ASSESSING THE IMPACT ON THE FLIGHT DECK OF DELEGATION OF SEPARATION TASKS

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Introduction

Delegation of separation from the ground to the flight deck is envisaged as a possible option enabling the air traffic management system to cope with increasing traffic. The new task distribution between controllers and pilots is expected to maintain unchanged core roles and working methods of controllers and flight crews. The delegation should not impose any change of responsibility since it can be considered as a new instruction.

Initially, major benefits were expected from the controllers perspective, mainly in terms of increased availability [1]. From a flight crew perspective, the delegation was expected to allow for more anticipation (less time-critical instructions to follow), to increase situational awareness, and to enable an optimisation of trajectories. It was 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.

Two real time simulations of a section of core European airspace, focusing on the controllers’ perspectives (ground side) were conducted in June and November 2000. The results showed that delegation allows for a significant reduction in the number of instructions given, specifically those near the exit point [2]. In addition, controllers’ feedback regarding the usability and usefulness of the delegation concept were encouraging. However, early studies of station keeping feasibility in part-task simulations pointed out an increase of workload in the cockpit, especially in final approach ([3], [4], [5]).

The operational implementation of delegation requires the assessment of its feasibility and acceptability from both air and ground sides.

Beyond the issues of designing procedures and setting up an air-ground experiment, a method of assessment integrating air and ground perspectives also needs to be carefully defined. In addition to identifying underlying hypotheses, attention needs to be paid to indicators and metrics enabling them to be invalidated or confirmed.

The work presented in this paper consisted in investigating the impact delegation could have on the flight deck, deriving from it the design of new information displays and defining measures and indicators enabling the concept to be assessed. Previous studies ([3], [4], [5], [6], [7]) investigated the impact new tools or new organizations could have on people’s performance mainly in terms of individual workload and success in achieving the task. Based on our experience, we identified additional indicators, such as impact on sequence of tasks, consistency between flying tasks (e.g. aviate, navigate, communicate) and delegation tasks.

The paper is composed of four sections. After the introduction, the concept of delegation is briefly presented in the second section. In the third section, the human factors approach is illustrated, not in terms of method followed, but rather in terms of results. Typically, identified central issues such as workload, safety, cognitive tunnelling are listed and discussed. In the fourth section, design choices motivated by the previous issues are illustrated. In the fifth section, the foreseen experimental set up enabling the evaluation of delegation is discussed. In particular, after reviewing the limits of standard subjective measures, we explain our experimental set-up, listing indicators and measures used.

Limited delegation

Taking as starting point existing human roles and activities, and more specifically the analogy with visual clearances, the concept of limited delegation
of separation is based upon the following key elements:

- Some separation related tasks are delegated to flight crews. Delegation is always initiated by the controller, but requires flight crew agreement.

- The delegation is limited since the controller can only delegate “low level” tasks (implementation and monitoring) as opposed to “high level” tasks (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.

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

<table>
<thead>
<tr>
<th>Delegation level</th>
<th>In-trail</th>
<th>Merging</th>
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<tbody>
<tr>
<td>Report separation</td>
<td>Report in-trail distance</td>
<td>Report merging distance</td>
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<tr>
<td>Maintain separation</td>
<td>Remain behind</td>
<td>Merge behind</td>
</tr>
<tr>
<td>Resume then maintain separation</td>
<td>Heading then remain behind</td>
<td>Heading then merge behind</td>
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Table 1. Sequencing applications.

The delegation is composed of three phases:

- Identification, in which the controller designates the target aircraft to the flight crew.

- Instruction of delegation, in which the controller specifies the task delegated.

- End of delegation, which marks the completion of the task delegated.

The task repartition between controllers and flight crews is defined for each application. The highest level of delegation (heading then merge) is illustrated now, with its associated procedure (Figure 1). In this example, DLH456 is the delegated aircraft, and AFR123 is the target aircraft. The two aircraft are flying along merging trajectories in descent with compatible speeds. The controller gives a heading instruction to create the separation, indicates the desired separation to be applied, and instructs the delegated flight crew: ➊ to report when the predicted separation at the merging point reaches the desired separation; ➋ to resume own navigation to the merging point, and ➌ to adjust speed to maintain the desired separation.

![Figure 1. "Heading then merge behind" scenario.](image)

**Human factors issues**

One point to note in the research reported here is the acknowledged importance of human actors. Indeed, efforts were put all along the design on keeping the human in the loop, in centring both the specifications and the evaluation on the future users of the systems. Whereas delegation procedures were designed in order to preserve existing roles and practices, they still induce new tasks in the cockpit.

A second point to note is the systemic vision adopted. Indeed, despite the initial context of the research, both air and ground sub-systems were considered jointly. Typically, procedures and tasks were designed for all involved actors rather than locally for only part of them. Initial investigations conducted on the ground side highlighted potential human factors issues to be tackled carefully. In addition to workload and situation awareness, less obvious issues such as controllers’ involvement in their tasks, trust in pilots and responsibility had to be taken into account.
Experience gained from these initial studies benefited the design and preparation of experiments focusing on the airborne side. When considering how pilots current tasks could be impacted by the delegation procedures, a series of issues, related to workload, tasks distribution and safety arose. These issues influenced the design choices, described later in the section and should serve as a framework for analysis.

**Removing versus adding tasks**

The concept of delegation aims at reducing the number of successive instructions (mainly speed instructions), possibly leading to fewer actions, in particular of time-critical nature. Yet, this delegation relies on the pilot’s capability to monitor and maintain separation from a target aircraft. This capability mainly depends on the provision of additional information in the cockpit. In the current setting, it requires pilots to set up appropriate information displays. So, the separation maintenance involves at least two additional tasks, one consisting of setting up displays, the second in performing the task itself (including identifying target, modifying flight parameters if required and monitoring the situation).

One essential dimension to assess is the impact of delegation on the overall flight crews performance, both in terms of workload and tasks’ consistency and compatibility. Typically, the integration of the separation task within the wider context of flying and navigating an aircraft from one point to another should be considered.

**Maintaining separation versus flying aircraft**

The concept of delegation induces the need to perform simultaneously concurrent tasks, potentially using the same information displays. This raises a few issues, such as the risk of cognitive tunnelling, the respective weight and criticality of information and the task distribution within the cockpit.

As stressed in ([8], [9], [10]), automation, and especially display features provided in the cockpit potentially induce attentional and cognitive tunnelling impacting perception and information processing. This might impair the flying capabilities of flight crew, in particular by disrupting the detection of significant events and the execution of associated tasks. In the context of delegation, and specifically for monitoring tasks, the use of an information display could have similar impact, in restricting a flight crew’s “field of view”. Therefore, the design should limit the head down time, and not encourage the human tendency to immerse oneself in displays.

Flying capabilities might also be impaired by high workload in the cockpit. Design must simultaneously consider the relative weights and context of occurrence of these tasks, and ensure that maintaining separation does not prevail over flying the aircraft. Typically, the acceptance and implementation of delegation is always conditioned by the flying context: problems encountered in the cockpit could indeed force flight crews to abort delegation.

The definition of respective roles of flight crews (and consequently of each member of the flight crew) influences the design of information displays, both in terms of information provision and required actions.

**Monitoring target versus controlling traffic**

In complex systems, people performance depends largely on their situation awareness, defined as their knowledge of the on-going situation. As extensively defined in [11], the initial requirements for appropriate situation awareness in a correct perception of the relevant information.

The issue of situation awareness and possible information display cluttering could be described in terms of confused task allocation. Indeed, providing information about surrounding traffic might spread a dangerous feeling among flight crews: it may lead them to think they are in a position to play a direct role in the traffic control. While they could without a doubt contribute to incident detection and prevention, they might also from time to time spend time either questioning controllers’ strategies or assuming controllers intentions. This is also highly related with the issue of cognitive tunnelling, where traffic information displayed on cockpit displays might possibly mask navigation and surveillance information and distract flight crews from their core task of maintaining separation relative to a single given target.
Regarding tasks allocation, the respective role of the two pilots should also be defined, typically in terms of tasks (e.g. maintain separation, monitor separation) and responsibility (e.g. who is in charge of interacting with the system).

Being aware versus interpreting situation

It is essential, when designing new supports for complex activities in the cockpit, to ensure the appropriateness and relevance of information, that is, as stated in [12]: "provide the pilot with all, and only the necessary information". As underlined in [13] (§6.2.2), a trade-off is necessary between providing sufficient information in terms of awareness, and cluttering the display (and consequently pilots’ cognitive resources) with excessive and superfluous information, that may induce an increase in the pilots’ workload, mainly in terms of filtering relevant among provided information.

Following the first level of cognitive activity (i.e. perception of information), a second level is described in [11], which is the comprehension of the situation, elaborated on the basis of the information perceived. The design of displays should here consider not only the appropriateness of symbols and codes chosen (and particularly their consistence with existing standards and practices in the cockpit), but also the task they are supporting. It is a first step to ensure that design options are easily understandable by future users. A second step consists in assessing their usability in terms of ease of use and usefulness.

In addition, whereas human activities in complex systems require people to perceive and quickly interpret information, these are too often distributed in the surrounding environment. It is therefore essential to provide various pieces of information in proximal locations, in order to reduce the cognitive cost of aggregating them and facilitate their joint understanding (avoiding for example graphic information on one display to be compared with textual information located on another display).

The provision of traffic information on the CDTI raises issues of advantages and costs of situation awareness. Whereas the benefits of situation awareness in terms of anticipation and safety are admitted, the risks associated to build and update it are seldom pointed out. Delegation might occur in cognitively demanding periods (terminal areas), when flight crews might not be in a position to filter and interpret a large amount of information. In such a context, the relevance of displaying surrounding traffic (in addition to the target) is questionable and should also be related to the issue of task definition. In particular the benefits of such an extended knowledge should be compared to the costs of building and updating it.

Anticipating versus reacting

In terminal areas, flight crews have to react to successive time-critical instructions resulting from vectoring. Pilots do not feel comfortable with this reactive mode, and sometimes with their lack of knowledge of the controller’s tactical objectives. The goal-oriented instructions induced by delegation (e.g. “remain 8NM behind target”) should contribute to expand the flight crews’ temporal horizon, enabling anticipation of required actions and a smoothing of overall activity. In addition, situation awareness could contribute to an anticipation of the future status, in providing a knowledge of what will happen next and be ready to cope with potential demands.

Delegation along with a cockpit display of traffic information (CDTI) should give flight crews more contextual knowledge (controllers’ strategy, possibly surrounding traffic). Whereas up to date situation awareness can enable flight crew to anticipate future actions and goals, as stated in [14], “a key to maintaining situation awareness is to anticipate; stay ahead of the airplane”. Even though the role of such situation awareness in the efficient and safe performance of flight crews is indisputable, its emergence and updating are still opaque.

Detecting versus generating errors

The addition of new “human” tasks might lead to the introduction of new human errors. As discussed in [15], new errors could occur at each step of the process (target selection, solution identification, implementation). Yet, the involvement of the flight crews in the monitoring and in the separation tasks might enable them to contribute to the overall system safety, typically in preventing errors (e.g. in
ensuring separation or in reducing controllers’ workload) detecting errors (related to target selection or applicability conditions) or suspicious target behaviour. In addition, compared to the conventional situation (without delegation), having the flight crew in the separation loop (with delegation) provides a redundant monitoring.

Therefore, the design of delegation requires the identification of potential errors, their prevention whenever possible and when not the provision of detection and tolerance means. Last of all, an evaluation method enabling the overall system to be tested should be defined, with a particular focus on the relevance and efficiency of tolerance means.

**Defining delegation-related tasks in the flight deck**

It was obvious from the start of the project that delegation-related tasks had to be integrated in the larger scope of flight crews tasks (usually defined as aviate, navigate and communicate). Indeed, involving flight crews in the design cycle aimed at understanding if and how delegation could be integrated in their current practices [16]. On the basis of the principles and procedures initially defined, four successive tasks were then identified for the flight crew: identifying the target, assessing the feasibility of the delegation, implementing the solution and monitoring the situation.

Two pilots (one test pilot and one airline pilot), involved in the design process, contributed to specify the information displays and interface behavior in providing feedback on proposed design options and suggesting additional specifications.

Initially, once the tasks were identified, general features had to be defined. After a review of existing information systems, it was decided to use the control and display unit (CDU) as the main support for setting up the delegation (i.e. input device) and the navigation display (ND) for assessing and monitoring the situation. Then, relevant and rationale symbols and colour codes were defined and validated by pilots. In addition to using existing symbols and colour codes (e.g. magenta for a constraint, green for non-modifiable information), new ones had to be defined. For example, new symbols had to be identified to represent the target aircraft and the location of the requested separation. Consistency between types of information (mainly textual and graphical) was also ensured. In addition, attention was paid to ensuring consistency between the CDU pages, in terms of format and position of information displayed.

**Task 1: Identifying target aircraft**

The initial step of the delegation consists of selecting and identifying the target aircraft upon controllers request (e.g. “DLH456, select target 1234”). This step has the aim of ensuring that the target aircraft is “visible” (electronically), and potentially contribute to error detection. Indeed, the absence of a target reveals problems, technical (e.g. unavailability of target data) or operational (e.g. misunderstanding with controllers, erroneous data input).

In terminal areas, surrounding traffic might be quite numerous. In order to reduce the time induced by the target selection, a direct input of the target identifier (the secondary surveillance radar code here) was decided, rather than a selection in a list of surrounding traffic. The resulting page displays details about the target (Figure 2), that are the SSR code, ground speed, current distance to own aircraft, relative altitude and vertical trend.

**Figure 2. Identifying target on CDU.**

The risks of errors related to inputting the code on the CDU are tackled with an explicit positioning of the target, which should contribute to detecting if the target appearing on the ND is the expected one (Figure 3). Moreover, in case the code entered does

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1 The displays presented in the figures are not direct screen dumps but rather drawings used in the specification process.
not correspond to an existing target, an explicit message “Invalid SSR code” is displayed on the scratchpad (CDU).

If delegation is not feasible, the value of the requested separation is displayed in amber, and the message “UNABLE DELEGATION” is displayed on the scratchpad. The pilots are then in a position to inform the controller of their inability to comply and then potentially contribute to detecting own errors or controllers error (wrong target code or non-applicable conditions).

If the delegation is feasible, in addition to the CDU display, visual information relative to the separation is displayed in cyan on the ND. The three cues supporting the flight crews in understanding the current situation are: (i) a link between own and target aircraft, anchored at the merging point if applicable; (ii) an arc of circle displaying the position of the requested separation (i.e. where the aircraft should be now if the separation was established); (iii) an “arc and arrow” indicating where the aircraft will be when separation is established. The position of these symbols is continuously updated (Figure 4).

It is worth noticing, that unlike design choices presented in [17], the relevant information to monitor is distance between the own aircraft and the arc, rather than the distance between the target aircraft and the arc. Merging situations where aircraft are not following the same path and where the target aircraft may potentially be off scale, motivated this choice.

Redundancy between information displayed takes the form of graphical and textual data. Typically, the current separation is represented by the links between own aircraft and target, and by textual information in the target information box. The requested separation is represented by the arc of circle and by a value also displayed in the target label. Color consistency reinforces the association between this redundant information.

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**Task 2: Assessing feasibility**

The flight crew can reject a delegation instruction in case of inability to comply with it. In addition to technical reasons (e.g. equipment failure), rejection could result from delegation-related reasons, in particular the non-respect of applicability conditions. For example, the ability to acquire the proper separation within the given time-constraint. Although inability to comply should be exceptional, flight crews always have to assess feasibility prior to the start of the delegation.

The initial step consists of selecting the type of application (e.g. remain, merge). In order to reduce the number of interactions with the interfaces, it was decided to limit the number of CDU pages. Therefore, the page displaying the features of the target is used as a “portal” leading to sub-pages.

Once pilots select a specific type of applications, they input the separation value (e.g. 8NM), and the merging waypoint if applicable (e.g. TUNOR). The system calculates if delegation is achievable in such a context, taking into account the time constraint (two minutes here) and the target current speed, position and direction.

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**Figure 3. Identifying target.**
Simultaneously with the feasibility assessment, the system calculates the “optimal” speed (given aircraft performances) enabling separation to be established within the given time constraint. The required speed is displayed on the CDU (Figure 5). Pilots involved in the design rejected the provision of such an information on the PFD.

Once the pilot has validated (i.e. pressed the INSERT option) and reported its acceptance to the controllers, a new page provides an update on the situation. The current speed (i.e. selected on the flight control unit) is used to provide an estimate of the time required on the CDU and to position symbols described previously. On the ND, the arc of circle now validated as a constraint is magenta (Figure 6). It is important to clarify that even though the solution suggested by the system is the “optimal” one, the flight crew might decide to choose a more appropriate one taking into account parameters not available to the system (e.g. weather conditions).

**Task 3: Implementing solution**

Even though controllers are in charge of identifying the objective (e.g. “DLH456, turn left heading 270 then behind target, merge to WPT to be 15NM behind”) it is up to the flight crews to identify and implement the appropriate manoeuvre. As expressed by pilots, support from the system in terms of suggesting this manoeuvre (e.g. speed, resuming point) would be of great benefit. Indeed, depending on the flight phase (cruise, approach) and the conditions of flight (duration, turbulence) pilots’ cognitive resources can be diminished or already completely monopolised.

An additional demand is related to automating the manoeuvre implementation, typically in coupling the delegation-related functions (e.g. suggestion of the optimal speed) with the flight management system (engagement of a dedicated managed guidance mode). This option still needs further investigation.
**Task 4: Monitoring situations**

The dynamic nature of the situation and the numerous evolving parameters (speed of target aircraft, altitudes) require flight crews to continuously assess the separation. Indeed, even when acquired, the separation needs to be actively maintained through continuous monitoring leading to potential adjustments. Yet, it is not possible to expect flight crews to remain continuously focused on the information displays, spending time assessing the situation. In this context, flight crews require support from the system, alerting on drifting situations, such as current separation becoming either above or below desired one.

Color-coding is used in order to inform pilots about the status of the situation and potentially capture flight crews’ attention in such situations. The links turning white (instead of cyan) reflect the nominal situation, when separation is established and maintained within pre-defined limits.

In case separation is lost, information is first displayed in amber and later on in red if the loss keeps increasing. The alerting color scheme is applied to the links, the target symbol and the target information box, excluding the separation value.

In addition, for the “resume then maintain” applications, flight crews require support to identify the appropriate moment to resume own navigation. The "arc and arrow" symbol previously described could play such a triggering role.

**Assessing the impact of delegation in the cockpit**

Whereas arising issues described earlier in this paper were used to inform the design of the interfaces, some issues are still pending at the evaluation stage of the project.

**Diversity of existing measures**

When investigating human factors issues (e.g. workload, situation awareness or safety), we are confronted by the dual use of subjective and objective measures. In our experiment, objective measures refer to automated analysis of systems recordings, while subjective measures refer to human interpreted data. A distinction, as introduced in [18], concerns the human performing the measures, which is the observer (implicit) versus the actor (explicit). In implicit measurements, the evaluator infers from the operator performance a certain level of workload or of situation awareness, depending on which concept is measured. These measures rely on the evaluator to redefine and identify events from which inferences could be drawn. Explicit measures require the operator's involvement, either in providing an estimate of the measure (e.g. very high, high, low or very low level of workload) or in answering questions from which the level could be inferred (e.g. level of details when describing the on-going situation). As discussed in [19], both types of measures have advantages and limits. Discussions about limits of measures of situation awareness ([11], [20] could also be extended to workload issues.

Regarding implicit measures, assuming that the knowledge of a given fact will lead inevitably to a specific behaviour is questionable. In addition, it hardly takes into account the complexity of the measured tasks and the interactions between factors. Indeed, in complex situations, often indeterministic, preparation and pre-definition of expected behaviours can not be exhaustive. Last of all, such a preparation is highly time consuming.

**Intrusiveness of measurements**

Explicit measures require less preparation (even though query times need to be carefully identified in order to be comparable across successive sessions), but present a serious limit, which is their intrusiveness. In real time simulations, they usually represent an additional task, disconnected from the primary ones (e.g. monitoring traffic, flying an aircraft), even though, in some cases, they could be assimilated to existing tasks (e.g. shift take over). Moreover, answering to external queries, or reacting to an external stimulus may disrupt, and potentially impair the on-going activity. Therefore, these interruptions should be as limited as possible. Last of all, external queries should also be discussed in terms of how they might impact the realism of the experiment. Indeed, whereas simulation environment often lacks of realism, the use of external queries might lead to an increased attention from the operators. Unless they are not aware of the use of queries (which could only be limited to the first trial), it is likely that operators will pay extra
attention to their performance or to the on-going situation in order to provide information.

**What is actually measured?**

In such experimental context, the main issue is the relevance of measures, and finally what do they reflect? As discussed above, it is more than likely that they reflect processes (of perception and interpretation) driven more by the experimental context than by the activity itself. Considering for example the workload issue, how do we integrate in addition to the estimated workload the cost of the additional task of estimating workload? Regarding situation awareness, do the results reflect the reality of data perception and processing, or are they induced by the context? Even though data must be perceived in real situations, how could we ensure that their processing would also take place in reality?

More importantly, we should question why we investigate such issues. Instead of absolute values per se, we would rather understand what the relative values induce or impair. In such a context, the search for comparable results should guide us more than the quest for "an" absolute measure.

**Resulting experimental set up**

Following the questioning of assessment methods in general, it is now necessary to envisage how the concept of delegation could be evaluated. The main objective is the assessment of the operational and social acceptability of the concept at a systemic level. Real time simulations, including controllers and pilots need to be conducted.

Studies of station keeping, even in so-called integrated environments, usually focus on the issue of feasibility, assessing how well pilots could establish and maintain separation to a target aircraft. Human factors issues, such as workload or situation awareness are mainly investigated with subjective measures, either through questionnaires and/or self reports. In addition to these standard practices, we identified as central to investigate how delegation could impact pilots strategies. Typically, the pilots actions in the flight deck, once recorded, will be analysed in relation to a series of pre-identified tasks of aviating, navigating, communicating and managing systems.

Because of the systemic nature of the concept, it is essential to investigate simultaneously and similarly airborne and ground sides. Indeed, the involvement of pilots in part of the controllers’ activity might impact both controllers and pilots ability to cope with the situation in modifying their workload and strategies. Typically, while delegation may induce a more global monitoring (as opposed to local one) among controllers, it may also reduce the pilots’ reactive behaviour and provide them with a better awareness of the context (goal-oriented instruction). Consequently, four main questions need to be answered:

1. Is the delegation feasible (and consequently can pilots ensure the separation)?
2. Are local strategies and activities modified?
3. Is the resulting local performance (including safety) impaired?
4. Is there a counterbalance effect between ground and air?

Based on previous analysis initially conducted from a controller perspective ([21], [2]), four dimensions will be analyzed: the acceptance of the concept, its impact on pilots performance, on flight efficiency and on system safety.

The pilots’ acceptance of the concept will be subjectively assessed through questionnaires and interview items. The impact on performance is assessed through a series of three high level indicators, which are the workload, the individual strategies and the overall cooperative activity.

Pilots’ workload will be subjectively assessed using the ISA (Instantaneous Self Assessment) device. Individual strategies and cooperative activity will be investigated through a posteriori analysis of pilots’ performances. Pilots’ actions in the cockpit (e.g. speed or heading changes, CDU inputs, display settings) will be used as indicators of on-going tasks previously defined as flying aircraft or providing separation. Thus, the information used, the interactions with information displays, the task distribution among flight crew, the temporal distribution of tasks, the concurrence between tasks and the consistency with controllers instructions will be thoroughly analyzed by a multidisciplinary team, involving human factor, engineers and pilots. Typically, the sequence of standard and delegation-induced tasks will be compared from a temporal perspective, questioning the impact delegation
could have on smoothing pilots activity. The impact on flight efficiency will be assessed through fuel consumed, time and distance flown. Safety will be assessed through analyzing losses of separation, fluctuations between separation values and errors observed in the cockpit (both while interpreting the situation and in interacting with system).

The issue of situation awareness will be investigated separately, from two different viewpoints. First, we wonder if and how it does contribute to the overall safety. Second, its cognitive cost (in terms of information perception and processing) needs also to be assessed and compared to its benefits. Typically, in addition to assessing levels 1, 2 and 3 of situation awareness (i.e. perception, comprehension of situation and projection of future status), we will focus on the ability of pilots to then identify and implement the required actions.

**Conclusion**

The delegation of separation from controllers to flight crews will obviously impact on the air traffic management system. Before envisaging an operational introduction, the feasibility and acceptability of delegation need to be assessed.

In this paper, we presented human factors issues to be considered carefully when evaluating the impact of delegation on both controllers and pilots. We focused more particularly on the impact it could have on pilots’ activity. Issues such as workload, task confusion and compatibility, situation awareness and safety were tackled. After the description of delegation tasks induced in the flight deck, the method used for assessment was addressed. Typically the need for a similar method of analysis is highlighted.

The foreseen analysis will be performed simultaneously and jointly on air and ground sides, in order to assess how the overall air traffic system is impacted by the concept of delegation. Objective and subjective measures will be combined. In order to limit the intrusiveness of measures, explicit queries will take place at the end of exercises, in asking pilots to summarize what occurred during the flight. In addition, unexpected events (e.g. speed variation, heading or level changes) will take place during the simulation, in order to assess how long it takes pilots to detect and recover from incidents.

**References**


