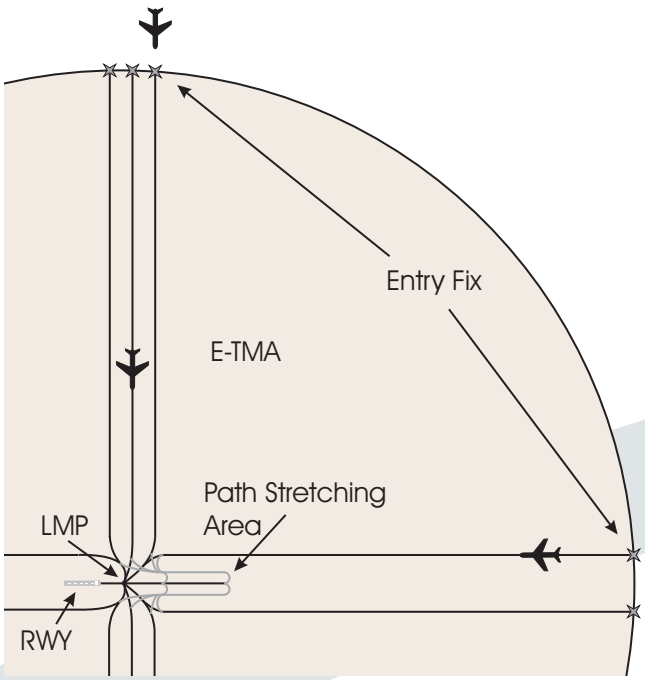
Time-Based Arrival Management for Continuous Descent Approaches

In the scenario of worldwide increasing air traffic controllers have to meet several challenges: besides guaranteeing safety they have to ensure the best possible use of the available airspace while avoiding air and ground queues. Additional requirements are raised by airlines in the form of fuel-efficient approach and departure procedures, airports and residents expect reduced noise disturbance, and environmental impact cannot be neglected either. To achieve this, it is necessary to use technological onboard improvements by new onboard and ground procedures.

A New Airspace and Approach Concept

Within our project Future Air Ground Integration (FAGI), a new airspace and approach concept was developed and validated. Motivated by SESAR, the central goal of the project was the integration of unequipped aircraft into a stream of fully 4D-FMS equipped aircraft following a user-preferred 4D trajectory (normally a continuous descent approach – CDA).

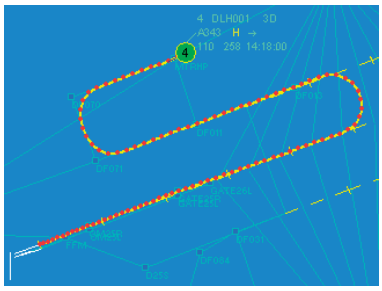
A central FAGI element is a modified airspace and route structure, featuring a late merging of arrival routes without requiring homogenous speed profiles for all aircraft. This is done by using different lateral routes to the new installed late merging point (LMP), approximately 6 NM before touchdown. The lateral separation between the routes enables each aircraft to choose an individual speed and altitude profile. Hence, aircraft only have to maintain a time constraint at the LMP. This move from distance-based to time-based arrival management is restricted to fully equipped aircraft which are able to perform a precise 4D-approach.



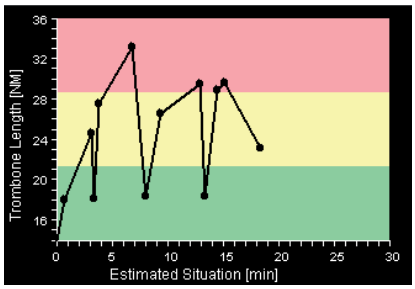
Independent RNAV routes to the Late Merging Point ensure lateral separation and enable individual speed and altitude profiles.

Interactive HMI-Technologies

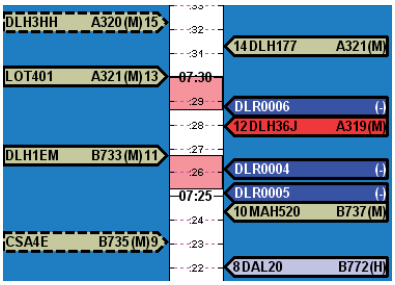
To fit the unequipped arriving aircraft, also separated by time, exactly into a stream of 4D-equipped aircraft the controllers need the support of a 4D Arrival Manager (AMAN) including new interactive HMI-technologies.



Flight path prediction with 4D trajectories



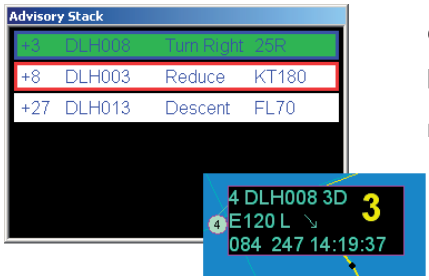
Maximum trombone length as controller workload indicator



Timeline with inbounds (brown) and outbounds (blue)

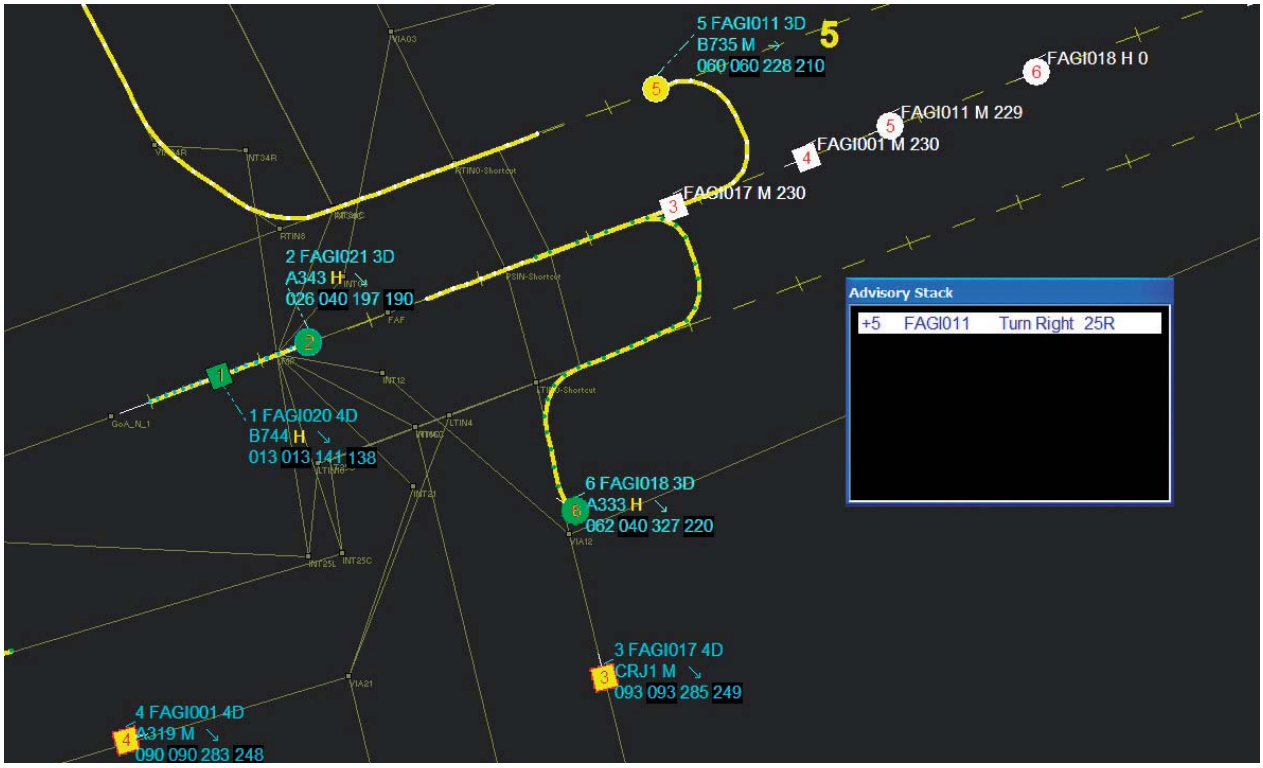
Ghosts and Targets

The ghosting and targeting concepts were enhanced and introduced into the Arrival Manager 4D-CARMA and validated within the FAGI project by different European controller teams.
In summary controllers' situation awareness was increased in mixed traffic and mixed equipment situations. Ghosts are a projection of an equipped inbound onto the (virtual extended) final. Hence, they replace the position of the equipped aircraft on the extended final before the late merging point. For unequipped aircraft, which are vectored by controllers to assure the separation, targets are introduced. The controller initiates a turn to base from the downwind segment so that the unequipped aircraft exactly matches with its target on the centreline to ensure minimal, but safe separation. As it is the controllers responsibility to safely guide the aircraft and differences occur between AMAN advisories and those of the controller, the arrival manager has to adapt its plans continuously and as fast as possible to the controllers' intensions.



Advisories in a stack and directly in the label

Nowadays radar data are the only input source of AMANs. Relying exclusively on this input channel the detection of deviations between the plan of the AMAN and the given advisories would need at least 30 seconds.



Screenshot of the HMI with extended functionalities of 4D-CARMA for time based guidance support. Circles are unequipped (No. 5, 6) and squares are equipped aircraft (No. 3, 4). White elements on the centerline are targets (No. 5, 6) respectively ghosts (No. 3, 4).

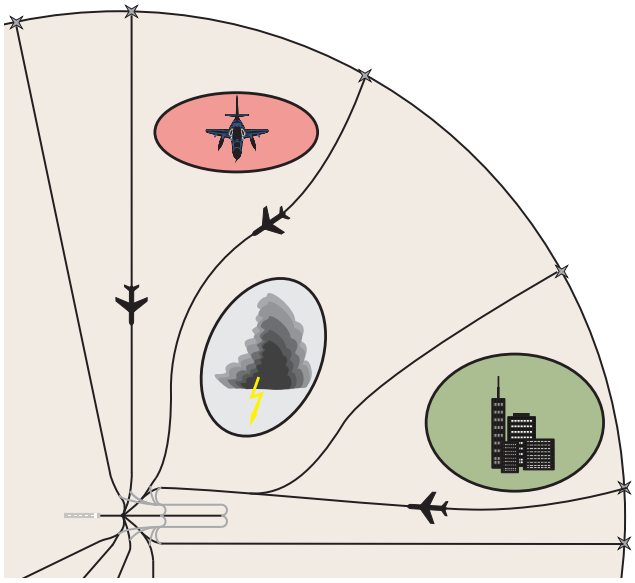
New Input Devices

During the detection of deviations the AMAN sequences neither fit the situation in the real world nor the controllers' mental model. To avoid this, the controller has to enter additional information, like a sequence or speed change. Mouse or keyboard inputs are, however, not the best choice, because in traffic peaks the workload of the controller is already high. Hence, actions which cause additional workload should be avoided. The solution here is to use the existing communication channel between pilot and controller.

In cooperation with the German Research Center for Artificial Intelligence (DFKI) and the Saarland University (UdS) the German Aerospace Center (DLR) uses speech recognition in 4D-CARMA to recognize the controllers' intentions.

From FAGI to flexiGuide

The explained FAGI project was a first step, which demonstrates the integration of fuel and noise efficient approach procedures (CDA) in high density traffic situations using time based arrival management with a late merging point. Its successor flexiGuide, a joint initiative of seven different DLR institutes located on five DLR sites, extents these innovative ideas and adapts it to European airports. FlexiGuide additionally addresses the quantification of noise reduction, fuel- and flight time savings as well as wind and weather influences. FlexiGuide also estimates the investments for required equipment which may have to be purchased and integrated by airlines, airports and air navigation service providers. The extended concepts of flexiGuide will be validated in human-in-the-loop simulations with controllers, pseudo-pilots, and controller assistance systems, using typical traffic movement scenarios of existing airports. The enhanced assistance systems support arrival, departure, and ground controllers. These systems plan and implement improved approach, departure, and taxiing procedures as well as coordinating them. With the described approach the contradictory positions of noise and fuel efficient approach procedures and capacity are fused. For more details contact us, the largest ATM research organisation in Europe.



Flexible route structure to consider time dependent restricted areas and to integrate over flights and departures requires advanced 4D controller decision support tools

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