ESCAPADE : Display of Downlinked Aircraft Parameters

B. Favennec, P. Salembier
CENA - Orly SUD 205
94542 Orly Aérogare cedex
☎ +33 1 6957 7012 / Fax : +33 1 6048 7020

Abstract –
The ESCAPADE project (Experimentation and Simulation of Controller access to Aircraft Parameters and Display Evaluation) aims at assessing the benefits of the display of DAPs (Downlinked Aircraft Parameters) on a controller screen, at first in the context of Paris/Orly Approach.
This purpose has been fulfilled through real-time simulations, successfully carried out at CENA in April 1998. A total of about 20 controllers from Orly have been involved in the whole project.
This paper presents the ESCAPADE simulation infrastructure, the operational scenarios as well as the conclusions reached after the analysis of the simulation recordings and the debriefing sessions with the participating controllers.
ESCAPADE is a French DGAC project, but has been integrated into Eurocontrol's PETAL II project in 1997.

1. Introduction

1.1 ESCAPADE project context

1.1.1 The DAP concept

The DAP concept (downlinking of aircraft parameters) aims at constituting and keeping up-to-date a ground database of aircraft parameters which will be used by several ground ATM functions. The resulting enhanced tools are likely to help the controller to deal with the foreseen growth of the traffic by improving Air Traffic Management features such as Capacity, Safety and Efficiency.

The DAP technology requires the use of an air-ground data link means to implement the real time collection by the ground of data calculated on board. It can be based either on the ADS-C application, ADS-B using Mode S or STDMA link, or on an optimized Mode S datalink protocol dedicated to the periodical collection of airborne data (Cf. §1.1.2 hereafter).

1.1.2 Mode S Enhanced Surveillance technology

Eurocontrol has launched a Mode S deployment programme for the European Core Area, called IIMSES (Initial Implementation of Mode S Enhanced Surveillance), which is expected to enable an implementation of the DAP technology by 2003/2005 in this airspace. This will require the deployment of Mode S sensors and the upgrading of ground ATC systems, along with aircraft wiring minor modifications and retrofit of Mode S transponders (at least level 2 with aircraft data formatting capability).
The Mode S « Enhanced Surveillance » concept relies on the so-called Mode S data link « specific services » (i.e. not directly integrable in the ATN), allowing the ground sensor to collect aircraft data in an optimized way, in addition to its classical secondary surveillance radar function (Figure 1). Neither the pilots nor the controllers are involved in the data link scheme used for « static » enhanced surveillance : a set of pre-defined aircraft parameters is automatically collected by the sensor and transmitted to the ground systems through the mode S chain.
Note that a dynamic mode is also defined for Mode S Enhanced Surveillance : in that case the ground end-user can obtain on-demand aircraft parameters ; however this process is still transparent to the aircrew.

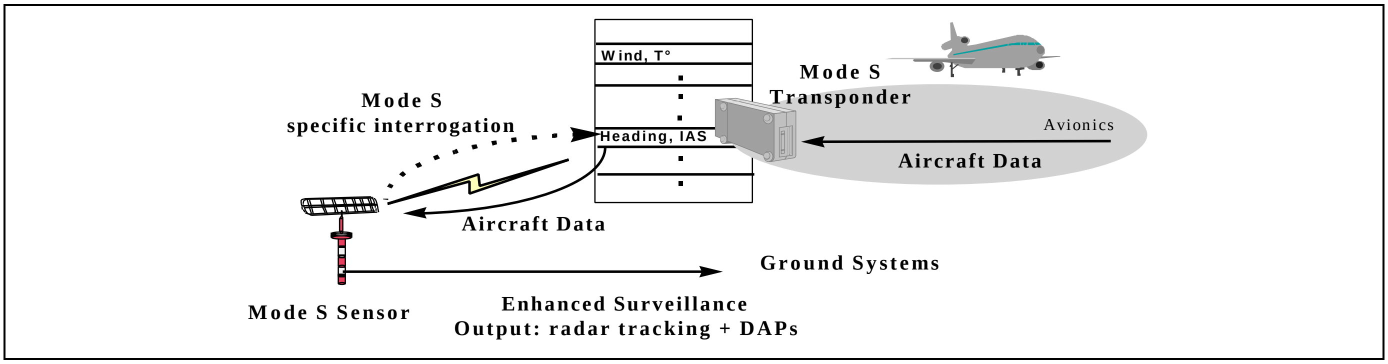


Figure 1- Mode S Enhanced Surveillance

1.1.3 ESCAPADE overview and operational context

Today, controllers have a limited access to aircraft parameters through the R/T channel (e.g. Airspeed or Heading, as a prerequisite to some clearances). This induces extra dialogues for both the aircrew and the ATC, with a risk of misunderstanding or overlapping of messages. To address this issue, and more generally to evaluate the use of DAPs in this context, the French DGAC has launched the ESCAPADE project in early 1996. It is one of the first experimentation to focus on the display of aircraft parameters on a controller screen, using the DAP technology. Its main purpose is to assess the benefits of this real-time display, initially in the context of Paris/Orly approach.

The operational scenario for ESCAPADE is based on the use of Mode S enhanced surveillance, as this technology is expected to be available at medium term in the European Core Area (Cf. §1.1.2).

In addition to requirements expressed by Paris/Orly controllers, ESCAPADE takes into account the work that has been carried out by Eurocontrol's « MOUSES » Task Force. This group of experts has indeed defined an operational concept for Mode S enhanced surveillance [1] and listed the expected benefits for the use of a DAP capability in IIMSES :

- Improved air picture and tracking (horizontally and vertically)
- Improved controller situation awareness
- Progressive reduction of R/T workload per aircraft
- Improvements to the Safety Nets (e.g. STCA).

Among those benefits, *Improved Controller situation awareness* and *Progressive reduction of R/T workload per aircraft* are directly linked with the objectives of ESCAPADE.

1.2 Objectives and phases

The objectives of ESCAPADE fall into two categories, resulting in two main phases for the project:

A➔ *Evaluate, in approach airspace, the impact of the display of DAPs on the controller screen.*

This requires the study of various operational cases and therefore corresponds to a **simulation phase,** where key variables (rate of DAP-equipped aircraft, traffic situations, Meteorological situations, ..) can be easily controlled. The aim is to:

- evaluate the suitability of the DAP visualization to controllers needs, which includes the list of required parameters as well as the HMI/display aspects ;
- evaluate the impact on controller-pilot communications ;
- evaluate the impact on the quality of Air Traffic Control service ;
- and investigate other possible effects of the displayed DAPs on the controller's activity.

B➔ *Demonstrate the technical feasibility of downlinking aircraft parameters via SSR Mode S and thus make the controllers and pilots aware of this concept.*

This aim will be achieved by the **live traffic** phase which will take place at Orly. It involves:

- Commercial aircraft equipped with Mode S/DAP Capability ;
- SSR mode S experimental subnetwork, including a mode S sensor in Orly ;
- IRMA/S display system (IRMA is also used for the simulation part, Cf. §2.2 hereafter).

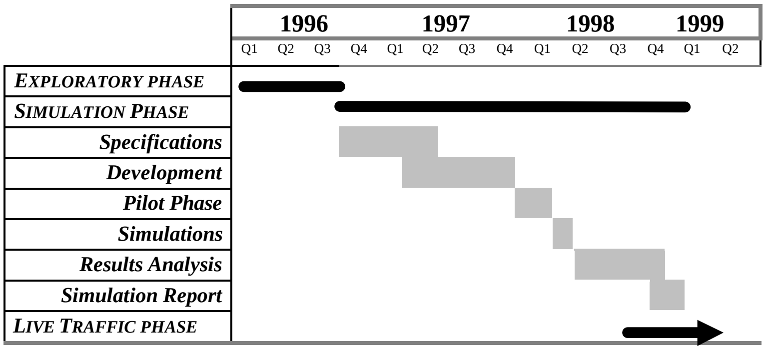
1.3 Participating organizations

The following table depicts the role of each organization involved in the ESCAPADE project :

Organization	Role in ESCAPADE
CENA	Project management / coordination, specifications, simulator development, results analysis / evaluation
STNA	Mode S experimental sensors, IRMA/S displays
Aéroports de Paris	controllers expertise, specifications, simulations
SCTA	Project launch phase / Coordination
Eurocontrol HQ	Integration into PETAL II
French Met Office	Realism for Meteorological data in the simulation
Air France, Air Liberté, ..	equipped aircraft
Eurocontrol EEC	aircraft Mode S equippage

1.4 ESCAPADE project schedule

ESCAPADE overall schedule has been established as follows :



As ESCAPADE's live traffic phase is a complementary technical demonstration which is still currently under definition, this paper only presents the results of the simulation phase.

1.5 The Place of ESCAPADE in PETAL II

PETAL II is a Eurocontrol project aiming at validating operational concepts for datalink communications in Europe. It involves Maastricht UAC controllers, as well as equipped aircraft from European and U.S. airlines.

ESCAPADE has been formally included in PETAL II in the beginning of 1997 as a separate and complementary set of trials. ESCAPADE indeed :

- is independent from PETAL II infrastructure
- focuses, in a first stage, on the approach airspace ATC
- will provide an assessment of the CAP service in the frame of IIMSES.

In this context, DNA is a Core Partner in the PETAL II project structure.

2. Simulation phase specifications summary

The ESCAPADE project reached a major milestone in April 1998 with the successful run of the simulation trials at CENA's premises in Athis-Mons. The ESCAPADE simulations specifications which are summarized hereafter have been jointly produced by a working group composed of CENA and STNA engineers as well as AdP/Orly controllers.

2.1 Operational environment : Paris/Orly approach

As inbound traffic for the Paris/Orly approach generates more complex problems for the controllers (and as departing and arriving flights are separated thanks to airspace structure), the ESCAPADE simulation focuses on arriving traffic controlled by Paris/Orly approach and more precisely, on the « initial » (INI) and « intermediate » (ITM) control positions (see diagram below).

This traffic comprises arrivals at several platforms : Paris/Orly, Villacoublay, Toussus-le-Noble, Brétigny and Melun. Controller's work includes management of holding patterns when required, accurate radar guidance to ensure the steady flow of the traffic on the final approach axis and allocation of the « scheduled time of approach » to the pilots. The ITM position is opened in case of heavy traffic in order to relieve the INI controller of the guidance work in the intermediate approach and for the ILS axis interception management. Co-ordination between INI and ITM controllers is presently performed by both paper strips and voice.

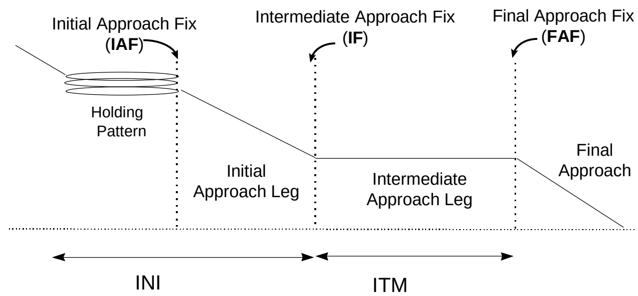


Figure 2 - Paris/Orly approach trajectory

Traffic entering the Paris TMA is handed over from the Paris en-route ACC, after coordination with en-route control when pre-sequencing is required to ensure optimal traffic management. This coordination work is performed in Orly by a « coordination » controller (a.k.a. « cordon »). In all ESCAPADE simulation scenarios, INI and ITM positions are both active due to the traffic load. A « cordon » position, (associated with an additional simulation pseudo-pilot) is also simulated in order to obtain realistic traffic patterns at the en-route / approach interface[1]. The following map depicts the Orly airspace, with three beacons supporting holding patterns - Epernon (EPR), Melun (MEL) and Boursonnes (BSN):

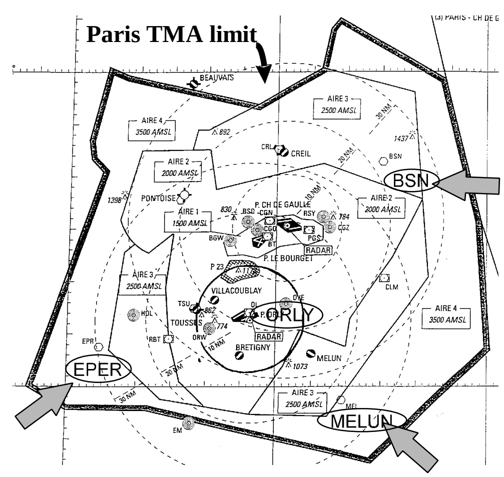


Figure 3 - Paris TMA : Orly approach holding patterns

[1] The « cordon » position is not considered for the evaluation of the benefits of the CAP service in ESCAPADE.

Note that the holding pattern associated with BSN is managed by Roissy/Charles-de-Gaulle approach control. In ESCAPADE simulations, this holding pattern is never active : inbound flights on northern routes are handed over from the « cordon » to the INI controller well after BSN.

2.2 Downlinked Parameters List and Display

The list of aircraft parameters to be displayed in ESCAPADE has been defined as follows, taking into account the MOUSES parameters list and adding Paris/Orly controllers requirements :

BASIC SET :

- Indicated Air Speed (high priority)
- Magnetic heading (high priority)
- Vertical speed
- Wind (direction/speed)

EXPLORATORY SET

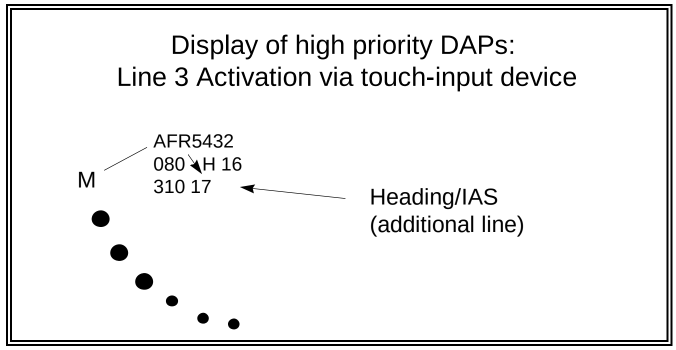
- Minimum approach speed
- VHF Frequency in use
- ILS Frequency
- Selected Flight Level

The ***« basic » set*** is composed of aircraft parameters which have been judged very useful by the controllers during the specification phase. It should be noted that those parameters are already available onboard modern aircraft types (e.g. having ARInc busses). Among those parameters, Heading and IAS were defined as « high priority » parameters.
As for the ***« exploratory » set***, it comprises aircraft parameters that are not always available onboard today, at least with an associated validity indicator. Their availability in a near future is subject to confirmation by co-operation work currently in progress with the aircraft industry. The evaluation of their usability in ESCAPADE will be an input to this ongoing co-operation.
The controller displays used in ESCAPADE are the current operational IRMA workstations, upgraded to add Mode S enhanced surveillance support (IRMA/S). Taking into account HMI features of IRMA and Orly controllers needs, the following specifications were defined for DAP display on IRMA :

<u>Aircraft DAP Capability</u>
Equipped aircraft (Mode S/DAP capability) are identified by a specific color for the actual position marker on the screen (which is actually a letter: flight family identifier) : light blue instead of yellow.

<u>Basic Set - High priority parameters :</u>
Those DAPs are easily displayed for each equipped aircraft : as long as the « LINE 3 » key on IRMA's touch-input device is pressed, a third line appears on the label for each equipped flight. The complete label consists of three lines :

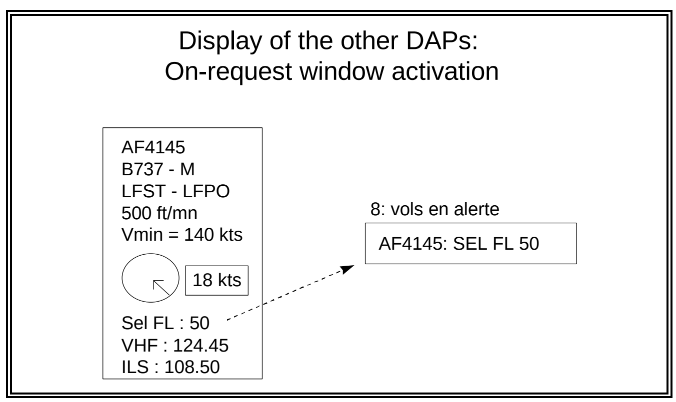
- **Line 1** : Call Id
- **Line 2** : Flight Level (3 digits), a/c vertical evolution (arrow for climb/descend), turbulence category (**H**igh, **M**edium, **L**ow) and Ground Speed (2 digits, expressed in tens of knots)
- **Line 3** : Magnetic Heading (0-360°) and IAS (2 digits, in tens of knots).



<u>Other Basic Set parameters and Exploratory Set :</u>
Those parameters are displayed on a separate window on IRMA's screen, during a limited time after the flight is selected via a trackball. The window content comprises :

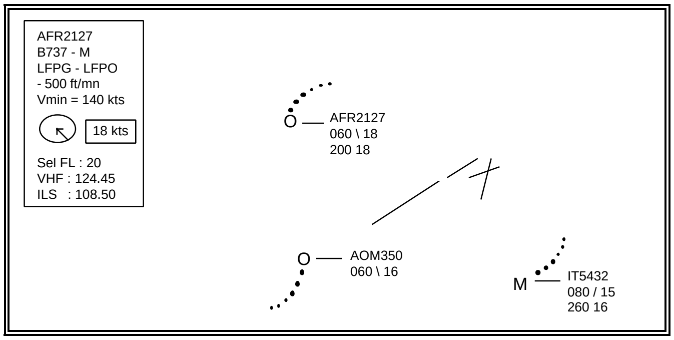
- Call Id, Aircraft Type/turbulence category, Departure/arrival airports (for all aircraft)
- Vertical speed, Minimum approach speed, Wind, Selected FL, VHF frequency, ILS frequency (only for DAP/Mode S equipped aircraft).

Up to two such windows can be displayed at a time.



<u>Selected FL Alarms :</u>
Additionally, in the simulation, a simplified mechanism has been implemented to raise alarms as soon as, in a specific airspace forbidden area, the Selected Flight Level is not consistent with active FL limits. Each time a FL limit violation occurs around this area, a « warning window » pops up on the screen, indicating Call Id and current value of Selected FL, as depicted in the above diagram.

Example of DAPs display on IRMA :



2.3 Simulator Architecture

The simulator architecture is based on CENA's « MASS » traffic generator. Additional modules have been specifically developed in order to emulate radar tracking, simulate aircraft parameters collection via Mode S datalink, and generate Selected FL warnings/alarms as described above. Messages are then generated using Eurocontrol's ASTERIX format and sent to the IRMA/S workstations via CENA's local network.

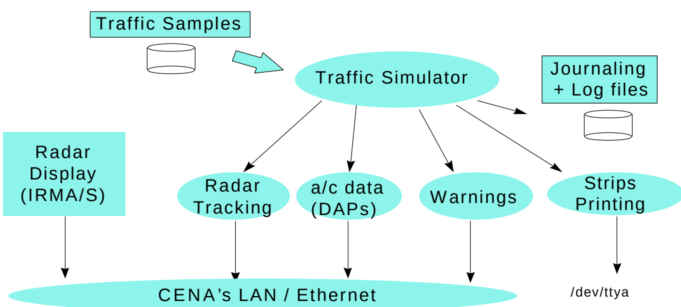


Figure 4 - ESCAPADE simulation architecture

Mode S radar simulation is implemented with the following simplifications :

- Three transponder buffers being required for the transmission of all aircraft parameters (basic + exploratory sets), aircraft data is available (and valid) at every antenna scan (4 seconds). Moreover, *dynamic Mode S enhanced surveillance (See §1.1.2)* is not used.
- Future tracking improvement using enhanced surveillance is comparable to the direct use of MASS position/speed vector data for each aircraft.

The validity of those hypotheses has been checked against POEMS sensors requirements, transponder's buffer definition for IIMSES, and CENA's studies on radar tracking. As concerns the integrity of downlinked data, it is ensured by Mode S datalink 24 bits address/parity encoding, resulting in a 10^{-9} error rate.

2.4 Simulation Infrastructure

The simulation infrastructure has been progressively installed in CENA/Athis-Mons between July 1997 and March 1998, in order to fulfill the various requirement levels arising from the very first simulator phased integration tests, the traffic samples validation tests, the pilot phase and eventually from the simulation trials themselves.

This infrastructure is basically split into two rooms (a « controllers » room and a « pilots » room) as depicted in Figure 5 below :

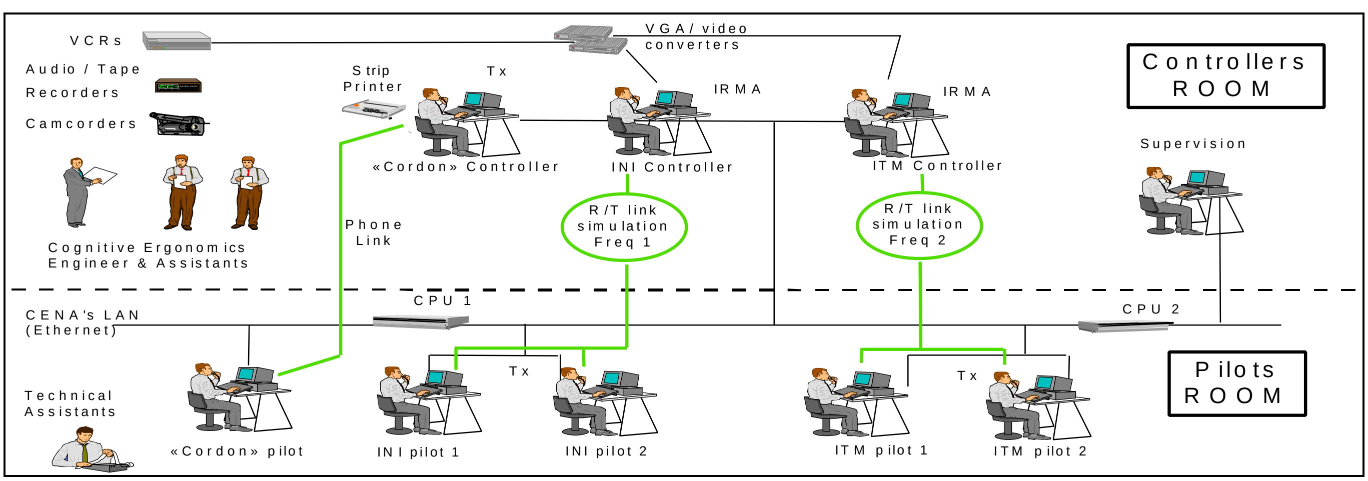


Figure 5 - ESCAPADE Simulation Infrastructure

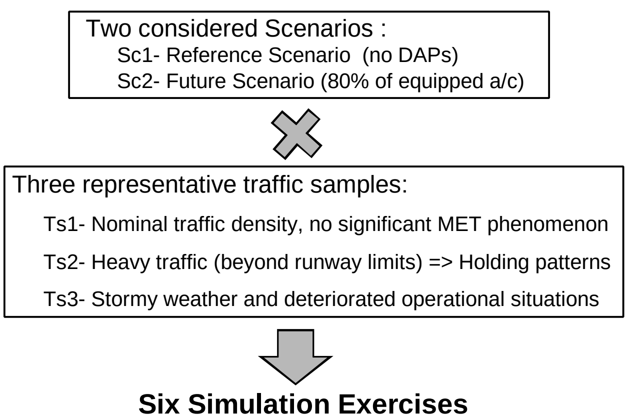
In addition to IRMA/S workstations (used for the INI/ITM controllers), Unix® workstations and X terminals (supporting MASS simulator and pilots HMIs), a multi-channels voice loop has been installed in order to simulate pilot/controllers VHF voice communications for INI and ITM sectors.
The recording capabilities of the simulation infrastructure range from IRMA/S and MASS log files to audio recordings of controller/pilot voice communications and video recordings of the controllers displays (See §4.5 hereafter).
Although our purpose was not to implement a full-scale mock-up of AdP/Orly's IFR control room, a high degree of realism was nevertheless required (in order to realize the evaluation under experimental conditions as close as possible to the operational ones), and has been achieved.

2.5 Scenarios and Traffic samples

Operational situations in the MASS traffic generator used for ESCAPADE are implemented through:

- Traffic patterns/ flight plans, aircraft type/equipment and Meteorological conditions, which are all defined in the traffic samples files as an off-line input to the simulator ;
- Real-time pilot actions on the traffic via the simulator's pilot HMI.

As described below, by combining the scenario cases and the basic traffic samples, a total of six simulation exercises have been defined in ESCAPADE :



The three traffic samples have been developed with the following requirements :

- adequacy to the evaluation needs in terms of impact of the use of the DAPs
- realism of the resulting simulation traffic.

In order to create operational situations allowing to explore interesting uses of the DAPs, pilot scripts have also been defined, for each of the three basic traffic samples, so that pilot actions result not only from controllers instructions but also from specific orders described in those scripts (e.g. error in selecting a VHF frequency, etc..).
This introduced a complex phased development of the traffic samples files and pilot scripts, requiring early test phases (and thus early availability of a simplified simulation platform) in the life cycle of the project, as described below :

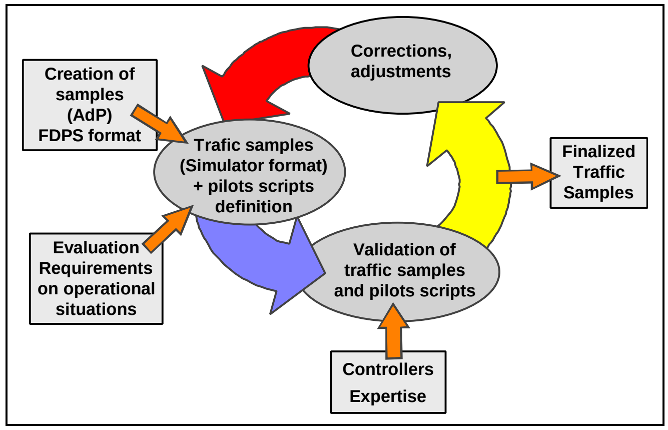


Figure 6 - Traffic samples & pilot scripts development

3. Human Factors Issues

From a Human Factors point of view, the ESCAPADE simulation is an « exploratory oriented » experimentation, as it is an early assessment of the use of DAPs. Its high degree of realism places it between « part-task » and « full scale » simulations.

Our aim here was to put more emphasis on ecological realism (simulated field studies approach) even if it means less on strict experimental control (which anyhow remains a largely hypothetical ideal in complex work settings). At a methodological level this approach stresses systematic description of verbal protocols gathered in parallel with performance of the activity and puts statistical processing in second place.

The classical phases have been followed :

- 1- Definition/Preparation of the scenarios
- 2- Preliminary Trials (Pilot phase)
- 3- Experiment
- 4- Processing and analysis phase
- 5- Feedback to the people involved

Phase 1 is described in « *Scenarios and traffic samples* » above. Phases 2 and 3 were performed between end 1997 and April 1998 (see *ESCAPADE Simulation Trials* below).
Phase 4 is currently in progress while phase 5 will be performed by the beginning of 1999, in accordance with ESCAPADE project schedule.

4. Simulation Phase Trials

4.1 Pilot Phase

As a pre-requisite to the simulation trials, a pilot phase has been performed in two parts:

- Part 1 (December 1997): simulator/traffic samples - oriented tests
- Part 2 (March 1998): full simulation infrastructure and trials protocol acceptance tests

As the tests involved the use of the same traffic samples than those to be used during the simulation itself, the half dozen controllers involved in this phase did not take part to the rest of the experimentation.

4.2 Experiment

4.2.1 Subjects

The ESCAPADE Simulation Phase trials have been successfully carried out in CENA/Athis-Mons during 9 full days between April 2nd 1998 and April 30th 1998, involving the participation of 13 Paris/Orly controllers and 8 simulation pseudo-pilots for a total of 5 training sessions and 18 simulation sessions. Five stable teams of two controllers each (1 INI / 1 ITM) were constituted at the beginning of the trials.

4.2.2 Materials

Each simulation session consisted of a one-hour simulation run involving three controllers (« cordon », INI and ITM) and five pilots (1 « cordon » pilot, 2 INI pilots and 2 ITM pilots).

4.2.3 Procedure

Each of the 5 teams took part to 1 or 2 sessions per half day of simulation trials, for a total of up to 4 simulation sessions per team. Traffic samples duplication with small changes had nevertheless to be performed each time a controllers team was involved in two scenario cases for the same traffic sample. Each session was immediately followed by a « debriefing » interview of the participating INI/ITM controllers with a cognitive ergonomics engineer. The following table summarizes the number of simulation sessions that took place for each of the six different scenario/traffic sample cases (See *§2.5* above) :

Scenarios / Traffic samples	Reference Scenario (equipped aircraft: 0%)	Future Scenario (equipped aircraft: 80%)
Traffic sample 1 (« Nominal »)	2 SESSIONS	3 SESSIONS
Traffic sample 2 (« Heavy traffic «)	3 SESSIONS	4 SESSIONS
Traffic sample 3 (Stormy weather + degraded op. situations)	2 SESSIONS	4 SESSIONS

Note that the *Future Scenario* cases took priority over *Reference Scenario* cases when possible.

4.3 Simulator Technical behavior

The technical part of the experimentation was successful. The exercises ran correctly during all the sessions. Only one session had to be interrupted due to a computer memory saturation. However, the replay functionality of the simulator allowed a full recovery from the time of the crash and to continue the session until its normal ending time.

The pseudo-pilots had received instructions and training to correctly deal with aircraft behavior in the MASS generator. The controllers were very satisfied with the realism of the traffic samples and of the aircraft behaviors, as well as with the experimental conditions which were very close to true conditions.

All the required information for the analysis were correctly recorded in all exercises :

- Controllers actions on IRMA/INI and IRMA/ITM (among which the « DAP display » requests)
- Pseudo-pilots actions on the MASS interface
- 4D trajectories of all flights
- Video recordings of the IRMA's screens with controllers-pilots communications on audio channels
- Video recordings of strips boards (INI and ITM)
- Video recordings of controllers behavior along with their communications on audio-channels.
- Audio recordings of debriefing sessions

5. ESCAPADE Simulation Output Processing & Analysis

5.1 Simulation Sessions Output

The above information are first filtered and processed to give the following data (which represents the first step of analysis):

- Graphical representation of the traffic load for each working position as a function of time:
  aircraft_number = f1(t).
- Graphical representation of the number of DAP requests for each position:
  DAP_requests_number = f2(t).
  (A DAP request consists in a touch of the IRMA L3 key to access Heading/IAS or in the selection of a flight to display the mini-window with the DAP information).
- Integration of trajectories data into « Trace_routes » tool, which provides a full graphical view of the traffic and trajectories as well as useful tools for measuring distances and timings.

- List of all couples of aircraft in conflict (the ones for which horizontal and vertical separation are below a determined threshold).
- Sequencing of aircraft flying over a given geographical point.
- For each aircraft, time spent into one of the three Orly's holding patterns (BSN, EPR, MEL).
- Temporally ordered graphs of controllers activity.

5.2 Assessment criteria

The evaluation of DAP is done thanks to the exploitation of the above outputs and of the data drawn from retrospective verbal reports. It consists in evaluating:

- effect of DAP on communications (VHF occupancy rate, communications content,…)
- impact on safety
- possible incidents
- impact on steady flow (non optimal sequencing and landing rates, delays)
- impact on control strategies (choice of trajectories and sequences, induced consequences on the quality of the service,…)
- effect of the interface on the usability of DAP
- general assessment of the usefulness of DAP in different situations
- effect on collective aspects of the controllers' activity

6. First results

Broadly speaking, the successive phases in the data analysis process are :

- Quantitative analysis of DAP related events
- Analysis of the relation between DAP actions and field of practice tasks (sequencing, holding pattern management,...)
- Analysis of the relation between DAP actions and categories of cognitive activities

The results presented below should be considered as outputs from a first step in the analysis process. More detailed analysis are currently performed and will be published soon.

6.1 General

For each session we determined the amount of DAP related events : opening of a L3, opening of a basic /exploratory window, FL alarm (figure 7). The results show that during the 10 sessions taken into account for the analysis of results, subjects accessed to a DAP 386 times (mean : 38.6 ; min. 23, max. 62). The high-priority set (Line 3) was used 219 times (mean : 21.9 ; min. 5, max. 41) the basic/exploratory set (window) was used 145 times (mean : 14.5 ; min. 1, max. 29).

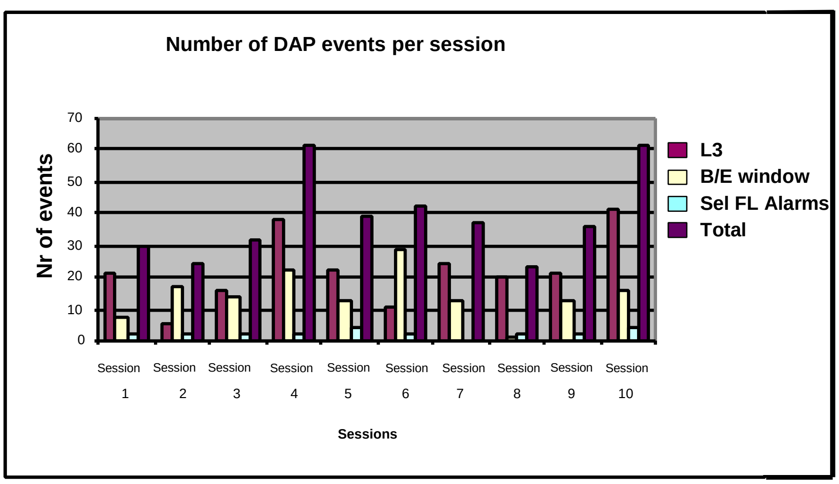


Figure 7 : Number of DAP events (10 sessions ; 5 teams)

6.2 Effect of the traffic sample

There is no statistical evidence that the characteristics of each traffic sample had an effect on the amount of DAP accessed during a session nor on the distribution of DAP related actions between INI and ITM workpositions.

6.3 Learning or familiarization effect

At a global level the results show that the amount of DAP displays opened during the third pass is more important than in the first and second ones. Unfortunately only one single team happened to work on a third sample. The overall difference is therefore due to the results of this team and no generalization can be made on this basis. If we consider the successive results of each team, there is no evidence that the progressive familiarization with the resource and/or the control/display from a session to another for each team might increase the amount of DAP openings but for the team 3, and only if we take into account the difference between second and third session for this team.

6.4 Results by team / Effect of the subjects

At a global level, the results show some differences between the teams, taking into account the fact that team 4 played only one session (table 2).
As it seems that these difference cannot be explained by the simple effect of a single factor (relevant explanations have to be elicited from the examination of the contextual features of each session).

Table 2 : DAP events per team.

Nr of DAP events	Teams					
Sets of DAP events	1	2	3	4	5	Tot.
L3 set	41	27	78	38	35	219
B/E set	8	30	43	22	42	145
Selected FL Alarm	4	6	8	2	2	22
Total	53	63	129	62	79	386
Mean	26.5	31.5	43	62	39.5	38.6

6.5 Effect of the task

The total amount of DAP related actions can be distributed into 216 actions for the INI position (mean : 21.6 ; min. 9, max. 47) and 170 for the ITM position (mean : 17 ; min. 7, max. 28).The L3 set was used 143 times by the INI controllers (mean : 14.3 ; min. 2, max. 34) and 76 times by the ITM controllers (mean : 7.6 ; min. 0, max. 16). The basic/exploratory set was used 62 times by the INI controllers (mean : 6.2 ; min. 1, max. 12) and 83 times by the ITM controllers (mean : 8.3 ; min. 0, max. 19).

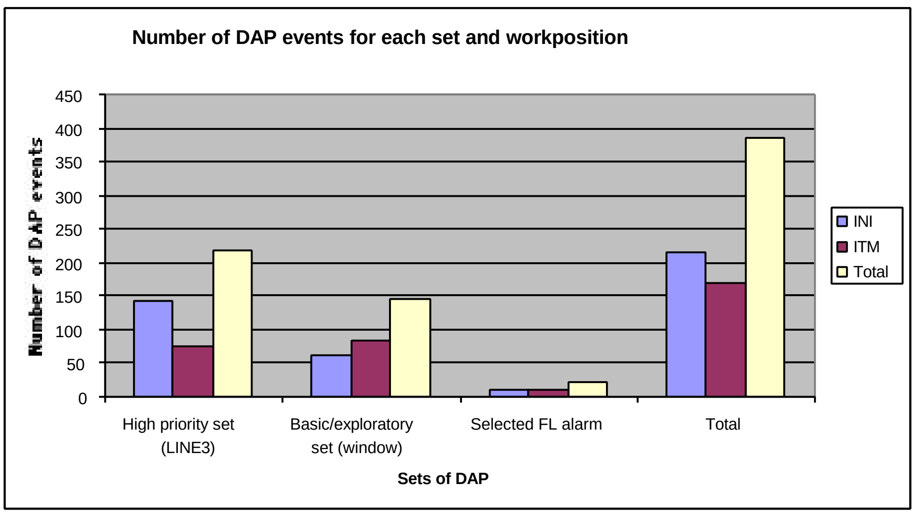


Figure 8 : Distribution of DAP events for the 10 sessions and for each workposition

The differences observed between the INI and ITM controllers' use of DAP could be explained by the nature of the demand specific to each task. For example the separate window includes DAP which could be expected to be more directly useful to the ITM controller (for instance the Minimum approach speed and the ILS frequency) than to the INI controller.
A deeper analysis of the results show that this point is more complex : in five sessions both INI and ITM controllers utilized L3 set more than basic/exploratory set ; in one single case INI and ITM controllers opened more basic/exploratory window than L3 ; in four sessions INI controllers utilized L3 more often than B/E (Basic/Exploratory) set, when ITM controllers utilized basic exploratory set more often than L3 set.

Table 3 : Comparative patterns of DAP relative use by INI an ITM controllers ; grey cells indicate the more used DAP resource.

	INI	ITM
L3 set		
Bas./expl.		
Sessions :	S1,S5,S8,S9,S10	

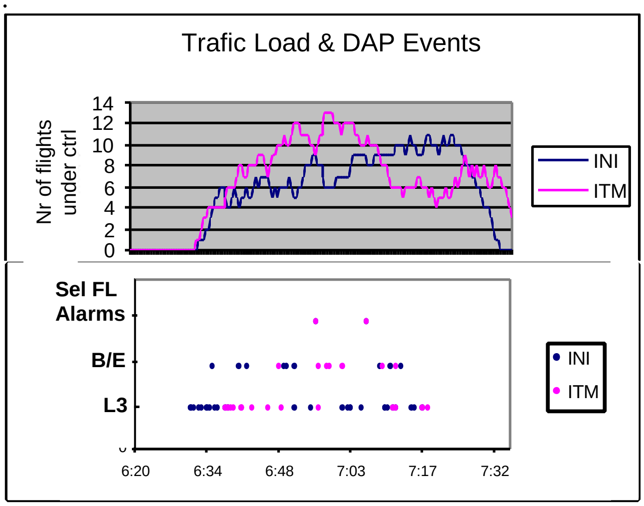
	INI	ITM
L3 set		
Bas./expl.		
Sessions :	S2	

	INI	ITM
L3 set		
Bas./expl.		
Sessions :	S3,S4,S6,S7	

These elements put into evidence that even though ITM controllers used more often basic/exploratory set than INI controllers, we do not have a symmetric inversion since half the time ITM controllers used the L3 more often.

6.6 Effect of the traffic load

At this stage of the analysis, no simple relation between the traffic load (which of course should not be confused with hypothetical "workload", whatever it can be) and the use of DAP can be identified. If we put together a typical pattern of traffic load for each workposition in scenarios 1, 2 & 3 (see figure 9 for an example) and the distribution of DAP events over each session (figure 10), there is no linear relation between the amount of flights simultaneously under the control of the operators and the "density" of DAP actions over a sequence of time.
This does not mean that traffic load had no effect on the use of DAP. We could for instance interpret this lack of linear co-evolution as a relative decrease of the DAP related actions. This is corroborated by controllers' verbal reports which stress that in high traffic load situations, they tend to focus on short-term operational tasks and eliminate other activities. This obviously does not mean that DAP are less useful in high traffic load situation ; for example the MAS (Minimum Approach Speed) parameter is seen of great interest by the controllers in situations where they have to call the board to get the current value of MAS , but avoid to do so, so as not to disturb the pilots during a tricky flight phase.
A more likely hypothesis could be formulated in terms of interference between pressing tasks and « peripheral tasks » (such as consulting DAP displays or any other resource).



Figures 9 & 10 : Representation of the evolution of the traffic load during a session (Team 1 ; Traffic sample 3) ; Distribution of the DAP related actions over the time for session 10.

6.7 Which DAP, When and Why…

The next step of the analysis will be to identify which particular DAP or sub-set of DAP was reached during the openings of either the L3 or the B/E window, during which phase of the flight and to which intend.

The analysis of verbal reports has enabled us to provide some cues to the "which" question. Analysis performed on 50% of the data show that the speed is the most used parameter both for INI and ITM controllers. As expected there is a strong relation between the use of a particular DAP and the tasks to be performed on a workposition. For example, the Minimum Approach Speed (MAS) is the second most consulted DAP for the ITM workposition.
Furthermore, the results put into evidence that it is possible to associate operational situations (normal or incidental) to a particular DAP.

In a further phase of the analysis, DAP data will be analyzed in terms of their relation with cognitive activities, in order to identify whether DAP resource supports a particular aspect of cognition. This further steps needs a translation from the language of the ATC field of practice to the language of cognitive activities (planning, decision-making, diagnosis,…).

Table 4 : Type of DAP consulted by INI and ITM positions

	Workpositions		
DAP	INI	ITM	Total
Speed	66	16	82
MAS	9	15	24
Heading	5	10	15
Selected FL	7	6	13
ILS	1	8	9
Vertical speed	9	0	9
Wind	0	2	2
Destination	0	1	1
Origin	0	1	1
Total	97	59	156

6.8 Communications

When analyzing the DAP events in relation with the controllers-pilots communications, we noticed the occurrence of a particular sequence of action where a DAP information is consulted and simultaneously asked to the board. This sequence can be seen as ambiguous, as one of the expected effect of the introduction of DAP resource was to lower the amount of VHF communications. What explanation could be given for this redundancy ?

So far we have four possible answers under consideration:

1. Lack of training
2. Lack of confidence in the information displayed by the system or in the information given by the pilot
3. Need for redundancy in hazardous situations
4. Loss of illocutionary value linked to each speech act when asking something on the VHF

7. Conclusion and Perspectives

The strength of the experimentation are:

- high degree of realism in the technical environment and operational situations (simulation infrastructure, aircraft behavior in the simulator, traffic samples).
- high level of preparation of the simulation
- huge amount of empirical data for further in-depth analysis

At this stage of the data analysis process, the results suggest the following points :

- The controller's general comments are highly positive (regarding both the operational usefulness of the information displayed and the way they can be accessed).
- The use of DAP fits to the controllers' needs in different steps of their activities (diagnosis, planning, tactical decision-making, global supervision).
- We could notice an insertion of DAP resource in the controllers' coordination/cooperation practices.
- In many situations the DAP provides fine-grained information which allows a more efficient decision-making (management of holding patterns, insertion of flights into a sequence,…)
- The results concerning the alarms are very promising
- The experimentation provided some feedback on the operational display
- Feedback from operational partners put into evidence the fact that the scope of DAP set up could be extended to other approach workpositions (Local and "Cordon" controllers).

The short/middle term perspectives in the frame of the DAP concept will be achieved through:

- the EOLIA/DADI project, aiming at displaying DAPs to en-route controllers
- the taking into account of the airborne point of view
- Further analysis including Cost/benefits
- Other projects related to datalink in approach : ALCODA (ground to air control delegation), ADAGIO (holding patterns and approach trajectories management),..

An « ESCAPADE video » presenting the project is actually being produced. The participation to the PETAL II press day (mid 99) is also planned.

Lastly, The live traffic phase of ESCAPADE is currently still under definition and will be achieved with ADP, STNA, EEC and airlines (Air France, Air Liberté, Airbus Inter Transport, Dassault Falcon Service). It will complement the simulation by a technological demonstration in mid-99.

Glossary—

AdP : Aéroports de Paris
ADS : Automatic Dependent Surveillance
ADS-B : ADS - Broadcast (airborne data are spontaneously broadcasted)
ADS-C : ADS - Contract (airborne data are downlinked in the frame of an air-ground ADS contract)
ASTERIX : All purpose Structured Eurocontrol Radar Information eXchange
ATM : Air Traffic Management
CAP : Controller access to Aircraft Parameters
CENA : Centre d'Etudes de la Navigation Aérienne
DAP : Downlinked Aircraft Parameters, or Downlinking of Aircraft Parameters
DGAC : Direction Générale de l'Aviation Civile
DNA : Direction de la Navigation Aérienne
EATCHIP : European Air Traffic Control Harmonisation and Integration Project
ESCAPADE: Experimentation and Simulation of Controller Access to Aircraft Parameters and Display Evaluation
GICB : Ground Initiated Comm-B : a mode S specific protocol dedicated to optimized aircraft data collection from the ground.
IIMSES : Initial Implementation of Mode S Enhanced Surveillance
ILS : Instrument Landing System
IRMA : Indicateur Radar de Mouvements d'Avions
MASS : Multi-Aircraft Simplified Simulator
Mode S : an improvement of SSR, capable of selectively addressing the aircraft, hence allowing two-way data link
MOUSES : Mode S Operational Use of Enhanced Surveillance
PETAL II : Preliminary Eurocontrol Test of Air ground data Link, phase II
POEMS : Pre-Operational Eurocontrol Mode S Stations
SCTA : Service de Contrôle du Trafic Aérien
SSR : Secondary Surveillance Radar
STCA : Short-Term Conflict Alert
STDMA : Self-organized Time Division Multiple Access (VHF Data Link Mode 4)
STNA : Service Technique de la Navigation Aérienne
TMA : Terminal Manoeuvring Area

References—

[1] CONCEPT OF OPERATIONS - Mode S in Europe (Mode S CONOPS), Eurocontrol, SUR.ET2.ST02.1000-CNP-01-00
[2] ESCAPADE : General Presentation, CENA/NT97078