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I-4D - Flying a new dimension

World first: Initial four-dimensional flight trial took place on 10 February 2012

Summary

On 10 February 2012, the Airbus A320 test aircraft flew from Toulouse to Copenhagen and Stockholm and then back to Toulouse testing initial four-dimensional (I-4D) flight operations.

I-4D operations consist in using airborne computed predictions in the ground systems in order to establish far in advance a sequence for all aircraft converging to a merging point in a congested area. In practice, after coordination between the ground systems and the aircraft, each aircraft is allocated a time constraint at a merging point, and in compensation is allowed to fly its optimum profile up to that point, meaning without any vectoring instruction from the controllers.

This flight trial is the very first live demonstration of an initial four-dimensional flight, and is a key element of the SESAR programme towards 4D trajectory management. It is the culmination of months of collaboration between several SESAR partners: aircraft, avionics and ground equipment manufacturers; and air navigation service providers Maastricht Upper Area Control Centre (MUAC) and NORACON, with the support of EUROCONTROL.

Description

Partners

AIRBUS EUROCONTROL Honeywell indra noracon THALES

I-4D is part of the SESAR work programme, under the responsibility of the SESAR Joint Undertaking.

Operational partners: Airbus, EUROCONTROL's Maastricht Upper Area Control Centre (MUAC) and NORACON [1]

Ground Industry: Indra and Thales

Airborne Industry: Honeywell, Thales and Airbus

[1] NORACON is a consortium of eight air navigation service providers: Austro Control and the North European ANS Providers (NEAP), Avinor (Norway), EANS (Estonia), Finavia (Finland), IAA (Ireland), ISAVIA (Iceland), LFV (Sweden) and Naviair (DK). LFV and Naviair will participate in the I-4D flight trial.

Objectives

The I-4D flight marks an important milestone in the development of one of the essential pillars of the SESAR concept: moving from constraining flights towards optimising flights.

This means that once the concept has been proven and industrialised, aircraft will progress in four dimensions, sharing accurate airborne predictions with the ground systems, and being able to meet time constraints at specific waypoints with high precision when the traffic density requires it. This will allow better sequencing of the traffic flows and facilitate green descents to airport terminal areas. With a green descent (or Continuous Descent Operations) the aircraft descends continuously with near idle thrust, avoiding level-off as much as possible prior to the final approach, thereby using significantly less fuel.

For airlines, I-4D will allow the aircraft, with knowledge of all constraints, to plan and fly the most optimal, cost-efficient profile for the scheduled flight.

Overall, thanks to an optimised management of the arrival flows, the gains will be more capacity, better punctuality and flight efficiency as well as lower emissions.

Trajectory Management is an important step in Europe's modernisation programme, and forms part of SESAR Implementation Package 2 (IP2), the first implementation of SESAR R&D deployments, which will take place from 2015.

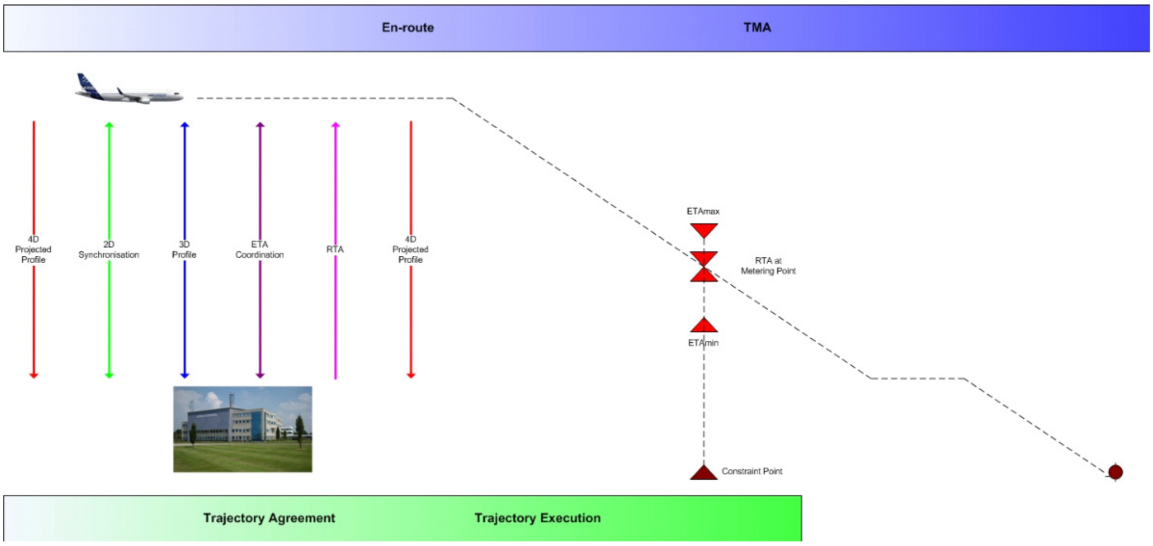
I-4D brings the industry a step closer to its ultimate SESAR goal of full 4D operations, where airlines and Air Navigation Service Providers will agree before the flight on a 4D trajectory covering the whole flight, thus significantly enhancing traffic predictability and optimising the management of the air traffic network. This 4D trajectory, known as business trajectory, could be updated or revised by data link during flight, in order to take into account non-predicted events, e.g. a large cumulonimbus along the route.

The trial

A team including operational partners Airbus, EUROCONTROL MUAC and NORACON, validation platform integrators (MUAC, Thales and Airbus), avionics manufacturers (Honeywell, Thales and Airbus) and ground equipment manufacturers (Indra and Thales) flew an A320 test aircraft from Toulouse to Stockholm using an I-4D flight profile.

The aircraft flew through the MUAC area of responsibility (upper airspace of the Benelux and North-West Germany), where the aircraft and the ground systems agreed on a time constraint at a merging point close to Copenhagen airport. The flight then continued into Danish airspace to demonstrate an optimised descent to Copenhagen. After reaching the first merging point, the aircraft climbed to a cruise level from which it negotiated a time constraint at a merging point close to Stockholm Arlanda Airport. The flight then descended into Swedish airspace in a fully optimised way up to the second merging point and then continued until it landed at Arlanda.

The trial aimed to verify that the Flight Management System and ground automation systems implement the I-4D technique through data link interoperability. It also aimed to validate how information exchanged is displayed to the controller and the pilot and which tools should be adapted to use this new information to its full extent.



With I-4D, controllers receive the four-dimensional intent of an aircraft via an ADS-C downlink. They can then ensure that the ground and air expectations are the same by checking, and where necessary uplinking, the lateral and vertical clearance. Should it be necessary to further constrain the flight at a fix, a time constraint that both meets the ground requirements and is achievable by the aircraft can be coordinated. Once this has been agreed, the aircraft can optimise its flight profile in the most economical and environmentally friendly way.

The aircraft

The aircraft used for the flight is the A320 flight test aircraft belonging to Airbus. A flight test aircraft was absolutely required for such flight, as the airborne system prototypes developed in the SESAR framework are not certified for commercial operations for reasons of time, budget and world trade regulations.

The Airbus flight test aircraft is fitted with the airborne I-4D function, which mainly consists of enhanced data link communication and flight management capabilities (see avionics section below). One of the key roles of Airbus has been to test the NAV and COM prototypes connected to each other and to integrate them into the real aircraft architecture.

Although today's Flight Management Systems are capable of managing en-route 4D operations, this unique SESAR partnership has made it possible for airborne and ground systems to be fully compatible and to extend the use of data link in support of I-4D operations both en-route and in the approach phases of flight.

Avionics

A Flight Management System (FMS) is a fundamental part of a modern airliner's avionics. An FMS is a specialised computer system that automates a wide variety of in-flight tasks, reducing the workload on the flight crew to the point that modern aircraft no longer carry flight engineers or navigators. A primary function is in-flight management of the flight plan. Using various sensors (such as GPS and INS often backed up by radionavigation) to determine the aircraft's position, the FMS can guide the aircraft along the flight plan. While first FMS were used in commercial aircraft in the early 80s, now all civil aircraft are equipped with this capability.

Honeywell Aerospace and Thales have used their expertise to upgrade their FMS products to integrate the capability to guarantee a reliable time of arrival at an instructed metering point as well as the capability to share the FMS predictions with the ground.

Airbus has developed the airborne data link communication system prototype, called ATSU, which is able to send and receive new controller-pilot data link messages and transmit airborne trajectory predictions to the ground systems.

Ground technology

Like the avionics equipment, the ground systems use the Aeronautical Telecommunications Network (ATN/VDL Mode 2) data link standard.

The SESAR ground Industry-Based Platform (IBP), operational at MUAC, hosts:

- an Indra-supplied trajectory-based Flight Data Processing System (FDPS) fully upgraded to support I-4D operations;
- an advanced Human-Machine Interface (HMI) derived from the HMI used daily by MUAC operational staff and maintained by MUAC; and
- a front-end processor which enables the VDL (VHF Digital Link) Mode 2 communications over the ATN network.

Simulations, including connectivity with Airbus, use the same IBP, feeding an upgraded version of the Maastricht ATC Training Simulator, including integration of an advanced FMS emulator driving I-4D aircraft.

The SESAR Industry-Based Platform in place at NORACON (Malmö) hosts a complete Thales-supplied ATC system adapted to the I-4D functions. It includes:

- a trajectory-based Flight Data Processing System (FDPS);
- a Data Link Server in support of connectivity to the VDL Mode 2 ATN network;
- a new generation HMI;
- an Arrival Management (AMAN) system; and
- all other system components necessary to ATC operations.

For the simulation exercises that complement the flight trial, NORACON will use the Thales-supplied ATC Simulator fully upgraded to use I-4D functionalities.

Interoperability of airborne and ground systems

For I-4D operations to be possible, airborne and ground systems must be fully interoperable and deliver the same information to both aircrew and controllers so that, together, they can best manage the trajectory of the flight while taking existing constraints into account. System interoperability, a direct result of the SESAR partnership between different operational and industrial partners, is a key element for more efficient network management.

Operational procedures

In addition to being a technological challenge, I-4D is an operational challenge. NORACON, EUROCONTROL MUAC and Airbus will validate, in real operational conditions, the operational procedures which are necessary to conduct I-4D operations in high-density en-route and Terminal Area (TMA) airspace.

Next steps

Another set of flight trials and further validations are planned for the end of 2012, and another for 2013, to refine the technology, correct any glitches, adjust operational procedures and explore ways to further enhance the tools and the operational concept.

If the validations are conclusive by the end of 2013, industrialisation could follow and some pre-operational deployment could start in 2018.

About SESAR and Initial 4-D

New technologies are critical for the future of air travel. With up to 27,000 flight patterns crossing European airspace every day, and with passenger numbers set to double by 2020, the current infrastructure will no longer be able to support growth in demand unless improvements are made.

SESAR (Single European Sky Air Traffic Management Research) is the technological dimension of the Single European Sky. It aims at creating a “paradigm shift”, supported by state-of-the-art and innovative technology. The SESAR programme will give Europe a high-performance air traffic control infrastructure which will enable the safe and environmentally friendly development of air transport.

In order to meet these objectives, SESAR synchronises all stakeholders’ contributions and federates resources. For the first time, all aviation players are involved in the definition, development and deployment of a pan-European modernisation project.

In the future air traffic management environment defined by SESAR, aircraft will need to behave in a more predictive way. This means that in addition to following the trajectory cleared by air traffic control, aircraft will need to fly over points of the airspace at accurate times. This evolution is referred to as the 4-dimensional trajectory concept, or 4D, meaning a three-dimensional trajectory plus time.

Initial 4D is a major step towards full 4D operations. Initial 4D implies most aircraft and ground systems being equipped with adequate capabilities. Air navigation service providers, aircraft manufacturers, avionics suppliers and ground system suppliers need to define this system together. Each SESAR member and expert brings in its specific expertise and SESAR provides the framework, to ensure that a consistent set of systems and procedures is defined to implement this technological improvement in a smooth and coordinated way.

Further information:

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