A BETTER WAY OF WORKING

A project in Germany has shown how controller assistance tools can improve capacity and efficiency without adding to personnel costs

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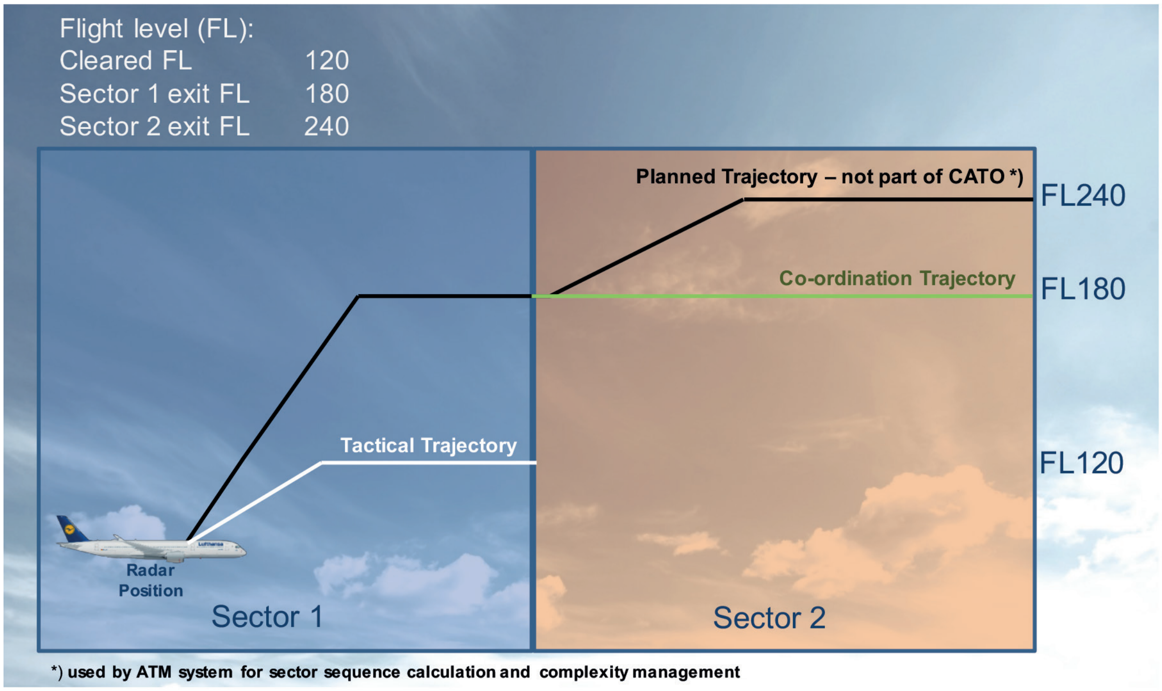


Left: 4D trajectories (CATO and ATM system) **Right:** Examples of CATO conflict detection and flight path monitoring: **Bottom right:** Example of the resolution advisory display

Responding to rising demand by boosting headcount is common in industries from hospitality to health care. Higher staff numbers allow a system's capacity to be raised. Air traffic control is not different.

However, the trade-offs are clear too. Higher staff costs and more coordination effort follow naturally from such a response. This article examines how DFS intends to lower these trade-off costs, adding capacity and increasing efficiency without adding unnecessarily to personnel budgets by exploiting the benefits of automation, new technologies and new procedures to assist controllers in doing their jobs.

As a result, air traffic controllers could be able to control up to 20% more traffic while maintaining the requisite safety levels.

Adding staff and complexity

For many years, air navigation service providers in Europe simply hired more staff and trained more controllers as a way to accommodate additional traffic. However, opening up new sectors and adding more staff to handle more traffic is not a sustainable approach. Splitting sectors is only viable up to a certain point. After this threshold, higher complexity and an increase in coordination tasks prevent further capacity gains.

"Efficiency increases need to be delivered by automation, new technologies and accompanying procedures rather than by simply adding more and more air traffic controllers", says Peter Ahlers, head of simulations and research at the German air navigation service provider DFS.

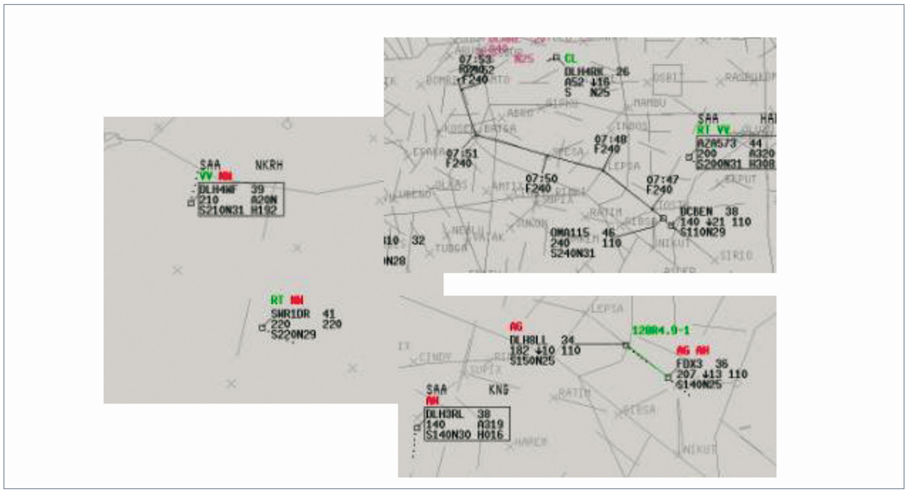
"If we can free up controller teams from routine duties, while at the same time providing tools to support and simplify their wide-ranging tasks, we should be able to increase the overall productivity of air traffic controllers."

Fast algorithms are essential for further automation in air traffic control

Tools for high-density airspaces

In the last 20 years, most controller tools and ATM system functions developed in Europe have focused on an operational environment with a high proportion of overflights and low complexity.

Unlike those tools, controller assistance tools (CATO) focus on high-density airspace with a complex traffic structure, such as the lower airspace surrounding terminal control areas. They are specifically designed for an operational environment with a high proportion of flights in vertical transition. The controller assistance tools support the



executive controller (EC) in maintaining separation between pairs of aircraft. The planner controller (PC) receives assistance in terms of both planning and implementation of co-ordinated handover conditions between sectors. Although the EC and PC each have a dedicated toolset that is designed specifically for their respective duties, both toolsets are displayed at all working positions. Providing information on the current work situation of the other controller role is expected to improve teamwork between EC and PC.

It is important to note that the fundamental responsibilities of both EC and PC will not be subject to any major changes following the introduction of the assistance tools. However, single tasks, operating methods and teamwork might be affected.

Executive controller tools

The controller tools rely on the prediction of 4D trajectories. The tools for the EC are based on the tactical trajectory, while the tools for the PC make use of the co-ordination trajectory. Figure 1 provides an overview of the different trajectories:

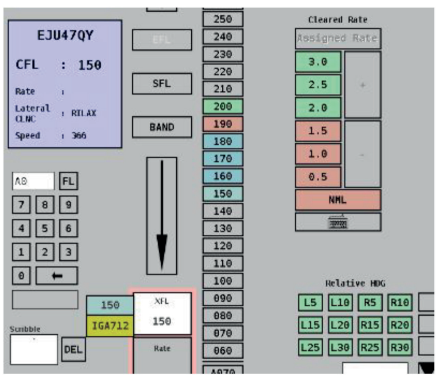
The tactical trajectory (white line) is based on clearance data. The cleared flight level (CFL), with an optional cleared vertical rate, is taken into account alongside the lateral clearance. The lateral clearance originally comprises the planned route, but may be modified, for example by a direct or heading clearances. In the example shown, the aircraft is currently cleared to FL120 by Sector 1. The EC of sector 1 needs to be aware of any potential conflicts with aircraft in the same level up to FL120.

The co-ordination trajectory (green line) takes into account the co-ordinated entry handover condition into the downstream sector. In the example shown, the aircraft is coordinated to enter Sector 2 at FL180. The PC of Sector 2 needs to be aware of any potential conflicts with aircraft that are expected to enter the sector at the same level.

The three tools, which are designed specifically for use by the EC, are based on the tactical trajectory: Conflict detection (see figure 2) is based on clearance data – executive conflict search (ECS); resolution advisory (see figure 3) as to whether potential clearances lead to secondary conflicts – ECS what-else probing (E-WeP): the probed clearances include vertical clearances (CFL with vertical rate) and lateral clearances (headings and directs) and the flight path monitoring (FPM) tools (see figure 2) indicate whether an aircraft is complying with its vertical and lateral clearances. In the event of a deviation, the trajectory is calculated based on this deviation, thereby also providing reliable conflict detection in these cases.

Planner controller tools

Two tools are specifically designed for the PC, these are based on the co-ordination trajectory. The conflict detection is based on co-ordinated handover conditions – planner conflict search (PCS). The resolution



advisory as to whether a potential handover condition could lead to secondary conflicts – PCS what-else probing (P-WeP).

DFS and the software company Gesellschaft für Luftverkehrsinformatik (GLVI) developed a technical data framework and high-performance algorithms as the basis for the CATO functionalities. The framework consists of functions for efficient data flow, flexible pre-filtering, fast analytical solving of equations and problem-orientated distribution of tasks. The hardware used is customised. The framework makes use of commercially available servers.

"From a technical perspective, CATO algorithms are unique because of their high level of performance. The processing speed of the tested algorithms is impressive. Fast algorithms are essential for further automation in air traffic control", says Lothar John, CEO of GLVI.

With regard to the resolution advisory functions, the platform is capable of calculating up to 750 different tentative trajectories for each aircraft at each radar update cycle. For the time being, this capability is unparalleled among ATM system providers.

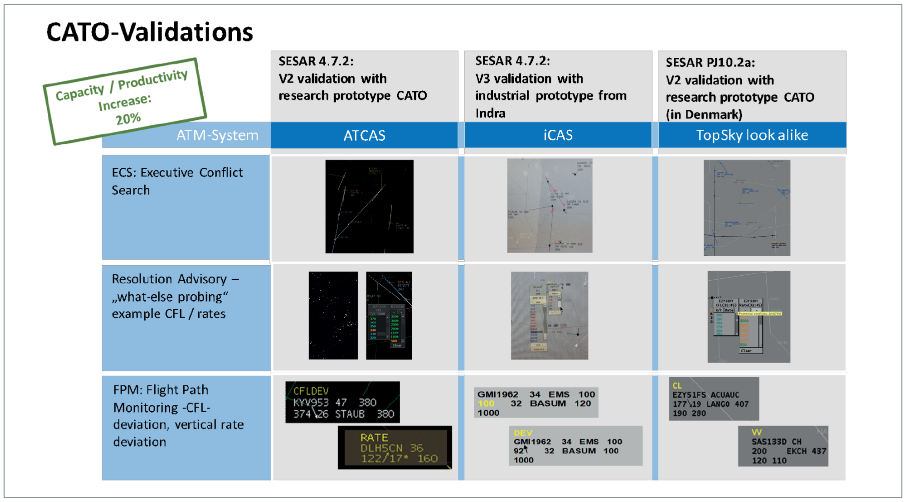
Development and validation

Over the course of the last few years, automation systems have been developing at a fast pace in Europe, particularly within the SESAR project. The tools have been implemented in different prototypes, both with a research focus to assess the operational benefits and with an industrialisation focus to address potential implementation issues. Real-time simulations were conducted based on different prototypes.

In Bremen and Munich Area Control Centers (ACCs) airspace a research prototype developed by DFS and linked to the current German ATM system for lower airspace (ATCAS), has been used. Real-time simulations in the Bremen ACC airspace have also been conducted, based on an industrial prototype by Indra linked to the future German ATC system for lower airspace (iCAS).

Furthermore, a research prototype by DFS has been made available to Danish air navigation service provider NAVIAIR which is similar to their TopSky ATM system. With the use of this prototype, real-time simulations have been performed in the Copenhagen ACC airspace.

For each of the simulations, two validation scenarios were defined in accordance with



Left: Overview of the display of CATO functionalities within the prototypes for the various real-time simulations **Below:** Visitor's day with real-time simulation in 2015 – with INDRA prototype on the iCAS platform

the established SESAR validation methodology. The reference scenario was conducted on the basis of current operations. The new functionalities – conflict detection and resolution advisory for the EC and flight path monitoring – were introduced for the solution scenario. The tools are displayed to both EC and PC working positions.

Three different traffic samples were used for each simulation, differing slightly in terms of sector load over time and complexity. The simulated average traffic load was between 120% and 150% compared to today's sector capacity limits.

The validation exercises comprised several training runs in advance of the exercise. As the controllers were familiar with the respective ATM system, the training sessions focused on the new tools. For each simulation, six to eight measured simulation runs were performed without the tools and six to eight measured runs were performed with the tools.

The following measurements were recorded as a way of facilitating assessment of the operational benefits both to current operations and future operations using the tools: Human performance; safety; operability; flight efficiency and environmental impact, and airspace capacity

Stephan Herr, project manager for CATO development at DFS, says, "The simulations, which at times had extremely high traffic volumes, showed that both controller productivity and airspace capacity could be increased considerably.

"Based on the results of the simulations, it is realistic to expect air traffic controllers to be able to control up to 20% more traffic when using the Controller Assistance Tool, while maintaining the requisite safety levels."

Introduction of CATO

Following completion of the development and validation process, DFS decided to introduce the functionalities at its lower airspace centres in a step-by-step approach. The Langen ACC was chosen as the initial implementation site as the need for capacity and productivity within the Frankfurt area was considered a priority in Germany.

The first step in the gradual adoption strategy for the Langen ACC comprises of a subset of functions: conflict detection, flight path monitoring and resolutions advisory based on the tactical trajectory. Further enhancements are expected to follow. The functions will subsequently be implemented in various sector families of the Langen ACC.

Future steps for further development include the validation of tools specifically designed for the PC, based on the co-ordination trajectory. Initial validation activities have already been performed in this area. The usage of downlinked performance data such as ADS-C (contract) EPP (extended project period) data, and wind data derived from Mode S mandated data fields is envisaged in order to further increase the accuracy of the 4D trajectories.

The development of further automated tools to enhance resolution advisory by recommendations will be determined in the future on the basis of the traffic situation and the flight efficiency.

Automation targets both capacity and efficiency, while potentially also increasing safety. Although the current coronavirus crisis has put paid to the imminent need for capacity gains for the time being, the need for efficiency gains will almost certainly arise again in the near future. Such tools and the productivity gains they deliver will enable DFS either to handle a given amount of traffic more efficiently or to handle more traffic in a given airspace at any one time.❖