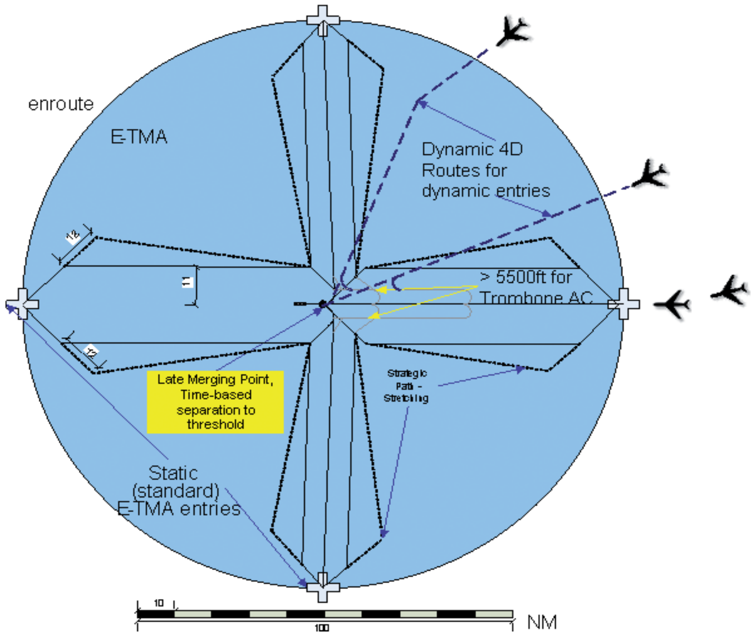
Future Air Ground Integration

A fundamental contribution to satisfying future demands in air transport like gain of capacity, reduction of environmental impact, improved flight efficiency and high predictability is often the term "4D". However, having a look at today's fleet only one out of nine aircraft is currently able to fulfill a requested time of arrival with high accuracy. Therefore, a successful transition to a 4D-ATM environment strongly depends on how especially the unequipped aircraft without flight management system (FMS) fit into the concept. In 2007-2009, the FAGI (Future Air Ground Integration) project investigated a new concept facilitating the transition to a 4D-trajectories based ATM operations.

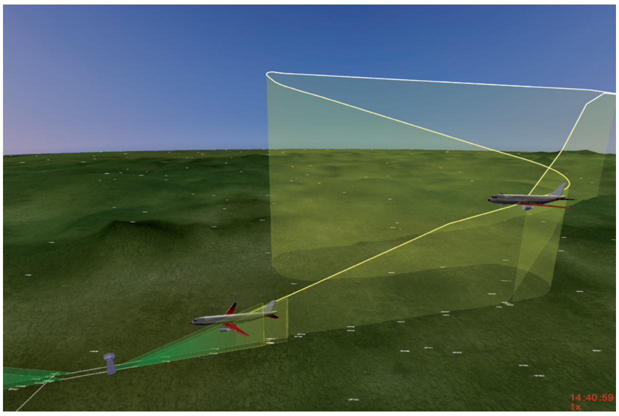
FAGI 4D-Concept

The main element of FAGI's 4D concept for an advanced TMA handling is the late merging of all arriving traffic. Before merging, arriving aircraft are separated procedurally by staggering them laterally in an extended TMA (E-TMA). When entering the E-TMA, a time constraint for the merging point is assigned to each aircraft. The figure below depicts an example E-TMA route structure with four static entries aligned north, south, east and west. The late merging point is located in the center, just before the final approach. The early assignment of time constraints enables arriving aircraft to fulfill the requested time in an efficient way, i.e. speed adaptation. Therefore, the E-TMA is rather big (80-120NM radius). If speed variation is not enough to reach the constraint, strategic path stretching (the dotted lines) can be used to delay the aircraft further. Parallel routes from every entry point to the late merging point enables each aircraft to fly its own optimum speed and altitude profile until merging.



Aircraft not entering near a static E-TMA entry are guided by means of dynamic routing. Depending on the equipage, there are two different approaches possible:

- 4D-equipped aircraft are able to generate their own optimum 4D-trajectory board-autonomously. They fulfill the time constraint at late merging with high precision, ideally without any interventions after the negotiation process with ground control. Equipped aircraft fly the direct routes to the late merging point. Aircraft violating their contract with ground control may be degraded to unequipped aircraft.
- Unequipped aircraft are not able to fulfill the given constraints on their own. Therefore, they are guided by a ground based 4D guidance system. To get them to the merging point precisely at their target time, they are guided along a trombone approach. Aircraft flying the trombone can be delayed to allow insertion of short term departures and simplify handling of emergency situations.



4D-equipped and –unequipped aircraft flying different routes

Support tools for human operators

In order to cope with the new demands, the question how human operators can be supported in performing the described tasks in the best way is crucial. New automation in terms of advanced 4D-arrival managers (AMAN) is necessary to help the controller with appropriate time-based planning functions for all aircraft. The 4D-AMAN permanently analyses the traffic situation and produces advisories for highly efficient guidance of all aircraft:

- Ghosting (i.e. projection) of equipped aircraft to the centerline assists the controller in filling the gaps between the equipped aircraft.
- The optimal position for unequipped aircraft on the centerline is provided using targets.
- An advisory stack assists the controller especially with speed control and turn advisories on the trombone.

FAGI benefits

Implementation of the proposed concept promises

- Improved flight efficiency due to more efficient (direct) routes
- Less fuel burn and less noise for equipped aircraft flying aircraft optimized profiles
- Less delays due to high mid-term predictability
- Increased usage of user preferred trajectories
- In combination with GBAS technology, situation optimized final approaches even under bad weather conditions

FAGI Flight trials with ATTAS and ATRA

From 2007 to 2009, DLR's Institute of Flight Guidance in cooperation with DLR's Institute of Communications and Navigation implemented above described concept.

Flight trials with DLR's testing aircraft ATTAS (a modified VFW614) and ATRA (Airbus 320) proved

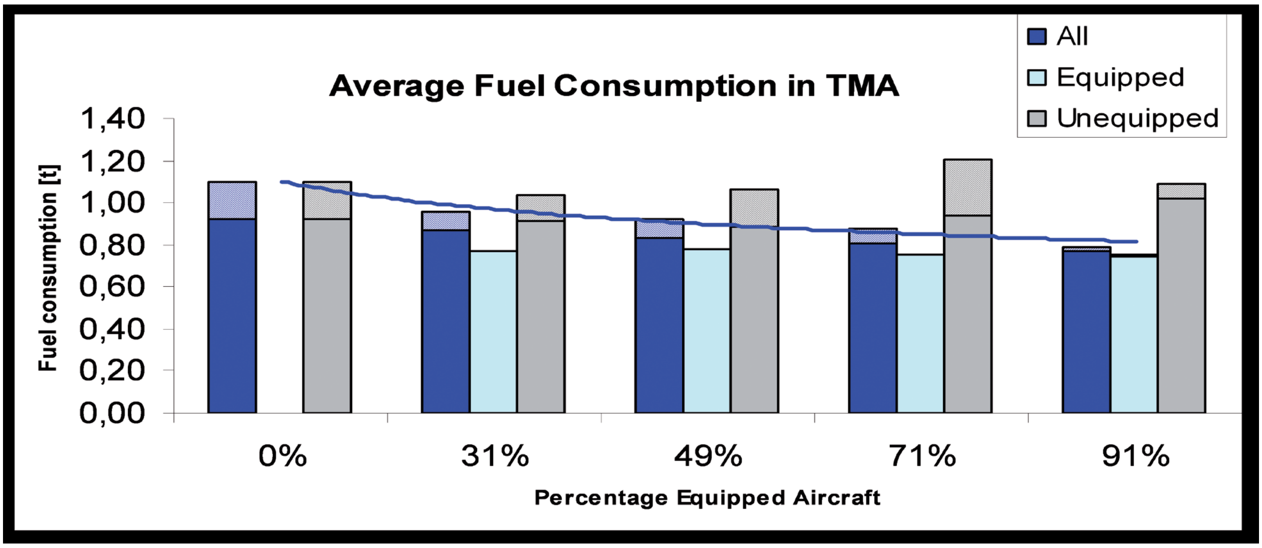
- Very high accuracy for flights controlled by an onboard 4D-FMS (4D-equipped aircraft)
- Good accuracy for flights controlled by a ground based 4D-FMS (4D-unequipped aircraft)
- High navigation precision and reliability using GBAS under CAT I conditions

FAGI Human-in-the-loop real time simulations

Furthermore, four final real time simulation studies with in total eight professional certified air traffic controllers proved a high feasibility of the concept. Results from these simulations compared to today's TMA concepts are

- Ghosting and targeting techniques highly appreciated by controllers
- Shorter flight times and better separation especially in high traffic conditions
- Less separation violations
- Aircraft fly higher altitudes and use less thrust in descend phase, noise reduced
- Less demanding for controllers
- ~150kg/aircraft less fuel burn with 30% equipped
- ~300kg/aircraft less fuel burn with 90% equipped

Two professional air traffic controllers realizing the FAGI concept



One part of the answer to future demands in air transport like gain of capacity, reduction of environmental impact, improved flight efficiency and high predictability is FAGI!

AT-One combines the strength of DLR and NLR in ATM Research

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