SESAR Demonstration
Initial 4D trajectory

4 March, 16:30 - 18:30
5 March, 11:30 - 13:30, 14:30 - 16:30
Rooms N109+N110
FOUR DIMENSIONAL (4D) TRAJECTORY

4D Trajectory Management creates an environment where air and ground stakeholders share a common view of the aircraft’s trajectory, including time, so that the flight can be managed as closely as possible to the airspace user’s ideal profile, while optimising the flow of air traffic.

At an early planning stage of operations, the 4D trajectory is shared between airspace users, Air Navigation Service Providers (ANSPs) and airport operators. It is then progressively refined, taking into account various constraints in airspace and airport capacity. Before the aircraft takes off, the 4D trajectory is agreed and becomes a reference that the airspace user agrees to fly and the ANSP agrees to facilitate. Throughout the flight, detailed information about the future projected-position of the aircraft is exchanged with all service providers on the route, and times are agreed with departure and arrival airports in advance.

Accurate 4D trajectories mean greater certainty about the projected position of aircraft in the sky and on the ground at any given moment, which represents benefits in terms of network predictability, safety and flight optimisation. In turn, resources can be effectively planned and use of airport and airspace capacity can be optimised. Better planning of flight trajectories also allows environmentally optimised flight profiles to be applied.
SESAR and i4D

Initial 4D (i4D) is a cornerstone of the SESAR Programme as it is the first step towards more predictable flights.

The core characteristic of i4D is making sure that trajectories are always synchronised between air and ground, which enables more efficient handling and certainty of flight profiles. Within the SESAR Programme, the necessary technical enablers are undergoing validation, such as an enhanced Automatic Dependence Surveillance Contract (ADS-C) system to downlink the Extended Projected Profile (EPP) - a package of refined information on the projected trajectory from the airborne side.

Furthermore, through the use the Required Time of Arrival (RTA) airborne function in the Flight Management System (FMS), i4D aircraft can self-manage their speed profile in order to achieve a Controlled Time of Arrival (CTA) at a metering fix. The use of CTA for ground metering offers new and promising operational possibilities to enhance the management of aircraft sequences, allowing increased airborne participation in achieving environmentally optimised flight profiles and optimised traffic delivery into Terminal Manoeuvring Areas (TMAs).

In 2012, SESAR reached an important milestone in the development of its i4D concept with the first i4D flight trial. In parallel, the Programme is carrying out many validation activities to further enhance the concept and bring all elements to the required level of maturity.

Demo participants
Four dimensional (4D) trajectory

The demonstration consists of a scenario whereby the avionics and ground platforms are upgraded and built on the recommendations of previous trials and simulations, providing ground systems with a more effective interface for managing trajectory information. In this validation, the flight is fully integrated into the traffic, receiving if necessary, tactical Air Traffic Control (ATC) instructions just as any aircraft flying in Europe will experience.

Three aspects of the i4D operations are presented in the demonstration:

**Cockpit**

Visitors to the cockpit platform will have the opportunity to step into the shoes of the flight crew during an i4D procedure, and thereby acquire a first-hand practical understanding of the progress achieved so far, in addition to the complexities, benefits, and comprehensive advantages of i4D from an airborne perspective.

The cockpit portion of the scenario illustrates how i4D is implemented with the aircraft and how its operation is seen and experienced from a flight crew perspective. This phase of the scenario
is designed to demonstrate the direct link and interaction between air and ground, via applicable cockpit displays and procedures, associated cockpit actions and interactions with the ATC, and resulting avionics automation.

In the aircraft, the i4D solution is enabled by enhanced data link technology - ADS-C and Controller Pilot Data Link Communications (CPDLC) - and enhanced FMS capabilities. These technologies enable the aircraft to exchange real-time trajectory information with the ATC, thereby absorbing TMA delays using CTAs over optimised flight profiles. The RTA functionality allows high metering accuracy of +/- 10 seconds with 95% confidence.

Both the ATC and the flight crew also proactively know and agree on the trajectory to be flown, and this trajectory will integrate airspace user preferences. As a result, i4D generates a wide range of benefits for airspace users, including improved flight efficiency, reduced workload in the cockpit, increased predictability and enhanced safety. Furthermore, the RTA functionality enables the optimisation of flight profiles to reduce fuel burn and emissions and reduces the need of penalising instructions such as vectoring and holding patterns.

Visitors to the en-route operations platform will see in detail the changes that have been made to the Controller Working Position (CWP), supported by the Flight Data Processing System (FDPS), and will be able to discuss with the project team the technology benefits, as well as the future development and deployment of i4D.

The en-route phase of the scenario follows a flight through the Maastricht Upper Area Control Centre (MUAC) area of responsibility, which includes the upper airspace of the Benelux and North-West Germany. In this phase, in addition to CPDLC, an ADS contract is established with the aircraft.
in order to downlink trajectory data. This data is processed on the ground by the MUAC trajectory-based Flight Data Processing System (FDPS). The aircraft and ground systems later agree on a time constraint over an en-route waypoint, and then at a merging point close to Copenhagen airport for arrival management.

The scenario illustrates the importance of an advanced Human Machine Interface (HMI) for making the new information fully usable. Controllers can clearly see on their screens both the expected ground and airborne trajectories and resolve discrepancies where necessary. Controllers are therefore no longer surprised by unexpected turns and anticipate the flight path with greater precision. Tools for conflict detection and resolution, as well as sector configuration planning, are able to use the best possible trajectory information.

In the long term, by making use of the FMS capability, flights will be able to fly accurately to time constraints, which will enable the arrival management to be extended into the upper airspace. This will increase the aircraft’s ability to fly the most fuel-efficient path.

Visitors to the approach and arrival platform will see the enhancements made to the ATM system and Arrival Manager (AMAN), and will be able to discuss the development of i4D procedures in a TMA + AMAN context with the project team.

i4D allows a flow-constrained TMA to work collaboratively with upstream en-route facilities, in order to establish an AMAN-derived CTA proposal as early as possible. This is optimised for each individual aircraft and supports the flow into the aerodrome.
DELIVERING BENEFITS

These demonstrations show how the SESAR Programme aims at bringing to the point of readiness for deployment i4D trajectory management procedures and technologies in the European ATM system.

Through SESAR, ANSPs, ground and airborne industries have come together and are in the process of validating the use of downlinked trajectories in a real ATM environment, demonstrating the benefits that can be achieved through the enhanced predictability of aircraft trajectories. Ongoing validations are exploring the use of airborne FMS functionalities, such as RTA, in air traffic management.

These show potential benefits for airspace users in the area of flight efficiency and a more strategic management of arrival flows. Further validations are planned in identifying how to fully exploit these benefits.

The progress made on i4D is a testament to the commitment and determination of SESAR members and partners to modernise Europe’s ATM system.

Enhancements to the ground system allow early ADS-C connection between the TMA ATC and aircraft, even when the flight is still under the control of an upstream en-route ATC facility. The ATC TMA ground system establishes an ADS-C contract, requesting the aircraft system to report the minimum/maximum time that the flight can be over the AMAN metering fix (ETA min/max). The aircraft sends an ADS-C report, providing the ETA min/max reliable window. Based on this information, the AMAN allocates a CTA, which is then sent to the upstream facility using enhanced inter-facility On-Line Data Interchange (OLDI) messages. The upstream ATC facility uplinks the CTA time constraint to the aircraft via CPDLC.

In i4D operations, the AMAN sequencing horizon is extended beyond the controlled airspace of the ATC at the destination TMA. Furthermore, CTA instructions are issued earlier allowing for smooth aircraft speed management. Airspace users can expect improved service provision, more efficient aircraft operations and a more frequent application of Continuous Descent procedures.
Members

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Further information
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