DELEGATION OF SEQUENCING OPERATIONS TO THE FLIGHT CREW
FIRST QUANTITATIVE RESULTS

Karim ZEGHAL*, Robin DERANSY, Isabelle GRIMAUD†, Eric HOFFMAN, Laurence ROGNIN‡
EUROCONTROL Experimental Centre, BP 15, 91222 Bretigny, France

Abstract

In the scope of assessing the impact of the delegation of sequencing operations to the flight crew, an experiment with twelve controllers from different European countries has been carried out. The airspace simulated was a part of the Paris terminal area, and consisted of two measured sectors with arrival flights from cruise level to initial approach fix. The feeling from controllers is positive: the delegation is perceived as satisfying, and should enable a workload reduction. The acceptance is also revealed by the significant rate of use. The delegation allows for a significant reduction in the number of instructions given, specifically those given near the exit point. This suggests a positive impact on controller activity. Typically, while building sequences still remain to the controllers, maintaining sequences were delegated to flight crews. It was observed however that the sector configuration has an impact on the use of delegation. In terms of efficiency, time, distance and fuel consumption are also reduced, and it appears also that trajectories become more stable. For one of the two sessions, workload issues were investigated through self-assessment and physiological measurements. However, due to problems encountered, they did not provide a clear view. In terms of safety, no significant trend emerges although errors were observed.

1 Introduction

One of the options aiming at supporting air traffic controllers to cope with increasing traffic is to envisage a new distribution of tasks between all actors involved. This has been widely investigated between controllers and systems through the development of assistance tools or automation, e.g. for conflict detection or resolution. New distributions can also be envisaged between controllers and flight crews, and the delegation of some tasks related to separation assurance is one possible option. The delegation is expected to increase controller availability and enhance flight crew situation awareness. This increased availability is expected to provide safety improvements and, depending on traffic conditions and airspace constraints, to be converted into enhanced airspace capacity or flight efficiency. The delegation of separation assurance takes advantage of emerging CNS/ATM technologies in pre-operational state [5] along with additional avionics such as a Cockpit Display of Traffic Information [6] or an Airborne Separation Assurance System [7].

The delegation of separation assurance is envisaged for both en-route airspace and terminal areas. For aircraft within an arrival stream in a terminal area, the delegation could consist in tasking the flight crew to determine and perform the necessary speed adjustments so as to maintain a given separation to the lead aircraft. A series of studies dating back to the beginning of the 80s aimed at capturing the essence of in-trail following in terminal areas, from system dynamics and pilot perspectives [2][8][9]. Later, merging operations have also been investigated [3]. These studies carried out analytical works and simulations using mathematical models, and pilot-in-the-loop experiments with cockpit simulators. The feasibility of a self-spacing technique in terms of dynamics was demonstrated: the separation can be accurately maintained by pilots from cruise to final approach fix, and no instability tendency occurs in strings of aircraft. However, an increase of workload in the cockpit clearly appears specifically in final approach. This raises the general question of identifying the appropriate level of assistance onboard, and beyond, the best trade-off between controller and pilot task distribution.

From a controller perspective, one of the main issues arising from the delegation is to identify the best “trade-off” in the level of tasks delegated. Indeed, on one hand, delegating too low level tasks may induce
additional communication with no gain in workload. On the other hand, delegating too high level tasks may induce a loss of predictability of aircraft trajectories ("mental picture"), resulting in a potential increase of workload. As an initial step to address this issue, the task distribution between controllers and flight crews has to be defined and the overall outcomes – benefits? – have to be evaluated.

Earlier in the course of this study [ref], we have defined a form of delegation both for sequencing applications in terminal areas, and for crossing and passing applications in en-route airspace [1]. An experiment with human-in-the-loop has been carried out to evaluate the expected benefits. The present paper aims at presenting the results for the sequencing applications. It is organised as follows: the next section outlines the principles of the delegation, while the following one presents the sequencing applications. The last two sections describe the context of the experiment and discuss the most significant results.

2 Principles of delegation

In the scope of defining a task distribution between controllers and flight crews, from the onset of the project, two key constraints were identified and adopted. The first one is related to human aspects and can be summarised by "minimise change in current roles and working methods of controllers and flight crews". The second one is related to technology and can be expressed by "keep it as simple as possible".

The proposed task distribution was actually designed around the human actors involved – controllers and flight crews. Taking as its starting point existing human roles and activities, and more specifically the analogy with visual clearances, it is based upon the following key elements:

- Some separation assurance related tasks are delegated to flight crews, upon controller initiative who decides to delegate if appropriate and helpful.
- The delegation is limited since the controller can only delegate "low level" tasks (e.g. implementation and monitoring) as opposed to "high level" tasks (e.g. definition of strategy). In addition, only one flight parameter is delegated at a time.
- The delegation is flexible since the controller has the ability to select for each situation the level of task to be delegated from monitoring up to implementation.

This form of task distribution is expected to maintain unchanged core roles and working methods of controllers and flight crews. Typically, the delegation does not impact on controller’s decision-making: situation analysis, identification of problems (e.g. conflict detection), definition of solutions, and decision of delegation are part of controller's role and responsibility. Consequently, the controller keeps the initiative and overall authority on traffic management. In addition, the delegation does not impose any change of responsibility since it can be considered as a new instruction. Thus, the controller would be responsible for providing the appropriate instruction (i.e. which ensures the separation and is flyable for the flight crew) while the flight crew would be responsible for following this instruction, once they have accepted it. Indeed, flight crews can refuse delegation in case of inability to comply with the instructions. The controller should be able to anticipate pilot future actions and to predict future aircraft trajectories as today through: (1) the delegation of no more than implementation tasks; (2) the restriction to only one parameter delegated at a time; and (3) the use of appropriate pilot reports. The flexible aspect of the delegation would provide flexibility to use the delegation under different conditions such as traffic density, airspace constraints, and practice level. It would also enable a gradual confidence building in the delegation. Indeed, the levels of delegation reflect increased use in practice. Each controller should thus experience his/her own “trade-off”. Major benefits are expected from controllers perspective, mainly in terms of increased availability. From a flight crew perspective, the delegation is expected to allow for more anticipation (less time-critical instructions to follow), to increase situational awareness, and to enable an optimisation of trajectories. It is also expected that safety would be improved (or at least maintained), through a better organisation of tasks and a redundant separation monitoring ensured by controllers and flight crews.

The delegation may however induce modifications in activities. Compared to visual clearances, the delegation is expected to be used more often, over a longer time period, and also will impose larger path alterations (to ensure radar-based separation instead of staying visually apart).

In terms of technology, no change on controller working positions, no controller-pilot data-link communication, no intent information from aircraft, no automation on-board, no coupling to the auto-pilot nor to the flight management system are expected at this point – although they could be of interest. Only the knowledge of a subset of the air traffic situation is needed on board aircraft along with appropriate display cues.

3 Sequencing applications

The delegation covers two classes of application: sequencing operations in terminal areas, and crossing and passing applications in en-route airspace. For the sequencing part, in-trail and merging situations are considered and three levels of delegation are proposed (Table 1).
The delegation is composed of three phases:

- Identification, in which the controller indicates the target aircraft to the flight crew of the delegated aircraft.
- Instruction of delegation, in which the controller specifies the task delegated to the flight crew.
- End of delegation, which marks the completion of the task delegated.

For illustration purposes, an example of the "Heading then merge behind" procedure is given (Figure 1). In the example, DLH456 is the delegated aircraft, and AFR123 is the target aircraft with 1234 as SSR code. The two aircraft are flying along merging trajectories in descent with compatible speeds. The controller gives a heading instruction to initiate the separation, and asks the flight crew:

1. to estimate and report when the predicted separation at the merging point reaches the desired separation;
2. to resume navigation to the merging point, and
3. to adjust speed to maintain the desired separation.

Once merging distance is 15Nm:

Pilot: "Turning left heading 270 then will merge to WPT to be 15Nm behind target, DLH456"

This delegation can be transferred to the next sector. When required, the controller in charge of the delegated situation ends the delegation:

Controller: "DLH456, end delegation, reduce speed to 220 kts"

Similar dialogues are proposed for the other applications.

4 Context of the experiment

A first small-scale experiment took place in June '99. The main objective was to collect feedback from both controllers and pilots, in order to assess the operational feasibility and potential interest of the concept. Beyond, the objective was also to refine needs and identify other possible evolutions, as well as evaluation metrics for future experiments. The simulation environment consisted of one “measured” sector, two cockpit simulators equipped to receive delegations (CDTI with basic display cues), background traffic not equipped and low traffic sample. Five controllers (2 English, 2 French and 1 Spanish), 2 airline pilots and 2 pseudo-pilots (to handle background traffic) took part in the experiment. Due to the assumptions made – simple operational environment, small number of participants and limited occurrences of potential delegations – no quantitative measures were searched for. The results were qualitative indications gathered through questionnaires and debriefings, with an inherent subjective component in controller and pilot responses. The overall feeling on the concept was "promising with a great potential". It could allow an increase of controller availability. The flexible use of delegation could provide opportunities to use the method under different conditions – traffic, airspace, practice level – however identifying the appropriate level of delegation did not seem easy. To ensure a safe and beneficial delegation, the procedures impose applicability conditions that shall be respected (e.g. aircraft shall have compatible speeds). It has been observed that the disregard of these conditions could result in an increase of workload, communication, and stress. This appeared as a potentially critical problem and was thus considered as an important aspect to be stressed on during the training in future experiments. This experiment allowed us to refine and restrict some of the applications. Typically, for the sequencing applications, the highest level of delegation that was proposed allowed the flight crews to create themselves their own separation through the modification of two flight parameters (heading and speed). This was hardly acceptable on both sides:

<table>
<thead>
<tr>
<th>Delegation level</th>
<th>In-trail separation</th>
<th>Merging separation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Report in-trail</td>
<td>Report merging</td>
</tr>
<tr>
<td>separation</td>
<td>distance</td>
<td>distance</td>
</tr>
<tr>
<td>Maintain</td>
<td>Remain behind</td>
<td>Merge behind</td>
</tr>
<tr>
<td>separation</td>
<td>Heading then</td>
<td>Heading then</td>
</tr>
<tr>
<td></td>
<td>remain behind</td>
<td>merge behind</td>
</tr>
</tbody>
</table>

Table 1. Sequencing applications.

Figure 1. "Heading then merge behind" scenario.

The proposed exchange is:

Controller: "DLH456, select target 1234"

Pilot: "Selecting target 1234, DLH456"

After pilot selection and identification on the CDTI:

Pilot: " DLH456, target 1234 identified"

Controller: "DLH456, turn left heading 270 then behind target, merge to WPT to be 15Nm behind"
controllers could not predict flight crew actions which is critical in terminal areas, and flight crews were unable to select the appropriate sequence of manoeuvres. The question of responsibility was raised as a major concern (this is however beyond the scope of the study).

The objective of the present experiment was to assess the concept of delegation and to evaluate its initial benefits in en-route and terminal areas. A subsidiary objective was to improve the procedures and the phraseology. The experiment consisted of two sessions, June and November for a total of four weeks of simulation. The November session also investigated flight deck issues through the connection of a cockpit simulator during the first week. Compared to the previous June 99 experiment, this experiment made use of a more realistic and comprehensive environment allowing quantitative measurements.

The June and November sessions were split into two distinct sub-sessions of one week each: one for sequencing applications and one for crossing and passing applications. Two distinct organisations were thus simulated: an extended Terminal Manoeuvring Area (TMA) exhibiting sequencing situations from cruise to the Initial Approach Fix (IAF); and an en-route airspace exhibiting crossing and passing situations. (The en-route part will not be described.)

The simulated airspace was a part of Paris Southeast area (Figure 2), and was thought to be representative of a dense area and generic enough to allow an easy assimilation by the controllers (only 1 out of the 12 controllers was familiar with the airspace). Four existing sectors were selected and combined into two measured sectors (denoted AO and AR). The grouping (which is applied in the reality when traffic permits) allowed for a handling of a majority of flights from cruise to IAF by the same sector. Thus, the delegations process could be simulated and analysed during a significant period of time. In addition, direct instructions to IAF that were intensively used specifically for merging applications did not require any co-ordination.

**Figure 2.** Airspace dedicated to sequencing applications (snapshot of the replay tool – not of the actual controller display). Flights landing at Charles de Gaulle (LFPG) are transferred to Roissy TMA (feed sector) over SUSIN (IAF) at FL80. Flights landing at Orly (LFPO) are transferred to Orly TMA (feed sector) over MEL (IAF) at FL70. The two measured sectors are denoted AO and AR. The AR sector has one converging point (DIJ), while AO has one main converging point (ATN) and a secondary one (OKRIX).
Each of the two measured sectors was manned with two controllers (executive and planning). The traffic samples were derived from two traffic recordings. The arrival traffic was slightly increased and adjusted to create clusters of aircraft, and the resulting traffic was close to a real high-density traffic. All the traffic was equipped to receive delegations, thus offering maximum opportunities to use delegation.

For the June session, the working environment replicated the current one (paper strips, no advanced tool). Thus, controllers were able to get rapidly familiar with airspace and traffic flows, and were able to concentrate on the delegation concept. Six controllers (2 Italian, 2 Portuguese and 2 English) and 4 pseudo-pilots participated. During the measured exercises, controllers were familiar enough with the airspace, the traffic flows and the delegation.

For the November session, the working environment was stripless with delegation marking capabilities on the screen as a support for controllers. Six controllers (3 French, 2 Irish and 1 Italian), 5 pilots (2 test pilots, 3 airline pilots), and 4 pseudo-pilots participated. Though we introduced a new interface, no specific training was planned. Indeed, we thought that either controllers were familiar enough with stripless environment, or they could easily get familiar with it. In addition, due to technical problems, they had to cope with interface trouble-shooting. Some of the controllers were not familiar with the type of flows and work (sequencing in extended terminal area). Consequently, during the measured exercises, controllers did not manage to get familiar enough with the delegation procedures and this impacted the results.

5 Experiment results

To assess the concept of delegation and to evaluate its initial benefits, four specific objectives were considered:

1. Users acceptance of the concept
2. Impact on controller activity
3. Impact on flight efficiency
4. Impact on safety

In addition to questionnaires, system recordings were analysed, allowing for subjective and objective results. Three exercises were simulated in each session (denoted June 1 to 3, and Nov 1 to 3). To allow for a relevant comparison, each exercise was simulated twice: with and without delegation. Each exercise lasted two hours, and controllers swapped roles at mid-exercise.

5.1 Controller acceptance of the concept

The controllers’ feedback, provided in questionnaires is positive. Indeed, June and November controllers understood the concept and found it satisfying. They stressed benefits in terms of workload, anticipation and quality of control. In terms of “objective” measurement, the controller acceptance could be reflected by the rate of use of delegation. Indeed, although controllers were invited to use delegation, they were not forced to. The rate of use can be represented by the number of aircraft delegated (Figure 3) and by the delegation duration (Figure 4). Different points appeared.

![Figure 3](http://www.eurocontrol.fr/projects/freer) Aircraft delegated (%)

Figure 3. Percentage of aircraft delegated compared to the number of arrival aircraft, i.e. potentially delegable.

![Figure 4](http://www.eurocontrol.fr/projects/freer) Duration of delegation (%)

Figure 4. Percentage of delegation duration compared to flight time in the measured airspace.

June vs. November: Considering the number of aircraft delegated, the two sessions show different average values, respectively 60% and 45%. Whereas the use of delegation was rather constant in June, it was more progressive in November. Considering the duration of delegation, differences are even higher: delegations lasted more than 40% in June and less than 27% in November. The difference between the two sessions could be related to the required familiarisation not only with the delegation, but also with the new interface even worsened by some
Potential for increased use: Although controllers felt the environment. controllers were getting more and more familiar with (specifically with duration of delegation) when the progressive increase observed in November significantly used delegation. The interesting point is: The rate of use shows that controllers use of the delegation.

AR sector vs. AO sector: Delegation is generally used more often in AR than in AO. This could be explained by the geographical configuration of the airspace. In AR, all the traffic converge to a single point (DIJ) located rather near the sector entry, allowing to easily give early delegations (typically merging instructions). The AO sector however, has two points of convergence (ATN and OKRIX), the second one located rather close to the exit. Although a majority of the traffic is going through the first one, integrating traffic at the second one does not facilitate the use of the delegation.

Acceptability: The rate of use shows that controllers significantly used delegation. The interesting point is the progressive increase observed in November (specifically with duration of delegation) when controllers were getting more and more familiar with the environment.

Workload is a serious issue to tackle, as on the one hand controllers feel that delegation reduces their workload, but on the other hand being too busy (i.e. with a high workload) is mentioned as one of the main reason leading them to retain delegation. One controller paradoxically evoked that high traffic forced him to delegate (i.e. delegation appeared as essential to deal with high traffic).

As a conclusion, delegation is perceived as a useful concept by 9 / 12 controllers, because it reduces the workload, provides more flexibility, more traffic capacity and enables a very accurate spacing between aircraft. The workload reduction is finally mentioned as a factor contributing to improving the airspace management and the safety in providing controllers with time to “verify situations” (quote).

In terms of objective measurements, two aspects will be discussed: the overall reduction of manoeuvring instructions*, and their geographical repartitions. These two points are thought to reflect a change in controller activity. It is clear nevertheless that this does not provide a complete picture of the overall activity and resulting mental workload, since for instance the monitoring task is not covered†.

The two following figures show the number of manoeuvring instructions (Figure 5) and the breakdown of each type of instructions (Figure 6). In June, the manoeuvring instructions were reduced by 35%, with a 40% rate of use (delegation duration). The reduction is even higher for the AR than for the AO sector. In November, there is no significant reduction while the rate of use was 27%. Considering the breakdown of instructions, the main reduction results from the reduction of speed instructions.

To provide a picture on the number of messages exchanged, the target selection related messages (“select target”, “deselect target”) need to be added to the previous number of manoeuvring instructions. It is important to note here that controller requests for information was not recorded, as in the simulator such requests do not require any operator input to be fulfilled. However we expect a reduction of such requests with delegation. In June, even despite the additional messages, the delegation still provided a 20% reduction of the number of controllers’ messages. The November results show however a 13% increase.

5.2 Impact on controller activity

In terms of feedback, 10 out of the 12 controllers (and 6/6 for June) describe delegation as a workload reduction. They feel that delegation enables earlier sequences, earlier solutions, reduced communications, reduced vectoring and reduced monitoring (less speed control). Therefore it helps reducing the workload during highly demanding phases of sequencing. Most of the controllers, the mental effort required to monitor delegations is lower or much lower, only one felt the effort similar. They felt that usually once delegated, an aircraft would not require anymore instructions from the controllers. For 11 / 11 controllers, the resulting mental workload is lower or much lower, because delegation enables a reduced monitoring of aircraft and an early organisation of the sequences.

The two main sources of workload identified by the controllers are the decision of delegation and the communication of the instructions. In addition to those, the November controllers mentioned the setting up of the marking functions. Even though they were described as essential and quite intuitive to read, the numerous sub-menus required to select and modify the delegation status represented an excessive source of workload. The controllers could not tell how the workload reduction induced by delegation would counterbalance the one induced by the marking functions. Workload could increase in degraded situations, when sequences of delegated aircraft suddenly need to be cancelled, each aircraft requiring an individual end of delegation.

Workload is a serious issue to tackle, as on the one hand controllers feel that delegation reduces their workload, but on the other hand being too busy (i.e. with a high workload) is mentioned as one of the main reason leading them to retain delegation. One controller paradoxically evoked that high traffic forced him to delegate (i.e. delegation appeared as essential to deal with high traffic).

In terms of objective measurements, two aspects will be discussed: the overall reduction of manoeuvring instructions*, and their geographical repartitions. These two points are thought to reflect a change in controller activity. It is clear nevertheless that this does not provide a complete picture of the overall activity and resulting mental workload, since for instance the monitoring task is not covered†.

The two following figures show the number of manoeuvring instructions (Figure 5) and the breakdown of each type of instructions (Figure 6). In June, the manoeuvring instructions were reduced by 35%, with a 40% rate of use (delegation duration). The reduction is even higher for the AR than for the AO sector. In November, there is no significant reduction while the rate of use was 27%. Considering the breakdown of instructions, the main reduction results from the reduction of speed instructions.

To provide a picture on the number of messages exchanged, the target selection related messages (“select target”, “deselect target”) need to be added to the previous number of manoeuvring instructions. It is important to note here that controller requests for information was not recorded, as in the simulator such requests do not require any operator input to be fulfilled. However we expect a reduction of such requests with delegation. In June, even despite the additional messages, the delegation still provided a 20% reduction of the number of controllers’ messages. The November results show however a 13% increase.

* A manoeuvring instruction refers to a standard manoeuvring instruction (speed, heading, and climb/descent) or a delegation instruction (“remain behind”, “merge behind”, “heading then…”).

† For the November session, workload issues were also addressed through self-assessment and physiological measurements. However, due to the problems encountered, they did not provide a clear view of the impact of the delegation, and are thus omitted.
In addition to the number of instructions given, the important aspect considered here is their geographical distribution (Figure 7). These two maps suggest that without delegation, a lot of instructions are given in the second half of the sectors. This is also visible on trajectories (Figure 10). To provide a more synthetic view, we represent the distribution of instructions (level instructions are not integrated since they are located in a same area reflecting the top of descent) as a function of the distance to the IAF where they were given (Figure 8). Three points can be observed:

**Build vs. maintain sequences:** Without delegation in the two sectors, it is interesting to see that following sector entry, most of the instructions are heading instructions, while they are speed instructions when approaching the IAF: This is evident in sector AR with the transition from heading to speed instructions showing up 100Nm from IAF. This reflects the two successive steps in conventional control strategy with arrival streams: building sequences (with heading) then maintaining sequences (with speed).

**AO sector vs. AR sector:** Without delegation, while AR (with one converging point at the sector entry) allows for an early building of sequences, AO (with two converging points, one at 50Nm from IAF, i.e. rather close to the IAF) constrains a late building of some of the sequences.

**With vs. without delegation:** Similar peaks can be observed when controllers build sequences (typically around 120Nm from IAF for AR), whereas the delegation allows for a reduction of the instructions given after, i.e. when controllers maintain sequences.

---

**Figure 5.** Number of manoeuvring instructions for both sessions, and for both sectors.

**Figure 6.** Breakdown of instruction type.

**Figure 7.** Geographical distribution of instructions without delegation (left) and with delegation (right).
Although the Figure 8 is related to selected exercises, similar trends can be observed for all the June exercises. The Figure 9 shows the median value of distance to IAF, even if this is a rough representation of the distributions. Increase of the median value can be observed for June exercises and specifically for the AR sector (about 30Nm) suggesting that instructions were generally given earlier. For the November exercises however, no significant trend emerges.

5.3 Impact on flight efficiency

An initial estimation of the efficiency variation was made through the record of time, distance and fuel consumption (Table 2). The flight efficiency is also graphically suggested on flown trajectories: with delegation trajectories become straighter (Figure 10). A minor benefit of delegation emerges. Even though the benefits are very light, it is at least important to stress that delegation has no negative impact on the flight efficiency.

<table>
<thead>
<tr>
<th></th>
<th>Time</th>
<th>Distance</th>
<th>Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 1</td>
<td>Without</td>
<td>34:52:30</td>
<td>13315</td>
</tr>
<tr>
<td></td>
<td>With</td>
<td>33:24:35</td>
<td>13027</td>
</tr>
<tr>
<td>June 2</td>
<td>Without</td>
<td>37:05:55</td>
<td>13329</td>
</tr>
<tr>
<td></td>
<td>With</td>
<td>34:28:35</td>
<td>13060</td>
</tr>
<tr>
<td>June 3</td>
<td>Without</td>
<td>35:42:50</td>
<td>13353</td>
</tr>
<tr>
<td></td>
<td>With</td>
<td>33:39:45</td>
<td>13026</td>
</tr>
<tr>
<td>Nov 1</td>
<td>Without</td>
<td>33:55:03</td>
<td>13332</td>
</tr>
<tr>
<td></td>
<td>With</td>
<td>32:16:25</td>
<td>12997</td>
</tr>
<tr>
<td>Nov 2</td>
<td>Without</td>
<td>33:48:20</td>
<td>13314</td>
</tr>
<tr>
<td></td>
<td>With</td>
<td>33:55:35</td>
<td>13414</td>
</tr>
<tr>
<td>Nov 3</td>
<td>Without</td>
<td>21:10:25</td>
<td>8204</td>
</tr>
<tr>
<td></td>
<td>With</td>
<td>20:52:25</td>
<td>8033</td>
</tr>
</tbody>
</table>

Table 2. Cumulative values of flight duration, flown distance and fuel consumption in the measured airspace.
Figure 10. Trajectories without delegation (top) and with delegation (bottom).
5.4 Impact on safety

The controllers have a positive feeling about the impact of delegation on safety. According to them delegation should contribute to a reduction of their workload as well as enable separation distance to be more accurate. Moreover, they feel delegation should increase pilots’ situation awareness and therefore enhance their contribution to the safety of the overall system. Yet, one issue raised by controllers is the risk of lesser involvement in delegated situations. It should be noticed however that the experimental situation (e.g. no real warning or refusals from pseudo-pilots, no interaction with controllers on feed sectors, no alerting tools on the radar screen) might have "encouraged" this form of disengagement. In addition to the issue of responsibility, controllers questioned the applicability of delegation to non-nominal situations and mixed equipages (aircraft equipped and non-equipped). The main potential negative impact of delegation is rather related to their doubts regarding the pilots’ performances, and in particular to the issue of responsibility, combined with pre-existing ideas about pilots attitudes.

The analysis of objective data (e.g. losses of separation, Aircraft Proximity Index) shows cases, both without and with delegation, when the safety is endangered. Yet, we felt that these figures were not sufficient to understand and qualify the impact of delegation. Therefore it appeared essential to identify complementary indicators. Typically, the transfer conditions to next sector appear to be a relevant indicator. Indeed, observing controllers during the experiments enabled us to detect cases where aircraft were transferred to the approach “catching up”. With delegation, since longitudinal separations are maintained, less “catching up” situations were observed. However, it should be noticed that the approach was not controlled in the experiment, which could explain the lack of consideration of these conditions of transfer. It should also be stressed that controllers shall ensure that applicability conditions (typically, aircraft shall have compatible speeds thus same range of altitude) remain satisfied during delegations, otherwise separation may not be maintained. Various cases where observed when they were not respected. This may be explained by overconfidence and excessive expectations from the delegation. In addition to existing indicators, the identification of the types of errors related to delegation would enable us to have more insight on the impact on safety.

6 Conclusion

In the scope of assessing the impact of the delegation of sequencing operations to the flight crew, an experiment with twelve controllers from different European countries has been carried out. The airspace simulated was a part of the Paris terminal area, and consisted of two measured sectors with arrival flights from cruise level to initial approach fix. The feeling from controllers is positive: the delegation is perceived as satisfying, and should enable a workload reduction. The acceptance is also revealed by the significant rate of use. The delegation allows for a significant reduction in the number of instructions given, specifically those given near the exit point. This suggests a positive impact on controller activity. Typically, while building sequences still remain to the controllers, maintaining sequences can be delegated to flight crews. It was observed that the sector configuration has an impact on the use of delegation. In terms of efficiency, time, distance and fuel consumption are also reduced, and it appears also that trajectories become more stable. For one of the two sessions, workload issues were investigated through self-assessment and physiological measurements. However, due to problems encountered, they did not provide a clear view. In terms of safety, no significant trend emerges although errors were observed.

Despite these promising results, a few questions remain. Typically, have we reached the maximum rate of use? If this rate can be increased, will benefits increase accordingly? How to design the training to reduce errors related to delegation per se, and typically on the applicability conditions? Could delegation be used in the approach?

The next experiment planned in Fall '01 will integrate approach sectors to assess the feasibility of delegation at low altitude, low speed, with different separation criteria (distance vs. time). Integrating the approach sectors will also allow to investigate transfers and coordinations. Human performance measurement will be re-addressed to assess the impact on workload, monitoring and situation awareness for controllers and flight crews. Safety aspects will be investigated, typically through identification and measurement of possible causes of errors [4].
7 References


