Demonstrating the green trajectory

Fuel efficient trajectory management tested on revenue flights

At the 5th Aviation and Environment Summit in Geneva, Switzerland, in September 2010, one could get an impression of the multitude of initiatives which our industry is pursuing, to fulfil its engagement for an environmental compatible growth. Besides research looking typically into improved airframe, engine designs and alternative fuels, the optimization of the flight trajectory is identified as an area where quick wins can be obtained when airlines, airports and Air Navigation Service Providers work hand in hand, often with the support of the aircraft manufacturer. This article depicts, through examples, how revenue flights can be instrumental to trial more fuel efficient Air Traffic Management procedures with the objective to implement them on a regular basis.

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Background

One of the programmes which takes systematically advantage of revenue flights is the Atlantic Interoperability Initiative to Reduce Emissions (AIRE), which was signed on highest level at the Paris Air Show in 2007, between the Administrator of the FAA (Federal Aviation Administration) and the European Union Vice President/EC Transport Commissioner. This initiative aims to reduce CO_2 emissions and to accelerate the pace of change by taking advantage of best Air Traffic Management (ATM) practices, as shown in figure 1. It enables the implementation of fuel efficient procedures for all phases of flights, taking full advantage of present aircraft capabilities in the Communication, Navigation and Surveillance (CNS) domain. The Asia and Pacific Initiative to Reduce Emissions (ASPIRE) is the equivalent programme for that region and was launched in February 2008.

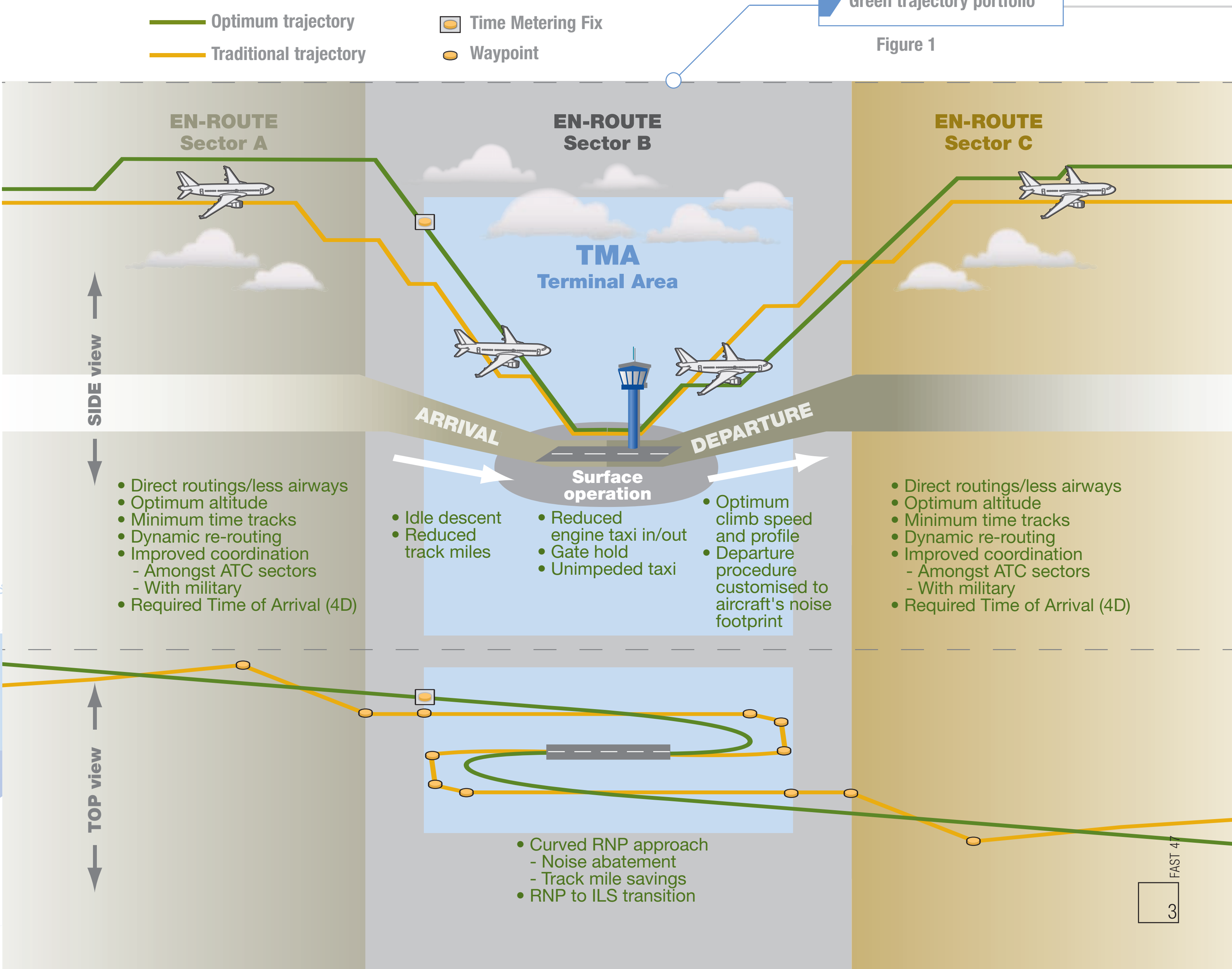
These programmes have to be seen in the wider context of SESAR (Single European Sky ATM Research) and NextGen, its sister initiative in the United States. Both started their respective development work for redesigning the ATM airborne and ground system, with the objective to enable sustained air traffic growth at a reduced service unit cost for the airspace user, reducing the impact on the environment without compromising safety.

glossary

ATC: Air Traffic Control
RNP: Required Navigation Performance
ILS: Instrument Landing System

Green trajectory portfolio

Figure 1



SESAR and NextGen put the business trajectory in the centre of their operational concepts, which implies that the airspace user's preferred way of flying is compromised to a minimum by Air Traffic Management (ATM). Enabled by enhanced on-board and ground systems, the adherence to the most efficient trajectory becomes the baseline for all flights.

In the light to ensure a smooth transition to this target concept, revenue flight trials started in the meantime to demonstrate locally some of the concept elements - as far as current equipment levels allow - under involvement of small but representative stakeholder consortia.

On the European side, the AIRE flight trials are overseen by the SESAR Joint Undertaking (SJU) - the management body which was set-up by the European Commission and Eurocontrol as founding members and which counts now 15 more members coming from air navigation service providers, airports and industries-, including Airbus - with a strong involvement from airlines. AIRE is building the first blocks of the SESAR Concept of Operations by testing 4D trajectory-based operations and Performance-Based Navigation (PBN). A batch of six revenue flight trial projects was executed in 2009 involving 18 partners and accumulating more than 1,000 trial flights (known as the European AIRE1 Exercise). This article will exemplary look at one of them, namely the Minimum CO_2 in Terminal area (MINT) project, in which Airbus had a partner role.

In May 2010, the SJU awarded another 18 contracts for the 'Performance of flight trials validating solutions for the reduction of CO_2 emissions'. This second wave of AIRE revenue flight trials (AIRE2) started in fall 2010 and involves 42 partners, with Airbus leading one of the projects (A380 Transatlantic Green Flights) and contributing as a partner to two further (Green Shuttle and VINGA).

A380 Transatlantic Green Flights

This project addresses shortfalls caused by congestion on ground and in oceanic airspace on Air France flights from New-York to Paris. The average departure taxi time at JFK is more than 40 minutes long which justifies a two, instead of four engines taxi in most cases, saving typically 23kg of fuel per minute. However, a prerequisite for this procedure is to inform the flight crew on the estimated take-off time which is provided in the frame of this trial to demonstrate one benefit of the airport Collaborative Decision Making (CDM) concept.

In the oceanic phase of flight, the most efficient trajectory is compromised by the North Atlantic Oceanic Track System (OTS), which imposes to stick to one of the predefined lateral tracks. Climbing to an optimum flight level is frequently hindered by other traffic. The A380 Transatlantic Green Flight trial takes advantage of the A380's rather high optimum cruise level (between FL390 to FL430) where little other traffic is encountered. The oceanic Air Traffic Control Centres of Gander (NAV CANADA) and Shanwick (NATS) make arrangements to free the aircraft from the OTS. This allows planning the flight on a minimum time track and to choose the most economic speed and cruise level.

Arrival flight phase with a high potential for optimization

The arrival is often the most constrained phase of the whole flight. Speed and altitude restrictions are frequent to manage the traffic flow within the Terminal Area (TMA) as well as the transition from the En-route Sector to the TMA. Noise avoidance often results in a considerable stretching of the flight path; 360° holdings or lengthy lateral 'trombones' are the ultimate Air Traffic Control (ATC) means to get the landing sequence built up. Successive clearances to lower altitudes and vectoring put the flight crew in a reactive 'open loop' situation, in which the arrival trajectory is not fixed, neither vertically, nor laterally. This prevents following a predefined route which is a prerequisite for properly planning and executing the most energy efficient descent profiles.

The 'Minimum CO_2 in Terminal area' (MINT) project addressed a good part of these issues. It used for the first time in Europe the aircraft's Required Navigation Performance with Authorization Required (RNP AR) for a +/- 0.3 nautical miles lateral accuracy in a curved approach (RNP AR 0.3) for the purpose of noise abatement at Stockholm, Sweden (see approach chart in figure 2). Before publishing the procedure, Airbus contributed with fly-ability analysis through simulator sessions and ensured that speed and altitude constraints are not compromising the most fuel efficient descent.

Novair, the airline partner in the MINT project, recently upgraded the Flight Management System (FMS) on their A321 fleet to the latest 'Release 1A' standard, which allows flying the RNP AR 0.3 procedure in combination with their first generation Electronic Flight Instrument System (EFIS).

The lateral trajectory of the 10 MINT flights was agreed with the ATC sectors of Stockholm and Malmö (Sweden), well before leaving the cruise flight level and the ATC enabled a Continuous Descent Operation (CDO) by avoiding altitude instructions. Therefore, the aircraft could follow the most efficient vertical profile with engines at idle, saving in an average 145kg of fuel per arrival. Further, 20kg were saved through reduced track miles when compared to the standard Instrument Landing System (ILS) procedure.

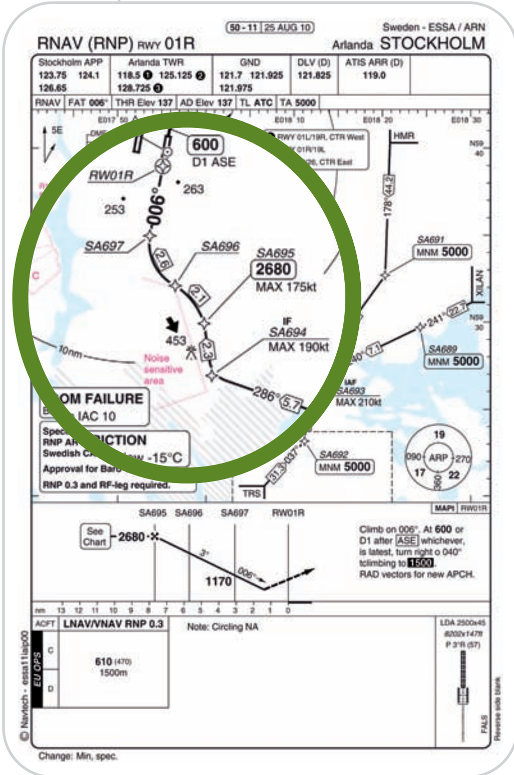
Combining Performance-Based Navigation (PBN) with Continuous Descent Operations (CDO) constitutes an operational concept which is feasible for many regional airports or for major airports at low traffic hours. Often, the main hurdles are more of an institutional nature and a question of changing habits, rather than technical. Suggesting a revenue flight trial project can be a good means for the airline to improve the situation and obtain buy-in from the Air Navigation Service Providers (ANSP) and airports.

Time as the 4th navigation dimension

For both, airborne and ground sides in high traffic situations, the optimization of the arrival trajectory is more complex and requires additional means which are developed in SESAR and NextGen. Some of these technical enablers are related to the addition of the time aspect for trajectory management.

Stockholm RNP AR 0.3 approach chart

Figure 2



Courtesy of Navtech

Curved noise abatement approach into Stockholm: After having been tested in the MINT project, the procedure was published and is now applied on a regular basis.

Required Time of Arrival (RTA) page on MCDU

Figure 3

This capability is rarely used today but will increase in importance as operational concepts emerge based on 4D trajectory management.

As the Continuous Descent Operation (CDO) prevents the Air Traffic Controller (ATCO) to apply the traditional altitude and heading instructions during the descent, the concept previews that additional information be provided in return, in the form of arrival time for a significant metering fix. This waypoint is defined from a traffic flow management point of view and may typically be a merging point or a Terminal Area (TMA) entry point. On-board, the adherence to the trajectory's time schedule is ensured within a certain tolerance by the Required Time of Arrival (RTA) function, which is accessible through the Multi-purpose Control and Display Unit (MCDU), via the Flight Plan (FLP) menu pages, as shown in figure 3. On the ground side, the ATCO is assisted by an Arrival Management (AMAN) tool which helps to build up, at an early stage, the sequence of incoming traffic and which alerts in case of conflicts.

In anticipation of this operational concept, the MINT trials looked also at the adherence to the estimated time of arrival over a waypoint which was chosen around an altitude of FL100, representing a typical altitude for entering the TMA. The observed deviation was below 10 seconds compared with what has been predicted about 20 minutes earlier, well before leaving the cruise level. More flight trials will be undertaken building up confidence in the aircraft time performance, in order to start using it for the sake of a smooth transition to the initial 4D operational concept of SESAR and NextGen.

Optimization from En-route to En-route

VINGA (Validation and Improvement of Next Generation Airspace) addresses all flight phases, arriving at and departing from Gothenburg Landvetter airport, in Sweden. En-route, the flight follows a planned direct routing, which becomes now possible with the implementation of the Free Route Airspace Sweden concept. Improved service level agreements amongst adjacent control sectors, including the Danish Air Traffic Control, shall enable that the arrival trajectory be known to the flight crew already before the end of the En-route phase. The crew then plans an idle continuous descent choosing the optimum top of descent point. Considering the traffic situation, vertical ATC clearances shall not compromise the most fuel efficient vertical profile.

The arrival trajectory leads then into a noise and fuel optimized RNP AR 0.3 procedure, followed by a transition to the Instrument Landing System (ILS) approach. Through this new combination, it is ensured that even under conditions of low approach minima, the most efficient arrival trajectory can be followed. Another particularity is that a RNP procedure will be designed, not based as usual on very conservative theoretical wind models, but on observed statistical winds which results in a further optimization. Comprising an important Performance Based Navigation (PBN) element, partners to the VINGA project are not only the typical revenue flight trial triplet consisting of the airline (Novair), airport (Swedavia) and Air Navigation Service Provider (LFV), but also Quovadis, the PBN service company. This recently formed Airbus subsidiary provides a complete set of RNP services including RNP procedure design and testing, flight operation safety assessment, documenting airworthiness compliance, training, RNP monitoring, and cost-benefit analysis.

The optimization of ground movements is addressed in the trial through single engine taxi-in and out, whenever feasible. In case of delays, 'gate holding' with engines off will be preferred over queuing-up on the taxiway.

VINGA looks also into the feasibility of more flexible and efficient departure trajectories, which shall be tailored to the noise footprint of the individual aircraft type. Instead of applying an unique Standard Instrument Departure (SID), aircraft with better noise values shall be allowed to accelerate earlier to the most economic climb speed and to turn earlier to the target heading.

Gothenburg, Sweden, could be taken as representative for a typical single runway regional airport and the described measures are certainly worthwhile to be studied in similar circumstances.

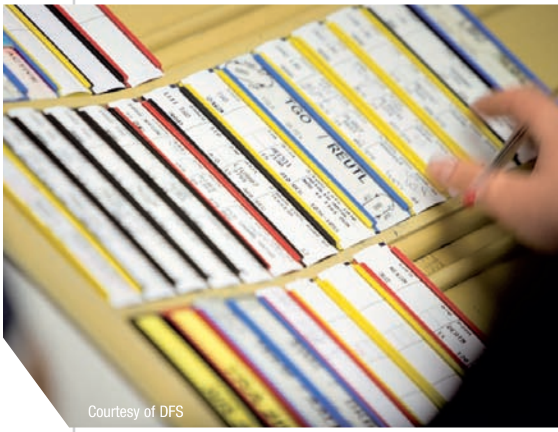
The Green Shuttle

The context is more challenging in the busy parts of central Europe, such as between the French cities of Paris-Orly and Toulouse, where Air France operates up to almost 50 flights a day with an A320 Family fleet. Although each flight duration is only around one hour, three ATC En-route Sectors are concerned and the shuttle flights are kept on sub-optimal lower altitudes, in favour of overflying long haul traffic. Here again, an improved coordination between the national ATC sectors managed by the French Air Navigation Service Provider DGAC/DSNA was key to obtain a more fuel efficient trajectory.

The Green Shuttle trials which were undertaken in fall 2010, demonstrated the feasibility to obtain under certain conditions optimum cruising levels and more direct routings, thanks also to a better coordination with the military stakeholder. Continuous Descent Operation (CDO) could also be demonstrated from top of descent into both, Paris-Orly and Toulouse. Airbus contributed with 'CDO fly-ability' analysis and advised on best speed and vertical windows for the hand-over between ATC sectors in descent.

Quantified findings of the fuel savings obtained in the AIRE2 exercise will be published by the SJU through a dedicated dissemination event in the first half of 2011. It is expected that the tested ATM procedures have a saving potential, which justifies their consideration in any airline's fuel saving action plan.

Air Traffic Controller strips



Courtesy of DFS

information

Quovadis
a 100% Airbus subsidiary, was launched in July 2009 to support airlines, airports, air navigation service providers and authorities in Performance-Based Navigation (PBN) deployment, as well as to provide related services.
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Conclusion

Revenue flight trials are an excellent means to experience and adjust more efficient Air Traffic Management (ATM) procedures, in a perspective to transit smoothly to their application on a daily basis. Airbus in general and Quovadis specifically for matters related to Performance-Based Navigation (PBN), are prepared to support revenue flight trials through customer services and expertise. There is a whole register of measures for bringing a flight nearer to the most fuel efficient trajectory throughout the different flight phases. Partnerships between the main stakeholders - airlines, Air Navigation Service Providers and airports - is the key for improvements.
The current context of ongoing major ATM development programmes such as SESAR and NextGen favours to challenge legacy operations in order to migrate to more efficient target operational concepts, which will be enabled by new technologies on-ground and on-board.

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