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EATCHIP III Evaluation and Demonstration
PHASE 3A
ADDED FUNCTIONS EXPERIMENT

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EATCHIP III Evaluation and Demonstration Programme
PHASE 3 A : ADDED FUNCTIONS EXPERIMENT

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R Salomon A Harvey E Jeannot R Graham	11/1999	x + 38	11	-	-	8

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Abstract:

This note describes the evaluation of system support for ATM added Functions, consisting of Safety Nets, Monitoring Aids, and Medium Term Conflict Detection. The experiment was conducted on the French civil airspace of Reims and Paris ACC, with French military Mazout Radar. Controllers from various European Administrations took part.

The experiment was affected by technical problems with trajectory prediction. Results are based primarily on participant's subjective comment.

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ABBREVIATIONS

Abbreviation	De-Code	Abbreviation	De-Code
AAF	ATM Added Functions	**LSD**	Least Significant Difference test
ABI	Advanced Boundary Information message	**MSAW**	Minimum Safe Altitude Warning
ACC	Area Control Centre	**MTAPW**	Medium Term Aispace Penetration Warning
ACT	ACTivate message	**MTCD**	Medium Term Conflict Detection
AFL	Actual Flight Level	**MTMSAW**	Medium Term Minimum Safe Altitude Warning
ANOVA	ANalysis Of VAriance	**NASA**	National Aerospace and Space Administration (USA)
ASM	AirSpace Management	**NM**	Nautical Miles
ATC	Air Traffic Control	**ODID**	Operational Display and Input Development
ATM	Air Traffic Management	**OLDI**	On-Line Data Interchange
APW	Airspace Penetration Warning	**PD1**	PHARE Demonstration 1
ATS	Air Traffic System	**PHARE**	Programme for Harmonised ATM Research in Eurocontrol
BFD	Basic Flight Data message	**PPD**	Potential Problem Display
CCR	Centre de Contrôle Régional	**REFGHMI**	REFerence Ground HMI
CFD	Change to Flight Data message	**(R)PVD**	(Radar) Plan View Display
CFL	Cleared Flight Level	**R/T**	Radio Telephony
CWP	Controller Working Position	**SIL**	Sector Inbound List
EATCHIP	European ATC Harmonisation and Implementation Programme	**SNET**	Safety Net
ECAC	European Civil Aviation Conference	**STCA**	Short Term Conflict Alert
EEC	Eurocontrol Experimental Centre	**SYSCO**	SYstem Supported CO-ordination
EONS	Eurocontrol Open and geNeric graphic System	**TCAS**	Traffic Alert and Collision Avoidance System
ERATO	En-Route Air Traffic Organiser	**TLX**	Task Load indeX (Workload Assessment Method)
FL	Flight Level	**VAW**	Vertical Aid Window
FUA	Flexible Use of Airspace	**XIN**	Crossing Intention Notification message
GETALIS	Sistema de GEstão de Trafego Aéreo de LISboa	**XPT**	Sector Exit Point
HMI	Human Machine Interface	**XRQ**	Crossing Clearance Request message
IHM	Interface Homme Machine		
ISA	Instantaneous Self Assessment (Workload Assessment Method)		

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SUMMARY

The objectives of the third experiment of the EATCHIP III ATM Operational Concept Evaluation and Demonstration programme were:

- To demonstrate safety net functions, namely Short Term Conflict Alert (STCA), Airspace Penetration Warning (APW), and Minimum Safe Altitude Warning (MSAW)

  and to evaluate:

- Monitoring Aid functions (MONA);
- Medium Term Conflict Detection tools (MTCD).

The experiment was conducted on Maastricht UAC Luxembourg airspace and the French civil airspace of Paris ACC and Reims ACC, with French military Mazout Radar. It was conducted over fifteen days, with the first five days reserved for training.

Six control positions (PARIS, YR and LUX sectors - civil Planning/Tactical), one military position, and three feed positions were simulated. Only the civil positions were measured for the purposes of analysis.

Measurement techniques included system recordings (HMI input/output, R/T), questionnaires, semi-structured interviews, Instantaneous Self-Assessment (ISA) and NASA Task Load Index (NASA TLX) workload measurement.

The simulation was affected by problems with trajectory prediction and a mis-match between participant's perception of conflict problems and that proposed by the MTCD concept of operation.

The experiment showed that:

- Controllers accepted Safety Net functions;
- MONA functions were considered useful, in particular Non Conformance Warnings (excluding Lateral Deviation) and the Transfer Reminder.

However, the MTCD as simulated was not considered optimal by participants. Controllers felt that supplementary information was required to assist them determine conflict resolutions and that poor trajectory information often meant that MTCD warnings were incorrect.

It is recommended to re-run the simulation with a new trajectory predictor and greater emphasis given to controller training and the application of a working method suited to the MTCD concept of operation.

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1. INTRODUCTION

1.1. CONTEXT: ADDED FUNCTIONS

One of the major aims of EATCHIP was to increase the capacity and efficiency of Air Traffic Management in the ECAC area, while maintaining current safety levels.

Experiment 3A was part of a series of experiments designed to demonstrate and evaluate the various elements, which form the basis of the EATCHIP III ATM Operational Concept. The project aimed to:

- Demonstrate and evaluate the EATCHIP III Operational Concept "hands on" and obtain feedback from Controllers.
- Demonstrate the EATCHIP III Operational Concept "hands on" to obtain feedback from National Administrations (Managers, Planners) and Industry.
- contribute to a review process of the EATCHIP III ATM Operational Concept.

1.2. EXPERIMENTAL APPROACH

The approach REFis based on an "Incremental Evaluation [3]". Its main characteristics, which constitute the principal differences compared with real time simulation are:

- small scale study experiments and in particular the fact that the study is *'just detailed enough*' to answer the questions posed,
- a high degree of continuity between successive studies, e.g. airspace etc. is changed only for specific reasons concerned with the operational and technical issues being examined,
- a high degree of dependency between studies. The purposes and objectives of each study are open to reflect the results and experiences of the previous studies,
- that, in order to yield reliable results, sources of variance are kept to a minimum in the course of the studies. This implies that:
    - ♦ variables other than those of interest are kept to a minimum,
    - ♦ variables of interest should also be kept to a minimum. That is, only one or two clear and direct questions are examined in each study.

This experiment was the third of a series of experiments planned for EATCHIP III. It followed two experiments, which were focused on co-ordination aspects: the first experiment addressed Civil Military co-ordination [7]; the second one dealt with System Supported Co-ordination (SYSCO) [8].

2. EXPERIMENT OBJECTIVES

2.1. GENERAL OBJECTIVES

The general objectives were to evaluate a set of ATM Added Functions (AAF) consisting of:

- Medium Term Conflict Detection (MTCD),
- core Monitoring Aids (MONA)

Safety Net (SNET) functions were in operation to demonstrate the whole concept, however, SNET was not subject to evaluation.

The general purpose was to:

- establish operational acceptance of the Concept and Operational Requirements;
- confirm that expected benefits from these AAF exist.

2.2. SPECIFIC OBJECTIVES REGARDING MONA

A Determine the effect of MONA Non Conformance Warnings (NCW) upon Controllers' activity.

- **A1** Determine whether MONA triggers an acceptable number of warnings (qualitative).
- **A2** Determine the average time to process a NCW (quantitative).
- **A3** Determine whether MONA triggers relevant NCWs (qualitative).

B Evaluate the usefulness of MONA reminders.

- **B1** Establish the hierarchy of the usefulness of the reminders (qualitative).

C Assess the usefulness to Controllers of the availability of a more accurate system trajectory compared with today's systems.

HYPOTHESES

The following predictions were made concerning MONA:

- Warnings: there will be an acceptable level of warnings triggered.
- Reminders: parameter values for the reminders have been defined by the design team. Hypothesis: these pre-selected parameter values will be considered as satisfactory by the controllers.

2.2.2. SPECIFIC OBJECTIVES REGARDING MTCD

A Examine if MTCD tools help Controllers in their task of detecting and resolving problems.

A1 Determine whether MTCD problems reflect the operational definition of problems (qualitative):

A1a Measure the false alarm rate (are all the problems detected by the MTCD considered to be problems by the controller?).

A1b Measure the miss rate (is the MTCD detecting all the problems, which the controllers would consider to be problems?).

A2 Examine if MTCD provokes the controller to solve the potential problems earlier (qualitative + quantitative).

A3 Determine whether MTCD reduces the number of short-term conflicts detected (quantitative).

A4 Determine whether MTCD reduces the number of clearances issued per aircraft (quantitative).

B Examine if MTCD helps Controllers to balance workload in a more efficient way.

B1 Identify who takes the actions related to MTCD (quantitative).

The following were added to B1 in order to address more precisely the MTCD effect on workload balance and task sharing:

B1a Determine whether MTCD changes the pattern of work between the Executive and Planning Controllers.

B1b If yes to B1a, examine whether it makes for a more balanced distribution of workload.

C Assess MTCD contribution to the expected increase of capacity.

C1 Determine whether controllers are able to accept a greater number of aircraft due to MTCD (quantitative).

D Determine whether controllers think MTCD provides a safer working environment.

D1 Establish whether controllers have confidence in MTCD (qualitative).

HYPOTHESES

MTCD is supposed to contribute to the anticipation in detection and resolution of problems. The predicted consequences are:

- a reduction of controller monitoring task workload due to MTCD,
- a potential means for assisting in the detection and resolution of problems earlier,
- a potential capacity increase due to a smoothed traffic flow and a reduced number of clearances issued per aircraft.

3. EXPERIMENT DESIGN

3.1. OPERATIONAL CONTEXT

3.1.1. SIMULATED AIRSPACE

The simulated airspace comprised three measured, one military, and three feed sectors.

The measured sectors were:

- PARIS sector (PA) from Paris ACC (civil),
- YR sector (YR) from Reims ACC (civil),
- LUX sector (LU) from Maastricht UAC (civil).

Each measured sector included 2 Controller Work Positions (CWP): the radar position (R) and the planning position (P).

The military sector was the same as in previous experiments:

- MAZOUT (MZ) Radar (military). The military airspace included the following French military zones: C2, C4, C20, and TRA16.

This sector included only one CWP. Though not measured, the military position was fully involved in the experiment, and provided variation in the simulated traffic.

The feed sectors simulating the surrounding airspace, were:

- Sector PARNO (PN), Paris ACC,
- Sector SEST (SE), Reims ACC,
- Sector MARR (MR), Maastrich UAC,

Controllers on feed positions acted as both sector controller and pseudo-pilot for aircraft assumed in their sector. Feed sectors responded to co-ordination requests, updated the CWP data and aircraft according to requests.

A detailed description of the simulation environment is provided in [4], section 2.

3.1.2. TRAFFIC SAMPLES

Four traffic samples were used in the experiment:

- Training: 60 flights per exercise
- Low: 86 flights per exercise
- Medium: 95 flights per exercise
- High: 119 flights per exercise

The training and low traffic samples were used during training. The medium and high traffic samples were used during measured evaluations.

Each traffic sample contained:

- flights outbound/inbound from/to Paris TMA
- flights inbound/outbound from/to Frankfurt and Brussels TMA's
- flights over-flying the simulation area.

To minimise the possibility of controllers becoming too familiar with traffic samples the medium and high samples had a small wind factor added. For these two samples a wind of 15kts was added with the direction of the wind being rotated through 120 degrees each time.

3.1.3. PARTICIPATING CONTROLLERS

11 controllers participated in the experiment:

- 2 civil controllers from Austria (Vienna ACC)
- 2 civil controllers from France (Reims ACC)
- 2 civil controllers from Romania (Bucharest ACC)
- 1 civil controller from the Czech republic (Prague ACC)
- 1 civil controller from Germany (Berlin ACC)
- 1 civil controller from the United Kingdom (NERC)
- 1 civil controller from Hungary (Budapest ACC)
- 1 former military controller from Hungary (Budapest ACC), manned the military position.

All participants were current validated en-route controllers with ATC experience ranging from 1 to 28 years.

3.1.4. ATC WORKING PROCEDURES

ATC working procedures used during the simulation were in accordance with current Letters of Agreement as defined for the simulated airspace.

The Civil Military crossing functions and procedures employed were identical to those employed and described for Experiment 2a [7].

The functionality for co-ordination and transfer of communication were identical to those employed and described for Experiment 2b [8].

Additionally, controllers were instructed to make use of the functionality for co-ordination and transfer of communication as often as possible to solve problems in advance, specifically those detected by MTCD functions.

Standard separation were applied - 5 NM or 1000/2000 ft

3.2. OUTLINE SYSTEM DESCRIPTION

3.2.1. CONTROLLER WORKING POSITION COMPONENTS

Each CWP consisted of:

- 28” (20” square) colour display, providing a multi-window working environment;
- 3 button mouse;
- individual radio/telecom panels with headset, providing:
  - ♦ link with all sectors;
  - ♦ communication with pseudo-pilots

The four measured positions on PARIS and YR sectors, were further equipped with an ISA input panel used for the capture of subjective workload assessment.

3.2.2. SYSTEM COMPONENTS

The baseline interface used in this experiment was designed from results of ODID IV and PD1 [4].

The system support for Civil/Military Co-ordination corresponded to the implementation of ORG2 of Experiment 2a, i.e. both full data exchange (BFD & CFD) and the management of Crossing Intentions (XINs) and Crossing Requests (XRQs) solely between the YR and Mazout sectors [4].

The System Supported Co-ordination corresponded to the implementation of ORG2 of Experiment 2b, i.e. support for a full SYSCO co-ordination [4].

3.2.2.1. TRAJECTORY PREDICTION

The trajectory prediction used in the simulation was not adapted to the concept of operation for this experiment. It was technically limited, and introduced discrepancies between the trajectory computed by the system, known as system trajectory, and the actual aircraft trajectory.

The following limitations and consequent trajectory discrepancies, impacted the experiment:

- no automatic recalculation to update the system trajectory based on radar tracked aircraft position.

- CFL input was not taken into account for trajectory prediction.
This led to problems being shown on the vertical axis despite having been solved by the controller.

- Aircraft current position (3D) was not taken into account when trajectory was recalculated based on controller input orders (the predicted system trajectory position at the current time for this aircraft was used.

Because the starting point of the new recalculated trajectory did not include the actual starting point of the aircraft manoeuvre, it led to false lateral NCW.

The potential consequences of these limitations were understood before starting the experiment (most of the issues could not be addressed on time to meet the experiment deadline) however, it was thought that benefit to be gained by continuing.

3.2.2.2. HMI COMPONENTS

- Radar Plan View Display (RPVD);
- Aircraft tracks with Radar Labels presenting flight plan information. The information displayed and the colour of the Radar Label were dependent upon the aircraft planning state;
- Extended Radar Label providing additional flight plan data, not available within the Radar Label;
- Radar Toolbox containing a set of tools which allowed the controller to change the display characteristics of the Radar PVD;
- Preference Tool enabling the controller to save and re-load a preferred display configuration (only partly implemented in this experiment);
- Sector Inbound Lists (SILs) displaying advanced information for aircraft planned to enter the controlled sector;
- Message IN and the Message OUT windows providing in-coming and out-going co-ordination messages exchanged with neighbouring sectors;
- Dynamic Flight Leg providing display of the selected flight’s currently planned path within the Radar PVD, updated after route changes;
- support for SYSCO Level 1;
- support for Civil/Military co-ordination;
- assistance for Inter-sector co-ordination between the measured and the feed sectors;
- support for aircraft Transfer;

Information was updated by system events and by controller inputs via the mouse.

3.2.2.3. SAFETY NETS (SNET)

SNET consisted of a number of elements:

- Alert Window where all alerts would be displayed with type of alert.
- Alert displayed on line 0 in labels of aircraft involved in an alert.
    - ♦ "STCA" displayed for aircraft facing a short term conflict;
    - ♦ "APW" displayed for aircraft facing a restricted airspace penetration;
    - ♦ "MSAW" displayed for aircraft facing a minimum safe altitude problem;
- Message of warning displayed in the Alert Window for all STCA, MSAW or APW detected.

3.2.2.4. MONITORING AIDS (MONA)

MONA consisted of an information message displayed on line 0 in aircraft labels. Some of these messages are active, that is, a click on warning with action mouse button (AB) acted as input:

- reminders included:
    - ♦ "TRANSFER" reminder, which was set to popup on sector border crossing event ;
    - ♦ Route "RTE…" reminder, which was set to pop up 60s before resuming previous route, and update every 10s,
    - ♦ Top of descent "TOD" reminder, which was set to pop up 60s before expected descent according to flight plan.
- non-conformance warnings (NCW) included:
  - ♦ Flight Level Deviation "FL DEV" NCW, triggered in case an aircraft deviates more than 300 ft from its (CFL) when cruising, or in case it levels off before reaching its CFL when climbing or descending;
  - ♦ Flight Level Bust "FL BUST" NCW, triggered in case an aircraft climbs above or descends below its Cleared Flight Level;
  - ♦ Lateral Deviation "LAT DEV" NCW, triggered when an aircraft deviates laterally more than 1.5 NM from its predicted trajectory.

3.2.2.5. MEDIUM TERM CONFLICT DETECTION (MTCD)

MTCD consisted of a number of elements:

- Potential Problem Display (PPD), a planning tool showing a graphical presentation of the following types of problems affecting the subject sector and a defined buffer area around the sector within the next 20 minutes:
    - ▪ Potential problems between two aircraft trajectories from AFL to Transfer Flight Level (TFL or XFL).
    - ▪ Airspace problems, for special use airspace penetrations – i.e. Medium Term Airspace Penetration Warning – and/or descents below lowest usable flight level i.e. Medium Term Minimum Safe Altitude Warning.
- Potential Problem Zoom Window (PPZW, presenting a system determined prediction of what the Potential Problem situation will look like on horizontal plan at its minimum nominal distance.
- Vertical Assistance Window (VAW), presenting the planned vertical profile of a flight through the subject sectors with a defined buffer area around it.
- Enhanced Dynamic Flight Leg (DFL), presenting Potential problems and Airspace problems detected by MTCD and superimposed on the plan view graphical display of the aircraft system trajectory.

3.2.3. SOFTWARE COMPONENTS

The baseline interface and the civil/military airspace crossing functions were implemented on the EONS Generic Working Position. This interfaced with the ESCAPE simulator, composed of: Air, Ground and Supervision.

3.3. EXPERIMENTAL CONDITIONS

3.3.1. ORGANISATIONS

Three organisations were defined:

- **ORG0**: the proposed baseline organisation. It consisted of OLDI and the three SNET components (referred to as 'S' in the figures).
- **ORG1**: this included the functionality of ORG0 plus MONA (referred to as '**N**' in the figures). It was used to address questions about MONA:
  - ♦ On its own to address questions A (A1, A2 ,A3)and B (B1),
  - ♦ Compared with ORG0 to address question C.
- **ORG2**: this included the functionality of ORG 1 plus MTCD (referred to as '**M**' in the figures). It was used to address questions about MTCD:
  - ♦ On its own to address questions A1a, A1b, B1, and D1.
  - ♦ Compared with ORG1 to address questions A2, A3, A4, B1a, B1b, and C1.

3.3.2. VARIABLES

Each measured condition was a combination of the following design variables:

- Organisations: ORG0, ORG1 or ORG2,
- Measured control positions: Radar or Planning,
- Traffic level: AM or PM
- Civil controllers: 3 for the civil YR positions, 3 for the civil LUX positions.

The Seating plan was built to obtain data for, ORG0, ORG 1 and ORG 2 for each combination of the variables "Traffic levels x PC/TC Teams per group", with civil controllers rotating through the civil sector's positions. This meant that a minimum of 18 exercises were necessary.

3.4. EXPERIMENT CONDUCT

3.4.1. COMMENT

Due to system problems and changes and the evolution of traffic samples, the quantitative data for this experiment was not of sufficient quality to add value to the results. Where possible, such data has been used, however, most of the results are based on qualitative data obtained from observation, debriefing and questionnaires.

3.4.2. TIMESCALE

The experiment took place from 9 to 27 November 1998. The first week was reserved for training; all measured sessions were run during the last two weeks.

3.4.3. TRAINING

The Training included classroom sessions on:

- HMI;
- Safety Nets (SNET), Monitoring Aids (MONA) and Medium Term Conflict Detection (MTCD);
- Airspace, working methods, and ATC procedures to be used;

Participants were provided with a Controller Handbook.

Hands-on training aimed at familiarising controllers with the simulation facility was conducted during the last four days of the training period.

From day 2, three training sessions of about 45 minutes each were run every day. Each measured controller participated in all sessions, either on measured or feed sectors, and was trained with each of the three organisations on at least one of the control positions (R or P) of the measured sector of interest (YR, LUX or PARIS).

3.4.4. EXPERIMENT

It was originally planned that 36 exercises would have been run over nine days.

However, due to technical problems 7 sessions were lost. The final count was 29 exercises, 9 representing ORG0, 10 for ORG1 and 10 for ORG2.

Because participants complained that traffic samples were not heavy enough, it was decided to increase the number of flights by 25% on certain routes[1] for all samples. These higher samples were used during all of the second week.

Although a high number of exercises were lost during the simulation (more than the expected worst case - 10% loss or less) the balance in exercise numbers was considered acceptable and it was decided to recuperate only one additional exercise.

The quantitative results are based on seven days of exercises. Data from other exercises has not been included because of the large number of modifications made to the traffic samples during the first series of exercises.

The duration of measured exercises was greater than 90 minutes and each sample was built with a slow traffic build-up during the first 15 minutes of the exercise; the build-up was not taken in account in the data analysis.

[1] The 25% increase in traffic was applied to flights starting in feed sectors (i.e. in NAVSTART) for which the first waypoint was BARAU, OKRIX, KIR, NIK or NOR. This increase was conditioned to the following: from KIR, concerned only Frankfurt outbound traffic requesting levels 300 or higher and passing through LUX, YR and SEST, with PTV or PON as final points; from NIK, concerned only Paris arrival to LFPG terminating at PGS, with level higher than 300 (passing through MARR, YR, PARIS, and PARNO) or below level 240 (passing through MARR, PARIS, and PARNO); from NOR, concerned only Paris arrival to LFPG.

3.5. DATA COLLECTION AND MEASUREMENT PLAN

3.5.1. DATA COLLECTION

For each of the measured exercises, a set of data was collected as follows:

MONA and MTCD related input/output:

- STCA;
- Potential Problem (MTCD);
- Airspace Problem (MTCD);
- Non Conformance Warnings;
- Reminders;
- Short term actions (pilot orders).

General HMI input/output:

- Interaction (controller actions and inputs).

Conventional (Telephonic) and Radio Message Exchange:

- Originator, Recipient, Number, Time;
- Message duration.

NASA TLX workload evaluation

NASA TLX ratings were used to measure the controllers' overall perceived workload. First, prior to the experiment, each measured controller established weightings for 6 factors (Mental demand, Physical demand, Temporal demand, Own performance, Effort, Frustration) contributing to their workload in general. Then, at the end of each exercise, each measured controller assessed his subjective workload on these factors.

ISA workload evaluation

ISA was used to measure the controllers' instantaneous perceived workload. Measured controllers were prompted every 2 minutes by the ISA system (red blinking light during 30 seconds on the ISA panel) to input their current workload rating on a scale ranging from 1 to 5 (1: Under-utilised, 2: Relaxed, 3: Comfortable, 4: High, 5: Excessive). Input was effected by pushing the appropriate button on the ISA panel and automatically recorded.

Interviews

Individual semi-structured interviews were conducted at the end of each day. Controllers were asked to express their opinions on proposed topics concerning the general baseline HMI, the crossing co-ordination function, the added functions under evaluation, and the experiment environment; all controllers were interviewed.

Questionnaires

A questionnaire was completed by each measured controller at the end of the experiment. It addressed all functionality available to the controllers, related HMI. General aspects of the experimental environment were also investigated, as well as training.

3.5.2. RELATION OF MEASURES TO HYPOTHESES

In the analysis plan, the appropriate subjective and objective data required to test the hypotheses were identified.

Question / Sub-question	Compared ORGs	Variables	Measures	Constraints	Comparisons / Hypotheses
MONA : Monitoring Aids					
A) Determine the effect of MONA Non Conformance Warnings (NCW) upon Controllers' activity.					
A1) Determine whether MONA triggers an acceptable number of warnings (qualitative).	Org 1		Questionnaire item "Was the number of warnings acceptable?" Temporal distribution of warnings Temporal distribution of ISA high scores Temporal distribution of time to respond to R/T call-in		Correlation of the temporal distribution of warnings with ISA high scores and with the time to respond to R/T call-in. There will be an acceptable level of warnings triggered.
A2) Determine the average time to process a NCW (quantitative).	Org 1		Temporal distribution of response time to NCW: time between NCW display and removal. Temporal distribution of number of aircraft on the frequency Temporal distribution of response to R/T call-in		Comparison of the temporal distribution of Response time to NCW with the number of aircraft on the frequency and response to R/T call-in.
A3) Determine whether MONA triggers relevant NCWs (qualitative)	Org 1	(Traffic level)	Questionnaire item "Were all the NCWs relevant?"	After each run	
B) Evaluate the usefulness of MONA reminders.					
B1) Establish the hierarchy of the usefulness of the reminders (qualitative).	Org 1		Questionnaire item to collect controller opinion by means of checklist (item ranking)		The pre-selected parameter values will be considered as satisfactory by the controllers
C) Assess the usefulness to Controllers of the availability of a more accurate system trajectory compared with today's systems.					
Assess the usefulness to Controllers of the availability of a more accurate system trajectory compared with today's systems.	Org 0 / Org 1		Questionnaire item "As compared with today's systems, is a more accurate system trajectory useful?"		

Question / Sub-question	Compared ORGs	Variables	Measures	Constraints	Comparisons / Hypotheses
MTCD : Medium Term Conflict Detection					
A) Examine if MTCD tools help Controllers in their task of detecting and resolving problems.					
A1) Determine whether MTCD problems reflect the operational definition of problems (qualitative):					
A1a) Measure the false alarm rate (are all the problems detected by the MTCD considered to be problems by the controller?).	Org 2	(Traffic level)	Questionnaire item "Were all the problems real?"	After each run	
A1b) Measure the miss rate (is the MTCD detecting all the problems, which the controllers would consider to be problems?).	Org 2	(Traffic level)	Questionnaire item "Did the system miss problems?"	After each run	
A2) Examine if MTCD provokes the controller to solve the potential problems earlier (qualitative + quantitative).	Org 1 / Org 2	ORG x traffic level	For each identified Problem (Potential or Airspace): Time between the display of the second aircraft of a problem in the SIL and end of the problem (results for all sectors / for each sector)		Comparison Org 1/Org 2 for each traffic level. In MTCD condition (Org 2), the problem should be solved earlier (the problem will be ended earlier).
A3) Determine whether MTCD reduces the number of short-term conflicts detected (quantitative).	Org 1 / Org 2	ORG x traffic level	Number of STCAs (results for all sectors / for each sector)		Comparison Org 1/Org 2 for each traffic level. In MTCD condition (Org 2) the number of short-term conflicts detected should be reduced.
A4) Determine whether MTCD reduces the number of clearances issued per aircraft (quantitative).	Org 1 / Org 2	ORG x traffic level	Number of short term actions per aircraft (expedite, heading, level, speed, c/d rate) (results for all sectors / for each sector)		Comparison Org 1/Org 2 for each traffic level. In MTCD condition (Org 2), the number of clearances issued per aircraft should be reduced.

Question / Sub-question	Compared ORGs	Variables	Measures	Constraints	Comparisons / Hypotheses
B) Examine if MTCD helps Controllers to balance workload in a more efficient way.					
B1) Identify who takes the actions related to MTCD (quantitative).	Org 2		Questionnaire item “Who took the actions related to MTCD?”	After each run	
B1a) Determine whether MTCD changes the pattern of work between the Executive and Planning Controllers.	Org 1 / Org 2	ORG x traffic level x position in team (PC/TC)	Workload distribution between PC/TC (results for all teams / for each team) (results for all sectors / for each sector) Questionnaire item “did the MTCD change your team work pattern?”	Same PC/TC team	Comparison of workload distribution pattern between PC/TC between Org 1/Org 2 for each traffic level.
B1b) If yes to B1a, examine whether it makes for a more balanced distribution of workload.	Org 1 / Org 2	ORG x traffic level x position in team (PC/TC)	Workload distribution between PC/TC (results for all teams / for each team) (results for all sectors / for each sector)	Same PC/TC team	Comparison of workload difference between PC/TC between Org 1/Org 2 for each traffic level.
C) Assess MTCD contribution to the expected increase of capacity.					
C1) Determine whether controllers are able to accept a greater number of aircraft due to MTCD (quantitative).	Org 1 / Org 2	ORG x traffic level	Workload distribution between Org 1 / Org 2 MBB sector workload capacity Questionnaire item “Does MTCD help you to accept a greater number of aircraft?”		Comparison Org 1/Org 2 for each traffic level. Comparison of workload with number of aircraft in sector. In MTCD condition (Org 2), the workload should be reduced (i.e. controller can accept more aircraft)
D) Determine whether controllers think MTCD provides a safer working environment.					
D1) Establish whether controllers have confidence in MTCD (qualitative).	Org 2		Questionnaire item “do you have confidence in MTCD?”		

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4. RESULTS

4.1. DATA ANALYSIS

This section provides the description of the treatment applied to measures and global statistics. Note that in the figures presented in this section, the organisations are labelled according to the tool set available. Thus Org.0=Org.S (STCA), Org.1=Org.N (NCW) and Org.2=Org.M (MTCD).

For measurements relevant to each objective a figure distribution in the form of a graph or a histogram was produced.

4.1.1. CONTROLLERS INPUT MEASUREMENTS

For each type of warning (MTCD, NCW and STCA) the percentage of warnings that were responded to in the 10 minutes after they were presented (2 minutes for STCAs) have been calculated. In each case the average response time in seconds was also computed. There is no way of knowing if these responses were linked to the warning itself; only that for whatever reason an input was made on one of the flights involved. Clearly within a ten-minute window there will be a significant proportion of flights for which the intervention of the controller may have been routine and not associated with the warning.

4.1.2. INTERVIEWS

The commented syntheses of interview results are presented. Some interviews were held in French; to avoid mistranslation of the controller’s responses; these comments are reported in French.

A post simulation interview occurred 6 weeks after the end of the experiment. This interview permitted the collection of controller’s outstanding recollection of the simulation. It included video viewing of exercises and permitted commenting on historical events from one exercise, to validate (or modify) the original interpretation of results.

4.1.3. OBSERVATIONS

During the simulation, exercises were selected for observation. Selection of exercises for observation was made on the basis of the seating plan in order to permit the observation of one exercise for each organisation and for each level of traffic on each sector. Observation sessions helped to direct the debriefing sessions, to enrich the interview guide and to help the interpretation of the collected data.

4.1.4. DEBRIEFING SESSIONS

Debriefing sessions were held at the end of each day, including the first week dedicated to the training of the controllers.

4.1.5. QUESTIONNAIRES

A questionnaire was designed to assess the controllers opinion of the main tools (added functions) the HMI, the training and the simulation environment.

When appropriate, responses to open questions are reported in the report. The qualitative interpretation of the questionnaire result is presented in the subsequent paragraphs.

4.2. SYSTEM PROBLEMS

4.2.1. TRAJECTORY PREDICTION

Trajectory prediction problems significantly affected the simulation.

The trajectory was infrequently recalculated which resulted in differences between actual aircraft position and calculated position. This resulted in incorrect conflict prediction and sector sequences, and false monitor alerts. It could also result in an incorrect system display through the HMI in comparison with the actual traffic (exit flight levels in the label compared to vertical view of the trajectory).

Recalculation was also based on the system-predicted position of the aircraft and not the actual radar tracked position. This posed a problem to deviation monitoring.

In addition, no vertical recalculation was made by the system unless provoked by a controller entry or exit level input order.

The outcome of the above was a general lack of controller confidence in system functions that relied on trajectory prediction, especially MTCD.

4.2.2. FUNCTION CHANGES DURING SIMULATION

Following controller remarks during training, two changes were made to the HMI:

- A new elastic vector behaviour was implemented for the input of a heading. This improved the resume navigation point following a heading input by selecting the next possible point that an aircraft would turn to after vectoring was considered to be completed (cursor position). This included aircraft turn capabilities (the aircraft turn was restricted to no more than 30°-40° to resume flight planned route).
- An estimation of flight time was added to the original heading and distance values displayed on the tracking vector. This time estimation was computed based on distance and current speed of the aircraft.

4.2.3. TRAINING

During the experiment, it was clear that some of the controllers were not sufficiently aware of all of the tools and associated functions or procedures (e.g. the correct use of the elastic vector). There was also a lack of understanding of the overall concept.

4.2.4. PLATFORM LIMITS AND ROBUSTNESS

Some failures were due to system design limits triggered by controller actions, for example, changes in aircraft transfer level occasionally resulted in an unexpected modification of the sector sequence for an aircraft.

The system did not always handle route modification correctly when sector re-entrance was generated. This problem led to a loss of control on traffic labels, which meant that transfers could not be effected. This happened often enough to be remarked upon by controllers as having an impact on the simulation.

These failures were due either to incorrect controller actions (lack of training) and system robustness or a bad trajectory recalculation. It was also related to the trajectory update and actual aircraft position being different and resulting controller inputs being registered for the wrong sector.

4.2.5. TELECOMMUNICATION

The new EEC simulation telecom system was used during this simulation. A number of technical problems were encountered which resulted in unplanned loss of communication between pilot and controller.

Controllers complained of a poor sound quality. The lack of gain control and the need to control the position of the microphone created a significant amount of frustration.

4.3. GENERAL FEEDBACK

4.3.1. OPERATIONAL CONCEPT

The MTCD concept of operation relied on the planning controller to manage an aircraft's trajectory through the "planning out" of problems. The tactical controller instructs the aircraft according to this plan; MONA provides feedback to the tactical controller if the aircraft is not adhering to the planned trajectory or reminds the controller of actions to continue to clear the aircraft according to the plan.

This concept requires that the both controllers can accurately update the trajectory concerning planned and tactical resolutions to problems.

The implemented system did not have a trajectory editor but permitted updating of the trajectory according to predefined controller input orders. This provided an approximate trajectory of the clearance passed to the pilot but would not take account of when the pilot would implement instructions or how the aircraft would fly according to given meteorological conditions, aircraft weight etc.

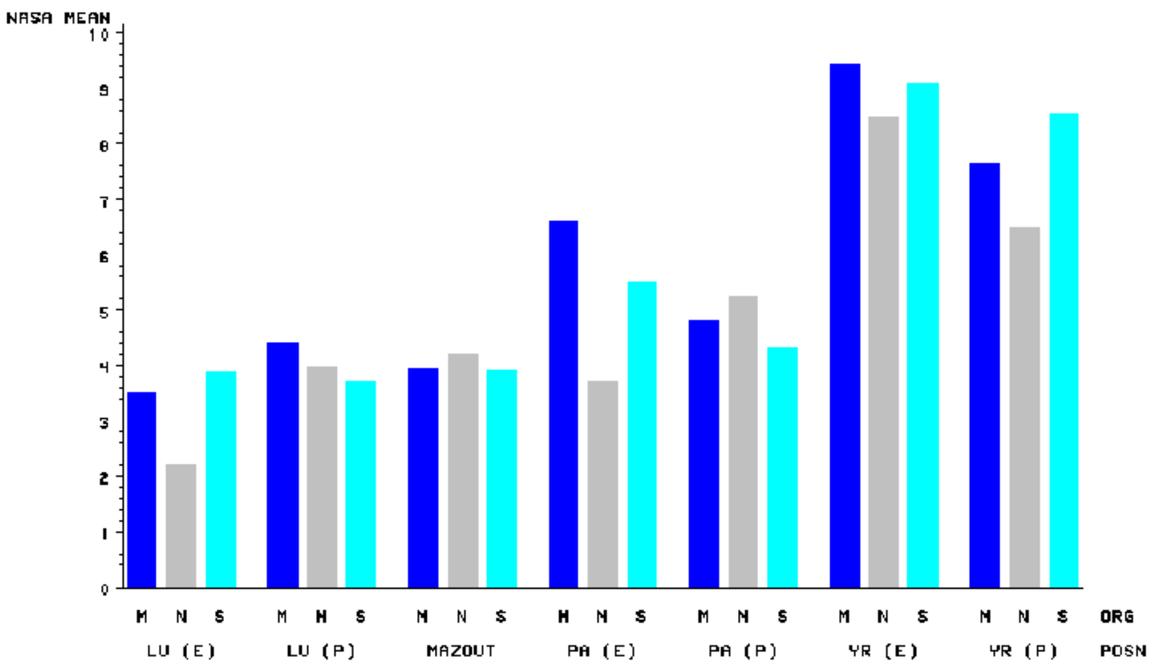
The actual concept of operation applied by the participants was equivalent to ATC today with the planning controller checking sector entry and exit conditions, but using MTCD instead of strips. This was not consistent with the MTCD concept of operation causing a mis-match.

4.3.2. WORKLOAD

TRAFFIC

It was apparent during the first week that the level of traffic was too low. Extra flights were added but it would seem from the NASA TLX results (cf. Figure 1) that the level was not sufficient to impose a significant workload. However, it should be remembered that achieving a level of workload through traffic sample design is delicate, particularly when it must take account of controllers who are not validated in the simulated airspace.

Figure 1: All experiment NASA TLX results



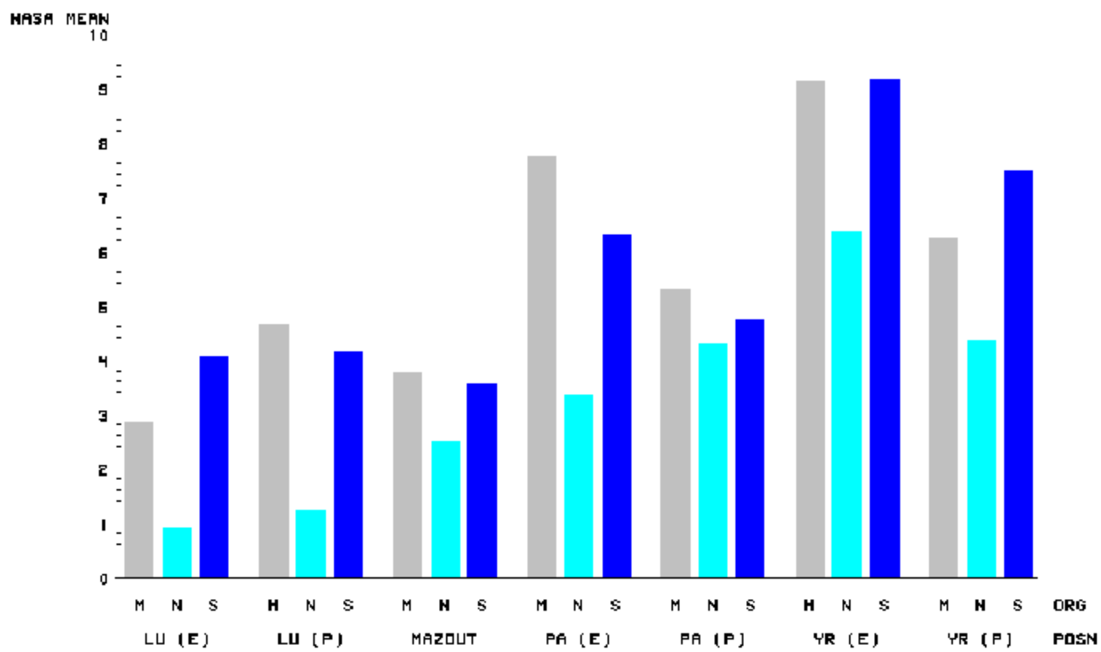
Averaged over all exercises, NASA TLX results show no significant changes in perceived workload by Organisation. However it should be noted that all the TLX results are low. The full scale of the TLX runs from 0 to 20; normally values between 7 and 12 correspond to a comfortable workload. Although this range is only a guide it is notable that only YR falls into this band. These results concur with comments made by the controllers that the level of traffic was too low.

This aspect impaired the assessment of the added functions and reinforced the natural tendency of involved controllers to control according to current practices.

This finding is also confirmed in the ISA results. Only 4 positions were recorded (YR/E, YR/P, PARIS/E, PARIS/P). The results show a median ISA value of around 3 (fair) for YR and of around 2 (low) for PARIS. The use of buttons 4 (high) and 5 (very high) was never more than 10%.

If only the last seven days of exercise are analysed the results look slightly different (cf. Figure 2). Prior to this date various modifications to the traffic samples occurred to increase the workload for measurement purposes.

Figure 2: Last week of experiment NASA TLX results



The result of these changes shows a consistent decrease in workload with Org1 as compared to Org2 and Org0. Although this pattern is seen for all positions there is no statistical difference between the results for each organisation and again it must be noted that the results are generally low.

The fact that this modification in NASA TLX occurred after the traffic samples were increased make it reasonable to think that different tools would have been used more intensively with higher levels of traffic. It is also reasonable to think that the results, data and comments gathered would have been clearer.

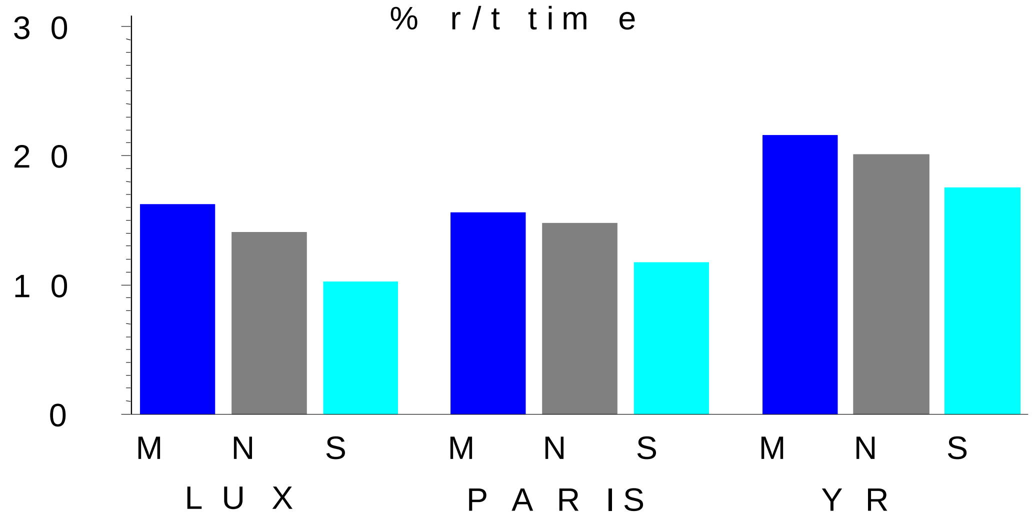
The following comment, made during a debriefing session illustrates perfectly this point: *"Easier to improve the partition EC / PLC with higher traffic. Here it was not efficient for partition: PLC had almost nothing to do"*

TELECOMMUNICATION

In keeping with the workload results, the recorded R/T values are low. Typically a busy sector might be expected to show up to 40% r/t usage. Here only sector YR exceeded 20%.

It is also notable (cf. Figure 3) that R/T usage increases consistently from Org0 to Org2.

Figure 3: time spent using R/T



Telephone use is extremely low; on average only one call was made by PARIS in Org.1 exercises. This is considered normal due to the availability of system assisted co-ordination (cf. Figure 4 & Figure 5).

Figure 4: Telephone usage - Duration

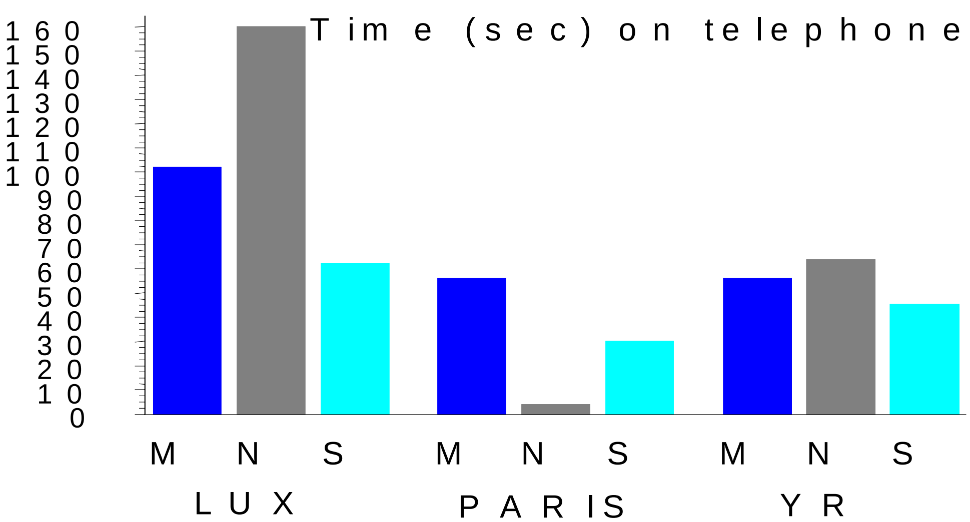
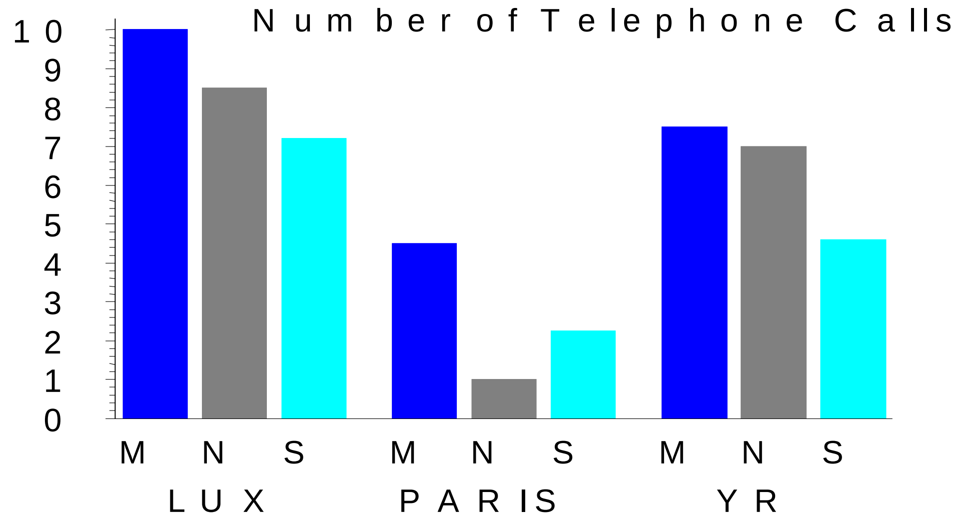


Figure 5: Telephone usage - Number



4.4. MONA

There were very few comments from the participants on MONA.

*C*ontrollers found the MONA display clear and unambiguous (however, one controller felt that the Top Of Descent reminder *"was not always at the right time and place"*). The use of aircraft modelling for determination of top of Descent should be calibrated through recorded data.

Controllers did not think that MONA would significantly change the way they do their job *"MONA gives useful reminders but I don't think it will fundamentally change the way job is done"*.

4.4.1. DISCUSSION OF HYPOTHESIS ON MONA WARNINGS AND REMINDERS

✈ OBJECTIVE A1- DETERMINE WHETHER MONA TRIGGERS AN ACCEPTABLE NUMBER OF WARNINGS.

◈ *HYPOTHESIS: THERE WILL BE AN ACCEPTABLE LEVEL OF WARNINGS TRIGGERED.*

This prediction is not validated. The number of Non Conformance warnings was considered too great, mostly due to the significant number of Lateral Deviation Warnings incorrectly generated by the system (Trajectory Prediction problem).

However, the participants appreciated FL Deviation and FL Bust.

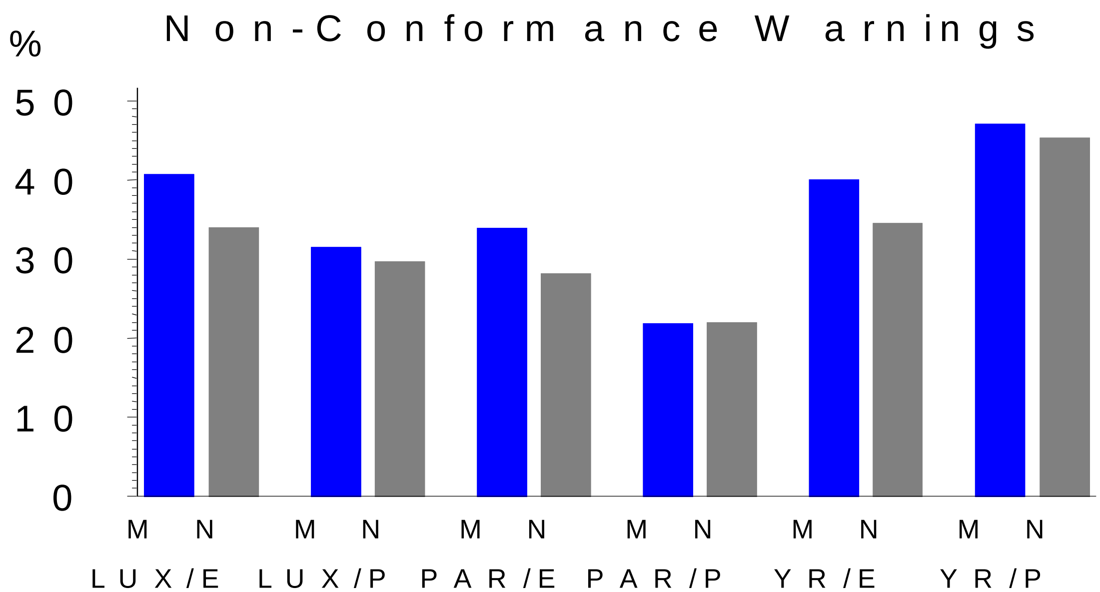
✈ OBJECTIVE A2- DETERMINE THE AVERAGE TIME TO PROCESS A NCW

For each NCW triggered during the exercises, the time until the next controller activity regarding the flight concerned was calculated. Controller activity in this context does not necessarily mean issuing control instructions to the pilot, it may involve nothing more than simply clicking on the radar label. The intention was to measure the time between the triggering of the warning and the controller giving attention to that flight. Clearly the method is not perfect, there is no way of recording controller attention if they do not at least move the mouse onto the radar label. However from observation it appears that controllers do in most instances move the cursor to follow their point of interest.

If no activity on the flight was found within 6 minutes it was considered that the warning was ignored.

For all NCW combined it can be seen (cf. Figure 6) that there is a small (non-significant) trend to respond to fewer NCW when MTCD was being used than when it was not. This trend is slightly greater for Executive controllers than for the Planners, who are fairly consistent in the percentage of NCW to which they respond.

Figure 6: NCW response depending on organisation



✈ OBJECTIVE A3- DETERMINE WHETHER MONA TRIGGERS RELEVANT NCWS.

It was clear from both questionnaires and debriefing sessions, that the different warnings are not perceived to have the same level of relevance.

Warnings concerning Level Deviations were considered as relevant even if less effective in the case of climbing or descending aircraft.

Lateral Deviation warnings were considered not relevant by 7 out of 11 controllers. Three controllers declared that they would have liked to switch this warning off. The parameters used seemed to generate too many nuisance warnings and it was also perceived to be a source of increased workload.

However, the general judgement on MONA is positive.

✈ OBJECTIVE B1- ESTABLISH THE HIERARCHY OF THE USEFULNESS OF THE REMINDERS.

All participants considered the Transfer Reminder to be most useful although one controller commented that this reminder was sometimes displayed too early.

Participants considered the Top of Descent reminder to be the least useful.

Questionnaire results class the reminders as follows:

- Transfer reminder 11 responses
- Route Reminder 7 responses
- Top Of Descent reminder 4 responses

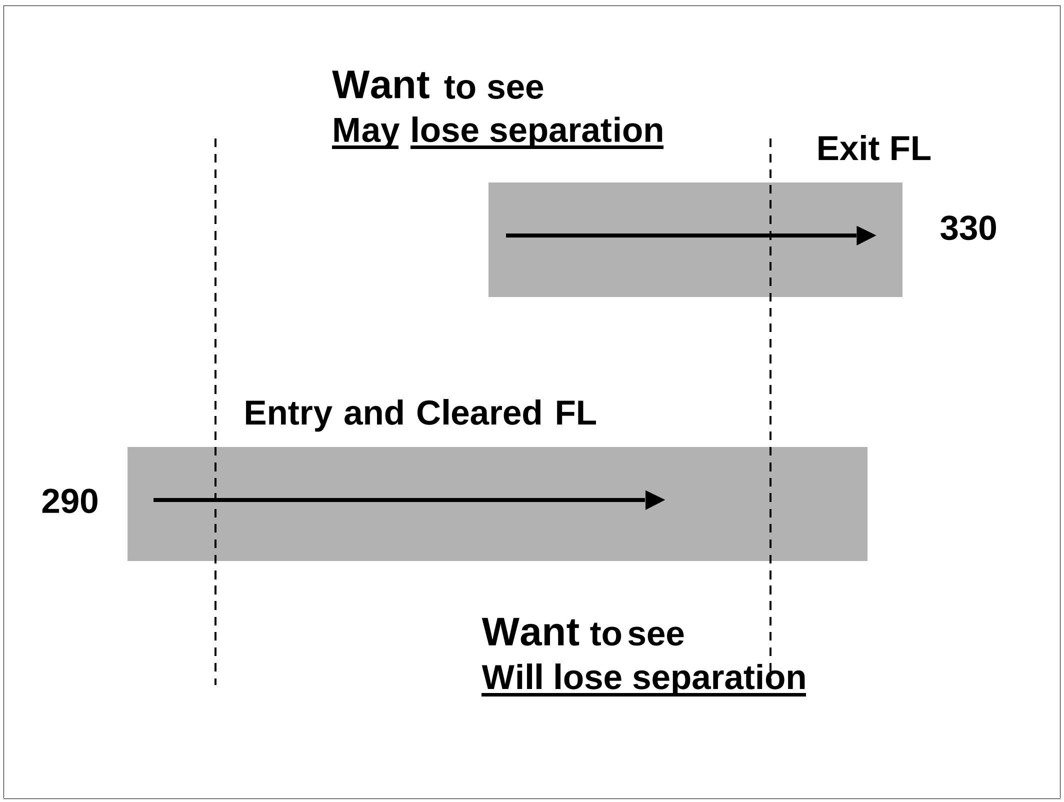
4.5. MTCD

4.5.1. GENERAL

MTCD provoked significant comment. The controllers primary concern was the potential affect on safety and how MTCD would affect their role and working method.

During post exercise debriefing, participants clearly expressed the need for conflict information on an aircraft's cleared trajectory, however, they also expressed the need to be able to identify conflicting traffic related to any planned exit condition (e.g. exit flight level change). Figure 8 indicates the preferred areas of interest based on "will lose separation" and "may lose" as expressed by the majority of participants.

Figure 7: Participants feedback on conflict information



It was proposed that there should be a clear distinction between the cleared trajectory predicted conflict and those predicted but not on the cleared trajectory.

Participants felt that the simulated MTCD was not adapted to their current day task and that the concept of planning out all problems was therefore not feasible. They saw MTCD as a useful tool for planning sector entry and exit conditions but less valid for through sector planning.

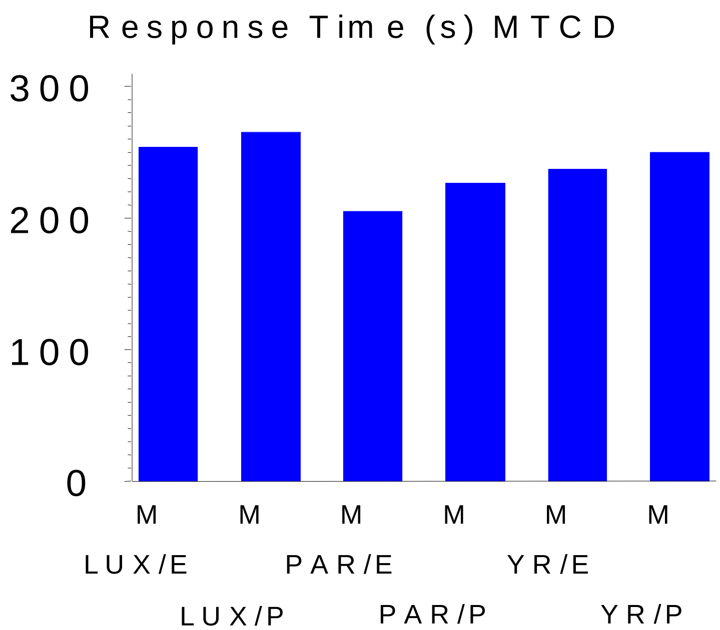
The HMI used for the MTCD tools was judged to be insufficient and too complex to assist in problem resolution

Controllers felt insufficiently trained to use MTCD.

It should be noted that participants related to the Potential Problem Display and the Zoom window when discussing MTCD. Interestingly, the Flight Leg was not associated to MTCD.

Using the same approach as described for the NCW, the time to respond to an MTCD was also calculated. In this case the time was measured between the appearance of the MTCD and the first identifiable activity made by the controller on either flight concerned by the alert. The time to respond to an MTCD is constant for a given sector. The mean value varied around 4 minutes depending on the sector.

Figure 8: Response time to MTCD



4.5.2. DISCUSSION - MTCD TOOLS OBJECTIVES AND HYPOTHESIS

✈ OBJECTIVE A1- DETERMINE WHETHER MTCD PROBLEMS REFLECT THE OPERATIONAL DEFINITION OF PROBLEMS.

Controllers perception of what comprises a "Problem" was different to that used for the definition of the MTCD OR. This difference is related to the availability of "environmental" traffic that a controller identifies and evaluates when deciding a problem resolution.

In this experiment, the MTCD HMI only presented problems along the trajectory, excluding potential conflicts with other aircraft in the sector if a decision to change the trajectory would have been made.

As a result, ATCOs perceived that MTCD was not working, missing conflicts or presenting "non-conflicts" when it was operating "normally" according to the simulation set-up. This is something that should have been addressed and managed in training. It was further compounded by trajectory calculation problems.

Controllers wanted to see real problems based on AFL/CFL profiles and potential problems based on outstanding planning e.g. PEL and XFL (reference Figure 10).

✈ OBJECTIVE A2- EXAMINE IF MTCD PROVOKES THE CONTROLLER TO SOLVE THE POTENTIAL PROBLEM EARLIER.

◈ *HYPOTHESIS: MTCD IS SUPPOSED TO CONTRIBUTE TO THE ANTICIPATION IN DETECTION AND RESOLUTION OF PROBLEMS.*

This hypothesis could not be confirmed by quantitative data.

The doubts expressed by participants on the operational validity of the information presented by the MTCD makes it difficult to evaluate if this group of tools contributed to the anticipation and early resolution of conflicts.

The use of Vertical tool was rarely observed.

It is clear that the controllers had little trust in the MTCD tools. In addition:

- the low traffic level permitted controllers to work according to current practice (without MTCD);
- MTCD was insufficiently integrated into a defined working method during training.

Participants did not develop a new working method that could have made best use of the MTCD tools.

Despite this "gloomy" situation, the questionnaire shows that 5 controllers tended to agree that MTCD helped them to solve potential conflicts earlier.

✈ OBJECTIVE A3- DETERMINE WHETHER MTCD REDUCES THE NUMBER OF SHORT-TERM CONFLICTS DETECTED.

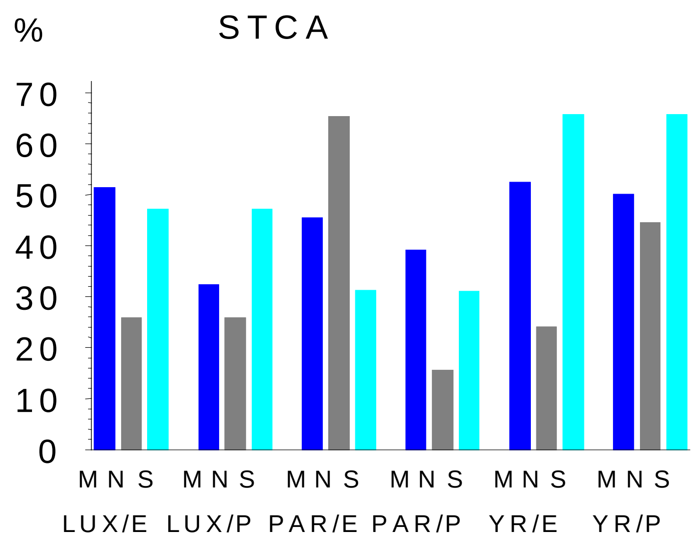
This objective could not be answered due to insufficient quantitative data.

Using a method similar to that already described for NCW and MTCD, the identifiable responses to STCA have also been computed. An STCA is considered to have been responded to if some sort of activity was observed concerning either flight in the 2 minutes following the triggering of the STCA.

Although the response of interest in these situations is clearly the executive's, it is interesting to note that in nearly all cases the planner also responded.

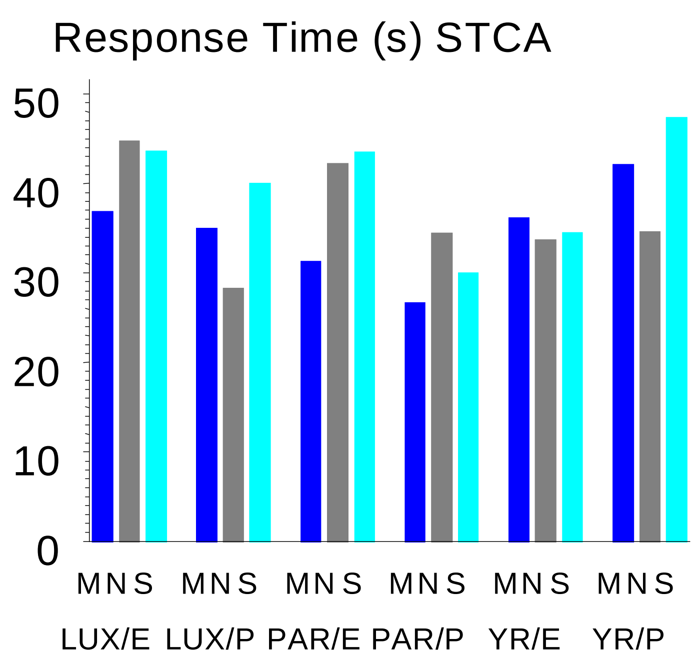
It is also noteworthy that approximately half of the STCA receive no response. This could be explained by the fact that the controllers only update the system after the alert has been resolved, or that the STCA was not considered real.

Figure 9: STCA response depending on organisation



There does not appear to be any correlation between STCA response time and MCTD and/or MONA availability. Where there was a response to an STCA the response times (cf. Figure 10) were just under 40 seconds, irrespective of Organisation or sector.

Figure 10: Response time to STCA

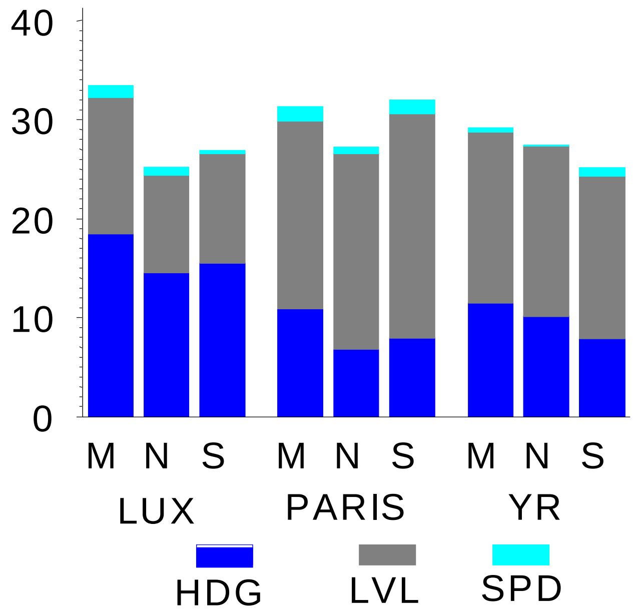


✈ OBJECTIVE A4- DETERMINE WHETHER MTCD REDUCES THE NUMBER OF CLEARANCES ISSUED PER AIRCRAFT.

◈ *HYPOTHESIS: THE CONSEQUENCES SHOULD BE A POTENTIAL CAPACITY INCREASE THANKS TO A SMOOTHER TRAFFIC AND A REDUCED NUMBER OF CLEARANCES GIVEN PER AIRCRAFT.*

This hypothesis is not confirmed: the use of instruction to control flight level, headings and speed shows only slight variations with organisation (cf. Figure 11).

Figure 11: Controller orders to aircraft



✈ OBJECTIVE B- EXAMINE IF MTCD HELPS CONTROLLERS TO BALANCE WORKLOAD IN A MORE EFFICIENT WAY.

It would appear that the low level of traffic and associated low impaired the assessment of this objective.

Participants expressed that the MTCD combined information for the Planner and the Executive which some felt was incorrect, expressing that strategic and tactical was mixed up in the experiment and that the MTCD was more tactically oriented than strategically.

Controllers commented that the Zoom window, which was attributed to the Executive task, was missing geographical references that would be needed to permit a quick and effective use.

The Potential Problem Display, which was attributed to planning tasks, was thought to present tactical information by participants. Controllers felt that problems occurring inside the sector were strictly radar problems and not relevant to this planning tool.

It was considered that there was insufficient distinction between entry and exit planning problems and in-sector tactical problems.

✈ OBJECTIVE C ASSESS MTCD CONTRIBUTION TO THE EXPECTED INCREASE OF CAPACITY.

This objective could not be answered due to insufficient quantitative data.

✈ OBJECTIVE D1- ESTABLISH WHETHER THE CONTROLLERS HAVE CONFIDENCE IN MTCD.

It is clear from the controller comments that they did not have confidence in the simulated tools. It was noted that controllers felt they had to interpret too much, were upset by a high number of false alerts and did not find the simulated concept of operation or the information presented to them to be intuitive.

As a consequence, it was felt that the MTCD was not a reliable tool in the simulation.

4.6. FEEDBACK ON HMI AND TRAINING

4.6.1. HMI

The general feeling concerning HMI (MTCD) was positive. 10 out of 11 participants thought that a similar HMI could form an acceptable basis for an operational system.

However, the need for an efficient label anti-overlapping system was underlined.

Controllers also pointed out that the radar label leader line and vector were of the same colour which made it difficult to link labels to position symbols.

The colour coding of the label was highly appreciated and mentioned as one of the good aspects of the HMI.

STCA coding was considered too strong by some controllers.

A problem was experienced due to the movement of the radar label field when selected. This created frustration when trying to update a field.

For the MTCD displays, the Problem display window was preferred over the CZW and the flight leg.

4.6.2. TRAINING.

Controllers expressed general satisfaction with training although felt that there should be greater emphasis to “hands on” sessions.

Familiarisation with sectors and operating rules was also commented as something that could be reinforced. Most controllers were not familiar with the airspace used in the experiment.

Controllers were affected by the lack of common working method. Two points were made:

1. Participants came from different cultures and had different methods;
2. A working method suited to the concept and tools should be used by all.

5. CONCLUSIONS

5.1. GENERAL

Concept

(1) Controllers were not sufficiently aware of the operational concept underlying the simulation. This meant that they were allowed to revert to current day operating practices, which were not optimal for an advanced ATC environment.

(2) This was highlighted by the participant's different perception of the definition of a problem; this was critical since the basis of MTCD operation was not understood.

Training

(3) Training was insufficient. Controllers lacked understanding of the operational concept, the functions available and how they should be used, the airspace and associated procedures, and fundamentally, participants were not taught an underlying working method.

(4) It would seem that insufficient “hands on” training was given with little opportunity to explore tools and their operational capacity and limits.

Traffic

(5) Traffic samples were inefficient despite being validated. The sector loads were not sufficient to load the participants and therefore removed the need to fully use the MTCD tools optimally.

(6) Changes in traffic samples during the exercises meant that recorded data was not suited for comparative analysis

Trajectory Prediction

(7) The trajectory predictor used in this simulation was not suited to the task. The lack of recalculation linked to radar tracked aircraft position updates and the absence of automated vertical recalculation resulted in a significant difference in ground and controller views of the traffic situation.

(8) Trajectory prediction is critical to the concept of MTCD. On this occasion the inefficiency of calculation significantly impacted on the evaluation and MTCD concept.

HMI

(9) The HMI for the simulation was considered to be good. However, controllers did not feel well served by the information displayed in the various tools depending on the task they were allocated. There was confusion on the tactical and strategic information. It would seem that the information displayed was generally considered to be best suited to tactical control.

(10) The label anti-overlap was inefficient.

(11) Problems were experienced in linking position symbols and data blocks due colour confusion. Some controllers found it difficult to select a data block field for data input.

(12) The STCA colour coding was considered to be too strong.

5.2. MONA

(1) The trajectory prediction problems affected the evaluation of MONA.

(2) MONA was well received by participants and considered to be a valid tool in an advanced ATC system; the effect of MONA Non Conformance Warnings (NCW) upon Controllers' activity was considered positive.

(3) It was not possible to identify if an acceptable number of warnings were generated due to the number of nuisance lateral warnings, which can be attributed primarily to trajectory prediction and a badly defined parameter value.

(4) The time to process a NCW was identified between 2 and 3 minutes.

(5) NCWs were considered relavent by participants but it should be noted that other system functions may negate this and that predefined system parameters play an important role.

(6) It was concluded that the most useful NCW was transfer followed by Route then Top of descent. The Lateral deviation reminder was heavily criticised and perceived to provoke workload due to the reasons described in (3) above

(7) It was not possible to identify the usefulness to Controllers of the availability of a more accurate system trajectory compared with today's systems.

(8) It was not possible to validate the prediction that MONA would trigger an acceptable number of warnings. This was due to the poor system trajectory prediction and badly defined lateral deviation parameter.

(9) With the exception of the lateral deviation warning, there were no adverse comments or indications concerning the predefined system parameters for the remaining NCW's.

(10) The preferred reminders in order of choice were:

- Transfer
- Top of descent
- Route

5.3. MTCD

(1) Trajectory prediction problems affected the evaluation of MTCD.

(2) Despite the problems experienced by the simulation there was an indication that MTCD tools can facilitate Controllers in their task of detecting and resolving problems. However, the allocation of responsibilities between controllers, the display of information and the interaction with other system functions need to be developed and further evaluated to understand more clearly the potential benefit.

(3) The MTCD problems as defined and displayed in this simulation did not reflect the operational definition of problems as perceived by the participating controllers.

Controllers felt that additional information on other traffic (environmental, potential or just traffic implicated in problem resolution) was required.

The role/task allocation and the information that was displayed with regard to entry, exit and in-sector problems confused controllers. The information was generally considered too closely tied to the predicted aircraft trajectory, excluding other potentially interfering traffic.

(4) Controllers did not develop confidence in the simulation and it was not possible to measure and analyses the false alarm rate. Nevertheless, the participants perceived that there were too many "non-conflicts" displayed to them and that the information required too much interpretation; it was not intuitive.

It is possible to attribute a significant number of these problems to poor trajectory prediction and recalculation, especially in the vertical dimension.

(5) It was not possible to measure the miss detection.

(6) Although quantitative data was not available, comments from controllers suggest that they were able to resolve some problems in advance (through anticipation) due to MTCD.

(7) It could not be determined if MTCD reduces the number of short-term conflicts.

(8) It could not be determined if MTCD reduces the number of clearances issued per aircraft.

(9) The low level of workload generated during the simulation meant that controllers could not develop working methods that would lead to a more balanced workload in the sector team.

It seems that allocation of new task responsibilities is feasible but that this should be predefined and not left to evolution during the simulation as controllers need a reference from which to operate and develop.

(10) It could not be determined who takes actions related to MTCD. Controllers found that the information displayed to them was not always consistent with their allocated role/task.

(11) It could not be determined if MTCD changed the pattern of work between the Executive and Planning Controllers.

(12) It could not be determined if MTCD contributed to an increase of capacity.

(13) It could not be determined if controllers were able to accept a greater number of aircraft due to MTCD.

(14) Controllers did not gain sufficient confidence in MTCD and therefore could not agree that it provides a safer working environment.

(15) It was not possible to validate the prediction that a reduction of controller monitoring task workload would result from use of MTCD.

(16) It was not possible to validate the prediction that MTCD provided a means towards earlier problem detection and resolution although controllers had commented that they could work by anticipation of problems using the MTCD tools.

(17) It was not possible to validate the prediction that a potential capacity increase could be realised through a smoother traffic flow and reduced number of clearances issued per aircraft.

6. RECOMMENDATIONS

It is recommended that:

(1) The simulation is repeated using an improved trajectory prediction, predefined controller roles and working method adapted to the tools.

(2) The concept of operation should be clarified to assure a harmonised and integrated approach that takes into account system functions, HMI, and defined Controller Roles and working methods.

(3) The definition of a problem should be clearly elaborated and explained to participating controllers.

(4) Controller roles, tasks and working methods should be predefined and in accordance with the expected tool operation.

(5) A training programme should be developed to ensure that controllers are fully aware and comfortable with the -

- Concept of operation;
- Planned role and working method of each control position;
- HMI and associated functions;
- Airspace and associated operational rules and agreements;
- Functioning of the tools.

(6) The training should be directed towards “Hands on” session as far as practicable.

(7) Traffic samples should be developed to test the tools and controllers in a realistically heavy traffic environment.

(8) Traffic samples should reflect the requirements of the hypothesis to be tested.

(9) The Trajectory Predictor to be used should be clearly defined and validated against the tools requirements; the output of controller orders and system provoked recalculated should be identified, tested and made known to the participants.

(10) The trajectory recalculation should be linked to the current radar tracked aircraft position.

(11) Trajectory recalculation is required in the vertical dimension.

(12) An efficient radar label anti overlapping function should be developed and implemented.

(13) The radar Label field should remain stable when selected for reading and/or data input.

(14) The radar label lead line and vector line should be differentiated by colour.

(15) The STCA colour coding should be reviewed.

(16) Lateral deviation warning should be reviewed and new system parameters defined and tested before being used in the simulation.

(17) Environmental traffic should be added to MTCD Tool windows to facilitate the problem resolution process.

(18) The information displayed in MTCD tool windows should be classified according to the tactical or strategic relevance. The classification should then be applied to the expected use according to the defined controller roles.

(19) The system provide the controller with the ability to filter information in order to reduce cognitive activity involved in evaluating problems detected by MTCD.

7. REFERENCES

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