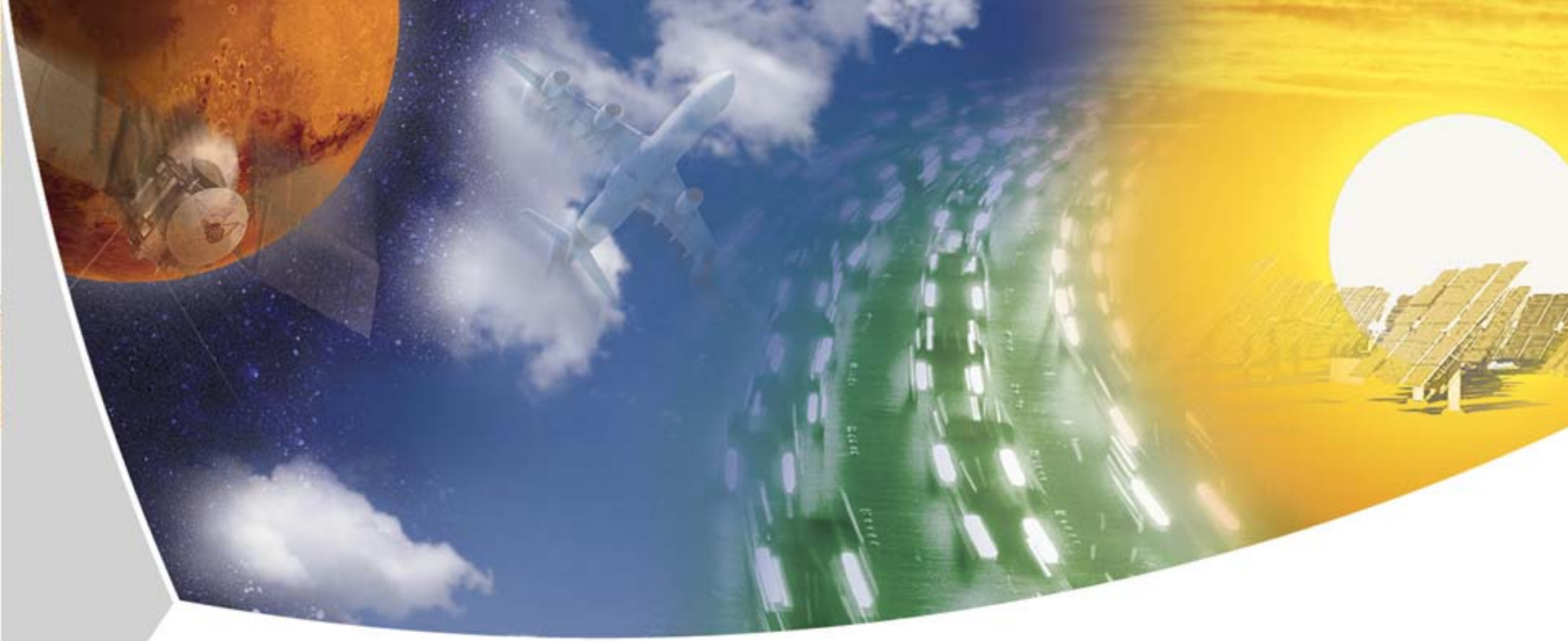

# Controller Aids for Integrating Negotiated Continuous Descent Approaches into Conventional Landing Traffic

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# Motivation

What do we want to achieve:

- Fuel saving
- Noise abatement

by Continuous Descent Approaches (CDA) at highly frequented hub airports

The challenge is:

Continuous Descent Approaches decrease capacity

# Why is capacity decreasing by CDA

- Controllers get a problem to predict the trajectory timely at waypoints along the approach path
- Controllers have to deal with aircraft flying CDA and those flying conventional approches (e.g. LDLP) on the same transition routes
- The airspace layout is not fitted to the needs of mixed traffic

As consequence the coordination workload for the controllers increases in situations where they are already working at their limit

# DLR-Project Future Air Ground Integration (FAGI)

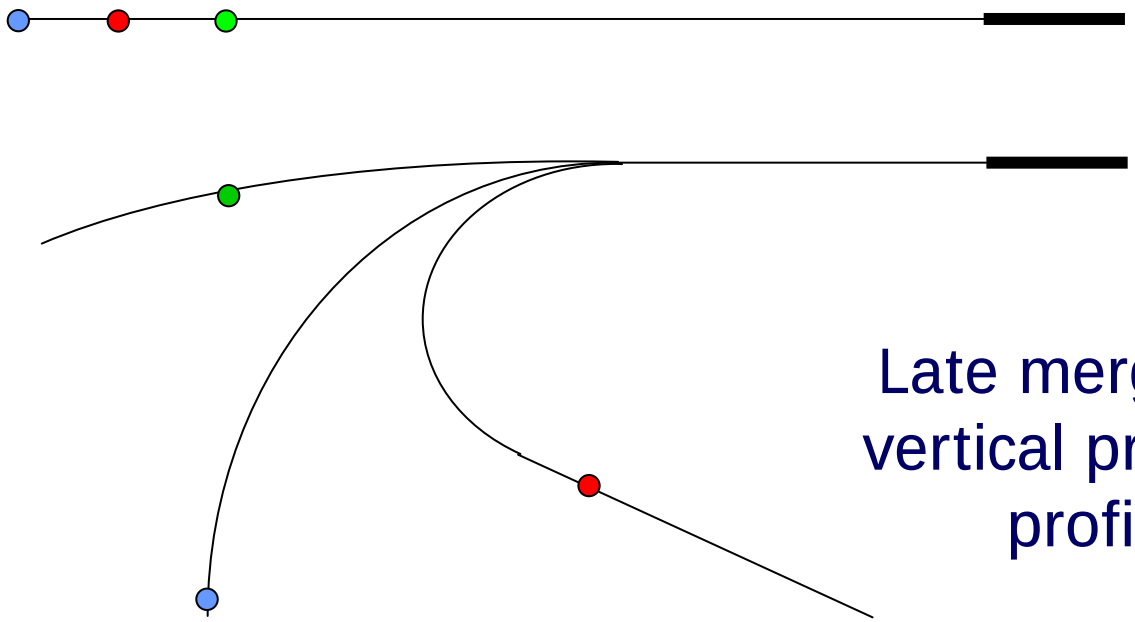
- Operational Concept
  - Use the potential of the 4D-FMS for CDA
  - Ease the integration of CDA into conventional approach stream by
    - Deployment of a decision support AMAN with a tailored HMI
    - Integrated air ground negotiation
    - Redesigned airspace layout

# FAGI Airspace Layout

- Late Merging of conventional approaches with CDAs not before 6 NM to threshold
- Several horizontally separated approach routes from all approach directions
- Conventional traffic is still guided with radar-vectoring over a path stretching area (trombone-pattern)
- Basic conflict reduce potential
  - By disjunct arrival routes
  - Level separation by profile layout at cross points for aircraft flying conventional approach and CDAs

# Why introduce Late-Merging-Point to integrate CDAs?

Early merging – different speeds → loss of capacity



Late merging – different* vertical profiles and speed profiles possible

*source: K. Wichman, GE Aviation, DASC 2002

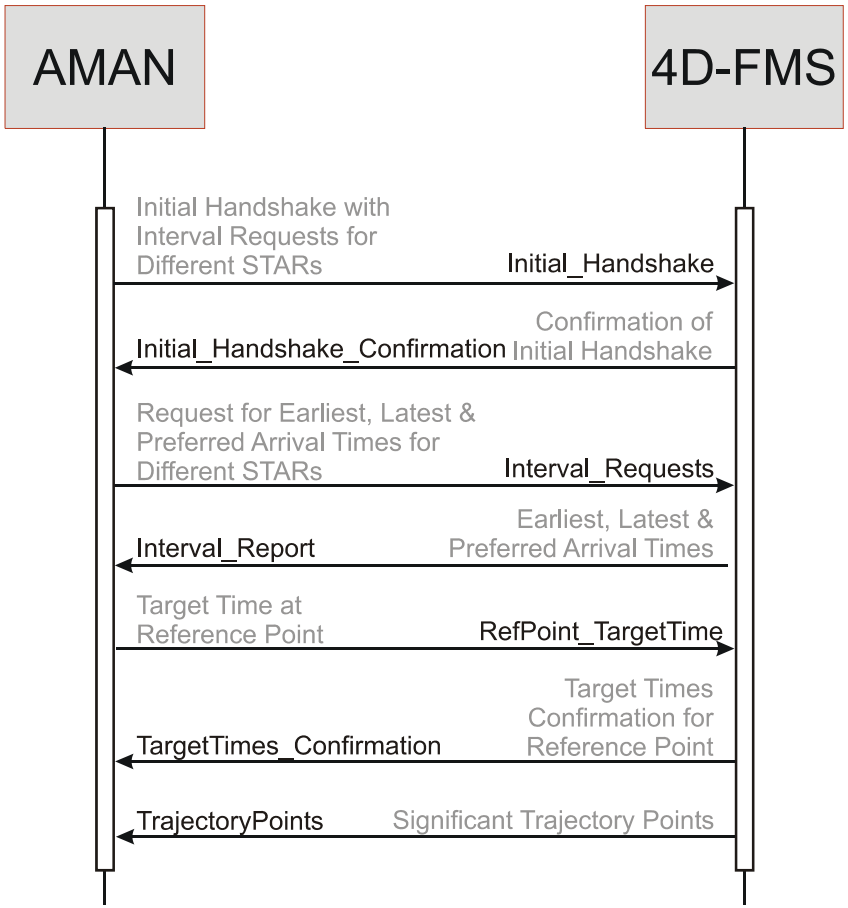
# FAGI Air Ground Integration

- Motivation
  - Timely integration of CDAs into conventionally guided traffic
  - Less radio contact between pilot and controller
  - Improved turn-around-processes at the airport by early known, precise target times at threshold

- Target times at LMP and threshold and the assigned arrival route are result of automated negotiation processes (N-CDA) between 4D-FMS and AMAN over data link

- Aircraft flying N-CDA profiles may be degraded to conventionally guided ones automatically in case of trouble or manually by controller action

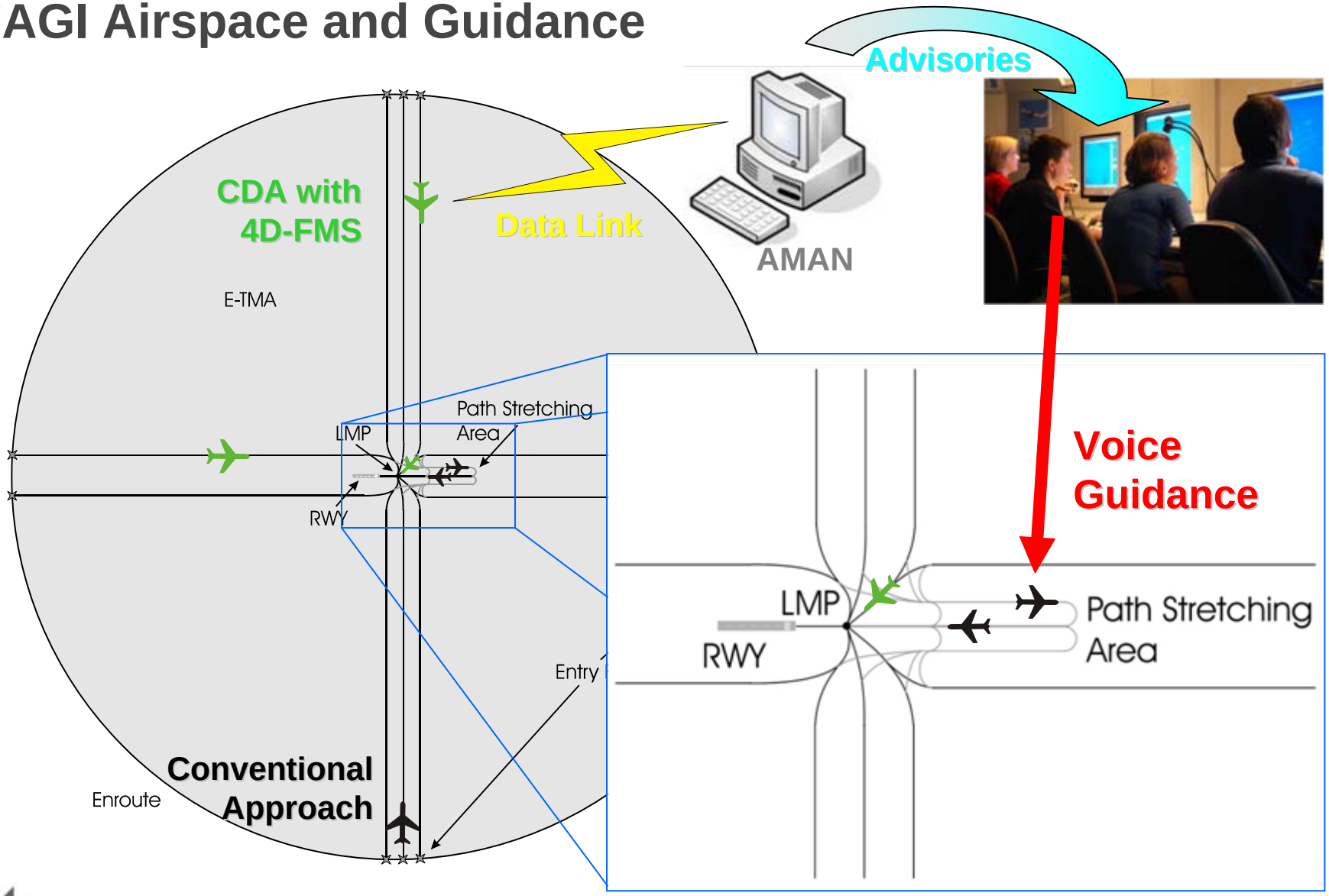
# Air Ground Negotiation Protocol




Excerpt of the air ground protocol

- *Initial Handshake*
  - Approach conditions
    - QNH
    - Operation mode
    - Visibility conditions etc.
  - Request of earliest/latest interval for a specific arrival route
- Messages can be confirmed automatically or manually by the crew
- Negative *Target Times Confirmation* message leads to new *Interval Requests*

# FAGI Airspace and Guidance



# New Challenges for the Controller

- The controller‘s mental picture and situation assessment will be highly influenced by the FAGI concept

- Significant changes to approach controller‘s nowadays task profile
  - Equipped aircraft are not under his control as long as he gives no commands to them
  - Difficult to estimate profiles of equipped aircraft
  - Reduced communication with equipped aircraft may lead to loss of situation awareness
  - Final approach profiles differ a lot depending on aircraft equipment level
  - Manage late merging
  - He is not used to time based guidance, usually guidance is distance based
  - He has to trust the decision support system
  - Automated planning takes effect on his creativity and flexibility
  - The paradigm „First Come First Serve“ may no longer be valid

# FAGI Automated Controller Support

- Integration of FAGI controller interface into DLR‘s 4-Dimensional Cooperative Arrival Manager (4D-CARMA), the modular trajectory based prototype for validating innovative ATM-concepts
- The controller is supported by timely precise guidance advisories
- Sophisticated aids delivered by 4D-CARMA are displayed on the FAGI HMI designed in cooperation with controllers

# Controller Aids Timeline, Move and Freeze


- Information for the controller
  - Target times
  - Callsign, WVC, position in sequence
  - Equipment status
  - WVC H
- Active influence on sequencing
  - Move position
    - Drag and Drop
  - Freeze from position 1 to X
    - Pull Down Menu

# Controller Aid Advisory Stack

Eases time based guidance

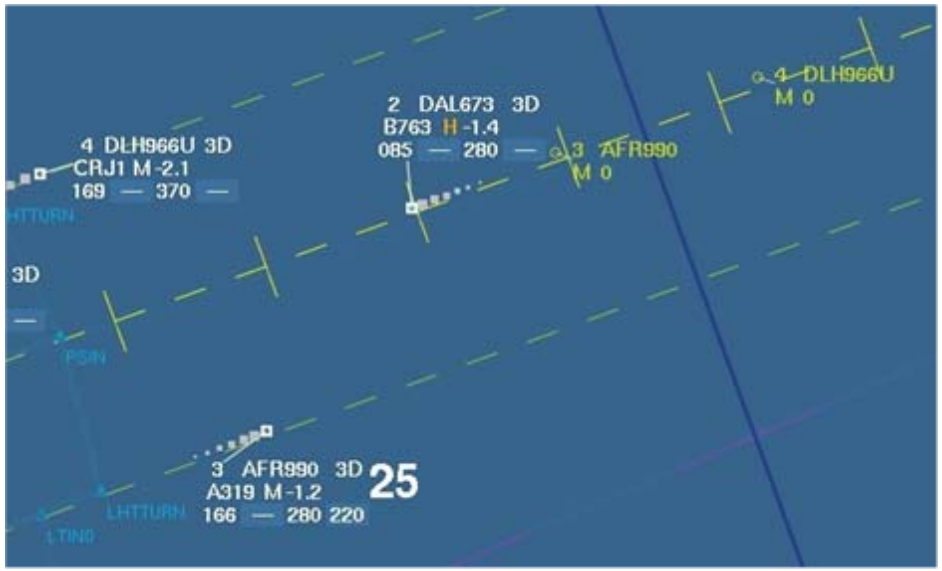

Advisory layout:

- Counter in sec.
- Callsign
- Command
- Target Value

- Accept
- Reject

Counter for turn on Situation Data Display

# Targeting

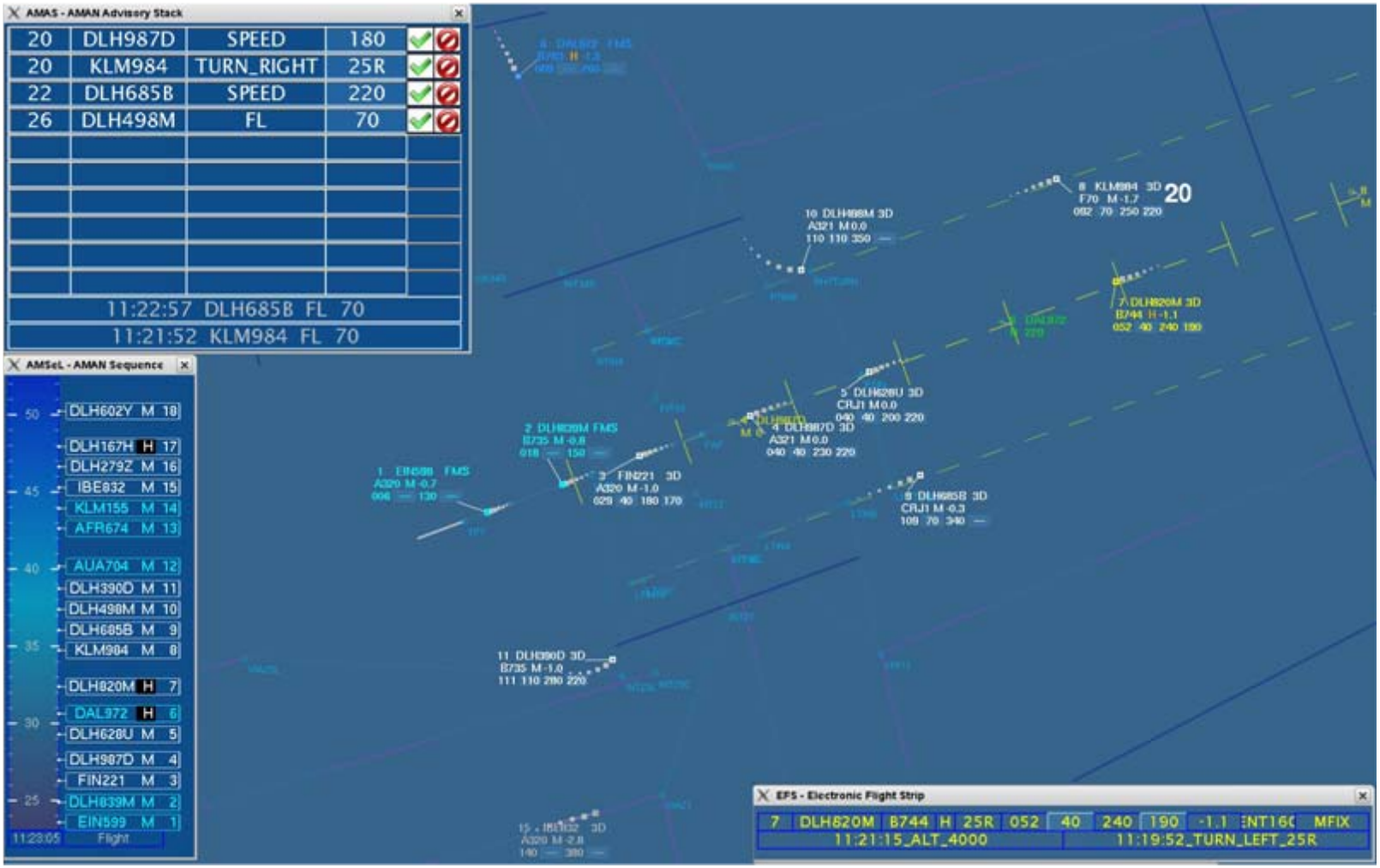



- Conventionally guided aircraft
- Target on centerline
- Meet target by timely turn
- Projection calculated by trajectory length mapped to centerline
- Disappear when target met

# Ghosting


- Equipped aircraft flying CDA
- Projection on centerline
- Remaining flight time mapped to average profile of conventionally guided aircraft
- Disappear near LMP

# Controller Aids at a Glance



# Validation Trials

- Validation trials in November 2009 with controllers from France, Germany und Luxemburg
  - Traffic mix 70% conventional and 30% equipped aircraft
  - AMAN always active timeline displayed
  - Scenarios (low and high traffic, 32 resp. 36 a/c per hour)
    - Base Line (no CDA, all conventionally guided)
    - Late Merging with Turn-Advisories und Ghosts
    - As above with additional Targets

# FAGI Real-Time Trials at DLR

Air Traffic Controllers

Radio Communication

Pseudo Pilots

Advisories

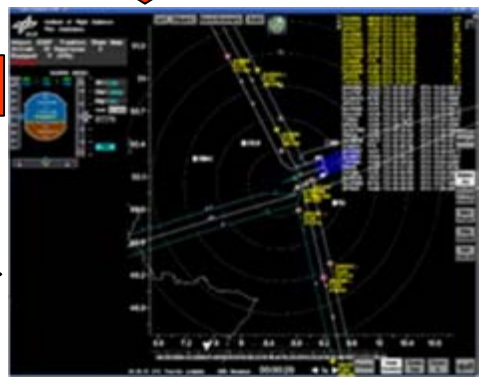
HMI Features

Radar Vectors

Arrival Manager

Radar

Negotiation with equipped Aircraft



Traffic Generator

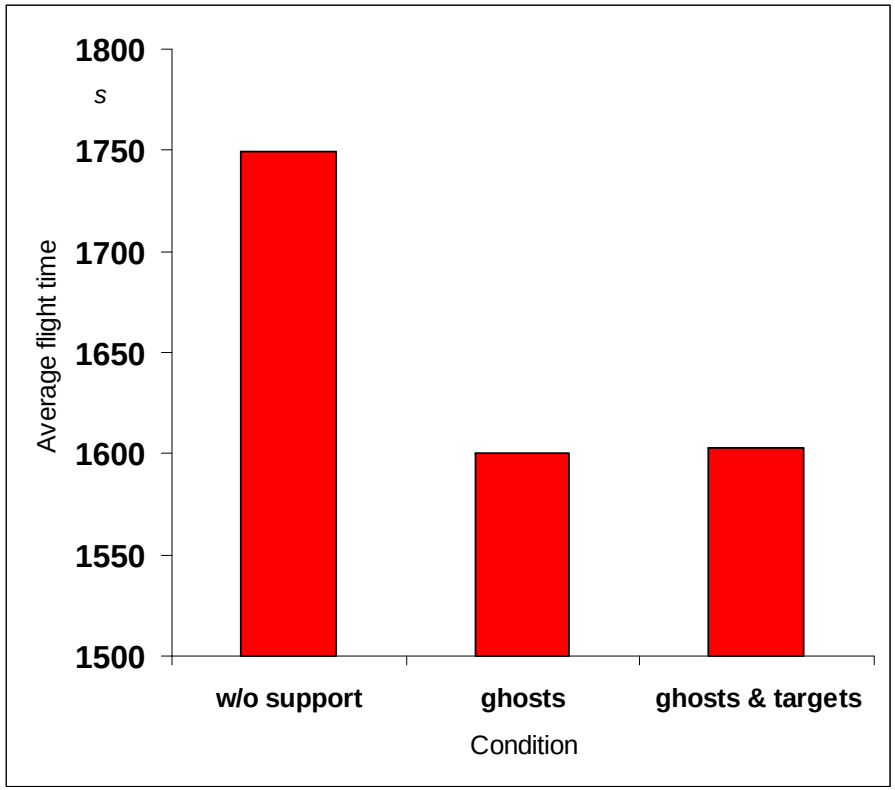
# Systematic Data Collections

- Situation Awareness with SAGAT-Measurements
- Workload with NASA-TLX Interviews
- Results to be pointed out
  - Workload is highest, when no additional controller aid active
  - Workload during „Base Line“ scenarios is indicated by intensive radio communication
  - Low traffic scenarios are not considered in further outcome, they showed low impact on safety and efficiency through controller aids

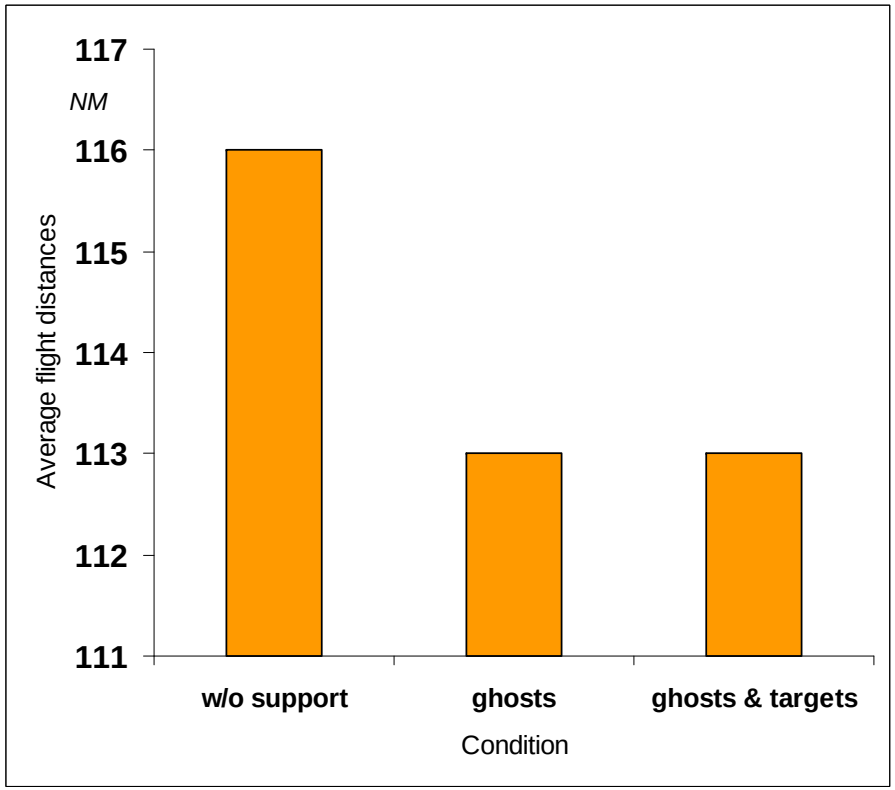
# High Traffic Scenarios and Levels of Controller Support

| Scenario and Support | Base Line | Late Merging I | Late Merging II |
|---|---|---|---|
| CDA | 0% | 30% | 30% |
| Timeline | + | + | + |
| Sequence Position in Label | + | + | + |
| Turn to Base | - | + | + |
| Ghosts | - | + | + |
| Targets | - | - | + |

# Average Flight Times and Distances in Dependency of Support Conditions

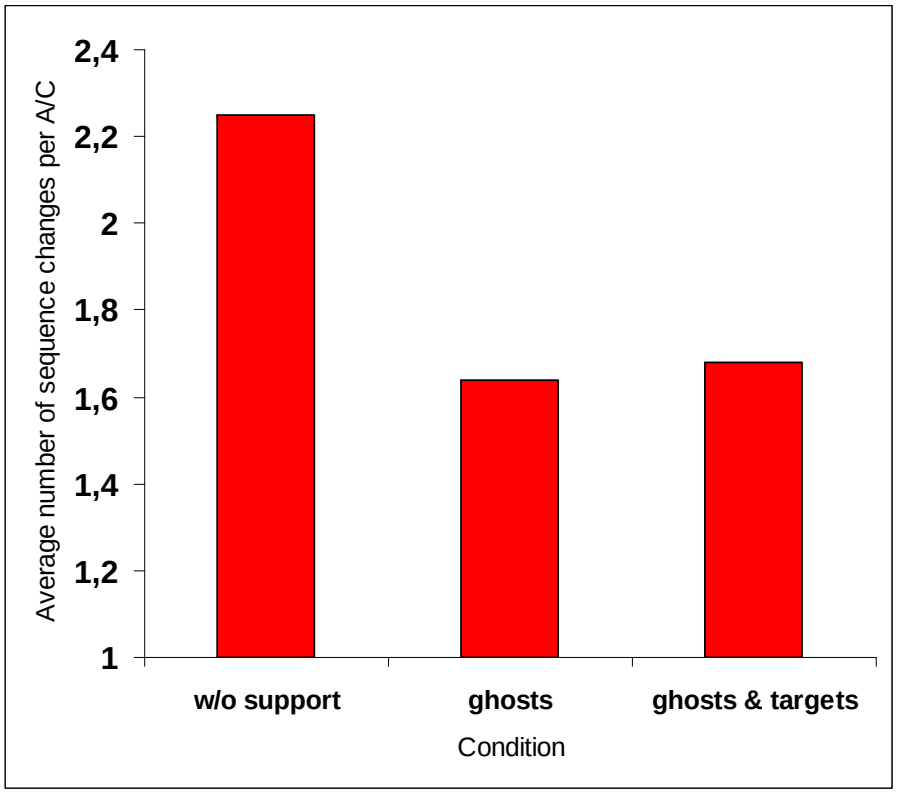



Flight Times

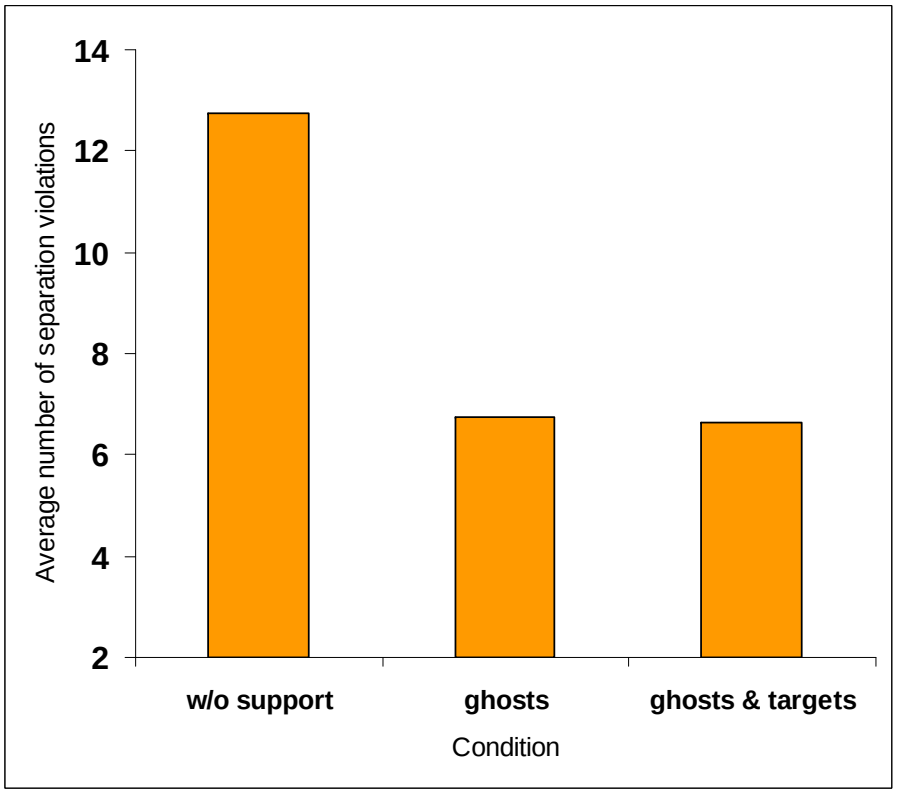



Flight Distances

# Average Numbers of Sequence Changes and Separation Violations




Sequence Changes



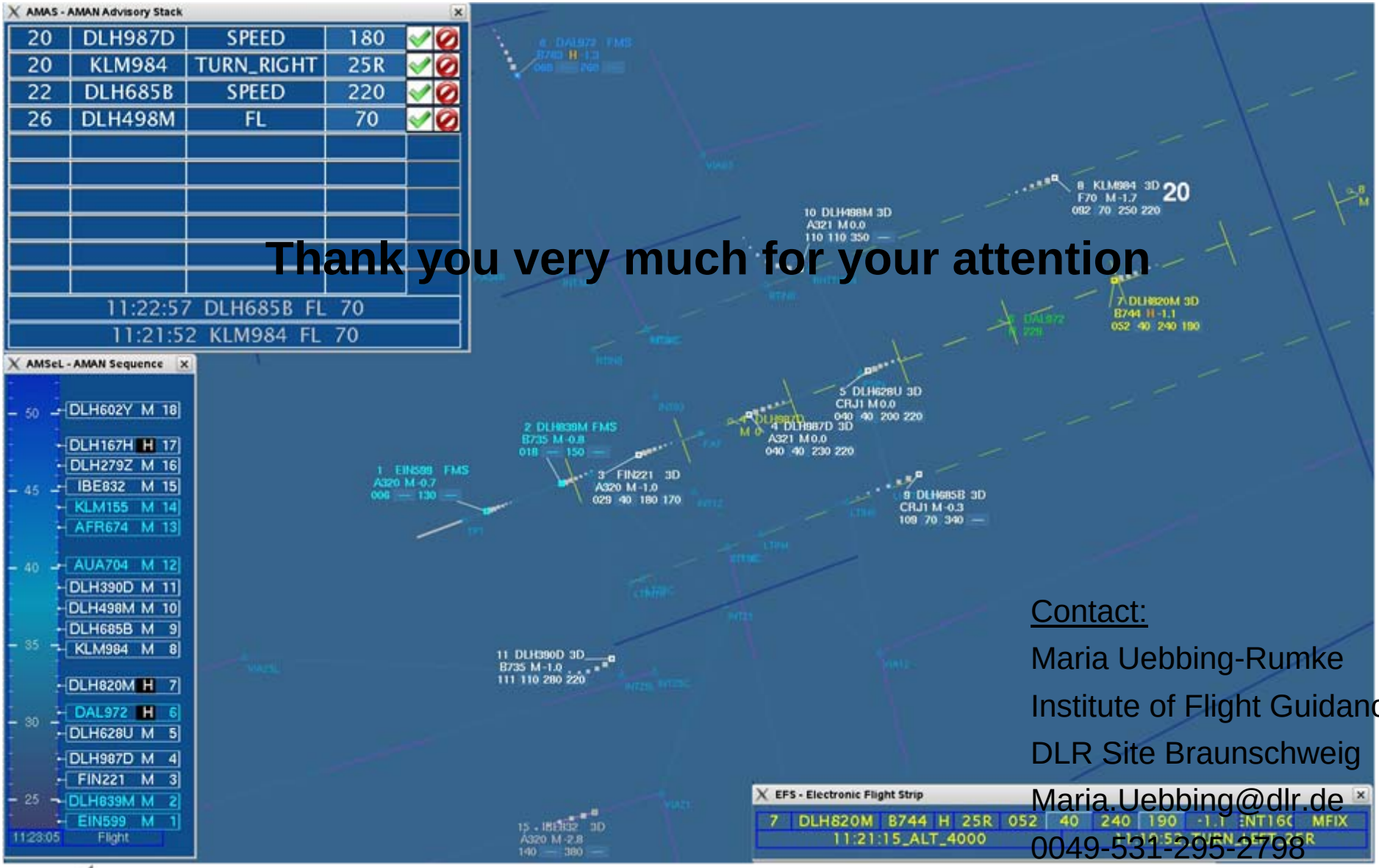

Separation Violations

# Summarised Controller Feedback

- Merging approaches of conventional and equipped aircraft is seen as a great challenge
- If all possible guidance advisories are shown on the display the controller feels degraded in his task, he complains about loss of situation awareness
- Sometimes the controller feels the display is overloaded with movable icons when targeting and ghosting functions are active
- Countdowns for the turn-advisory at the aircraft label are very helpful
- The possibility to degrade equipped aircraft with negotiated contract is indispensible in terms of safety
- The timeline is essential as communication interface between controllers in role of pickup an feeder

# Conclusion

- Guidance of high traffic with mixed profiles is not possible without tailored controller aids by a ground tool
- The controller needs additional support for
  - Situation analysis
  - Prediction and monitoring
- Controller feels „in the loop“ by direct communication with the AMAN (Move, Freeze)
- Average duration and distance of flights and even the separation violations are reduced as result of smart airspace layout and controller aids
- Air ground negotiation of target times and routes enables time based guidance for all flights
- The controller workload will not be increased because of sophisticated controller aids developed in the FAGI concept.

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