

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

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Abstract—This paper deals with the challenges that appear if Continuous Descent Approaches (CDA) with landing times negotiated in an air ground protocol have to be integrated into approaching traffic on heavily loaded airports using standard arrival profiles like Low Drag Low Power. The controller is not able to guide those flights and standard approaches simultaneously in an efficient and safe way because of unpredictable flight levels and speeds of CDAs over the timely progress of the landing procedure.

Therefore controllers will need assistance by a ground system that is calculating suitable landing sequences and landing times. The support system will have to take into account data about the CDA flights it has got by the negotiation process and the results of its own trajectory prediction engine. This engine calculates possible profiles for the standard approaches. These profiles can be translated to timely precise controller commands to be displayed on a controller human-machine interface (HMI). As result of intensive human-in-the-loop investigations during the DLR project Future Air Ground Integration (FAGI) further controller aids were developed to support controllers to implement time-based arrival management by having the possibility to use their distance based procedures.

Keywords—ATM; CDA; time-based arrival management; 4D-CARMA; air ground integration; late merging

I. INTRODUCTION

As air traffic has always grown over the last decades and no end of growth is in sight, we have to state that airports and especially big hubs reached their limits of capacity [1]. Furthermore the population in many countries is no longer willing to suffer from increasing pollution and noise output from air traffic sources. So research in this sector is concentrating on making better use of technical equipment that allows timely precise and therefore energy-saving and noise reducing flights especially in the landing phase. An optimised profile for landing is the Continuous Descent Approach (CDA) and modern aircraft are able to fly this profile with a notable accuracy in time and way.

On the other hand these procedures are seldom flown by aircraft in high traffic situations at Terminal Manoeuvring Areas (TMA) because of the complex guidance situation arising for the controller when they are mixed with aircraft flying other profiles.

II. BACKGROUND FAGI CONCEPT

In the project Future Air Ground Integration (FAGI) the DLR Institute of Flight Guidance developed a time-based operational concept to mix up arriving traffic with different procedures by negotiating landing times for CDA aircraft and supporting the controller's task with appropriate guidance assistance on his human-machine interface (HMI). The concept was validated by several international controller teams and their input was constantly used for concept improvement [2]. As the concept is time-based it complies with the SESAR activities of the European Commission with their key concept of the so called business trajectory [3].

The FAGI concept includes a bundle of arrangements that are all together responsible for the success of managing mixed approach traffic in the above described environment [4]:

- A sophisticated decision support AMAN on ground for the controller.
- An air-ground protocol for the negotiation over data-link with the CDA flying aircraft.
- A new layout for the TMA with the concept of "Late Merging".

III. AIR SPACE STRUCTURE WITH LATE MERGING

Let us start with the last: The enabler for the concept of Late Merging is a specially designed TMA. The execution of noise and fuel saving CDA approaches without negative impact on capacity requires strictly spatial separated approach routes [5]. For safety reasons the standard separation minima would have to be increased, taking into account the unknown profiles of CDA approaches. Therefore the FAGI airspace layout is very well adapted for the needs of optimizing arriving

traffic with mixed profiles. We propose a so called Extended TMA (E-TMA) with a radius of about 100 NM, which is much bigger than an average TMA is today. If there are e.g. four directions of incoming traffic we propose three entry fixes per direction with lateral separated parallel standard arrival routes (STAR). The ACC controller has the possibility to split up the traffic from one direction, to three different entry fixes, so that they will not get near to each other for the next 15 minutes. These STARs are used by all incoming traffic.

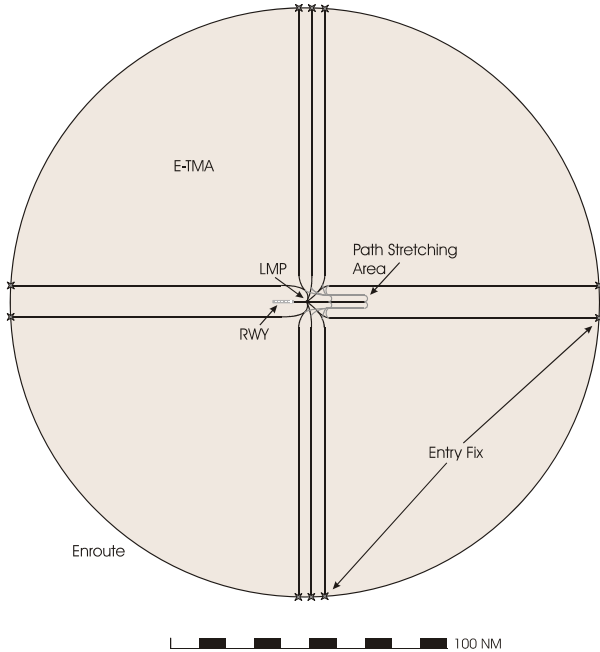


Figure 1. Schematic illustration of the FAGI E-TMA with four Entry Fixes, horizontal disjunctive arrival routes, path stretching area, and the LMP around five Nautical Miles before the threshold.

In the inner circle about 10 NM from the runway the CDA approaches and the conventional ones are using different routes to the Late Merging Point (LMP) that is located on the final six NM before the threshold. The CDA aircraft already in flight levels less than FL 40 are lead immediately to the LMP, the conventional ones in flight levels about 70 uses a trombone pattern with path stretching functionality before intercepting the centreline. They all meet at the LMP. That is the point where they have to be delivered in a well separated distance according to ICAO rules.

To transfer the concept of Late Merging to an operational concept the two kinds of arriving aircraft have to be clearly distinguished. A CDA only can be performed by aircraft that are equipped with 4D-FMS and data link capability. The 4D-FMS is required for the precise prediction of times at waypoints that have to be passed. The data link is required for the negotiation of target times at LMP and threshold that can be realised by the aircraft with a precision of a few seconds. When entering the E-TMA this negotiation takes place and if it is successful there will be as a rule no more controller commands to the landing of the aircraft. It has the possibility to fly its preferred profile, regarding its weight, aircraft type, airline preference and other characteristics [6].

The conventional aircraft are guided by the controllers as it is known up to now. They get clearances for an STAR, speed, descent and turn advisories and have the disadvantage to be lead over the longer way in the trombone pattern. The arrival sequence in whole is planned by a ground based decision support tool, the 4D-CARMA Arrival Manager developed by DLR [7]. It helps the controller with his complex task of mixing two kinds of traffic. The so called “equipped aircraft” (aircraft with a 4D-FMS on board) as described above get some kind of gratification because of their higher equipment status. This benefit should lead to a faster re-fitting with modern FMS and data link technology.

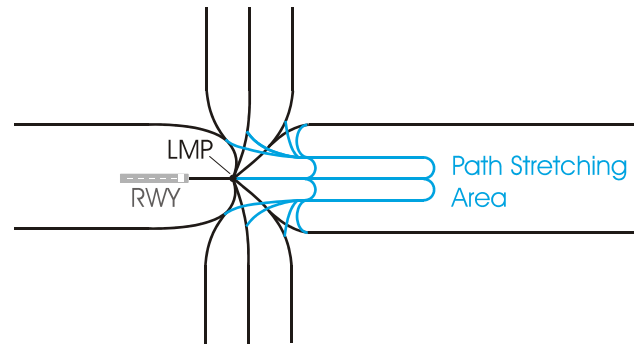


Figure 2. Schematic illustration of the different arrival routes for direct approach (black) and conventional approach, guided via the path stretching area (blue).

Furthermore it is possible for the controllers to guide the conventional aircraft directly to the LMP in low traffic situations.

IV. AIR GROUND TARGET TIME NEGOTIATION

The target time negotiation at the LMP between the aircraft FMS and the ground based arrival manager is one of the main issues of the FAGI concept. The contract fixing the time at Late Merging Point between airborne FMS and ground-based 4D-CARMA Arrival Manager makes the guidance much easier for those aircraft. It decreases the contact rate significantly and by the precise prediction of landing times the turn-around processes on ground are improved [8].

Modern 4D-FMS are able to compute a whole landing trajectory regarding meteorological constraints. In future planning systems with broadband data links this trajectory could be used for improving trajectory prediction on ground and especially for conflict detection and resolution. So the situation awareness of controllers can be meliorated for equipped aircraft flying negotiated CDAs.

The FAGI airspace layout with strictly disjunctive arrival routes reduces the effort to implement an air ground communication protocol resulting in a negotiated landing time. The STARs can be identified by unique names and so be assigned to aircraft by the ACC controller. The negotiated CDA approaches and the conventional ones over path stretching areas are not brought together before the Late Merging Point. The ground based sequencer has to merge them taking into account the prescribed separation minima. With other words it has to produce empty intervals on the centreline

where the CDAs can slip in at the Late Merging Point. As mentioned above the standard profiles of conventional and CDA approaches are by definition separated at their crossing points through sufficiently different flight levels.

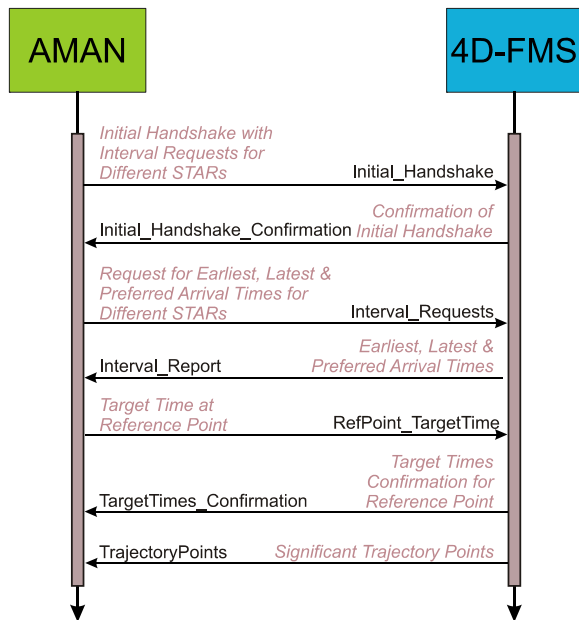


Figure 3. Simplified illustration of the air ground data link negotiation protocol.

As soon as an equipped aircraft enters the E-TMA the ground system contacts the 4D-FMS over data link. The distance from the threshold is crucial as it has to be so far away that the aircraft still has the possibility to change its Top of Descent point. This variability allows the 4D-FMS to compute a time interval for the Late Merging Point. After the Top of Descent the variability gets poor. To attenuate this effect in the FAGI trials the participating 4D-FMS calculated trajectories with the possibility of including a level flight at flight level 100 for about three minutes. The first message from AMAN to FMS is called “Initial Handshake”. The message includes information about airport constraints as QNH¹, operation mode, visual conditions, etc. Furthermore, it contains a request for the time interval at Late Merging Point for the prescribed STAR. As an alternative the message can be sent to aircraft with data link but no 4D-functionality. In that case it contains only airport information. A 4D-FMS equipped aircraft answers either with an “Initial Handshake Confirmation” message or immediately with the computed time interval at LMP with the “Interval Report” message. All messages from ground can be manually accepted by the crew, but must not.

The times from the “Interval Report” are now taken by 4D-CARMA to calculate an optimized sequence for all known aircraft approaching the airport. The time intervals reported by the 4D-FMS equipped aircraft are considered as a hard

¹ QNH is a pressure setting used by pilots and air traffic control to refer to the barometric altimeter setting which will cause the altimeter to read altitude above mean sea level within a certain defined region.

constraint, that means the system tries to fulfil the requirement to plan those aircraft in their preferred interval and thereby allow them to fly their planned CDA. If the resulting sequence matches all optimization criteria of the AMAN a “RefPoint Target Time” message with the planned time at LMP is sent to board. The answer is a “TargetTimes Confirmation” message. If the time does not fit anymore because of the duration of the communication process then it can be started once again by sending a negative “TargetTimes Confirmation” message inducing a new “Interval Request” by the ground system.

If the time interval sent by a fully equipped aircraft cannot be used for sequence building by the ground system or the aircraft deviates a lot from its planned trajectory there is always the fallback case of leading this aircraft like a conventional one. In FAGI we called this process that a 4D-FMS aircraft is degraded to a conventional one.

V. CHALLENGES FOR THE FAGI CONTROLLER

Essential attention has to be paid to the controller working position when implementing the FAGI concept. Without specially developed controller support the time-based integration of negotiated CDAs cannot be realised. This was the statement we got from the controller teams that validated the concept in the DLR’s simulation environment. What are the characteristics and challenges that are extraordinary in the FAGI context?

We start with a description of the controllers’ tasks that were involved in the validation trials. Because of the big extension of the TMA we disclaimed the role of the ACC controller, it would have taken too long in one simulation scenario to guide aircraft from outside the E-TMA to the threshold and the controller on the ACC position would have had very little to do as we did not simulate overflights and departing flights. So, we focussed on the role of the pickup that welcomed the aircraft in the E-TMA and implemented a pre-sequence by speed and descent advisories for the conventional aircraft. If they leave the prescribed STAR he will also give direct commands to integrate them in the approach queue again. In case of a 4D aircraft this leads to revoke the negotiation result and degrade the aircraft to a conventional one. The role of the second controller called feeder is to build the sequence on the centreline by a timely precise turn-to-base command and appropriate speed and descent command for intercept the centreline and grant the prescribed separation on the last nautical miles before landing. In high traffic situations especially the feeder is forced to communicate over radio almost without a break with the pilots.

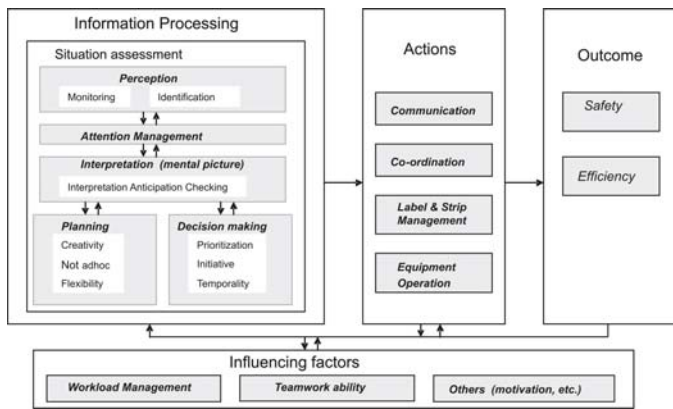


Figure 4. ATC Performance Model [9].

If you look at the ATC Performance Model derived by Oprins, et al. you get an idea of how important the task of situation awareness is for all controller working positions [9]. All his tasks of monitoring, identification of objects on the radar display, interpretation, anticipation and checking of the situation, planning and decision making are influenced by the FAGI concept. There are aircraft on his display that are flying without his intervention only following a contract they negotiated with a ground tool. The concept generates challenges really new to approach controllers:

- He has to estimate the flight level and speed profile of the equipped aircraft. The only detail that is known of this trajectory is the predicted time at the LMP.
- The poor communication with the equipped aircraft leads to losing the situation awareness for this category.
- The approach routes from equipped and conventional aircraft differ by default.
- He has to cope with the late merging of conventional and equipped aircraft that never appeared on the centreline. In normal operation mode all aircraft are put into a row on the centreline before touchdown. Then the controller gets a good idea of how to produce the separation by speed commands.
- The concept of time-based guidance does not fit to his traditional distance-based guidance. The radar position display and the controller aid of mileage icons lead to work intuitively distance-based.
- The high level of automation produced by the negation of CDAs and integration of the target time results as input to the planning tool forces the controller to rely on the advisories of the system. He gets difficulties to communicate his own planning intention to the AMAN and the system gets difficulties to recognize those intentions in time.
- The advisories of the planning system narrow the creativity and flexibility of the controller and may influence his situation awareness.

- The general principle of fairness as he knows it in ATM, you can call it “first come first serve” is affected as equipped aircraft fly on shorter routes by default and thereby reach the threshold earlier than their conventional neighbours.

VI. SOPHISTICATED CONTROLLER DECISION SUPPORT

A. Arrival Planner Setup

4D-CARMA is a time-based Arrival Management System developed by the DLR Institute of Flight Guidance as prototype for validating innovative operational concepts in the ATM environment. The data management is strictly divided from the modules that implement different functionalities. There are kernel functionalities and others that result from special requirements by projects like FAGI. The functionality of kernel modules covers:

- Identification of the two dimensional approach route
- Estimation of earliest and latest times at threshold and other significant waypoints
- Sequence Planning by regarding several optimisation criteria with resulting target times at the prescribed reference point
- Generation of trajectories
- Derivation of guidance advisories for controllers from the calculated trajectories
- Visualization for development purposes

Additional modules for the FAGI concept are listed below.

- Route, i.e. STAR assignment
- Air Ground Communication Interface
- HMI Communication Interface
- Ghost and Target Calculator

Some of the functionalities are described in the chapter about additional controller aids in FAGI.

B. Controller Aids for FAGI Working Positions

During the development of the FAGI concept our focus was especially set to support the controller working positions with additional aids for the ambitious task of integrating negotiated CDAs in conventional traffic at busy airports [10]. Several controller teams have been invited over the three years duration of the project consulting the developers. They introduced their ideas of coping with the requirements of automated and time-based guidance of approaching aircraft flying different profiles on different routes to the threshold. The resulting 4D-CARMA features based on these ideas are described in the following sections.

1) Visual Aids

To visualise the planned landing sequence and target times the controller is supported with a time line. You can find it in Figure 5. at the left side. The time is displayed top down to the actual scenario time. Right to this time line you see icons fixed

to it from all aircraft planned by 4D-CARMA. The icons contain callsign, wake class and position in the sequence. Furthermore the wake class “heavy” and the equipment status are signed by a colour code. Additional to the time line the system supplies the controller with an electronic flight strip as displayed in Figure 5. at the bottom left.



Figure 5. Screenshot of the HMI radar display.

From the trajectory predictor running for the conventional aircraft the system derives timely precise guidance advisories for the controller. They will be displayed to him in an advisory stack at about 30 seconds before they should be executed (Figure 5. button left). The 30 seconds are displayed as countdown to zero. This gives time to contact the pilot over radio, give the command and have it read back and executed. The 30 seconds are a default by 4D-CARMA but can be changed by the controller to a time span fitting to his own guiding preferences. If the controller clicks on the hook it means that he triggered the execution of the command. The corresponding value of speed or flight level is moved to the aircraft label in the radar display. If the controller clicks to the crossed circle it means that he does not accept the guidance advisory. Both click actions lead to removal of the advisory from the stack. Beside the guidance aids in the advisory stack the countdown of the very time critical turn-to-base command is also shown near the label of the corresponding aircraft so that the feeder is not forced to shift his focus from the radar display to the advisory stack (Figure 6.).



Figure 6. Screenshot of the HMI radar display with the turn-to-base counter at the label of flight “KLM984” (sectional enlargement of Figure 5.).

As FAGI is following the modern concept of time-based guidance the controllers feel uncomfortable not to be able to continue with their distance-based procedures they are used to.

It is almost impossible to translate the scheduled time distances of the AMAN to comprehensible spatial distances for the controller. So we implemented in 4D-CARMA a target label function, which project an additional aircraft “target” label of a conventional approach label with its remaining (AMAN-planned) flight distance to the threshold on the centreline. Figure 6. shows flight “KLM984” on the downwind with a remaining flight distance of 23 NM to the threshold. The target label (yellow circuit with number 8 on the right of the figure) is the projection of the 23 NM flight distance onto the centreline. The target label is moved with the AMAN-planned speed in the flight direction of the final.

The feeder has the task to meet the target label by giving the pilots time precise turn-to-base commands. The second items called “ghosts” are those representing negotiated CDA approaches. That means we compute where the negotiated CDA aircraft would be located on the centreline if it was taking this way (Figure 7. The green label of flight “DAL972” on the bottom right of the screen shot represents the “ghost”, moving on the final. The label of the real aircraft is the light blue label on the top left, coming from the north).



Figure 7. Screenshot of the HMI radar display with the blue reporting line on the left between the light blue displayed flight “DAL972” and the white flight “DLH498M”. The green label of flight “DAL972” on the bottom right is the projected ghost label on the final of the same flight on the upper left corner of the screenshot (sectional enlargement of Figure 5.).

These ghost labels can be well distinguished from the targets and help the feeder to produce gaps on the centreline where later on the CDAs can be threaded in at the LMP. The target positions are computed based on the trajectory predictor output that means the distance from the aircraft position to its planned intercept point is displayed as vector starting at the intercept point in reverse runway direction. On the final the target indicates the ideal position and speed of the real aircraft to meet the LMP at its scheduled time with the regulated wake vortex separation to its predecessor and successor (Figure 8.).



Figure 8. Screenshot of the HMI radar display with the labels of flight “DLH987D” (white) and its “target” (yellow). The target represents its ideal position on the final from the AMAN’s scheduling view (sectional enlargement of Figure 5.).

When calculating the ghost we have to deal with not knowing the precise profile of the approaching CDA aircraft. Therefore we use an approximation algorithm that was called two-segment-ghosting. The remaining flight time is transferred to the average flight profile of conventional aircraft on the centreline to the LMP, i.e. starting with a constant phase followed by a reduction phase.

2) Procedural Aids

As the guidance of the aircraft flying negotiated CDAs is not requiring radio activities apart from transferring control to other controller working positions the controllers complained of losing situation awareness for them. They proposed to force the pilots to call in at a so called “reporting line” that is near the position where the pickup would transfer the control to the feeder (Figure 7.). This report helps the controllers, both pickup and feeder not to neglect an aircraft close to the LMP heading for it automatically. At this point they get the last chance to make use of the fallback procedure by giving a direct to, reduce or descent command to an equipped aircraft and thereby degrade and treat it like a conventional one. If an aircraft is degraded automatically because its time interval at LMP is not accepted by the ground system the controller gets a warning message on his display telling him he has to guide this aircraft conventionally.

In the last chapter we described the special challenges for the controller caused by the automated planning in the FAGI context. To supply the controller with a powerful procedure to communicate his own planning intentions to the system the functionality of “freeze” and “move” was implemented in the time line management on the controller’s display. The freeze command makes it possible to fix a sequence from any position to the bottom of the timeline where you will always find the aircraft with position one in sequence. This means the system is not going to change the position of any aircraft in the frozen sequence. The functionality overrides all optimization criteria that are fundamental to sequence building in the sequencing algorithm. A comparable effect is achieved by a move command. If the controller decides to move the aircraft A at position 8 to position 10 after aircraft B then it will remain there until landing or until the controller decides to release the moved aircraft again. The move command is implemented as drag and drop on the timeline. If move or freeze commands were given, you will have a colour coding of the concerning areas on the time line. Moving of aircraft with negotiated

CDAs is not permitted as they are not allowed to change their target times.

VII. FAGI VALIDATION RESULTS

The validation of the FAGI concept took place in several large validation runs with international controller teams from France, Germany and Luxemburg. They included the teams that accompanied the FAGI project over the whole time of development. From the examination of test runs and briefing sessions we already stated the following results before doing the final validation trials:

- The guidance of mixed traffic with heavy load is not possible without additional controller aids. So the base line scenario for the validation trials did not contain any automated CDA approach.
- The controller feels degraded himself when all guidance advisories (reduce, descent turn-to-base) are displayed to him. His situation awareness gets poor, he feels like an advisory reading and executing automat. Therefore we displayed only the very time critical turn-to-base advisory to him in the validation trials

The setup for the final validation trials in November 2009 was as follows:

- All scenarios had a traffic mix of 30% equipped and 70% conventional aircraft
- There was always a time line displayed by 4D-CARMA

These setups of displayed controller aids were used in a high traffic and a low traffic scenario:

- Base Line: without aids and all aircraft flying conventional profiles
- Late Merging with two aids, timely turn-to-base advisories and ghosts
- Late Merging with three aids, timely turn-to-base advisories, ghosts and targets

In the runs with low traffic scenarios the assistance functions had almost no effect on efficiency and safety and are neglected in the following examination. The base line scenario trials are outstanding with their frequency and timely length of radio activities. During the sessions we collected systematically data from the participating controllers about situation awareness with Situation Awareness Global Assessment Technique (SAGAT) and about workload with NASA-TLX interrogation. You find those data and their evaluation results in the FAGI evaluation report [11].

The following section summarizes comments, advisories and statements extracted from the debriefing sessions:

- The workload is stated as highest by the controllers when no controller aids are active.

- The controllers stress out the impact of the time line as communication vehicle between several controller positions.
- The merging of approaching aircraft flying different profiles that result on the one hand from automatic negotiation on the other hand from controller advisories is seen as the biggest challenge for the controller's task by all controllers who took part in FAGI trials.
- Some controllers feel that the display gets overloaded by too many movable icons on the screen when all aids with ghost and targets are active.
- The countdown of the turn-to-base command is very helpful.
- The reporting line supports them in keeping situation awareness for CDA flights
- The fallback procedure to degrade a CDA flight to a conventional one is a must in terms of safety.

From the validation runs we can record the following results. In an airspace especially designed for guiding negotiated CDAs together with conventional approaches you can practice safe and efficient procedures for both kinds of approaching traffic without losing capacity. If you take the amount of separation violations as indicator for safety the validation trials proved that it will decrease by use of controller aids (Figure 9.). They were almost cut in half when the controllers took advantage of the 4D-CARMA support functions.

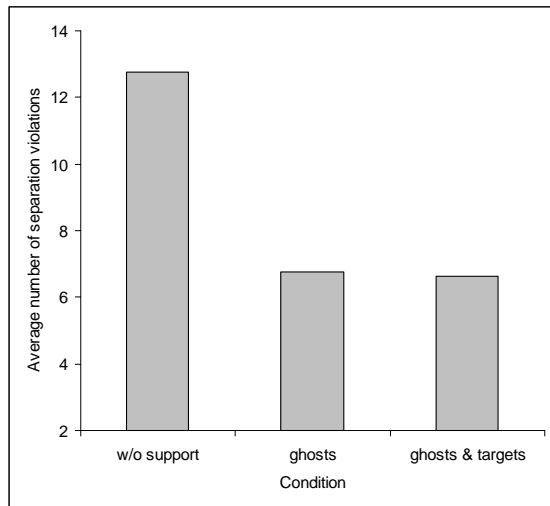


Figure 9. Average number of separation violations during high traffic scenario trails with 42 aircraft movements per hour.

To measure the efficiency of flight profiles during the trials we recorded flight time and distance of the flown trajectory of all aircraft from the moment they entered the scenario to their landing at the threshold. We can state that the application of 30% CDA approaches and additional visual controller aids by the arrival management system would save about three NM flight distance per aircraft (Figure 10.) and about 150 seconds

of flight time (Figure 11.). The extraordinary reduction of flight times can be traced back to the fact that the negotiated CDAs are flying those profiles with longer phases in high flight levels and at remarkable higher average speed. This will result in significant saving of fuel consumption of around 150 litres kerosene every CDA-approach.

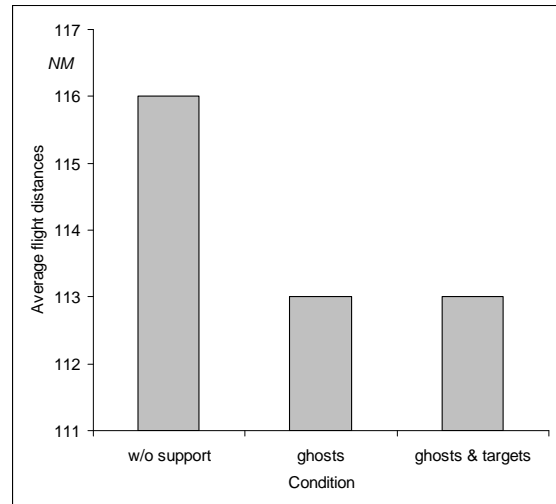


Figure 10. Average flight distances of all aircraft (equipped and conventional together) in the E-TMA during high traffic scenario trials.

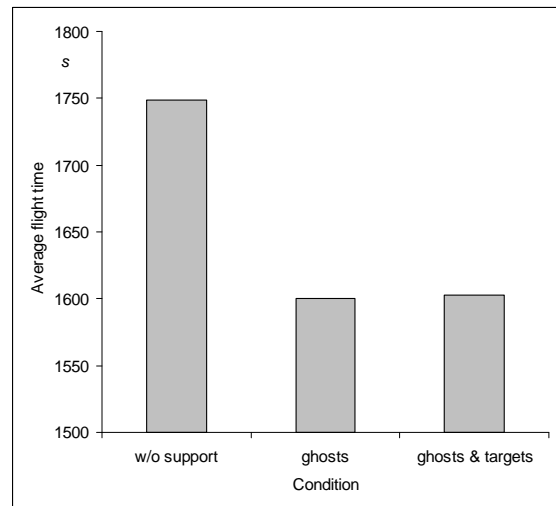


Figure 11. Average flight time of all aircraft (equipped and conventional together) in the E-TMA during high traffic scenario trials.

Furthermore the human-in-the-loop trials show by means of the average number of sequence changes during scenario runs, that the controllers, using the ghosting and targeting functionalities, implement more steady arrival sequences. Steady arrival sequences stand for a reduced number of short time changes in aircraft landing orders (Figure 12.).

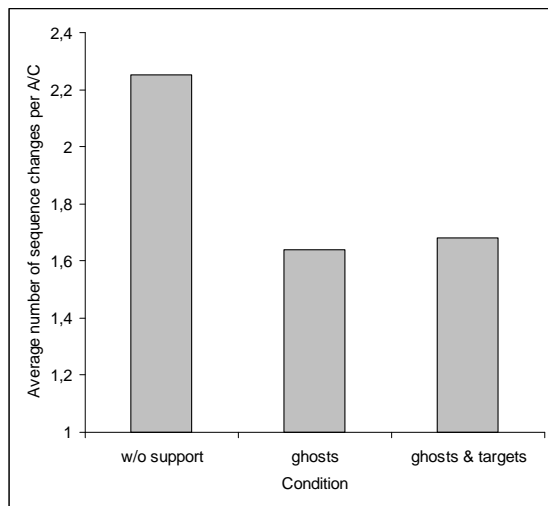


Figure 12. Average number of sequence changes per aircraft starting with the flight into the E-TMA and ending on touchdown.

VIII. CONCLUSION

The integration of negotiated CDAs into the approach traffic of big hub airports is highly affecting the working position of approach controllers. Their tasks of planning and decision making get more challenging as the complexity of the traffic situation perception and anticipation increases. The interpretation of the picture on his situation display is much more difficult as he has to distinguish between aircraft with two types of approach procedures, one of them not flying according to his own commands. His mental picture, the base of his actions, has to be stated more precisely to fulfil his tasks of situation analysis, anticipation, and monitoring. To meet these requirements specific controller aids were implemented in the DLR AMAN. Amongst others these aids cover ghosting functionalities and timely precise advisories for turn-to-base commands. If the controller does not agree with the recommendations of the system he has the possibility to change them by his own input. So he will always feel in the loop and keep situation awareness.

The further assistant part of the FAGI concept is the air ground negotiation of CDA approaches with aircraft equipped with data link and 4D-FMS. If you do not negotiate times at waypoints a CDA may not be integrated in a conventional sequence planning. There is no possibility to anticipate its flight profile and landing time. So you will not get a stable sequence at about 20 min. before landing and thereby no trusted information for the ground handlers. The optimal use of runway capacity cannot be guaranteed. So if you install negotiated CDAs you can plan the whole approaching traffic in one time-based sequencing system.

The evaluation of the FAGI trials showed that the workload of approach controllers must not be inevitably increased by integrating CDAs. The average flight time and flight path length was decreased in mixed traffic scenarios. The progress in developing innovative decision support tools and FMS functionalities will allow the implementation of air ground

communication based concepts as are propagated by the SESAR program.

ABBREVIATIONS

4D-CARMA	4-Dimensional Cooperative Arrival Manager
4D-FMS	4-Dimensional Flight Management System
ACC	Area Control Centre
AMAN	Arrival Manager
ATC	Air Traffic Control
ATM	Air Traffic Management
ATMOS	Air Traffic Management and Operations Simulator
ATTAS	Advanced Technologies Testing Aircraft System
CDA	Continuous Descent Approach
DLR	Deutsches Zentrum für Luft- und Raumfahrt
E-TMA	Extended Terminal Manoeuvring Area
FAGI	Future Air Ground Integration
FL	Flight Level
FMS	Flight Management System
HMI	Human Machine Interface
LDLP	Low Drag Low Power
LMP	Late Merging Point
NASA-TLX	NASA Task Load Index
N-CDA	Negotiated Continuous Descent Approach
RWY	Runway
SAGAT	Situation Awareness Global Assessment Technique
SESAR	Single European Sky ATM Research Programme
STAR	Standard Arrival Route
TMA	Terminal Manoeuvring Area
ToD	Top of Descent

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