 and other installations in the system. Within this cap, companies receive emission allowances which they can sell to or buy from one another as needed. The limit on the total number of allowances available provides certainty that the environmental objective is achieved and ensures that the allowances have a market value.

At the end of each year each company must surrender enough allowances to cover all its emissions, otherwise heavy fines are imposed. If a company reduces its emissions, it can keep the spare allowances to cover its future needs or else 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 is reduced over time so that total emissions fall.

The EU ETS now operates in 30 countries (the 27 EU Member States plus Iceland, Liechtenstein and Norway). It currently covers CO₂

emissions from installations such as power stations, combustion plants, oil refineries and iron and steel works, as well as factories making cement, glass, lime, bricks, ceramics, pulp, paper and board. Between them, the installations currently in the scheme account for almost half of the EU's CO₂ emissions and 40% of its total greenhouse gas emissions.

The EU ETS will be further expanded to the petrochemicals, ammonia and aluminium industries and to additional gases (PFCs and N₂O) in 2013, when the third trading period starts. At the same time a series of important changes to the way the EU ETS works will take effect in order to strengthen the system.

The legislation to include aviation in the EU ETS was adopted in November 2008, and entered into force as Directive 2008/101/EC of the European Parliament and of the Council on 2 February 2009. The proposal to include aviation in the EU ETS, made by the European Commission in December 2006, was accompanied by a detailed impact assessment.

Under the EU ETS, the emissions cap is increased to accommodate the inclusion of aviation. This addition to the cap establishes the total quantity of allowances to be allocated to aircraft operators. This quantity is defined as a percentage of historical aviation emissions, which is defined as the mean average of the annual emissions in the calendar years 2004, 2005 and 2006 from aircraft performing an aviation activity falling within the scope of the legislation. In July 2011, it was decided that the historical aviation emissions are set at 221,420,279 tonnes of CO₂.

The additional cap to be added to the EU ETS in 2012, the first year of operation for aviation, will be set at 97% of the historical aviation emissions. For the period from 2013 to 2020 inclusive the additional cap will be set at 95% of the historical aviation emissions.

Aircraft operators flying to and from airports in 30 European states from 2012 will be required to surrender allowances in respect of their CO₂ emissions on an annual basis. The large majority of allowances will be allocated to individual aircraft operators free of charge, based on their respective aviation output (rather than emissions) in 2010, thus rewarding operators that have already invested in cleaner aircraft. In 2012, 85% of the total quantity of the additional allowances (or "cap") will be allocated free of charge according to this benchmarking methodology, while in the 2013-2020 trading period 82% of the additional allowances will be allocated free of charge in this way. In the 2013-2020 trading period, an additional 3% of the total additional allowances for aviation will be set aside for allocation free of charge via the special reserve, to new entrants and fast-growing airlines. The remaining 15% of allowances will be allocated each year by auction.

Aircraft operators that choose to emit more than their free allocation of allowances will be able to source allowances from other participants in the ETS (including those outside the aviation sector), from intermediaries who trade allowances, from Member States via auctions, or they can use specific quantities of international credits from emissions reduction projects in third countries (e.g. CDM credits and ERUs).

The system also includes a de minimis provision under which commercial aircraft operators with a low level of aviation activity in Europe are excluded from its scope. This is likely to mean that many aircraft operators from developing countries will be unaffected by the scheme and, indeed, over 90 ICAO states have no commercial aircraft operators included in the scope of the EU ETS.

The EU legislation foresees that, where a third country takes measures of its own 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 scheme. 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 this Directive as it applies to aircraft operators are necessary.

Anticipated change in fuel consumption and/or CO₂ emissions

The environmental outcome of an emissions trading system is pre-determined through the setting of an emissions cap. In the case of the EU ETS, an addition to the overall cap is established for aviation emissions. However, aircraft operators are also able to use allowances allocated to other sectors to cover their emissions. It is therefore possible (indeed highly likely given traffic growth forecasts) that the absolute level of CO₂ emissions from aviation will exceed the number of allowances allocated to aviation. However, any aviation emissions will necessarily be offset by CO₂ emissions reductions elsewhere, either in other sectors within the EU that are subject to the EU ETS, or through emissions reduction projects in third countries. The "net" aviation emissions will however be the same as the number of allowances allocated to aviation under the EU ETS.

In terms of contribution towards the ICAO global goals, the states implementing the EU ETS will together deliver, in "net" terms, a 3% reduction below the 2005 level of aviation CO₂ emissions in 2012, and a 5% reduction below the 2005 level of aviation CO₂ emissions in the period 2013-2020.

Other emissions reduction measures taken, either at supra-national level in Europe or, by any of the 30 individual states implementing the EU ETS, will of course make their own contribution towards the ICAO global goals. Such measures are likely to moderate the anticipated growth in aviation emissions in Europe and therefore reduce the extent to which the absolute level of CO₂ emissions from aviation will exceed the number of allowances allocated to aviation. However, assuming that absolute aviation emissions will nonetheless in future exceed the additional aviation cap, the aggregate contribution towards the global goals is likely to remain that which is determined by the EU ETS cap.

Expected co-benefits

The EU ETS covers both international and domestic aviation and does not distinguish between them. It is not therefore possible to identify how the “net” emissions reductions it delivers are apportioned between international and domestic aviation.

5. 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.

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. ACI EUROPE is looking at expanding the geographical scope of the programme through the other ACI regions. Discussions are currently under way with ACI Asia Pacific for a possible extension of the programme to the Asia Pacific region.

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”. 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.

I In June 2011, 2 years after the launch of the programme, 43 airports were accredited, representing 43% of European passenger traffic. ACI/Europe’s objective for the end of the 3rd year of the programme’s operation is to cover airports representing 50% of European passenger traffic. Programme’s implementation is twofold: on top of recruiting new participants, individual airports should progress along the 4 levels of the programme.

Anticipated benefits:

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

	2009-2010	2010-2011
Total aggregate scope 1 & 2 reduction (tCO2)	51,657	54,565
Total aggregate scope 3 reduction (tCO2)	359,733	675,124

Variable	Year 1		Year 2	
	Emissions	Number of airports	Emissions	Number of airports
Aggregate carbon footprint for 'year 0' ¹⁵ for emissions under airports' direct control (all airports)	803,050 tonnes CO2	17	2,275,469 tonnes CO2	43
Carbon footprint per passenger	2.6 kg CO2		3.73 kgCO2	
Aggregate reduction in emissions from sources under airports' direct control (Level 2 and above) ¹⁶	51,657 tonnes CO2	9	51,819 tonnes CO2	19
Carbon footprint reduction per passenger	0.351 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)	2,397,622 tonnes CO2	6	6,643,266 tonnes CO2 ¹⁷	13
Aggregate reductions from emissions sources which an airport may guide or influence	359,733 tonnes CO2		675,124 tonnes CO2	
Total emissions offset (Level 3+)	13,129 tonnes CO2	4	85,602 tonnes CO2	8

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

¹⁵ '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.

¹⁶ This figure includes increases in emissions at airports that have used a relative emissions benchmark in order to demonstrate a reduction.

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

The scope of *Airport Carbon Accreditation*, i.e. emissions that an airport operator can control, guide and influence, implies that aircraft emissions in the LTO cycle are also covered. Thus, airlines can benefit from the gains made by more efficient airport operations to see a decrease in their emissions during the LTO cycle. This is coherent with the objectives pursued with the inclusion of aviation in the EU ETS as of 1 January 2012 (Directive 2008/101/EC) and can support the efforts of airlines to reduce these emissions.

SECTION 2 - National actions in Sweden

This section is complementary to section 1 Supra-national actions 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 such as Single European Sky and its ATM Research program. 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.

AIRCRAFT EMISSIONS STANDARDS

Reference is made to Aircraft emission standards and the development of an aircraft CO₂ standard described in SECTION 1.1 Supra-national actions. The Swedish Transport Agency is providing co-leadership for the development of certification procedures for a new CO₂ standard in the CO₂ task group within CAEP's Working Group 3.

IMPROVED AIR TRAFFIC MANAGEMENT, INFRASTRUCTURE USE AND OPERATIONAL IMPROVEMENTS

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".

United Danish-Swedish airspace and joint air traffic services

In 2009, Danish and Swedish airspace became one joint Danish-Swedish Functional Airspace Block (DK-SE FAB) with a joint company, NUAC (Nordic Unified Air traffic Control), which in 2012 takes over the responsibility for operating the three control centres in Copenhagen, Malmö and Stockholm – and by this the air traffic control of the en-route traffic in the DK/SE FAB. NUAC is the first – and so far the only – fully integrated ANSP (Air Navigation Service Provider) in Europe, operating the traffic control across national airspaces.

Besides securing harmonization and streamlining of traffic control, the objective of the new integrated ANSP is to reduce fuel consumption for flights in DK/SE FAB, reducing the emission of environmentally damaging gases.

In November 2011 FRA – Free Route Airspace was implemented in Swedish and Danish airspace. With Free Route Airspace, the airlines and pilots will be able to plan a direct flight route through the Danish-Swedish airspace. Theoretical calculations based on Eurocontrol's standard models shows that the concept will give a total fuel saving of approximately 13,800 ton a year thus reducing CO₂ emission by approximately 43,600 ton.

With the new concept, the aircraft can depart with a little less fuel on board, and the reduced weight leads to reduced fuel consumption during the flight. Although the saving on each flight is relatively small, the total saving with approximately 950,000 flights each year becomes quite substantial with consequent positive environmental effects. Furthermore, the calculations show that airlines will save almost 7,500 flight hours per year compared to the flying time of the flight plans.¹⁸ During the next years, NUAC has made a commitment to

¹⁸ www.naviar.dk

ensure a reduction of CO₂ emission in DK/SE FAB by least 52,000 tonnes of CO₂ annually.

Structured co-operation between different stakeholders

LFV is in charge of the action Eco-Fly. In a structured forum the operators SAS, Norwegian, Malmö Aviation, Novair, and Nextjet continuously map and analyze airspace, procedures and working methods with pilots and air navigation services. The aim is to find areas of improvement in both the long and the short term, and to add environmental gains in the process. EcoFly has not only served to enhance the understanding between pilots and the ANSP, the co-operation has also resulted in modified working methods at LFV regarding speed restrictions after take-off at some of the country's major airports. Another result is that several operators have adopted a fuel optimized speed control during the descent. During the spring of 2012 representatives from Swedavia are participating in the Eco Fly forum in order to further strengthen the knowledge basis and to widen the possibilities to carry out environmentally adjusted changes.

Green approaches

LFV is actively working with offering operators Green approaches. A green approach means that an aircraft descends continuously from its cruising altitude at an optimum top of descent to the runway. By descending continuously, the aircraft requires almost no engine thrust, thereby saving fuel and reducing emissions. This procedure is often referred to as a Continuous Descent Approach (CDA) or Continuous Descent Operations CDO and can result in a fuel gains in the range of around 50 kg of fuel¹⁹. There are several ways to measure green approaches. LFV has, together with Swedavia, developed tools for measuring completed CDA's from 5000 feet and 10 000 feet²⁰. But the main objective is to find a way to measure a CDA from top of descent for every aircraft inbound Swedish major airports.

Approximately 50% of all arriving traffic to Arlanda are conducting a CDA from 10 000 feet. The annual increase the last three years is around 2-3%. 10% of all arriving aircraft to Arlanda are offered an optimum Green approach from top of descent i.e. they are cleared and can follow a closed P-RNAV STAR.

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. If 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,

¹⁹ Estimation mad by LFV 2008 between Green approach from top of descent and an average approach inbound Stockholm Arlanda Airport.

²⁰ Swedavia is using the ANOMS-system for measuring. A successful CDA contain maximum one level segment comprising maximum two nautical miles.

shortening of routes to minimize emissions) and departure and arrival procedures (to decrease noise exposure and/or emissions).

LFV assists Swedavia in several environmental processes regarding new permits for some of the major airports. These processes comprise analysis on improvements and how leading edge technology can reduce the environmental impact. As a result of the work with new environmental permit applications to the Land and Environmental Court, Swedavia will suggest amongst other initiatives to introduce fuel optimized RNP-procedures as well as changed conditions for handling of take-offs along the SID in order to reduce fuel consumption.

In the environmental impact assessment (EIA) for Stockholm Arlanda 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.

Today Arlanda has a mandatory condition stating that all aircraft must follow the SID until they reach 1850 metres, which normally occurs at 17 km from the airport. The height has been selected with the MD80 in mind since this was a very common aircraft type in the mid 90's when the airport applied for its current permit. At 1850 metres the MD80 is estimated to make less noise than the maximum noise level, 70 dB (A), on the ground.

In the recent application Swedavia suggests that the aircraft should be allowed to leave the SID when the noise level is below 70 dB(A) on the ground, which means that a large number of aircraft will leave the SID at much lower heights than 1850 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 suggestion 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 below the recommended standard. Swedavia is planning to make this suggestion a 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.

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.

SESAR AIRE VINGA

VINGA²¹ at Göteborg Landvetter Airport was ended January 2012. Vinga was collaboration between LFV, Swedavia, Novair²², Airbus, Quovadis²³ and Chalmers²⁴.

The high-level objective of the VINGA project was to demonstrate the potential of reduced CO₂ emissions and noise from the en-route phase of the arriving flight into Göteborg Landvetter Airport, Sweden, through the approach, landing, and surface phase until parking on the gate, by using a state-of-the-art validation aircraft and by using best technique and best practice. The validation activities then continued in the departure phase, until the aircraft left Swedish airspace.

The key results of the VINGA project show that the implementation of RNP STARs and RNP AR approaches has a potential of fuel savings in the magnitude of 22-90 kg (70-285 kg CO₂) per flight, depending on RWY in use, compared to the traditional P-RNAV STAR structure followed by an ILS approach. This corresponds to fuel savings in the magnitude of 3-11% per flight, measured from a given distance, corresponding to a radius of 200 NM from the airport reference point. The savings have been achieved by flight path shortening and by allowing the validation aircraft to leave the en-route phase at an optimum ToD, followed by an unconstrained CDO. The VINGA project also show that implementation of RNP STARs followed by RNP AR approaches does not include any major differences for the ATM system in comparison with implementing any other closed procedure.

The analysis of speed constraint removal in the departure phase, conducted by Chalmers, showed that 55 kilos of fuel (165 kilos CO₂) per flight could be saved for a typical mid-sized aircraft as Airbus 321, with negligible changes to the noise contours in respect of the Swedish environmental legislation.

A major breakthrough was performed within VINGA on April 7th, 2011, when Novair landed an Airbus A321 using two separate navigation systems. The aircraft approached Göteborg Landvetter Airport via a completely new satellite based navigation trajectory, with extremely high navigation precision, and was then guided to the actual landing by the ground based navigation system ILS (Instrument Landing System) during the latter part of the approach, to hit the runway on the exact right spot. Satellite based navigation allows a more environmentally conscious approach but today lacks the accuracy necessary to land in thick fog. The ILS system is then required, to guide the aircraft safely to the runway. This time a combination was used – for the first time in the world.

SESAR AIRE Green Connection

LFV is leading the ongoing project SESAR AIRE Green Connection. The project includes LFV, Swedavia, SAS - Scandinavian Airlines System, GE-Aviation and Rockwell Collins, and represents a continuation of work done between the partners to develop initial concepts that will be applied to this project.

²¹ Validation and Implementation of Next Generation Airspace

²² Novair – airline operator. An affiliate of Apollo, Sweden’s third largest tour operator. Novair is participating in the SESAR as Airspace User Expert.

²³ Quovadis – Flight Service Company wholly owned by Airbus dedicated to Performance Based Navigation consulting.

²⁴ Chalmers University of Technology - situated in Gothenburg. Focuses on research and education in technology, natural science and architecture

The two airports involved are Sweden's largest — Stockholm-Arlanda Airport and Göteborg Landvetter Airport.

The AIRE Green Connections (AGC) project is focused on the improvement of Air Traffic Management (ATM) through existing and widespread technology that is not fully used today. Green Connections will allow for a reduction of track miles during approach to Stockholm Arlanda Airport. AGC will also allow for efficient and controlled flight profiles.

Green Connection flights are featuring datalink communications and clearances to aircraft beginning with their departure from Göteborg Landvetter Airport followed by a continuous climb departure. Aircraft is receiving direct routing to the terminal area in Stockholm, when possible. When necessary, a Controlled Time Over (CTO) the Stockholm Terminal Maneuvering Area (TMA) entry will be assigned to the aircraft. Continuous Descent Arrivals (CDA) from the aircraft's Top of Descent (ToD) will be executed by AGC flights.

In the Stockholm TMA, aircraft is using a newly designed RNP-AR procedure to Stockholm Arlanda Airport's Runway 26, Arlandas busiest runway. This new procedure will reduce the flown distance by approximately 20 kilometers compared to today's shortest approaches. The resultant fuel savings are expected to be up to 100 kilogram per approach resulting in a CO2 reduction of 300kg. Upon arrival, aircraft will be provided with taxi routing prior to landing and they will, when aircraft conditions permit, taxi with only one engine to their arrival gate.

During the entire flight, the Green Connection flights will transmit their FMS predicted trajectory data to the ground via datalink. This trajectory will be compared to the actual trajectory flown.

The project will end during the summer of 2012, and up until May 2012 the participating airliner has conducted around one hundred RNP AR approaches.

BIOFUELS FOR AVIATION

The Swedish government is supporting national projects for research, development and production (demonstration plants) of 2 G low-carbon transport biofuels. The aim is to develop Swedish production technology for transport biofuels with high efficiency. There are ongoing projects with a total State funding of almost 100 million euro. The focus is on road transport and there are no specific aviation biofuels projects. However, several biofuels' production techniques/methods that are dealt with in the projects may also be suitable for aviation.

The strategy for research, development, demonstration and commercialization is that biofuel development should be focused on ligno-cellulosic feedstock. Wooden biomass is an important national resource and Sweden has a long industrial record to utilize such feedstock for various purposes and has a high R&D competence.

Pilot and/or demo plants supported by Sweden:

Plant / Biofuel	Feedstock	Production Technique	Scale
Örnsköldsvik pilot /Ethanol	Wood chips	Enzymatic hydrolysis + Fermentation	Pilot
Sveg pilot /Ethanol	Wood chips and Straw	Acid hydrolysis + Fermentation	Pilot

DP-1 / DME	Black liquor (Kraft process)	Gasification	Pilot
PEBG / DME	Wood powder	Gasification	Pilot
Domsjö /DME	Brown liquor (Sulfite process)	Gasification	Demo
GoBiGas / Methane	Forest waste	Gasification	Demo

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 HC 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.

FLEET RENEWAL

The goal for SAS is to reduce total flight emissions by 20 % in 2015 compared with 2005, and to reduce the flight emissions per unit by 50 % in 2020 compared to 2005. This is primarily done by fleet renewal, where older MD80's and B737 Classic are replaced with new A320's and B737NG before 2015. Between 2016 and 2020 a number of A320neo will replace current generation A320's. SAS is currently investigating a potential long haul replacement with the target to start the replacements before 2020. 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.

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.

The fleet renewal plan for charter operators licensed by Sweden is to replace 3 A321 aircraft with 3 A320neo family aircraft in 2016 (estimate fuel savings to be around 15%) as well as a replacement of 2 B763 aircraft within 5 years with 2 new B787 aircraft (estimated fuel saving to be around 10%).

EUROPEAN AIRPORT CARBON ACCREDITATION

The Airport Carbon Accreditation Scheme is described in section 1.5. It 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 Göteborg Landvetter Airport, Umeå Airport, Bromma Stockholm Airport, Malmö Airport, Åre Östersund Airport and Ronneby Airport have been accredited. That means that as of June 2012 the Swedish airport operator Swedavia owns and operates seven of the total of eleven airports in Europe with the highest level of accreditation. In 2012 Swedavia plans to apply for accreditation at the highest level for the remaining three state owned airports.