A-SMGCS Visibility Condition 2 – 3 Simulation (Executive Summary)

SUMMARY

This Paper contains the Executive Summary of the A-SMGCS Levels 1 & 2 Visibility Condition 2-3 Transition Simulation performed at Airbus, Toulouse.

The full report is available at: www.eurocontrol.int/airports.
EXECUTIVE SUMMARY

With regards to the aerodrome traffic, the ATC provides to users:

1) Separations on the runway

2) Traffic information over the aerodrome circuit and the manoeuvring area (an aerodrome controller does not ensure separations on the manoeuvring area)
   - Transmitted clearances and, in addition to traffic information, any information aim at avoiding collision and at ensuring a safe, ordered and fast routing for the air traffic.

Whenever visibility conditions are as degraded as the controller could no more exercise control over all traffic on the basis of the visual surveillance (i.e., from visibility condition 2 onwards), his external “visual” vision is supposed to be replaced by an external “electronic” vision provided by an A-SMGCS Level 1 display.

Up to visibility condition 2, visibility is sufficient for the pilot to taxi and to avoid collision with other traffic on taxiways and at intersections by visual reference. Then, in visibility conditions 1 and 2, the A-SMGCS display Level 1, can still be used by controller while maintaining current pilots’ and controllers’ respective responsibilities on the manoeuvring area. That is to say that up to visibility condition 2, pilot – when receiving traffic information, with an associated clearance – can still assume an interval estimated as sufficient with another mobile in order to maintain the aircraft safety.

That would no more be the case while transiting from visibility condition 2 (VIS2) to visibility condition 3 (VIS3), because in that case, pilots could no more avoid other traffic and then - even when receiving an traffic information, with an associated clearance – pilots could no more maintain aircraft safety.

From the moment ATC can no more visually monitored the manoeuvring area from the tower (in order to maintain aircraft safety), the current Low Visibility Operations (LVO) forces to come back to procedural control. It is the aim of A-SMGCS level I and II to replace the controller inability to visually monitor by an ability to use a dedicated surveillance display, until the point (VIS 3) when pilots can no more see and avoid.

Provided that presently, the visibility threshold at the VIS2-VIS3 transition is not completely defined, the present validation aimed at assessing from pilot’s perspective, the real minimum visibility at which a pilot can still safely ensure its operation on runways and taxiways. With current LVO rules, this means assessing the visibility threshold before transiting to procedural control, assuming that A-SMGCS LEVEL I and II release the need of procedural control in VIS2.

Knowing that a controller only knows the RVR, and not the real visibility on the manoeuvring area, the present validation aimed at providing preliminary elements to assess the margin a controller has at his disposal in case a traffic information would be missing.

Finally, the validation aimed at evaluating the efficiency of traffic information under low visibility conditions. Subsidiary, it aimed at assessing the visibility threshold below which the traffic information delivery becomes ineffective, because upon receiving the traffic information, pilots can no more see the announced mobile so as to give way to it.

Experiments were carried out with four different crews from three different commercial airlines (Air Bourbon, Air France and Star Airlines). Totally 8 pilots participated to the real-time simulations: in-operation instructors, captains and first officers, all qualified on Airbus (A320, A330 or A340), ranging from 1.5 to 33 years of total number of flight years, all applying their own procedures and, sharing their experience in low visibility taxiing.

Each crew of two pilots was involved in one of the four experiment sessions that were held on 21st, 22nd, 27th and 28th of October 2004 in Toulouse with EPOPEE, the research A340 simulator of AIRBUS France. Each crew run four simulations exercises, each exercise simulating a particular visibility condition (ranging 100 m, 200 m, 300 m or 400 m). Two simulation exercises were run under day conditions and the other two under night conditions. Each exercise lasted 20-25 minutes and simulated a taxiing phase during which the crew would

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1 In procedural control, the aerodrome is structured in blocks and each aerodrome block is used by one and only one aircraft
have encountered 4 mobiles that were in the vicinity of their aircraft, triggering a potential risk situation depending on the visibility conditions. The mobiles were either aircraft or vehicles crossing left at 90° the crew aircraft, or crossing it right at 45°, or facing it, or being in front of it allowing a catching up. Simulated mobiles were either on movement or still. Generally, the controller announced the mobiles to the crew, using a traffic information. However, for some events, the traffic information was missing.

In night conditions, the simulator introduced a bias because of insufficient marking and airport lights and because of poor brightness of aircraft and vehicles lights. However, with regards to reality, the halo effects around highly enlighten airport areas (e.g., in the vicinity of parking or fret areas) tone down contrasts (i.e. white headlights on white halo) providing contrasts equivalent to the simulated ones.

This means that, although simulated night conditions are to be considered as worst observable climatic cases, they are representative of realistic situations.

The main conclusion of the study is that the minimum visibility threshold below which pilots are unable to comply with ATC instructions based on traffic information requiring him to see and avoid traffic is somewhere between 200 and 300 meters.

For detection performances, from visibility condition 300 meters, pilots start activating functions that they did not feel necessary at visibility condition 400 meters. Detection performance is better for visibility 300 meters than for 400 meters. The Yerkes & Dodson’s human factor phenomenon is then observed: performance increases with the level of activation.

In other words, pilots experience the visibility condition 400 meters as normal visibility, and they consequently had nominal behaviors, while their detection functions start being mobilized from visibility 300 meters onwards. From visibility 200 meters onwards, despite the mobilization, there is a physical limit to detection performance (condition felt as a major risk for 25% of involved pilots, degraded detection performances, uncomfortable situations...).

As preliminary elements for assessing the margin a controller has at his disposal in case a traffic information would be missing, nearly catastrophic situations occurred at real visibility 200 m, when traffic information is missing: a buffer of approximately 4 seconds to prevent a major incident.

Note however that although pilots submitted, for simulation purpose, to conditions that sometimes they would not have accepted in the real life, no major incident has been observed during the experiment, even in cases where pilots did not detect other traffic due to the low visibility conditions.

In low visibility, without surveillance, ATC and pilots are both blind. It appears from this simulation that pilots highly appreciate traffic information in low visibility. This point is a positive benefit of A-SMGCS since ATC can then provide accurate traffic information.

Traffic information becomes less effective from visibility 300 meters and below, reaching its efficiency limit at visibility 100 meters. Indeed, whereas visibility 300 meters is not critical yet, it was observed that some pilots adopted a taxiing strategy (e.g., stopping, reducing speed,…) that may make some traffic information ineffective. This was reinforced by the fact, with regards to the simulator, several elements of the airport representation were not completely representative of an airport as defined in Annex 14. Particularly, the lack of stops bars and holding points on the ground incited pilots to stop their aircraft where it was as soon as the traffic information was received. Such pilot's taxiing strategy is not known by the controller – since it is not a standard practice – and could lead to safety problem, especially in LVO, before transiting to procedural control (VIS3). In a real environment, the LVO with procedural control would have been applied, forcing to taxi only one aircraft at the same time, and this taxiing strategy would have not occurred.

With regards to traffic information efficiency results, visibility 300 meters proves to be the minimum acceptable threshold at which pilots can safely maintain their aircraft. To ensure traffic fluidity in low visibility condition and to prevent procedural control, we recommend, at visibility
300 meters, use taxiing rules that would prevent pilots to adopt a strategy that might make traffic information ineffective. For instance, aerodrome blocks, similar to those used in procedural control, could be used, without however restricting the taxiing in each block to a single aircraft. Taxiing rules could impose to pilots to taxi until the next stop bar or holding point on the ground so as to prevent them to stop where they are upon receiving the traffic information. Under these conditions, the traffic information would be effective and fluidity would be kept on the manoeuvring area without major problem.

On the contrary, below visibility condition 300 meters, we recommend to keep in force procedural control.

A visibility threshold ranging between 300m and 400m by day, and above 400m by night is considered acceptable and comfortable by all crews involved in the simulations. However, at visibility condition 300m, pilots are still able to comply safely with ATC instructions based on traffic information.
A-SMGCS Real Time Simulation Results (Executive Summary)

SUMMARY

This Paper contains the Executive Summary of the A-SMGCS Levels 1 & 2 Real Time simulations carried out at the CENA Facility, Paris.

The full report is available at: www.eurocontrol.int/airports.
EXECUTIVE SUMMARY

Matching the validation plan described in the Simulation Validation document, Roissy Charles-de-Gaulle and Paris-Orly real-time simulations for A-SMGCS Implementation levels I and II took place from June to October 2004 at the CENA (Athis-Mons, France). This chapter summarises the outcomes from the results of the real-time simulations.

The real-time simulations were conducted on the SALSA-SALADIN platform, developed by the CENA, which allows to create a simulated environment of ORLY and CDG airports. The aim of the real-time simulation sessions was to assess the benefits and/or difficulties bringing by the implementation of A-SMGCS level I and II in comparison with baseline system thanks to the SALSA-SALADIN platform.

Five large scale real-time simulations sessions (20 days) were organised, involving 15 ATCOs from CDG and Orly airports in total. A CENA ATCO/A-SMGCS expert helped by the Human Factors Team prepared the set of scenarios and special events to ensure the completeness and realism of situations played.

In order to compare efficiently A-SMGCS level I and II and Baseline system (i.e. SMR), different experimental conditions were included during simulation session, namely: the rotation of the controllers on three working positions, the visibility conditions (VIS.1, VIS.2 and VIS.3), the traffic samples, and the insertion of disruptive events.

Before real-time simulations and in order to be familiar with the A-SMGCS and airport environments, training sessions were organised to prepare the controllers and pilots and learn them the A-SMGCS procedures.

- In total, 45 real-time exercises were run, representing 34 control hours (11h30 in VIS.1, 15h in VIS.2, 7h30 in VIS.3).
- During each session, 3 ATCOs (RWY, Ground and Ground Assistant) were confronted to 9 scenarios (45 minutes each). Each exercise required the involvement of up 15 people: 3 ATCOs, 2 Human Factors experts, 5 up to 7 pilots to manage the traffic, one ATCO/ASMGCS expert in charge of triggering and managing special events, two supervisors (operational, technical).
- More than 25,000 radio communications exchanges took place between ATCOs and Pilots, representing 2300 managed aircraft (about 1900 landings and take-off). When MLAT was in operation, about 650 identification procedures (inVIS.2/VIS.3 conditions), 50 multiple line-up in VIS.2 conditions, 600 line-up procedures, 5500 traffic information and ATC instructions were issued by ATCOs (sequencing, taxiway conflicts in VIS.2/3).
- During reduced visibility conditions, ATCOS were confronted to a total of 150 special events (runway inspection triggering a go-around, aircraft lining-up before take off, arriving aircraft crossing departure RWY without clearance, aircraft and vehicle problems, aircraft lost, etc.).

Relevant data were collected during and after the real-time simulations, but it should be kept in mind that as realistic the SALSA-SALADIN platform is, it presented some limits for the analysis. The data collection method was either performed by automated means, with for instance the record of the taxi time, either gathered through observations and questionnaires, for instance the errors done by controllers.

Once the data were gathered, they were verified and analysed. During the real-time simulation sessions, four high-level objectives were assessed with the data collected in order to evaluate the benefits and/or difficulties brought by the implementation of A-SMGCS level I and II in comparison with baseline system, namely:

- **Human factors**, decomposed into A-SMGCS procedures, Human Machine Interface, and Workload;
• **Safety**, decomposed into Situation Awareness, Runway safety net and Head-down time in tower operations;

• **Capacity and throughput**;

• **Environment**.

The data gathered through the real-time simulation sessions allowed to validate all assumptions notified in the Simulation Validation document i.e. to demonstrate that the A-SMGCS level I and A-SMGCS level II bring benefits in the above high-level objectives.

The following presents a synthesis of results for each parameters described above:

• **Human Factors**
  - **A-SMGCS procedures**: Controllers applied all the procedures related to A-SMGCS concept. They found them usable and relevant.
  - **A-SMGCS HMI**: Controllers found that A-SMGCS Level I HMI was more usable than Baseline HMI due to aircraft identification. Thanks to secured labelling, they were always informed about mobiles identification and location. Controllers found that A-SMGCS Level II HMI was even more usable than A-SMGCS Level I due to runway safety net which helped detecting runway incursions. In Vis 2 and Vis 3, A-SMGCS surveillance data fully replaced visual observation and sometimes in Vis 1, when appropriate.
  - **Workload**: According to controllers perception and number of radio communication, workload per aircraft was reduced in A-SMGCS in comparison with baseline thanks to the information controllers were provided with (i.e. identification of all cooperative mobiles and provision of alerts by the runway safety net). A-SMGCS surveillance data also proved to be of great help to anticipate traffic and potential conflicts. However, the difference between Baseline and A-SMGCS global workload assessment scores is not so important owing to the fact that more disruptive events were detected in A-SMGCS environment than in Baseline and that controllers did accept to handle more mobiles in A-SMGCS environment than in Baseline. Regarding mental demand, controllers reported that, although always important in control activity, it was felt higher in Baseline context than in A-SMGCS context. It was mainly due to the fact that without labels, identification and memorisation task of each mobile was very demanding. Controllers spent a lot of time in asking for confirmation of mobiles position or identification.

• **Safety**:
  - **A-SMGCS**: A-SMGCS provided a situation less prone to error occurrence due to increased controllers availability and reduced time-critical actions.
  - **Situation awareness**: A-SMGCS Level I improved effectiveness of monitoring and analysis of traffic situation. Controllers were more able to identify and locate mobiles. They also were more able to anticipate traffic and conflict.
  - **Safety net**: A-SMGCS Level II enabled controllers to prevent and better handled unexpected events thanks to runway safety net. The majority of controllers think that they should remain in charge of deciding which solution must me applied when an alert is triggered by the safety net.

• **Capacity and throughput**:
  - **A-SMGCS**: A-SMGCS allowed to take in charge a greater number of aircraft and helped in reducing holding time per aircraft and global taxi time from push back to take off.

• **Environment**:
  - **A-SMGCS**: A-SMGCS might participate in reducing noise impact and gaseous emissions on environment in reduced visibility conditions. However straight conclusions cannot be established from real-time simulations since tendencies have been derived from ground holding times and taxi-out times. Results indicate that the
environmental impact per aircraft movement is reduced through reduced taxi times and delays. However positive effect on mean holding time and taxi-time per aircraft provided by A-SMGCS (compared to baseline) is often mitigated - from an environmental point of view - by a greater number of aircraft taken into account.

Real-time simulation sessions revealed that A-SMGCS level I and II bring benefits in human factors, airport capacity and improve the level of safety in airport movements, especially in low visibility conditions. All the procedures described in [A-SMGCS Proc] were found relevant and applicable by the ATCOs.

In order to complete the conclusions of the real-time simulation, future tests such as operational trials will be made.