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ANNEXES

CENA PD/3 FINAL REPORT

Annex C2: Specific Results for TEPS, DM and APD Tools

EUROCONTROL

EUROCONTROL
96 rue de la Fusée
B-1130 BRUXELLES

Prepared by: C Chabrol, F Fichant, J Garron

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1. INTRODUCTION

This second part of the Annex devoted to the results of the PD/3 experiments presents detailed issues devoted to three advanced tools provided to the controllers according to their role or the simulated sector. These tools are as follows :

- TEPS tool (all sectors and controller roles) ;
- DM tool (TMA sector only - the whole set of DM functions to the DEP PC only) ;
- APD tool (ETMA and En-Route sectors only - no PROSIT labels for the ETMA - all controller roles).

Descriptive curves are shown in the following sections and picture the mean results of the recorded data. In addition, the 25th (below the square basis), 50th (within the square) and 75th (above the square basis) percentiles are shown.

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2. TEPS TOOL

No specific detailed analysis has been made in this section relating to the way the TEPS tool was used by the controllers. This advanced tool was indeed strongly linked to the main concepts of PD/3 (i.e. advanced planning and trajectory negotiation with board) and thus was likely to be investigated throughout the overall analysis of PD/3 results. Nevertheless, descriptive curves are proposed so as to enrich some statements which are reported in various parts of the main report. Therefore no comment is directly associated to each curve in this section. The reader will find it in the main report (section 6.6.2)

2.1 USE OF TEPS TOOL BY PC AND TC

Descriptive curves presented hereafter show comparisons between controllers rules (PC/TC) for :

- average number of trajectory editions per run ;
- average number of TEPS activation in DISPLAY mode per run.

Those measures are presented in Figure 2-1 to Figure 2-4. They were extracted only from En-Route and ETMA sector insofar as Departure planning and tactical controllers worked on very separated traffics and tools (DM and pre-departure aircraft were allocated to the DEP PC and radar image and post-departure aircraft in TMA were allocated to the DEP TC). Therefore, no sharing of the TEPS tool was observed within TMA.

Observations and debriefings with controllers did not bring to light any influence of introduction of DL equipped aircraft on the average number of trajectory editions. It was clearly confirmed by the objective measures (they are not reported in this section).

In other respects, it seemed also to be of interest to assess the influence of the introduction of equipped aircraft on the way the TEPS was used in DISPLAY mode by the TC. Indeed, qualitative data (observations and debriefing) made the observers feel that the more important the percentage of Data-Link equipped aircraft was, the stronger the need for the TC to consult the trajectories was : it might be a clue of difficulties they could be having for memorising and integrating this category of aircraft that some controllers called ‘ghost aircraft’. Those measures are presented in Figure 2-5 to Figure 2-6.

Qualitative data has also brought to light the large contribution of trajectory editions on controller perceived workload. Thus, specific measures devoted to the average time spent by the controllers for editing trajectories are reported in this section. Only measures concerning the PC rule are presented since the sharing of tasks largely attributed trajectory editions to the PC. Those measures are presented in Table 2-1.

2.1.1 Influence of controller roles

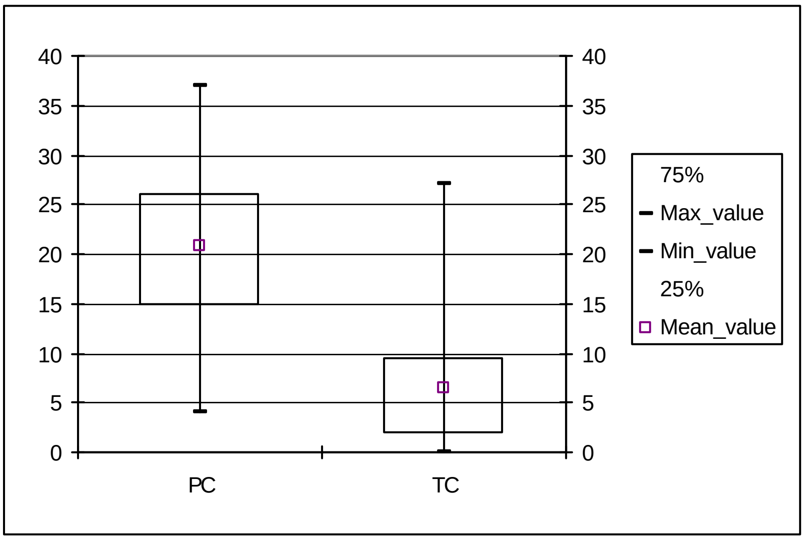

Figure 2-1: Number of trajectory edition per run in ER sector (all traffic volumes and advanced ORGs)

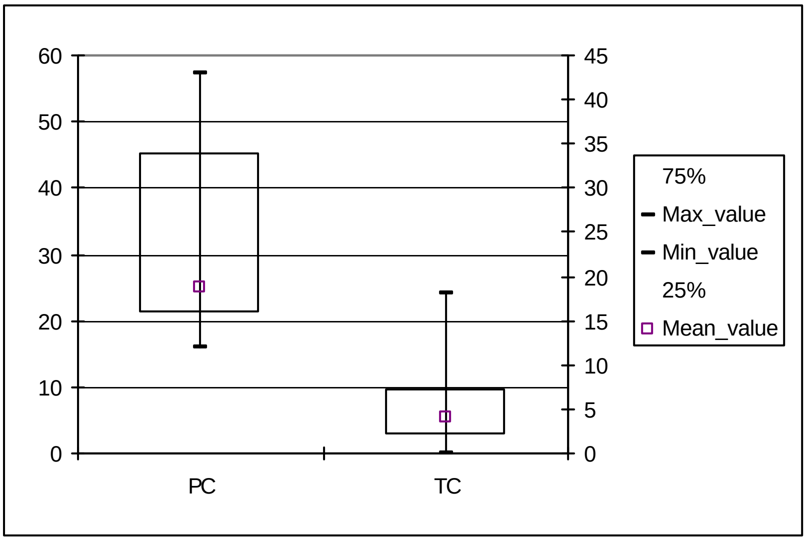

Figure 2-2 : Number of trajectory edition per run in ETMA sector (all traffic volumes and advanced ORGs)

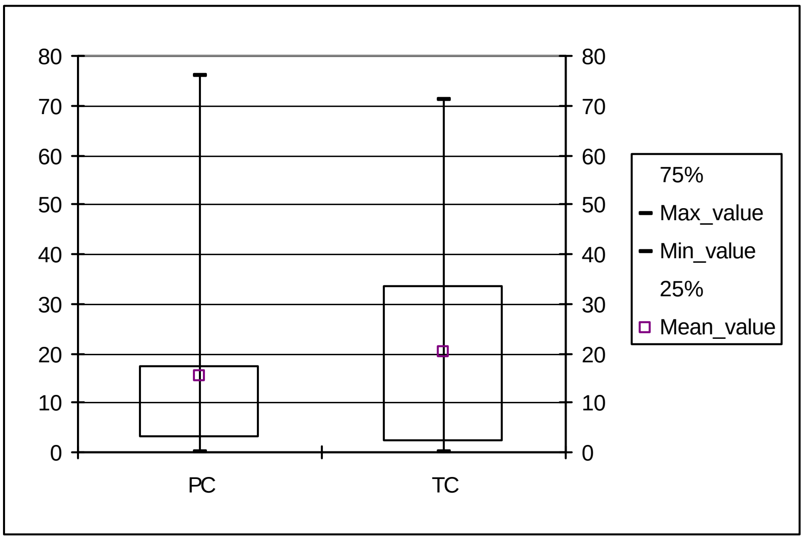

Figure 2-3 : Number of TEPS activation in DISPLAY mode per run in ER sector (all traffic volumes and advanced ORGs)

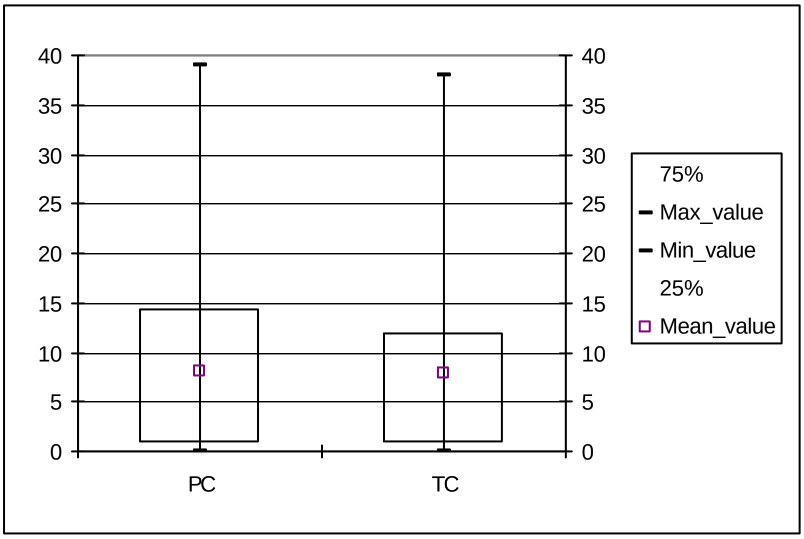

Figure 2-4 : Number of TEPS activation in DISPLAY mode per run in ETMA sector (all traffic volumes and advanced ORGs)

2.1.2 Influence of advanced ORGs

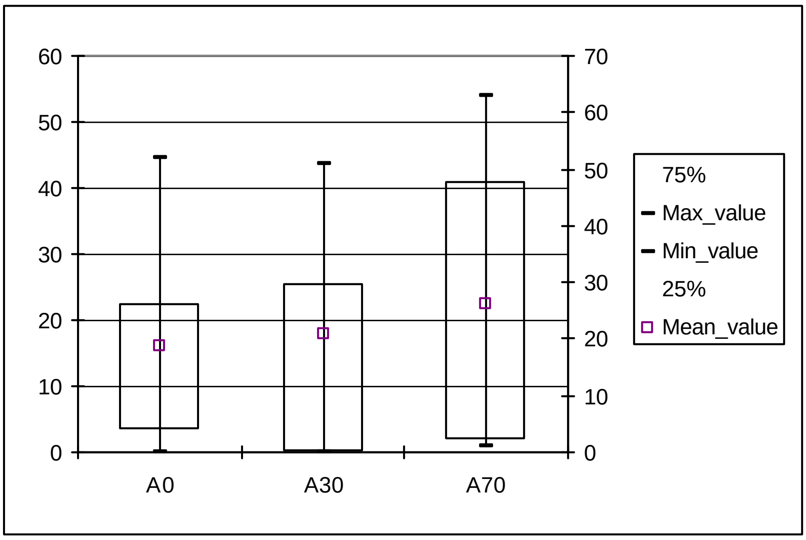

Figure 2-5 : Number of TEPS activation in DISPLAY mode per run by TC in ER sector (M+H)

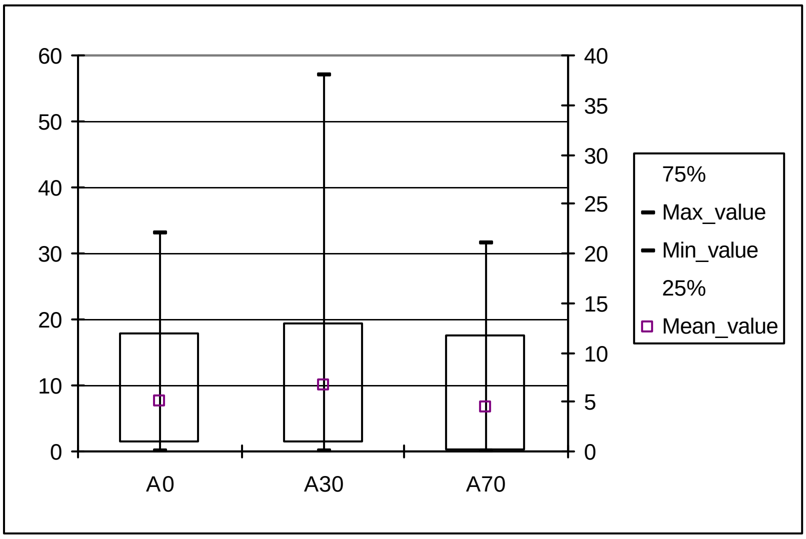

Figure 2-6 : Number of TEPS activation in DISPLAY mode per run by TC in ETMA sector (M+H)

2.2 CONTRIBUTION OF TRAJECTORY EDITION[1] ON CONTROLLER WORKLOAD

Sector	Traffic Volume	Edition mean length	Validate mean length	Validate Max length
DEP	L	46.5s	6s	7s
	M	36.9s	7s	9s
	H	33.7s	7s	9s
ETMA	L	28.2s	7s	8s
	M	29.6s	8s	10s
	H	27.6s	9s	11s
ER	L	30.2s	5s	7s
	M	21.2s	7s	9s
	H	23.4s	8s	12s

Table 2-1: Details of duration of trajectory edition per run (all advanced ORGs and PC position)

Meaning of Table 2-1 items :

- Edition mean length = average of time per run that took activities of trajectory edition
- Validate mean length = average of delay between the Validate action and the system feedback[2]
- Validate Max length = Peak of length that was observed for Delay VAL

[1]The edition step began with the TEPS activation in EDIT MODE and ended with the action of Validation.

[2] System feedback mean = Send (4D), Register (3D) or Co-ordination activation.

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3. DM TOOL (DEPARTURE POSITIONS)

3.1 INTRODUCTION

3.1.1 Prerequisites

During the training sessions Departure controllers had a briefing on the respective rules and actions they were expected to perform on each position (DEP PC and DEP TC).

3.1.1.1 Regarding Advanced Organisation

DM use obviously had an important place in the new operational environment they were taught. Instructions for using DM in DEP PC position tended clearly to extend the current co-ordinator role to a Local and even a Ground Controller role. So due to the real cut regarding traffic environment (mostly pre-departure aircraft for the DEP PC and mostly post-departure aircraft for the DEP TC) a very specific planning controller role was proposed. Of course they were told that it was in a large part due to experiment limitations since we could not simulate all ground positions. However we exposed our strong intention to get their expert co-operation in order to assess the DM tool as far as possible within the specific context of the simulation (including the very specific role attributed to the DEP PC) but also by extrapolating their feelings onto future ATC environment. Throughout the knowledge of all these instructions it was up to the controllers to find new reference marks and build a new operational environment.

3.1.1.2 Regarding Baseline Organisation

No strong evolution has been brought compared to Today's environment. The major difference was that DEP PC and DEP TC were provided with DEP SIL windows (one for each runway). Thus they had information about the aircraft which were forecast to take-off within a 5 min period. Neither ground sequence monitoring nor planning action was expected from the DEP PC. He only had to manually trigger the take-off event. By this fact DEP PC was allowed to intentionally delay a specific aircraft when required by the traffic situation in TMA. Most part of his activities were oriented toward a direct assistance of the DEP TC.

3.1.2 DM / DEP TEPS

In both Main phases DEP PC and DEP TC were provided with **DM display**. However the entire DM support (sequencing functions associated to trajectories functions) was available to DEP PC only. Thus, in order to cope with PD/3 concept of early trajectory planning, DEP PC was provided with TEPS facilities for pre-departure aircraft in parallel of ground sequencing activities. They were specifically called **DEP TEPS functionality** in extension to the **TEPS functionality** that was available through both radar label and DM labels for post-departure aircraft (reminder : DEP TEPS facilities were available via DM labels only).

DEP TC had no possibility to intervene on ground sequencing and had the planning authority on pre-departure aircraft only after transfer (implicit or explicit[1]) from DEP PC position. However he had the possibility to consult system trajectory (future trajectory known by ground and board) as soon as it was created.

[1] Transfer automatically made after Acceptation of equipped aircraft trajectory / transfer manually performed for non equipped aircraft

3.2 DEP PC POSITION

3.2.1 Operational aspects regarding Ground Sequencing

The main support DEP PC got from DM display was the overall display of pre-departure aircraft which allowed a **clear view of the pre-departure traffic pattern** : next take-off configuration (time, following aircraft, separation, ...) for the short term, synthetic view of general balance of aircraft on both runways in parallel with the sequence optimisation on each runway for the middle-long term.

Recurrent pattern for DEP PC windows set in the 20 inches square screen was as shown in Figure 3-1 :

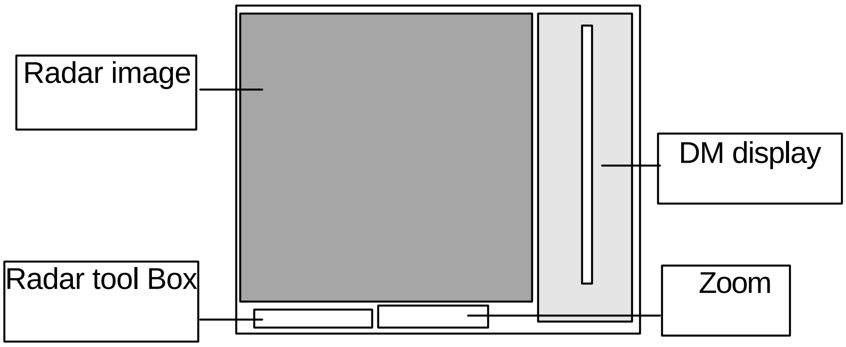

Figure 3-1 : Recurrent DM display in main screen of DEP PC position

Two fundamental axis for use of DM provided a strong guideline for the DEP PC activities : **ground sequencing** activities and **preparation of SID trajectories** (by DEP TEPS invocation).

3.2.1.1 A matter of responsibility

DEP PC activities through DM display were mostly devoted to the DEP TEPS invocation (via the DM label of pre-departure aircraft). It highlighted the major part of the responsibility DEP PC naturally assigned to their own function ; they considered that overall **ground sequencing was mostly a matter of DM responsibility**.

In this case they avoided to intervene on DM sequencing and voluntarily limited their interventions to a DM labels checking and to some isolated actions on DM (re-sequencing, permutations, change of runway) mostly when DM proposal made the controllers disagree. Figure 3-2 below presents the average number of manual re-sequencing per run performed by the DEP PC for the Medium and Heavy traffics. The observed values, which are quite similar on both traffic loads (14 for Medium and 13 for Heavy), correspond to one hour time of activity and thus can be considered as quite limited.

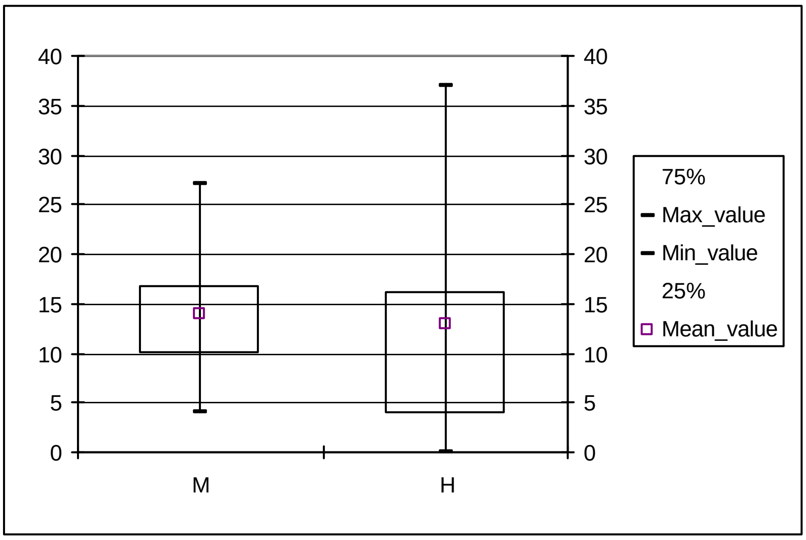

Figure 3-2 : Number of manual re-sequencing per run by DEP PC (all advanced ORGs)

It is of real interest to note that the events DEP PC used for checking were mostly configurations of sequence that **potentially created conflict on future trajectories** (e.g. risks of catch-up or wake turbulence due to a non sufficient separation on the runway) and their strategy was completely independent of the aircraft equipment (equipped or not equipped).

Some of their most significant reactions regarding DM sequencing are presented here after :

- « The DM sometimes proposed a light aircraft behind a heavy one with less than 3 min of separation and I could not accept it because we do not do that in today's environment »
- « The DM proposes to me a fast aircraft behind a slow one with just one min separation and I do not agree with that. I understand that permuting those both aircraft is not a good solution because it would induce a three min separation (747 creates wake turbulence that could be dangerous for the following propeller). Thus what DM should do in this case is to tune its first sequencing activity by finding an alternative trajectory that for instance will turn earlier the propeller and let it at a low level »
- « The DM should have advised that two aircraft (a propeller before a jet) may catch up on their common initial trajectory (15 Nm common between East and North trajectory) even if they are expected to diverge after ! (see section 3.7, DM rules) »
- « The DM should alert the DEP PC when two successive aircraft have the same exit point but only if a catch up risk exists (with different performances for instance) »
- « I wanted to change the runway of an aircraft just to avoid a catch up and for me, the DM should have done it before » ...

Most of those reactions clearly showed that DEP PC paid specific attention on DM sequencing in relationship with the first climbing part of the SID trajectory (the first 15 Nm are the most critical).

However it can be reported that the controllers have globally a positive opinion on the sequences proposed by the DM because no strong incoherence has been detected during the runs.

Controllers reported that their point of view deserved to be investigated further with different operational configurations of CDG (e.g. departures facing East or specialised runways).

3.2.1.2 DM logic vs. controllers logic

A major inconvenience that controllers have met in performing manual re-sequencing was that most of the time they failed against **DM refusal** when they tried to intervene so as to cancel remaining constraint violation or to optimise the sequencing. Therefore in such case they were unable to propose a better solution than the DM one (e.g. to insert a departure before an arrival) and by consequence really lost their time. For instance a controller did not succeed in reducing the high delay of an aircraft without CFMU time slot (he thought at this moment that the overall average of delays was too much shared in favour of aircraft with CFMU time slots), by changing runway for an aircraft. Most of the time controllers did not succeed in moving any aircraft forward in time scale. It induced a real frustration in controllers mind : « **Some DM rules are too much inflexible** ! ».

This point emphasises a typical and forecast problem of simulation where some rules of a tool aim at reproducing specific human activities that normally take place in a very complex environment. There is obviously a strong simplification of the reality and thus a lack of consideration of all exceptional events due to human factors (meanwhile these events may be considered as normal by controllers). Therefore the algorithm rules that were essential for the DM function like « aircraft with CFMU time slots are to be prior in the sequence », « an aircraft can not be assigned to a specific runway if all required conditions to use this runway are not fulfilled », « an aircraft can not be forwarded in the sequence under the theoretical minimum delay to reach the holding point » represented sometimes too strong limitations for the controllers point of view.

3.2.2 GHMI aspects regarding Ground Sequencing

3.2.2.1 General considerations

When manual intervention occurred on ground sequence, no serious problems in interacting with the DM display was observed. The response times of the system for the manual sequencing activities seemed to be quite less disturbing than they were for DEP TEPS activation (it has been observed that some first DEP TEPS activation[2] lasted 8'' ...) and TEPS edition (see Table 2-1 in section 2.2). Moreover despite the fact that some difficulties existed during the first runs for consolidating in memory various DM coding and dialogues (difficulties that were reinforced by the low frequency of sequencing activities performed by the DEP PC), it appeared that controllers did not meet serious problems for DM HMI assimilation.

3.2.2.2 CFMU time slot

Regarding the notion of **CFMU time slot** (reminder : one of the major DM responsibility was to keep as much as possible all the aircraft in their CFMU time slots), it appeared that the main information to be provided was whether an aircraft had a CFMU time slot or not and if it was the case whether this aircraft was within its CFMU time slot or not. DEP PC was provided with three levels of coding in order to

[2] Remind : the first DEP TEPS activation triggered the trajectory functionality of the DM (choice of the most suitable trajectory between the standard SID and the associated alternative trajectories).

well discriminate those different status. The coding seemed to be quite efficient insofar as a very few number of mistakes has been detected for interpreting them. However some problems were observed when those coding were associated to the information of delay (delay compared to the first ETD) since in this situation the second information seemed to be of secondary interest and somewhat confusing for the controllers : « I often made confusion by understanding 2 min outside the CFMU time slot instead of 2 min of delay » or « A DM label presented a 3 min delay and in fact the aircraft was 10 min late on its backward CFMU time slot ».

3.2.2.3 DM notifications

Regarding the sequences proposed by DM it was forecast that some ground configurations would not allow the DM to propose a ground sequence without any constraint violation. Therefore GHMI coding has been specified to advise the DEP PC that one or several sequence violations occurred (advising square on sequence area of the DM labels and messages in MIW called **DM notifications**). Despite the fact that controllers considered ground sequencing as being mostly under DM responsibility (it has significantly decreased their attention demand for DM notification messages), DM notifications were of some interest but only when they advised them there was a lack of separation between two successive aircraft that could lead to a real catch-up risk. In this case the associated coding on DM label (sequence area) was quite efficient (even if some improvements for visibility are needed). At the opposite, considering the very small part taken by the MIW in the overall controller activity (see Main Report, section 7.5.4.2), it appeared that the redundancy of the information through a clear message displayed in the MIW was useless.

3.2.2.4 DM labels animation

The concept of **DM labels animation** deserves to be kept even if some aspects clearly need to be improved (e.g. DM refusal animation was a little exaggerated and added useless waiting time). Indeed it provided an efficient support that allowed controllers to better detect each DM action (and notably a change of runway) and follow DM reaction after a manual sequencing. However it still remains true that sometimes controllers felt puzzled in front of a DM re-sequencing that involved numerous DM labels. This change of general DM configuration made the controllers loose their real time references and this feeling was worsted when they had not enough time to quickly check the new sequence.

3.2.3 Operational aspects regarding SID preparation

3.2.3.1 Priority given to a specific subset of DM labels

DEP PC generally paid attention on subset of DM labels that had exceeded a threshold of 10 min before take-off. All upstream DM label on time scale were not considered as prior in the point of view of DEP PC activities: on the one hand they were considered as being too far from their take-off time and therefore basically worsted the **« operational gap »** (see Main Report, section 7.6.2.2) with the DEP TC, on the other hand the controllers considered that the estimated take off time was too much imprecise and the sequence still in a rough state.

3.2.3.2 DEP TEPS invocation

The principle of strongly integrating trajectory planning functions to the ground sequencing events tended to cope with an anticipated planning concept gaining benefits from an optimised ground sequencing. However the **lack of precision for take-off time** constitutes a strong limitation to such a principle. Controllers do not clearly see today what could be in the future the improved system that would be able to ensure a reliable take-off time so that the following situation could be avoided : a planned trajectory turns into an obsolete one each time an unexpected ground event significantly changes the STD (with all consequences that may occur for conflict events).

3.2.3.3 Trajectory edition for pre-departure aircraft

DEP PC should have gained concrete benefits from TEPS facilities (possibilities to add or cancel level or geographic constraints, to design direct routes...) through the Radar image and the Profile window since they seemed to cope with the operational needs in TMA : a constant thought for shortening trajectories (anticipating turns and above all favouring continuous climbing phase) while keeping it safe (e.g. maintaining a level off if necessary to ensure crossing with arrival traffic). Unfortunately several factors in trajectory edition (see Table 2-1 in section 2.2) induced **excessive time demand** and thus kept the DEP PC from efficiently performing planning activities.

3.2.4 GHMI aspects regarding SID preparation

3.2.4.1 DM labels coding

As it was for the sequencing activities, none of the proposed coding within DM display (and specifically in DM labels) received negative wording from the controllers. However it can be noted that a part of the coding devoted to trajectories exchanges with pilots (bestfit, pilot requests) and to all co-ordination aspects deserves deeper assessment (the associated events like bestfit and pilots requests have not been frequent enough).

DEP PC quickly established a hierarchy for taking into account various DM labels coding. Coding on SID area were the ones they considered before all (matter of SID trajectory information): the plannable state coding was the one which drew controllers' attention in the most efficient way. Principle of other coding like « working trajectory », « pilot request», « current co-ordination» has been positively perceived by controllers. Indeed they agreed such coding had to be presented to the controller and linked to a specific trajectory status area. However no real operational assessment has been performed insofar as concrete use of those coding was much too rare during the simulation ('operational gap' between PC and TC, low number of real negotiation and lack of pre-departure co-ordination forbid trajectory exchanges devoted to pre-departure aircraft).

3.2.4.2 Trajectory design

Providing the controller with information of entire SID trajectory was likely to cope with controllers activities but the rough display of trajectory could induce some trouble for the departure controllers. Indeed in TMA sector, configuration of turns actually has a very important role in anticipation and separation activities. The very simplified angular sections[3] did not allow controllers (DEP PC and DEP TC) to feel really comfortable with the design of trajectories since it made the mental visualisation of real future trajectories very difficult.

3.2.4.3 Trajectory activation and Conflict information

Through the first DEP TEPS invocation, the DM activated SID trajectories comparisons between standard and alternative ones in order to provide an optimised and conflict free trajectory. Such a principle is of great interest in the framework of DEP PC activities.

Whatever the advanced ORG and the traffic load (Medium or Heavy), the controllers chose the alternative SID trajectory in ten percent of times on average instead of the standard one or a new edited one. This value can be considered as significant since one or two alternative trajectories only by standard SID were proposed to the

[3] instead of arcs of circle that would much more precisely represent each turn section.

controllers. The technical staff who is in charge of the DM development aims at progressively adding new alternative trajectories. It should result in a great enrichment of the proposed choices and thus greatly increase possibilities of quickly ensure and optimise SID trajectories.

Problem was that due to simulation limitations (see section 3.7), **no conflict information was available** through DM labels nor pseudo radar labels. Therefore DEP PC felt sometimes strongly insecure when they could not ensure that a trajectory given to the DEP TC was really conflict free (reminder : this situation occurred when DM kept the standard trajectory instead of alternative one or when DEP PC edited a new trajectory for a pre-departure aircraft).

On the second hand the first trajectory activation of an aircraft **could take an excessive time**. So if we also consider the delays that DEP PC had sometime to face with trajectory edition it can be raised that general management of pre-departure trajectories really induced artificial and penalising time pressure. This fact kept the DEP PC from really co-operating with the DEP TC (lack of situation awareness of TMA traffic by DEP PC, impossibility to evaluate concrete consequences of his prepared trajectories, ...).

3.3 DEP TC POSITION

At the beginning of the experiments all DEP TC clearly completely cut their attention from the DM display. Most of them progressively began to pay some attention on a very small section of DM time scale that represented time interval from a couple of min (3 min max.) before take-off until take-off including sometimes period of 5 min after take off (5 min past view area). In this context DM display provided quite the same information and not more as did the DEP SIL within the Baseline organisation.

Such issues were concretised by recurrent pattern for windows set that showed radar image window displayed on the entire width of screen. The DM display was hidden behind it with only the here above described section of time scale emerging at the bottom of the screen.

Recurrent pattern for DEP TC windows set in the 20 inches square screen was as shown in Figure 3-3 :

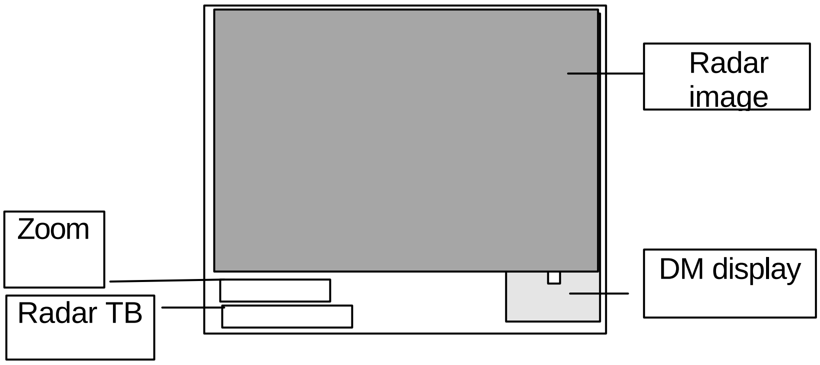

Figure 3-3 : Recurrent DM display in main screen of DEP TC position

3.3.1 Operational aspects regarding ground sequencing activities

Most of the time DEP TC was just glancing at the bottom of DM display in order to discern the global sequence traffic that was about to take off on each runway (number, separations and next time of take off). Such information was considered of interest insofar as they were provided with minimum clues to better anticipate the next future workload. In fact they would currently appreciate in today's conditions that Local controllers provide them more frequently with the incoming departure sequence.

DM display was also punctually used when pilots called early after taking off whereas associated radar label was not already displayed in the radar image.

No very deeper information was searched through this window and overall organisation of DM display seemed to fit well with these DEP TC quick looks.

3.3.2 Operational aspects regarding DEP TEPS use

DEP TEPS functions were of some interest for DEP TC since he sometimes activated the DEP TEPS in DISPLAY mode for aircraft that were about to take off. The prerequisite of this situation was that DEP TC had the time to do it (it was not very frequent ...) and the triggering context was mostly a specific mood of the controller who felt somewhat troubled by the advisories failures or the lack of knowledge of the equipped aircraft trajectories. Therefore he tried to glance at the trajectories just before the take off so that he had less risks to be surprised in real time by the aircraft behaviour.

Figure 3-4 below clearly shows that the DEP TC rarely used the DEP TEPS whatever the traffic load (Medium or Heavy). The great standard deviation that can be observed for the Medium traffic bring in light the strong difference between the controllers.

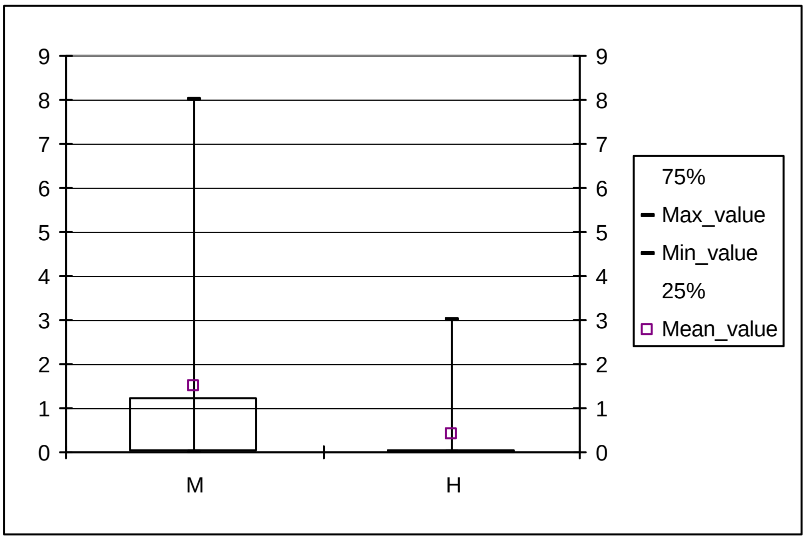

Figure 3-4 : Number of DEP TEPS activation in DISPLAY mode per run by DEP TC (all advanced ORGs)[4]

DEP TC also had in theory the possibility to edit a new trajectory for a pre-departure aircraft (once the planning authority had been transferred by the DEP PC) but this action was never performed during the simulations. The tasks sharing between both DEP PC and DEP TC clearly explains this fact (pre-departure aircraft were exclusively a matter of DEP PC).

[4] This measure was not considered of interest regarding the DEP PC since he acceded systematically to each trajectory display by activating the DEP TEPS in EDIT mode.

3.4 CO-OPERATION ASPECTS

As it was introduced previously, the radar assistant function of DEP PC was almost non-existent. This lack of real time co-operation with DEP TC (previously called the « **operational gap** »), was brought to light through several events during the experiments.

The DEP PC paid his attention almost exclusively on time interval that concerned pre-departure aircraft from the time they left the block until their take-off time (preparation of SID trajectories). This period (about ten minutes before take off) henceforth represented the primary space-time environment for the operational context of DEP PC at the expense of post-departure traffic in TMA. Meanwhile DEP PC kept in mind that it would have been sometimes much more helpful to the DEP TC to be assisted in some tactical contexts.

The only little help that he brought to the DEP TC through the system was the few manual re-sequencing he performed on DM display in order to avoid turbulence or catch up problems.

In order to make up for this situation, a DEP PC also tried to only focus on DM labels that had less than 5 min awaiting before take-off so as he could prepare SID trajectories with a greater awareness of consequences in TMA. But it proved quite difficult to perform it because of the long time that SID preparation procedure took for each aircraft.

In fine DEP PC felt very frustrated not being able to spare enough time to extract his attention from the DM and DEP TEPS in order to look on radar image and follow the DEP TC activities.

3.5 CO-ORDINATION ASPECTS

It turned out that Co-ordination activities between TMA and ETMA was a very particular and limited operational context for tools assessments. Thus existence in today environment of LOA (Letter Of Agreements) between Departure sector (TMA in the context of simulation) and TN/TB sectors strongly decreases the needs in telephone co-ordination. In fact it can be stated that currently a co-ordination is rare and most of the time can be characterised by a very unusual configuration (for instance exit conditions that DEP TC could not meet for any reason). Therefore, by keeping the existing sectors and LOA, strong limitations were *a priori* induced. Furthermore most of these co-ordination require to be quickly resolved : on the one hand crossing time of aircraft in TMA is very short (between 5 and 8 min), on the other hand the situation can be synonymous of conflict in entry part of ETMA...

Limitations reminded here above grew stronger by the fact that no co-ordination was allowed before take-off time. Therefore controllers in ETMA had plannable state only after aircraft take-off. Under such conditions DEP PC could perform any change on SID trajectories for pre-departure aircraft including large modifications of exit conditions (exit point, transfer level) without triggering any co-ordination. At the opposite no one today can state that allowing co-ordination before take-off would not appear in a next step as too strong a constraint for the DEP TC...

However the question of early planning has been raised anyway and if controllers generally agreed with the concept, they perpetually turned back on the recurrent problem of take-off time accuracy. Indeed, as long as this take-off time is not frozen, risk remains to have to cancel previous out going co-ordination if meanwhile an aircraft has a significant motion in the ground sequence. Conversely request from ETMA can hardly be treated as long as the aircraft is not stabilised in the ground sequence. Of course it can be imagined that co-ordination on exit level or on exit point may not be closely dependant on a precise take-off time and thus co-ordination are more flexible but we stay here at general considerations level. This topic of co-ordination for pre-departure aircraft deserves to be further investigated.

3.6 MISCELLANEOUS COMMENTS

Controllers clearly expressed that consistent operational judgement regarding DM tool could not be reported because of some experiment limitations, notably regarding the trajectory function (see section 3.7). Indeed they met some difficulties to project their current assessment and feeling into consolidated opinions for the future. However, really interesting information have been collected during both main phases 1 and 2 and discussions have taken place bringing to light some orientations for further DM assessment...

3.6.1 Take-off time

It is clear that one of the major limitations regarding the negotiation via the DM display is about the trajectory function (DEP TEPS) and the **incertitude of take-off time**. Most part of DEP PC activities was obviously based on the DM technical environment. That means that except in case of a manual (triggered by the controller) or automatic (triggered by the DM) re-sequencing all pre-departure aircraft were forecast to take off at the precise time displayed through the time scale. No external events could appear to reconsider the take off time whereas numerous unexpected events might occur before (e.g. passengers during boarding) or after (pilot can take his time even after a take-off clearance) the aircraft has left the block. This experimental assumption was accepted by controllers within the framework of the simulations but represented for most of them a significant obstacle for the introduction of DM in a future real operational environment.

3.6.2 Regarding DM/controller suitability

It can be considered that whatever the scenario we can imagine for the future, the DM will propose and up-date ground sequence that a ground controller (or maybe several controllers in accordance with each other) who supervises this sequence will aim at realising as closely as possible. But it still remains true that different kind of events will directly influence this activity and sometimes oblige the controller to manually intervene on the sequence. Therefore, keeping the man in the loop means providing a flexible and upgradable DM tool so that, conversely to what happened during the runs, DM never keeps the controller from doing something in the sequence that he intentionally wants to do (maybe a specific mode would have to be implemented so as to inform the system that the controller has chosen to force a forbidden event by DM algorithm).

Some of the stronger requirements relate to the possibility of changing the runway of an aircraft whenever the controllers want to (in this case we note that the delay has to be precisely up-dated with the running time to reach the new allocated holding point) and the possibility for moving forward an aircraft even if the new STD becomes inferior to the ETD (this requirement is particularly important for aircraft that are at the holding point).

3.6.3 DM and Arrival traffic

DM includes in its processing (STD assignments) time interval limits given by the AM (Arrival Manager) to each arriving aircraft. It also has the possibility to regularly propose changes in the arrival rate in order to cope with the departure rate. Those co-operation aspects have not been assessed since no Tower positions neither other ETMA sectors (specialised for arrival traffic) were simulated and the arrival traffic sequence was frozen (Departure controllers had no possibilities to intervene on it). In today's environment Departure controllers consider these exchanges with Arrival actors as essential for the departure traffic organisation (e.g. negotiations with AM should be useful to optimise take-off configuration). Therefore they should be further assessed as an entire part of DM activities.

3.6.4 DM and neighbouring airports

No aircraft from neighbouring airports (e.g. Le Bourget, Toussus and even Orly) was taken into account in the DM activities. Through a second DM display (annex that could be actionable by switching with the real DM display), it could be presented to CDG ground actors a rough sequencing of pre-departure aircraft on neighbouring airports. Such a feature would provide the controller with direct view on incoming traffic from those airports and thus allow to anticipate the trajectories that will cross the CDG sector. It would notably allow the controller (this probably should be done by the DEP PC) to plan in advance (by the mean of DEP TEPS available on those pre-departure aircraft) the future trajectories section in CDG sector. Under this condition Co-ordination and conflict management regarding these traffic flows might be improved.

3.6.5 DM in the future Departure process

Controllers well imagined a general sequencing activity whereby the DM tool involving Tower positions for ground sequencing (*pre-departure*, ground controller for pre-sequencing *and Local for sequencing)* and Departure positions for SID trajectories preparations (DEP PC working on the basis of a more stabilised sequence). A kind of supervisor (tower manager, new DEP PC position ?) could be responsible for the overall sequencing taking into account needs and possibilities of all those controllers thanks to the DM tool. In that way such a supervisor according to the incoming traffic load could also perform a sector sharing (e.g. to specifically allocate a controller for the North flow if there is a very foreseen load traffic on it). Thus, the idea of a DM tool that might be shared between several ground positions seems to be quite well acceptable in Departure controllers' mind. In fact, one of the most efficient service that DM would have to provide is likely to be a **« co-operative »** display between these controllers allowing each of them to be better informed of the direct operational environment of previous or next controller in the process (e.g. time pressure, traffic constraints, controller intentions ...).

In such a situation, it is agreed that each ground controller position will be provided with specific DM functions and displays according to their specific role. Tower positions should be provided with DM that display overall time scale from take-off time up to 30 min or more before take-off. Available functions should be centred on sequencing ones (aircraft permutations, change of runway, ...). Departure positions should be provided with DM display that mostly focuses on time scale from take-off time up to 5 min maximum before take-off. Available functions should be centred on trajectories ones (DEP TEPS invocation, activation of trajectories comparisons).

3.6.6 To allow a better DM activity in sequencing aircraft ...

Whatever could be the forecast scenario (see section 3.6.8), it is useful to note that the DM could be an efficient tool on each position and in all departure chain only under the condition that it could be fed with a **very precise report of ground position of aircraft (and operational event)**. This one would trigger in real time DM up-dating with all successive positions of each aircraft on the ground (block, push back, taxiway, holding point) and in the same way all interfering events (aircraft brake down, excessive in boarding time, unforeseen pilot behaviours, ...).

Real time DM up-date means regular changes in sequence pattern. Existing animation seemed to be sufficient regarding the observed activities during the experiments. But this specific point can not really be assessed simply because the DEP PC rule was not centred on the ground sequence even if he punctually intervened on it. After a manual intervention controllers felt sometimes surprised by the DM reaction and also quoted some DM reactions they did not agree with. Hence a **What if mode** in which the controller can cancel or validate a manual sequencing action should be tested in the future. Existing animation could also be deeper investigated with a simulation of Tower positions (that would directly utilise DM display for ground sequencing).

3.6.7 To enrich link between sequencing and trajectories function ...

It has been generally agreed by the controllers that the DM should be able to tune in a more efficient way the ground sequencing by trajectories « inputs ». It is partially done by the first trajectories comparison (standard SID and alternative) that allow the system (DM requesting TP and CP facilities) to propose a conflict free trajectory. A requirement for deeper involvement of potential trajectory conflicts is illustrated by the examples as follows :

- First of all the DM should be able to monitor conflict events in order to up-date its proposition of alternative trajectories[5] (it implies the possibility for the DM to perform trajectories comparison several time on the same aircraft) or to alert the controller of newly created conflicts.
- The DM already takes into account information of allocated runway exit point and aircraft type (resulting in the same SID) for separating aircraft in the sequence. It should also consider two successive aircraft in the sequence with different SIDs but a common initial part (e.g. MARGY and ARSIL). If a catch up risk appears on this part between the two aircraft, the DM clearly has to inform the controller through a conflict coding (and not a sequence constraint violation coding) before the take-off (and possibly after) but it should be able first to apply if possible sequencing solutions (greater separation, permutation, ...) in order to make the conflict disappear.
- The DM is already fed with conflict events as crossing trajectories in TMA (crossing points with arrival for instance) but it should also consider aircraft that present potential problems through simultaneous take off on runways 27 et 28.

All situations described above would contribute to enhance concretely both DEP PC and DEP TC work. However a statement can be raised that such considerations may question the basic DM processing. Indeed, current sequences constraints are taken into account in priority by DM and trajectories aspects are taken into account so as to tune the sequencing. Should we not consider that inputting too many trajectories constraints into the sequencing activity of DM may have a general negative impact on the ground sequencing ? Will it be possible to keep a clear priority in each sequencing step between delays, runway balance and conflicts ? Do such orientations make sense if we consider the remaining problem of take-off time accuracy ?

3.6.8 One scenario among others

Despite the questions devoted to the problem of take-off time precision, some scenarios could have been thought by controllers as potentially coping with future operational needs. Of course precision of take-off time should and surely could be improved in the future by reconsidering various aspects of ground control activities (including in-board activities notably at the block and at the holding point) but reaching a « mathematical » precision really seems to be utopian even

[5] Maybe these alternative trajectories should be extracted from a specific catalogue adapted to each own controller strategies.

if we think about year 2015. Assumption however can be made that this fact is not an appalling one provided that a suitable working environment is established. An example of what could be such an environment is given hereafter:

« We consider that the DM is in charge of trajectory function without controller intervention (except consultation) until few min before take-off and the aircraft are 4D Data-link equipped. First the DM allocates the standard SID to the aircraft after the pilot call. Once the aircraft has left the block, it performs a first rough trajectory calculation (in an automatic way and not by the controller activation) taking into account the current STD (Scheduled Time of Departure). As it was in PD/3, the DM triggers a specific tool (TP and CP) and trajectories comparisons (standard and alternatives) so as to find a conflict free trajectory. If all the alternatives (shorter trajectories) present a conflict only the standard stays proposed to the controller. If several alternatives are conflict free, the shorter one is selected as a proposal for the controller. It is understood that conflict detection at this step is rough (separation used are larger so as to take into account the uncertainties of take-off time). Every minute or after each change of STD (re-sequencing performed by controller or DM) a new rough trajectory calculation is invoked so as to update the conflict search with new STD or potential evolution in the TMA configuration (due to powerful calculation and time demand it may also be proposed that trajectory calculation is updated whenever controller activates it but only in this case). Each result of calculation stays in proposal state and is not automatically allocated to the pilot. It seems effectively important that pilot stays with the information of standard as longer as possible in order not to give him a feeling of being penalised with any further DEP PC decision.

The DEP PC is focusing exclusively on DM labels of aircraft that reach the holding point and thus trigger a new trajectory calculation (at this point most of potential changes of STD have already occurred) and on DM labels of aircraft that had taken-off less than 2 min ago. He is provided with a clear information of conflicts whenever needed and thanks to a specific coding he can see quickly for each pre-departure aircraft whether an alternative trajectory is proposed. If there is one and according to the circumstances and the possibilities of take-off time evolution, he will decide to allocate it to the pilot or not (by the mean of Formalised Clearances). If not he will wait for the take-off and the new trajectory calculation performed with the real take-off time (it will be automatically triggered by take-off event). If a new alternative is proposed, DEP PC will consult it and then choose between several actions : to let the aircraft on its standard, to allocate the proposed alternative, to choose another one in a pre-formatted set or modify one of them through a very quick procedure (e.g. a sort of macro-procedure to cancel the first level constraint) before allocating it to the pilot (always in Formalise Clearance procedure).

Note that at the first pilot call in TMA, DEP TC will give him a generic instruction « Continue as planned » independently of the trajectory status (standard or alternative) but a clear coding will inform him at a fist HMI level if an alternative has been allocated (and what kind of) and if a conflict is still remaining. »

This scenario is one among many others and has of course several limitations (it notably absolutely needs an efficient ground radar system and a powerful calculation system for trajectories) but intends to raise that a rough trajectory proposal can be of interest provided that DEP PC keeps this status in mind and integrates the information according this status (and not more) in his thought knowing it can evolve more or less until the take-off event. The second advantage is brought by a closer space-time environment (by focusing on aircraft very close to their take-off time) which should allow the DEP PC to be more involved in TMA traffic awareness.

3.6.9 And tomorrow ...

Considering all the points raised in the previous sections further experiments including DM tools associated with notably :

- new operational scenario that among other points will decrease the operational gap between DEP PC and DEP TC ;
- a ground radar providing information of precise aircraft ground position and state (block, push or pull back, taxi way, holding point) ;
- both simulated Ground and Departure positions (ground controller, Local, DEP PC and TC, ETMA) ;
- co-ordination for pre-departure aircraft ;
- DM display of neighbouring airports ;
- a connection with an Arrival Manager tool (AM) ;

really deserve to be carried out in a near future ...

3.7 REFERENCED NOTES FOR DM

- **DM rules**

1. DM began to take into account aircraft as soon as flight plan is available.
2. DM re-sequenced every minutes or after each controller manual sequencing.
3. DM Gave absolute priority to aircraft with CFMU time slots at the expense of others aircraft
4. DM shared aircraft on runways according attributed SID, Type, noise characteristics, ... and kept the controller to infringe those rules
5. DM did not accept departure insertion when too close to an arrival in the slot
6. DM did not accept an aircraft to be put earlier in the sequence when it infringed the theoretical minimum time to reach the runway access.
7. DM did no try to separate aircraft when they have different exit points even if there is a catch up risk on an initial common part of the trajectory.
8. DM did not change runway for an aircraft if this one had less than 10 min delay (so not yet in penalised state)
9. DM froze a DM label as soon as this one was moved by the controller (but only the frozen state following the first DEP TEPS activation was shown to the controller ...)

- **DM notifications for ground constraint violations**

1. A light before a heavy aircraft with a 2 min separation
2. No notification (nor advising square on sequence are) when two aircraft was no on the same SID even if both trajectories have a common initial part (with a catch up risk ..)
3. Even with two aircraft with the same performances, a 2 min of separation between those aircraft was notified to the controller.

- **Simulation limitations**

1. DM was using the Conflict Probe (CP) in order to compare SID standard with alternative trajectories. If the CP found an alternative without conflict, it proposed it to the DEP PC (an alternative trajectory was by definition more efficient than the standard due to a suppression of level(s) off or more direct route), conversely if not conflict free alternative trajectory was found, the CP sent back the standard trajectory. Unfortunately, **in the last case the controller had no information about the standard trajectory status** (conflict free or not).
2. Conflicts were not up-dated before the take-off
3. As DM had aircraft only 5 min before their EOBT (Estimate Off Block Time), it was sometime unable to optimise runway balance.
4. Departure facing East would have been much more significant : in this case North departures (that represented the most significant traffic throughput for the simulations) can be shared on both 27 and 28 runways (against only 27 in facing West configuration), moreover in facing East configuration there is no climb constraints. Therefore DM functions would have been much more involved..
5. Single mode runways would have been more adapted for the DM assessment compared to an unmarked runways configuration (more significant sequencing actions)
6. Co-ordination with ETMA was no allowed for pre-departure aircraft

- **DM operational limitations**

1. Trajectory function of DM is based on precise take off time.
2. DM did not take into account departure from Orly, Toussus and le Bourget and thus induced a too simplified environment (they also were too easy to handle in TMA)

4. APD FUNCTION (ETMA / EN-ROUTE POSITIONS)

4.1 PC POSITION

4.1.1 Operational aspects regarding use of PROSIT (En-Route)

This session only refers to the En-Route position for the reason that the ETMA position was not provided with the PROSIT part of the APD. Concerning ETMA sector, it has been decided before the experimentation not to provide this sector with PROSIT support since it was considered that the APD algorithm was not mature enough to promote notion of problems display in such a sector[1] (see reference [15], Chapter 4.5.1 Use of CT in ETMA).

Some strong recommendations were given to the controllers regarding the management of the APD. The PCs were asked to use the APD as a support in order to plan the traffic flows through the sector in a safe and efficient way. Their activity mainly consisted of analysing the problems displayed in the APD and ensuring a maximum of problem resolution so as to minimise the transfer of workload to the TC. The PCs had to make a particular effort in the management of their APD mainly by cleaning it up so that the TC's APD would not be cluttered by too many PROSIT. The PCs were in charge of taking care that the problems appearing in the TC's APD would only be the ones that the TCs could handle.

The PCs generally relied on the APD to structure their planning activity. They analysed each PROSIT label, determined which were the relevant ones and tried to apply an immediate solution. As a principle, the APD / PROSIT structure was well received and found to be a useful tool allowing to better anticipate and decomplexify entering traffic configuration. Thus APD appeared as a good support to encourage anticipated planning by the PC.

4.1.1.1 Applied strategy

The controllers working method usually consisted of looking first at the APD, analysing the existing problems. Then, they regularly looked at the Sector Inbound Lists (SIL) in the radar image so as to integrate the incoming aircraft by opening the TEPS in Edit Mode (via the XPT field of the SIL). Should the trajectory show any conflict, the PCs would usually come back to the APD to consult the corresponding PROSIT. Then they display the PROSIT Filtered View and occasionally use the extrapolation function, which was a good support for decisions.

Indeed, the extrapolation function helped the controllers to determine if there was a real problem or not (moving the aircraft along their trajectory to see the estimated separation) and if so, to confirm the choice between the aircraft on which to apply a resolution. As the controllers said, being able to get rid of a conflict as soon as detected is an enhancement comparing to the current situation. Today they wait for the aircraft coming closer and have to keep them longer in memory.

After they decided on which aircraft to work, the PCs came back to the radar image and opened the TEPS to edit the chosen trajectory.

4.1.1.2 Impact of the controller workload on the global strategy

In general, in case of low traffic, the PCs performed the conflict resolution in advance (the APD displayed the problems at least twenty minutes in advanced) which allowed

[1] It seems that some parts of the interaction detection function have to be redesigned in depth, notably the handling of sequenced aircraft on the same SID

them to free their attention and transfer it on the rest of the traffic. In order to make the APD an efficient enough tool, the controllers tried to use it at their best (i.e. trying to regularly take the PROSIT into account), even if they encountered interaction problems and if they had a restricted confidence in the APD (see further considerations regarding APD logic in section 4.1.1.3).

But with increasing traffic, they tended to work in real time and lost the benefit of working in advanced. In this case two behaviours were encountered :

- either the PC concentrated on the radar image, not using the APD anymore;
- or the PC completely relied on the APD but losing the picture of the traffic situation.

Firstly, the consequences of not taking the APD into account, led to the appearance of many alert coding in the radar image (on the radar labels), corresponding to aircraft in conflict, involved in the PROSIT, which reached the limit time of resolution in the APD. This contributed to attract, sometimes uselessly, both the attention of the PC and the TC on aircraft which might not be in real conflict. **It clearly showed that the regular management of the APD by PC up-dating was a demanding but absolutely necessary task to fully play its role of detection and safeguard**.

Figure 4-1 below shows that an average of 35% of displayed PROSIT reached the limit time for conflict resolution (no variation of the percentage is observed between the Medium and the Heavy traffic). Besides the here above considerations, some technical limitations [2] can explain these quite high values.

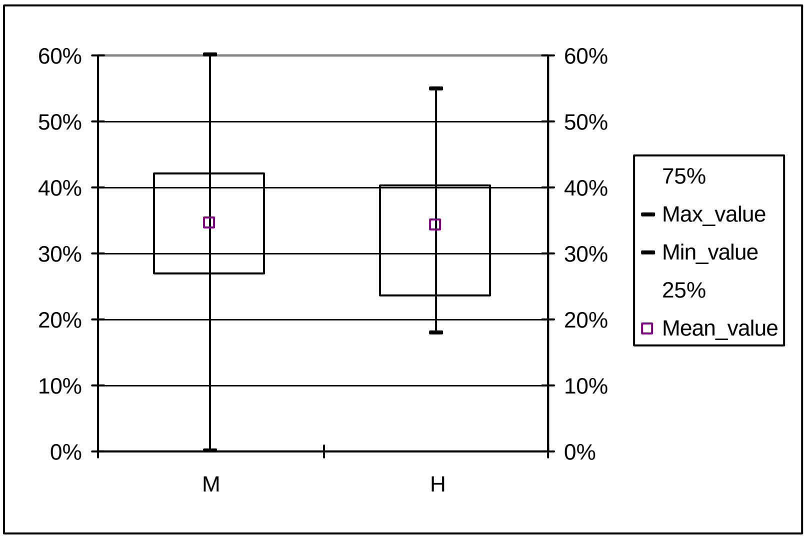

Figure 4-1 : Percentage of PROSIT in alarm per run (PC position / all advanced ORGs)

[2] **Technical limitations associated to the use of APD**

1. failures of space layers mechanism sometimes occurred that hide climbing aircraft to En-Route controllers until it reached FL 240 (the first lower level of En-Route sector is 250).
2. failures of dialogue for PROSIT manual removal appeared which kept the controllers from doing it and led them to drag the PROSIT down to the bottom of APD scale in order to make them earlier disappear (and by this fact resulted in an alarm triggering of the subject PROSIT).

Secondly, when the PC completely relied on the APD, they felt they did not perform real control activities. Given the logic of the APD (presenting all the problems as soon as detected even though involving not yet visible or plannable aircraft), the generally huge number of problems occurring per run and the difficult management of the APD (see footnotes for technical limitations), the PC could hardly leave the APD in order to come back to the radar image so as to build an image of the traffic situation (see consequences on co-operation aspects in section 4.3).

4.1.1.3 APD logic vs. controller logic

Some specific reasons due to PROSIT status kept the PC from fully relying on the APD. First of all APD regularly presented PROSIT involving aircraft that were not yet visible on the screen (see technical limitations in reference [15]) or not in a plannable state so that the controllers could not do anything on them (e.g. the pre-departure aircraft at CDG could be involved in a future problem but their planned trajectory could not be modified by the PC ETMA as long as the aircraft was on the ground). It has been notably noticed that many problems involving departing aircraft were postponed and pushed back in the APD or suppressed because the aircraft were not yet visible[3]. Such problems presentation that could not be solved proved to be useless and induced an unnecessary workload.

In other respects the controllers had difficulties to understand the logic of the APD for PROSIT sorting. According to them, the PROSIT labels were not always well sorted, some urgent problems being placed after less urgent ones (according to priority of resolution). So it might induce supplementary workload to the controller when he had to analyse which problem was to be considered in priority.

Finally, the system's capacity to detect potential conflicts did not really convince the controllers. The algorithm of the APD (CT) was conceived to detect potential **problems** whereas the TEPS (via PS) presented real **conflicts**. On the one hand some problems detected by the APD were not relevant and at the opposite it occurred that some relevant problems were not detected by the CT. On the other hand, the lack of consistency between the problems presented by the APD and the conflicts presented by the TEPS (discrepancies between CT and PS algorithms) proved to be disturbing to the controllers (see reference [15], Chapter 4.5.2 PS / CT / CP Co-existence and Chapter 5.2.3 Areas to be further investigated).

Figure 4-2 below presents the average percentage of displayed PROSIT which have been manually removed from the APD by the PC. This kind of action that proved to be quite frequent (amount of removed PROSIT equal to 27% in Medium traffic and 37% in Heavy traffic) clearly illustrates the need of PC for cleaning the APD by erasing useless PROSIT (non relevant conflict, obsolete conflict or too early display of PROSIT).

[3] This last action induced sometimes negative effect since the controllers might forgot them till the aircraft appeared in the radar image and again in the APD under the PROSIT format, but too late to be planned.

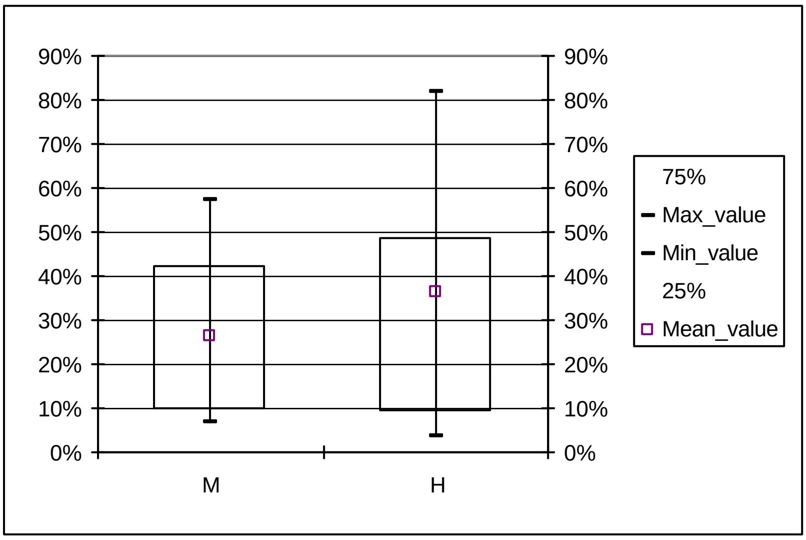

Figure 4-2 : Percentage of PROSIT manually removed per run (PC position / all advanced ORGs)

4.2 TC POSITION

4.2.1 Operational aspects regarding the use of Advisories labels (ETMA / En-Route)

In the En-Route sector the APD provided the TC with two kinds of tactical facilities : the **PROSIT** labels for remaining problems within the sector (they might be displayed 6 min in advance) and the **advisories labels** for pre-formatted tactical instructions to be issued (they concerned trajectories planned by PC and regarding non equipped aircraft). The use of PROSIT by the TC was rare since he mainly focused his attention on the overall tactical activities via the radar image and on the advisories management either via the APD or via the radar labels. Therefore, the very few time which was spared for taking into account PROSIT, added to the problems regarding some aspects of the PROSIT status (see considerations for the PC position above), did not allow suitable actions with regards to the tactical constraints.

As the ETMA sector was not provided with PROSIT support (see section 4.1.1), the following reports devoted to the APD tool will then focus on the advisories labels.

4.2.1.1 Applied Strategy

The TCs mostly used the advisories either via the APD, or via the radar labels so as to identify the next advisories and their time of execution.

As they rarely looked at the PROSIT column of the APD, the En-Route sector TCs sometimes inverted the columns[4] to have the one containing the advisory labels against the radar image, near their centred field of view. In a practical point of view, the display of the advisory text in the radar label proved to be necessary and most of the time sufficient (the advisory text was displayed in the radar label in alert coding two minutes before the timely execution). It allowed the controllers to keep their attention on the radar image with the recall of the advisory issuing two minutes before the execution.

[4] The APD was composed by two columns (one for the PROSIT and one for the Advisories Labels) which actually were two separated movable windows. It was possible to move them by means of the window name bar.

Nevertheless, when the TCs felt comfortable with the traffic situation, they could consult the advisory labels in the APD to see what were the next ones to come and also to get synthetic information about all the future tactical instructions associated to the planned trajectory. By consulting this trajectory via the TEPS tool the TC could visualise the advisory to be issued and verify if some were coherent or not. Such an analysis allowed them to understand what the PC intended to plan on a specific aircraft.

4.2.1.2 Impact of traffic load on the strategy

With traffic increasing, TCs had less and less opportunity to perform the analysis reported before. Not being efficiently supported by PC co-operation (see Co-operation section 4.3), they proved to be forced to issue the set of advisories without knowing the logic behind them. Therefore they firstly lost benefits of PC's work et secondly tended to loose the mental picture of the overall traffic.

To avoid such a situation, some TCs in En-Route sector adopted a particular strategy in order to ensure their acknowledgement without hindering their activity of control. They tried to acknowledge and issue the advisories before time when it was relevant according to the current traffic. Indeed the working method was to issue clearances as soon as possible to solve the conflict and move on other matter. The consequence was that issuing the advisories before time triggered the Flight Path Monitoring (FPM) alert. The controllers tried not to give their attention to these alerts, knowing the reason of their existence (i.e. the difference between the ground and the board trajectories), which made them useless.

When the TC workload became too critical, it was not rare to observe (mostly in ETMA sector) that TC totally gave up the advisories support (in both APD and radar labels) so as to perform tactical actions as if they were in baseline organisation.

4.3 CO-OPERATION ASPECTS

4.3.1 Co-operation through PROSIT support (En-Route)

The global instructions concerning the use of the APD for co-operation purpose were the following ones :

- the PCs should assure a maximum of problem resolution planning so as to minimise the transfer of workload to the TC (clean the APD so that the tactical area of the TC's APD would not be cluttered by too many PROSIT, only the ones that the TC could handle) ;
- the function of transfer of PROSIT in the TC's APD was recommended when the PC wanted to share information about a particular problem that could interest him/her (the PROSIT labels transferred (automatically or manually) in the TC's APD should be used to resolve outstanding problems delegated by the PC);
- the PCs should modify time stamping in order to arrange priorities.

4.3.1.1 Applied strategy

In case of low traffic, the PROSIT labels and PROSIT Filtered View were used as a support to discuss about a problem and to make decision about the solution.

In order to try to balance the workload between them, the PCs and the TCs often determined a clear task sharing. As recommended, the PCs resolved all incoming conflicts as much in advance as possible so that the TCs should only have to perform few tactical manoeuvres. They also often agreed that the PCs suppressed all the PROSIT involving departing aircraft as these ones were not visible till very late in the sector and especially because these PROSIT would have created useless alerts in the radar image when reaching the limit time for resolution.

As we saw before (see TC position, section 4.2), the PROSIT part of the APD proved not to be manageable for the TCs. Therefore the PCs finally made their best not to let any PROSIT be transferred in the TCs' APD (by resolving, suppressing or delaying them). Hence, it happened that the PCs actually moved up the PROSIT simply to delay the transfer to the TCs' APD more than in a frame of real management of the APD (sorting priority of resolution).

4.3.1.2 Impact of traffic load on the strategy

A really common outcome states that the PC and the TC generally worked in different timeframes (operational gap). Through the planning activities and the use of the APD for the PROSIT management, the PCs worked in advance on aircraft that were generally far away from the sector. On the contrary, the TCs were concentrated on the traffic in the sector. By this fact, they could not communicate between each other in an efficient way and the PCs found themselves unable to explain the TC the solution they chose for a conflict resolution.

4.3.2 Co-operation through the Advisories labels support (ETMA / En-Route)

4.3.2.1 Applied strategy

In case of low traffic, the advisory part of the APD, even if it was not systematically consulted by the TCs (reminder : they mostly used advisories via the radar labels), served as a support of communication between the PC and the TC. It was also an efficient support for the PC to check that the TC (who could pay attention at this time on other traffic events) did not forget to issue an advisory in time. In order to keep a suitable situation awareness, the TCs sometimes requested an explanation to the PCs before issuing an advisory.

4.3.2.2 Impact of the traffic load on the strategy

On the contrary, in case of heavy traffic, the TCs could rarely ask for information about the advisory labels. It also happened that the PCs were not able to remember what they had done minutes ago and hence, could not quickly and efficiently inform the TCs. Then, in order to respect their timely execution, the TCs often acknowledged the advisories prepared by the PCs and issued the instructions without knowing the rational that supported them (see Operational aspects regarding the use of Advisories labels, section 4.2.1). Finally, because the TCs could not be informed on time about their PC's actions and thus could not build a reliable representation of the traffic situation, it happened that they performed some actions on aircraft that caused problems with other aircraft previously planned by the PCs.

Extreme situation sometimes occurred (mostly in ETMA sector) where the TCs preferred to by-pass completely the advisories considering they were not enough reliable to cope with a time pressure period. The benefits of the PC planning was then completely lost.