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MTCD CONCEPT OF OPERATION
EATCHIP III EVALUATION AND DEMONSTRATION
PHASE 3A_BIS

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EATCHIP III EVALUATION AND DEMONSTRATION
PHASE 3A_BIS

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Abstract:

This document describes the proposed Concept of Operation for MTCD in EATCHIP III Evaluation and Demonstration Phase 3A_Bis to be conducted in December 1999.

The expected yield of spare capacity will be investigated as a result of the distribution of tasks and workload from the introduction of MTCD and associated Decision Support Tools.

The impact of such tools may change the roles, tasks, working methods and task-sharing of the Air Traffic Controllers and this will be examined.

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DEFINITION OF TERMS

Area of Responsibility (AoR) the volume of airspace for which a service is provided by the ATSU.

Area of Interest (AoI) a defined volume of airspace not constrained by the AoR within which the flight trajectories shall be available for all flights.

MTCD tactical level the activities associated with ATM where ATCO intervention is a mandatory requirement to ensure the minimum or greater required separation is maintained.

MTCD strategic level the activities associated with ATM where planning is, in general, of a non-tactical nature.

Trajectory a trajectory is a representation of the path of an aircraft, describing the horizontal and vertical profile over time.

Trajectory Prediction trajectory prediction is the process by which the predicted trajectory is determined.

ABBREVIATIONS

AAF	ATM Added Functions
ABI	Advanced Boundary Information
ACAS	Aircraft Collision Avoidance System
ACC	Area Control Centre
ACT	Activate Message
AoI	Area of Interest
AoR	Area of Responsibility
ATCO	Air Traffic Controller
ATM	Air Traffic Management
BOC	Bottom of Climb
CFMU	Central Flow Management Unit
CFL	Cleared Flight Level
CZW	Conflict Zoom Window
DST	Decision Support Tools
EATCHIP	European ATC Harmonisation And Implementation Programme
FAA	Federal Aviation Administration
FDPS	Flight Data Processing System
FPL	Flight Plan
HMI	Human Machine Interface
ICAO	International Civil Aviation Organisation
IDS	Information Display System
LoA	Letter of Agreement
MIW	Message In Window
MONA	Monitoring Aids
MOW	Message Out Window
MTCD	Medium Term Conflict Detection
NCW	non-conformance Warning
ODP	Operational and Data Processing (Domain)
OLDI	on-line Data Interchange
OR	Operational Requirement
PC	Planning Controller
PCPD	PC Problem Display
PVD	Plan View Display
RDPS	Radar Data Processing System
RPVD	Radar PVD
R/T	Radio Telephony
SIL	Sector Inbound List
SNET	Safety Nets
STCA	Short Term Conflict Alert
SYSCO	System Assisted Co-ordination
TC	Tactical Controller
TC	TC Problem Display
TOD	Top Of Descent
TP	Trajectory Prediction
URET	User Request Evaluation Tool

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1 INTRODUCTION

This document will present the operational perspective on requirements for the integration of Decision Support Tool (DST), so that the ATCO may provide optimised service in terms of safety, capacity, efficiency and expediency.

Limitations for consideration of these requirements:

- timeframe today up to the year 2005
- associated technological developments
- *strategic* planning time horizon from flight plan activation to end of AoR
- *tactical* planning time horizon across AoR

1.1 Purpose

One of the ATM Added Functionality (AAF) requirements is to alleviate the controllers' cognitive work load associated with focussing on relevant (task specific) information, detection and resolution on the potential problems within prediction horizon, the extent of which depends on the task at hand (i.e. planning and executive ATC). MTCD is part of AAF [1] Operational Requirements Document for EATCHIP Phase III ATM Added Functions

This document provides support to the second EATCHIP III MTCD simulation. In relation to this the purpose of the document is:

- to define the scope of MTCD
- to define the concept of operations of MTCD
- to define the role of the ATCO and the ATCO team in MTCD functionality
- to identify task-sharing opportunities in the use of MTCD

1.2 MTCD Requirement

The purpose of MTCD is to support the ATCO in planning and decision-making. MTCD *shall detect all* potential conflicts in the Area of Interest (AoI).

1.3 Monitoring Aids (MONA) Requirement

The purpose of MONA is to support the ATCO, in the Area of Responsibility (AoR), in monitoring traffic. MONA shall detect all non-conformance deviations by air traffic (clearance, special use airspace penetrations, lowest available flight level busts and track deviations).

1.4 Environment

The environment shall be considered as applicable to that of any ECAC airspace. The many methods and local procedures that are used in ATM should be adaptable to the integration of MTCD as DST. Harmonisation and Implementation programmes should facilitate a stepwise or gradual integration of MTCD tools, which may be site specific.

1.5 Document Structure

The document is divided into sections that address the overall concept and application of MTCD in ATM environments.

Section 2 is an overview of MTCD as a tool and it's application in the ECAC area. The ATM environment for integration of MTCD is viewed in the context of current ATM and the transition period to the year 2005. The introduction of the concept of co-operative decision making is addressed in a manner where the interactions of MTCD and MONA as both strategic and tactical tools are introduced. An integral part of integration of DST incorporates the use of SYSCO (System assisted co-ordination) and this is addressed in Section 2.13. The interface between user and machine will have specific requirements, which are addressed, in Section 3. The Concept of Operations is described in Section 4.

2 OVERVIEW OF MTCD

2.1 Background

The structure and configuration of airspace in the ECAC area is currently restrictive and complex. The capacity of a large percentage of this space is not optimised and in light of predicted growth in air traffic the requirement for provision of increased capacity without compromise to safety must be addressed. The need for DST, ATCO roles and work methods require investigation, definition and specification.

ODP-7-E1, EATCHIP III Evaluation and Demonstration Phase 3A investigated the integration of Added Functions MONA and MTCD. The need for further experimentation and clarification was identified. This document will attempt to further clarify requirements in an operational context.

2.2 General Concept of Operation

The use of DST including MTCD is integrated in a concept of operation, which requires that the human (or team) be kept in the loop.

ATCOs' monitor the air situation continuously and identify conflict potential. The provision of DST should assist the ATCO by providing:

- information on *all potential problems* that will exist in predicted traffic configuration(s);
- time to assess problem potential and nature;
- ability through filtering to investigate and prioritise different problem types;
- information on traffic in conflict;
- data compatible with ATCO perception of conflict potential;
- information on non-conformance with contracted trajectory (clearance);
- information at strategic and tactical levels of ATM;
- support for "what-if" probing.

The responsibility for provision of separation shall remain with the ATCO. MONA will provide the ATCO with non-conformance information and should reduce the workload associated with the ATCO's monitoring task.

The availability and reliability of the system should be monitored and any disruption or data corruption shall be immediately notified to the ATCO.

2.3 Conflict Definition

The ATCO in the process of conflict detection is looking for any configuration of air traffic that has potential for loss of required separation. This separation might or may not be the minimum that is acceptable or legal and may be the ATCO's subjective perception.

General definition of Conflict

A configuration of air traffic that has potential for unacceptable encroachment of the mandatory protected volume of space, around air traffic, without some intervention.(Author's definition)

This definition makes allowances for greater than the minimum separation specified which could be a requirement for particular conditions. The need for reassurance in borderline traffic situations is also encompassed in this definition (Dictionary definition - from Latin conflictus – act of striking together).

Resolution of conflicts necessitates one of three interventions:

- Tactical intervention (ATCO) *Note: This may be as a result of SNET activation;*
- Strategic intervention (ATCO);
- Airborne intervention (ACAS/Pilot).

2.4 MTCD as a Decision Support Tool (DST)

In the context of ATM Strategy for 2000+ ([2] ATM Strategy for 2000+ Vol 2, Section 4.9, Human Involvement and Commitment – Targets Section 4.9 p26), the development of ATM working methods, positions and systems to increase handling capacity and the addition of functional DST is required.

MTCD as a DST will support the ATCO in monitoring the future air traffic situation and in identifying problems. MTCD data should be presented in a manner that permits ATCO decision-making to be compatible with current cognitive processes.

(*Decision-making is one of the basic functions of ATC. It is an active cognitive process, which selects one out of a set of possible courses of action. It includes a weighing-up of the pros and cons of different alternatives (*[3] Integrated Task and Job Analysis of Air Traffic Controllers, HUM.ET1.ST01.1000-REP-03*)).*

2.5 Technical and Airspace Configuration

It is anticipated that the following will be available:

1. Advanced trajectory prediction.
2. Trajectory monitoring (MONA) or similar functionality.
3. SYSCO.
4. An HMI compatible with defined working principles.
5. MTCD will function as DST to provide the PC with enhanced strategic planning ability.

The concept of conflict resolution within a “co-operative decision-making” ATM environment is new and will require degrees of flexibility in airspace configuration (e.g. flexibility of sector boundaries) that currently are not applicable. The introduction of a new ATM planning layer will bridge a gap between current CFMU strategic/tactical (capacity) planning and the normal ATC planning at sector level.

Transition to enhanced DST will require:

- Acceptance that capacity increases will accrue from its introduction
- Reliability and acceptable accuracy of MTCD components
- Reliability and accuracy of MONA and its components
- Data from experimentation to provide statistical and validated proof of usefulness, robustness, effectiveness, compatibility with ATCO skills, safety enhancement and ATCO confidence
- Integration potential for any European airspace in current structure, sectorisation and associated ATCO functions

However, the probability that reconfiguration of European airspace will take place is considered negligible in the time frame under consideration.

2.6 Role and Working Methods of the Air Traffic Controller (ATCO)

Traditional ATC processes rely heavily on the cognitive skills of the ATCO. The introduction of any automation should be in a manner that provides compatibility with the ATCO’s cognitive processes. This will facilitate the inevitable evolution of new role definition and working methods for the ATCO and at the same time ensure that safety levels are maintained at current levels, as a minimum requirement. The role of automation will be that of assisting improvement in human performance either by magnifying the efficiency of cognitive resources or by improving cognitive resource management [4] Cognitive Aspects and Automation, Leroux Marcel

Expected yield from the introduction of DST will be an opportunity for increase in airspace capacity as a result of a more balanced workload between PC and TC. There is an inherent need for ATCO roles and work methods definition in the use of DST. The provision of SYSCO should reduce the task and workload demand associated with inter-centre co-ordination.

2.7 Method of Work and conflict notification

In general the detection of problems/complexity in air traffic management is a shared task between PC and TC. However, the associated working methods of ATCOs in the ECAC area are diverse. The provision of very limited DST creates a need for human activation of system tools (mostly by TC) in current air traffic analysis/assessment for the purpose of problem identification.

STCA is primarily a “last resort” ATM tool, and does not support medium term planning. Early conflict or problem detection will provide opportunity for strategic ATM by earlier strategic intervention (PC).

An earlier notification of problems and SYSCO availability should permit the PC a greater degree of flexibility in medium term strategic ATM. A for PC working method is outlined in figure 1.

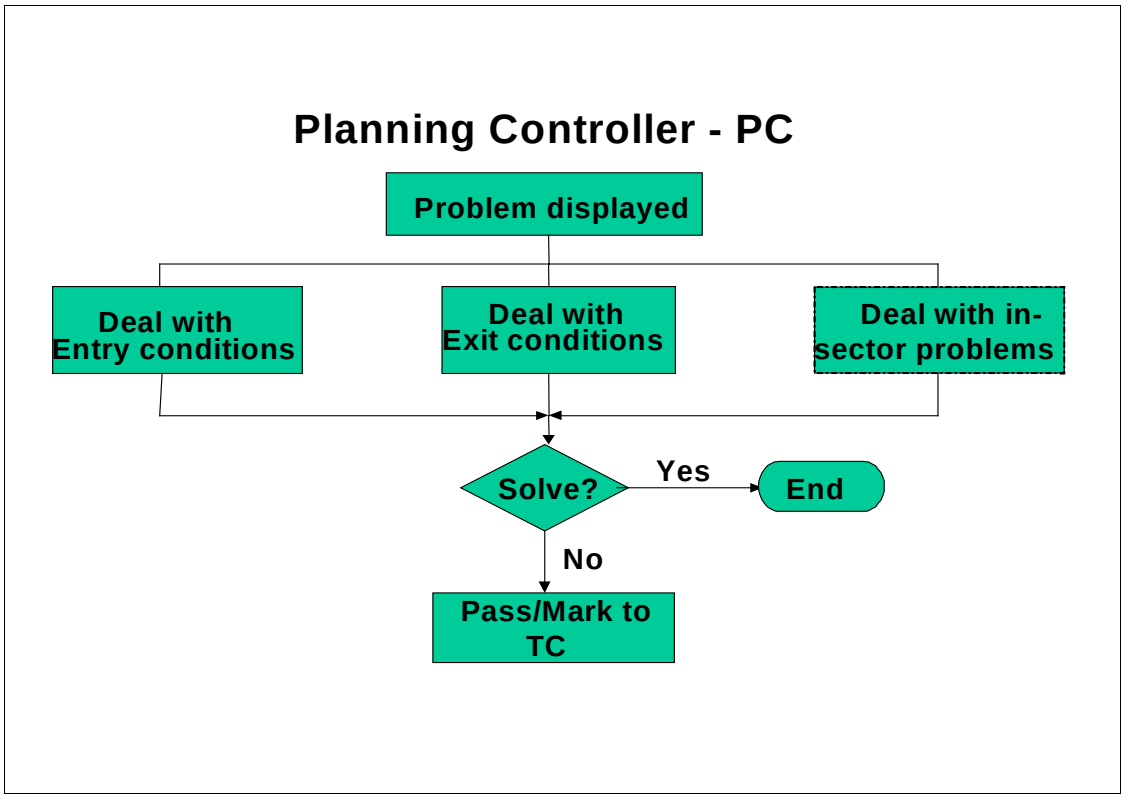

Figure 1. *Proposal for PC work method based on MTCD data.*

MTCD will provide problem information, which can be easily assessed by the PC. This will permit the PC with the aid of SYSCO, to initiate system assisted co-ordination where required to strategically resolve sector boundary problems while at the same time reduce the TC workload by identifying and addressing some in-sector problems. PC may have time and facilities for “semi-tactical” problem resolution. As a result, the TC will benefit from more strategically organised traffic and early problem/complexity identification.

2.8 Task Definition

In ATM, tasks and objectives are not clearly defined and evolve quickly. The level of risk in ATCO activity is important and the ATCO is always vigilant to guard against errors either by himself/herself or other actors and equipment involved in the ATM process. ATCOs have to process data that depend on a time factor. Data elements to consider are:

- Data value
- Data availability
- Data accuracy
- Data relevance
- Data flow
- Data bulk
- Data presentation
- Timing of presentation

The ATCO transforms relevant data into requirements and subsequently identifies goals and sub-goals. Intervention by the ATCO ensures safety, efficiency and expediency of air traffic. This is achieved with minimal DST in current environments.

The integration of DST should provide opportunity for earlier strategic and tactical planning by ATCOs. The associated definition of tasks and task sharing and allocation of responsibility are identified in the context of MTCD/MONA.

2.9 Time Horizons in ATM

Time horizons for ATM applications are currently system constrained. The dynamic nature of air traffic evolution and associated time constraints dictate the behaviour of the ATCO in addressing problems. To satisfy the objective of increased capacity, with current or greater level of safety, the provision of more time for assessment and planning must be satisfied. The integration of DST into ATM systems will permit the PC to have greater and productive strategic input to ATM and subsequently reduce the workload of the TC.

The intention initially is to permit planning of traffic from ACT (activation). The predictability of air traffic behaviour will be more accurate with some proposed trajectory predictors. The activation of traffic prediction on Advance Boundary Information (ABI) will be a feature of ATM that will be permissible on validation of compatible and accurate TP tools.

2.10 Transition Environment (-2005)

ATM as it is today will change. Progress to more automation assisted ATM will necessarily be stepwise. To address the introduction of proposed DST consideration must be given to impact, effectiveness and compatibility of additional tools. The environment structure and configurations of airspace do not facilitate the latitude that will be a requirement for effective integration of DST. Sectorisation has resulted from the need to provide increased capacity but the limits of its usefulness have been reached.

2.11 Integration of Decision Support Tools (DST)

The integration of DST will necessarily change the ATC roles, work methods and tasks. The notion that “a more formal task-sharing environment can be anticipated”, must be considered. Team Resource Management (TRM) is a new concept in ATM which may facilitate the use of DST in a team environment, permitting definition of teamwork as a result of changes to ATCO task management. The way information is communicated (shared and used by the ATC team) will need to be re-considered to ensure that the *team* is able to maintain a safe and efficient role within the system. This may reduce the likelihood that automation will interfere with the team structure that the ATCOs work within ([5] Human Factors in the ATM Design Life Cycle, FAA/EUROCONTROL ATM R&D Seminar, 1997, Paris, France).

2.12 Co-operative Decision Making

MTCD will provide the PC with *earlier* problem identification. This may provide for a semi-tactical PC role. Impact on the role of the TC can be considered in this context.

Figure 2 describes a sequence of data presentation events and PC actions.

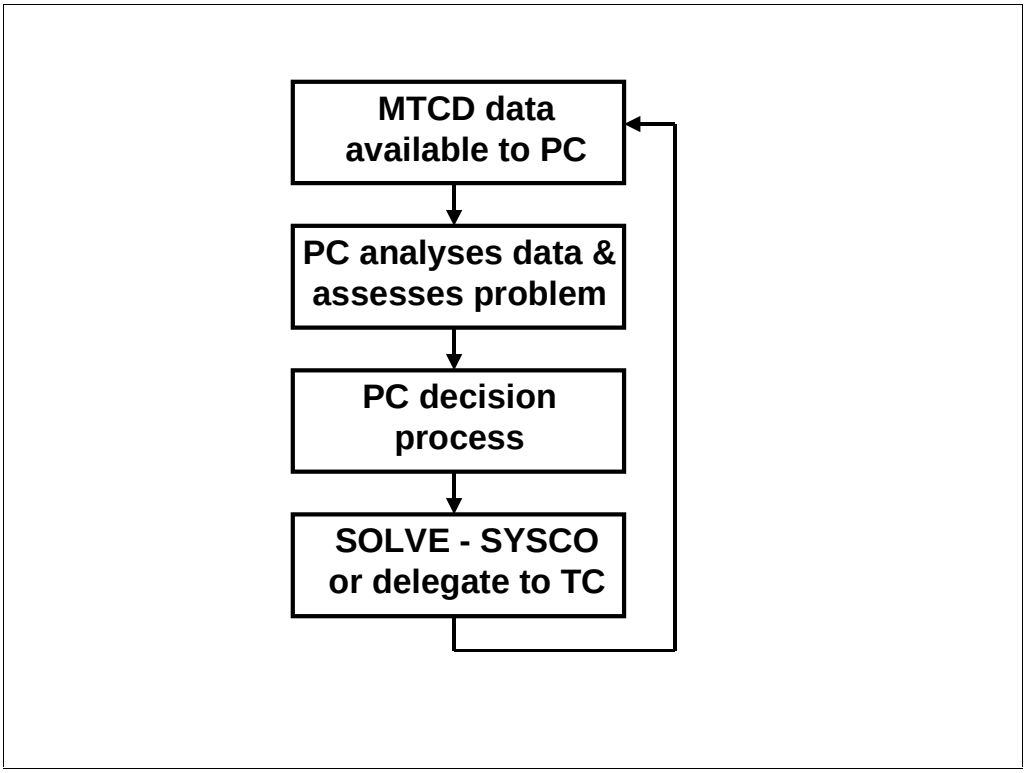

Figure 2. MTCD data sequence and PC.

The PC role in air situation assessment will not radically change but the opportunity for capacity increase must be assessed. Provision of traffic problem data (MTCD) permits definition and clarification of how capacity increase can be utilised:

1. Earlier problem identification and resolution.
2. SYSCO (shall provide low workload co-ordination).
3. PC can solve (entry/exit) problems that would normally be the task of the TC.
4. PC can identify *tactical problems* that will be the responsibility of the TC.
5. PC can mark and prioritise these problems for the TC (HMI).
6. PC can identify complexity and traffic load peaks.
7. PC can balance, or smooth, traffic load for the TC.
8. Intra-sector co-ordination will be required.

The reduction of workload for the TC (organised traffic, advance problem notification, complexity reduction, enhanced PC assistance etc.) and the perceived increase in workload for the PC should provide additional capacity (refer to figure 3).

The demand on the PC will increase but the primary shift will be towards ATM due to the assistance provided by DST and SYSCO.

The workload of the PC (today) is generated by:

- Co-ordination demand, inter and intra-sector
- Strip management
- System interface demand
- Conflict detection
- Monitoring
- R/T demand

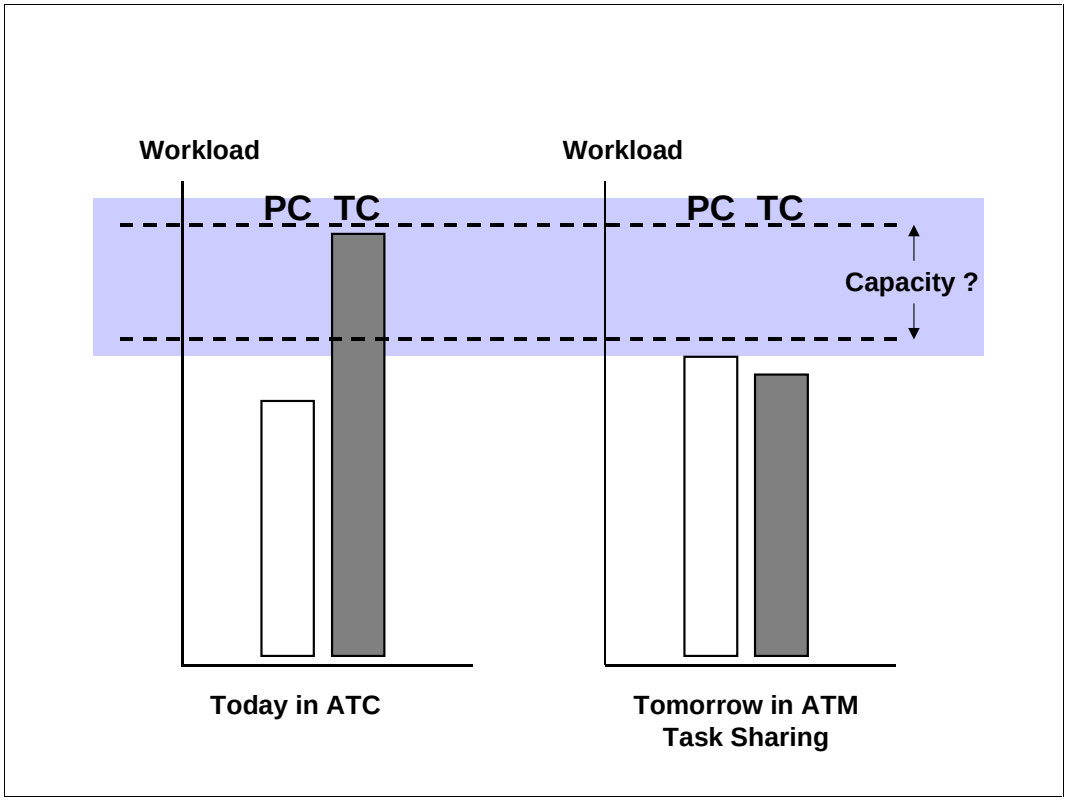

Figure 3. Example of possible *PC/TC workload and capacity availability.*

MTCD data availability provides for a co-operative decision-making environment. The PC/TC team function will be enhanced since the PC decisions impact on the TC. There is no “one best way” and the in-sector ATM will be performed in accordance with local procedures, LoAs etc. The primary area of concern for the PC will be sector entry and exit but the PC may address in-sector problems and solve/intervene *where workload permits*.

The requirement for co-operation between PC and TC is obvious since both are effectively responsible for air traffic safety and in-sector ATM.

2.13 System Supported Co-ordination (SYSCO)

[6] The EUROCONTROL Standard for On Line Data Interchange, Edition 1, which describes the technical protocol to be used, is superseded by the [7] EUROCONTROL Standard for Flight Data Exchange – Interface Control Document Part 1. Significant changes from Edition 1, which are relevant to MTCD are:

1. Incorporation of a dialogue procedure which allows:

- The identification and negotiation of non-standard transfer conditions by ATCOs performing the planning function (PC)
- The provision of the capability for the accepting unit to counter propose transfer conditions
- The provision of transfer of communication facilities as part of the transfer of control procedure

2. Definition of message content and format to support the crossing of a boundary by a flight on a track which is not a defined ATS route, but which is defined by the begin and end points of the route segment.

3 SPECIFIC OPERATIONAL REQUIREMENTS

To consider how MTCD should operate cognisance must be taken of current day ATCO roles, methods of work and the environments of ECAC airspace.

3.1 Comparison with today's environment – specific

In ATM operations the use of flight progress strips and their meaning to ATCOs have varied applications and interpretations. This is important in considering MTCD as DST. The current day FDPS/RDPS operate with varying parameters, which is airspace/sector specific. OLDI applications are not consistent and ACT notification times vary. The structure of sectors and their transit lengths vary considerably which in turn creates an array of procedures, which are site specific. If these and many other factors are to be taken into consideration when MTCD is introduced then the flexibility of MTCD is reliant on understanding current control methodology and the need to adapt this to the new functionality.

3.2 Flight Progress strips

The replacement of strips, electronically, removes some of the artefacts that ATCOs use in "picture building" (situation awareness). This is not perceived to be a problem but electronic "strip" data should provide sufficient information and stimulation to the ATCO. Consideration must be given to the use that ATCOs make of strips in annotating problem identification. The first requirement for MTCD operation, in this context, is the format for notification of anticipated problem(s).

MTCD shall provide indication of problem(s) identifying traffic involved and other pertinent information for defining problem resolution. (HMI)

FDPS/RDPS flight monitoring in current day systems allows for degrees of uncertainty and promulgates warnings in strip reprints for time deviations and track deviation warnings. *MONA will be used for non-conformance warnings, whether track or time deviations.* The problems created

by deviations may be either strategic or tactical and MTCD should detect and provide notification of these problems.

*MONA shall provide notification of problem(s) associated with non-conformance. (**HMI**)*

3.3 Intra-sector co-ordination

PC and TC co-ordination is not always explicit and takes many forms, therefore, matching with this element of ATCO performance is probably impossible. The main objective to consider is the requirement to ensure that co-ordination is effected. The EATCHIP 3A_Bis objective (A) specifies "Examine if MTCD tools help ATCOs in their task of detecting and resolving problems". If intra-sector co-ordination is considered in this context then it should be feasible to provide specification(s) for MTCD operation. The primary problem is that of HMI and compatibility with current day perceptions of how this co-ordination is effected. The practice of direct designation can be simulated with on screen notification (list or label) provided, primarily, by the PC for the TC. SYSCO provides for inter-sector co-ordination and thus automatically encompasses on-screen notification (i.e. CFL change, XFL change, XPT change etc.) for resultant intra-sector co-ordination.

SYSCO shall provide for inter-sector (where sector can be ACC) co-ordination and the associated notification shall be presented to both PC and TC. (**HMI**)

Actions by PC on perceived problems shall be notified to the TC where appropriate. Entry conditions are not necessarily a concern for TC but may have in-sector implications and if this is the case MTCD should provide notification to TC. (**HMI**)

*The PC will plan traffic based on MTCD data and current resources that are applied and where a problem persists shall be able to notify, implicitly or explicitly, it's existence and nature to the TC. (**HMI**)*

3.4 Task-sharing and MTCD

The configuration of ATCO support hardware is not consistent throughout the ECAC area. The PC may or may not have PVD display, the TC may or may not have strip access, strips may or may not be the domain of PC only and many other variations exist. The resultant evolution of task sharing is difficult to define and the requirement for a "generic opportunity for task-sharing" creation should be satisfied. This will permit the necessary flexibility for site specific task-sharing generation and application for particular needs of individual systems.

The trend toward dual-rated ATCOs (i.e. ATCO with both Planning and Radar licences) is commonplace. The assumption that this will be unilaterally applied is reasonable, in the context of MTCD. The requirement for availability of PVD for the PC shall be assumed to be the case. The issue of the limitations of what uses the PC can make of "radar–derived" information will have to be addressed.

The effective use of MTCD as a planning or strategic DST cannot be time-based, in the context of PC traffic assessment/analysis, as it is today.

The PC shall use PVD information where semi-tactical intervention can be effected using lateral/longitudinal *separati*on of traffic of, say, = or > 1*0nm rather than 10, or less minutes separation. The PC shall not tactically separate traffic but may assign/co-ordinate semi-tactical instructions (e.g. Inter-sector co-ordination – aircraft to maintain present heading and hand-over,*

or two aircraft in trail to maintain 1*0nm or greater with speed control (may/or not be subject of LoA) etc.). This type of strategic intervention shall be notifiable to the TC either verbally or, more important, by the system. (**HMI**)*

The PC will strategically manage air traffic with the use of MTCD as a DST. The nature of PC intervention will concern entry/exit conditions, load assessment and planning, limited problem resolution and to a much lesser extent in-sector traffic management. The main in-sector area of concern for the PC will be in relation to problems at or near the sector boundary to include downstream in-sector anticipated problems.

*If necessary the PC function can have time based limitations for use. The PC may assess traffic from MTCD derived information and plan strategically, the evolution of traffic. At all times PC intent must be notified to the TC, where it may be implicit or explicit, nonetheless, the system should have this capability. (**HMI**)*

3.5 ATCO roles and MTCD

The role of both PC and TC are not similarly defined in all ATM systems. The planning function is generally that of the PC but the use of strips for this function is not generic. The control of the strip board is not always in the domain of the PC and may even be the primary information base in some systems (e.g. operations of Swiss-control where the flight strip is the main key for strategic and tactical intent and action recording). The use of flight strips is not for consideration here, but in the context of ATCO role definition (MTCD) and clarification, it must be borne in mind.

The current planning or strategic role of the PC is generally assumed to be based on data received from ACT in the time horizon dictated by the ACT parameter (i.e. 8 – 20 minutes). The basis on which PC acts relates to time separations and detection of in-sector conflicts/problems.

MTCD shall provide data in the same time horizon for the PC (The 3A_Bis ACT parameter will be 12 minutes). The PC role shall be to assess all problems presented by MTCD. PC shall prioritise identified problems and resolve those that can be solved by use of SYSCO, as well as addressing those problems that cannot be solved by him/her by strategic means. This will necessitate either explicit and/or implicit notification to TC of a problem that must be tactically resolved (or problems that the PC cannot deal with).

3.6 Time Horizons

MTCD time horizons need to be defined and can be considered in a similar fashion to the current time horizons. The use of pending flight progress strips varies and the time of integration into the active board is not consistent even within ACCs.

The concept of early warning with opportunity for early planning for the PC implicitly dictates the parameter for MTCD data display. The ACT parameter is one dictating factor and sensibly is the earliest that the PC can use MTCD data. The other conditions that should be considered are bottom of climb (BOC) and top of descent (TOD).

MTCD data shall be activated at the latest on ACT message receipt. The PC planning shall begin on receipt of the ACT. It should be noted that this also facilitates SYSCO co-ordination.

The TC AoI is dependent on selected range of display. MTCD data shall be available from ACT receipt for the TC. Strategic co-ordination shall be the responsibility of the PC. The PC shall notify impact on TC, as a result of PC actions, to the TC.

3.7 Tactical Complexity

In today's environment the PC AoR is the sector defined by its boundaries with whatever associated flexibility's that are/not provided by the LoAs or other regulations, procedures etc. This should remain the AoR of the PC. The responsibility for in-sector tactical control remains that of the TC. The earlier strategic planning ability that MTCD provides should allow for "specific" tactical proposals by the PC. If this is viewed in the context of MTCD providing opportunity for early complexity identification then the PC should be in a position to reduce tactical *complexity by strategic means.*

The workload associated with complexity is generated by "task demand in a time period with limitations on options". The TC must identify all options where feasible, and decide on the best course of intervention. The TC must also recognise which action might be taken and at what time this action might be performed. A decision by the TC then is – What, When, How, and Where the action will be initiated. If MTCD can support strategic and tactical decision making in this context then it is apparent that workload can be decreased.

MTCD shall provide the PC with understandable complexity information in advance. This information shall identify location and time of complexity and number of aircraft involved. (**HMI***)*

*Note: for this special case, complexity shall be considered as 3 or more aircr*aft in a problem configuration. MTCD displays problem pairs.

PC proposals for TC tactical intervention shall be based on MTCD data provided in a time horizon defined by the ACT parameter as the starting point and extending across the sector span horizontally and vertically.

Note: if the filtering of MTCD display could be achieved in a defined (at ATCO request) vertical and/or horizontal plane then this could be a useful option for problem assessment/analysis.

MTCD should display problems in a filtered manner:

- *Problems with uncertainty probability close to 1.0 shall not be displayed.*
- *Problems with uncertainty probability close to 0.0 shall be displayed.*

(Note: This was a feature of URET and technically feasible if the appropriate rules can be defined).

TP accuracy shall be considered:

- Along-track or longitudinal accuracy/uncertainty
- Across track accuracy/uncertainty
- Vertical accuracy/uncertainty

Trajectory modelling is based on the considerations that a trajectory, is a sequence of points (horizontal position, altitude and time) with provision for uncertainties along-track, across-track and in altitude for each of these points.

Performance tuning may permit determination of alerting thresholds in terms of time to conflict and miss distance and conflict geometry (if a false alert target can be specified).

3.8 Strategic Complexity

The strategic management of traffic complexity for the current day operations of the ATCO is limited due to capacity constraints, LoAs, flow control, sector definition and many other factors. The need for increase in capacity is obvious but the limitation of environment configuration (sector boundaries and numbers etc.) may only change progressively to permit this. The assumption that the current environment will remain for the immediate future is reasonable. This will be the context in which MTCD introduction to ATM shall be considered.

The term “strategic complexity” refers to the traffic complexity presented to the PC primarily. Today the manner of identifying complexity is by way of strip information – this may be augmented by PVD use but only on an ad hoc basis. The number of aircraft and the problem content are the primary sources of complexity (this may be coincidental with an existing workload due to traffic in the system, poor system interface demand, distraction by external agencies etc.). The requirement for more assessment time and early detection of problem complexity and its nature should be satisfied by MTCD.

*It should be noted that the AoI in this case is at/or near the sector entry boundary. The greater part of the PC strategic planning relates to the Entry and initial sector segment of trajectories. The objective is to provide the PC with opportunity to assess traffic loading and complexity to enhance traffic load balancing within the sector by use of MTCD tools. (**HMI**)*

3.9 Emergencies

In the event of any unforeseen occurrence, such as an emergency, the behaviour of aircraft involved may no longer be subject to normal restrictions and obligations. The non-compliance or unpredictability of traffic in these circumstances makes it almost impossible to use system DST.

4 MTCD CONCEPT OF OPERATION FOR EATCHIP III A_BIS

4.1 General

The Planning Controller (PC), with the assistance of Decision Support Tools (DST), will strive to reduce the workload of the Tactical Controller (TC). MTCD will assist the PC in identifying problems earlier than at present. Earlier identification of problems permits the PC to intervene, assess and resolve *some* problems, thus balancing the workload of the TC. The working roles and methods of the controllers will be defined. The impact of MTCD and availability of SYSCO should result in redistribution of workload and a requirement for task and task-sharing clarification. The expectation is that the PC/TC team will be able to handle more traffic as a result of the provision of MTCD.

4.2 Main Features

The need to identify problems and co-ordinate, or resolve them in future traffic configurations will be the primary function of the PC. The evaluation of potential capacity availability, from earlier intervention by the PC with a priority for enhanced strategic traffic management and organisation for the TC is the primary objective of the introduction of MTCD. The addition of SYSCO reduces the task demand on the ATCO and provides facilities for effective and expedient inter-centre co-

ordination. MTCD and MONA facilitate the intervention by the PC and support the monitoring task of the TC.

Success of the concept is dependent on:

- the ATCO maintaining responsibility for air traffic safety;
- evolution in a progressive manner from the current ATM system while maintaining compatibility with ATCO cognitive processes;
- ATCO ability to interpret and comprehensively utilise MTCD tools and data;
- capacity to cope with increased traffic levels;

Training will play a significant role in contributing to the success of the EATCHIP 3A_Bis experiment. The training issues related to ATCO understanding of:

- The Concept of Operation;
- CWP and Tool use;
- Role, working method and task-sharing.

4.2.1 *Philosophy of MTCD*

Roles, tasks, task sharing and working methods for PC & TC controllers should be defined in the context of MTCD. This should provide relevant conflict information to the ATCO and alleviate the cognitive demand of current environments. MTCD should provide enhanced system support, while retaining the skills and know-how of the ATCO.

The provision of trajectory prediction and associated predicted problems should not degrade the ability of the ATCO to maintain his awareness of the air situation. Current safety levels shall be maintained or enhanced.

4.2.2 *Airspace Environment*

The subject airspace is that comprising Paris, Reims and Maastricht areas with associated military airspace. Procedures and associated constraints will be the same as for EATCHIP III Phase 3A Evaluation and Demonstration.

4.2.3 *Air/Ground communications*

Air/Ground communications will be performed via R/T only.

4.2.4 *Ground/Ground Communications*

Ground/Ground communications and co-ordination will be achieved by use of SYSCO or telephone/intercom.

4.3 Tools

4.3.1 *Trajectory Predictor*

The functionality's related to the profile calculation are:

- First profile calculation based on ICAO FPL route, ATC constraints and initial start level in the simulated ATC centre.
- Profile calculation triggered by a controller-input order or a ground internal order.

[8] EATCHIP III User/Software Requirements Document Profile Calculation, V1.1.1 11 December 1998.

The most relevant consideration is the applicable rules for trajectory prediction for MTCD. The TP assumes that the aircraft will climb as soon as possible after sector entry and descend as late as possible before sector exit. This has implications for the calculation and presentation of MTCD data (MTCD may display predicted problems that in reality are of no concern for the ATCO in a problem analysis context). ATCOs will be aware of this and should be able to interact to reduce such noise.

4.3.2 MTCD

Medium Term Conflict Detection (MTCD) is a function looking for potential conflicts along the trajectories of all aircraft. It looks at a 3D trajectory taking into account the clearances given to the aircraft. A potential conflict means that the trajectories and associated uncertainty areas of the involved aircraft are predicted to be separated by a nominal minimum distance that may concern the ATCO.

Presentation of the MTCD data will be on the RPVD for the PC and the TC. The associated windows for data display are similar for both ATCOs.

4.3.3 *MONA*

MONA:

- Is a tool, complementary to trajectory prediction which assist the ATCOs in monitoring all flights under control in order to detect deviations from system trajectories;
- assists in achieving a system trajectory, which will allow utilisation of a longer and operationally acceptable prediction horizon that can serve as a basis for conflict detection and other advanced ATM system capabilities;
- consists of conformance warnings and reminders. Non-conformance warnings assist the ATCO by provision of warnings of deviations from the system trajectory. A reminder is displayed to the ATCO to remind of previously planned actions. Reminders are either system generated or manually specified.

4.4 Time Horizons

MTCD predicted problems should be considered in two time horizons:

- Flight Plan activation (ACT) or Advance Boundary Information (ABI) to twenty minutes ahead (this includes 12 minutes ACT parameter i.e. 12 minutes before entry to 8 minutes into sector as a minimum).
- ACT to parameter time (e.g. sector exit boundary).

The objective that the PC could strategically manage traffic earlier will be satisfied by provision of potential problem data at the time of receipt of the ACT message. Entry and early in-sector conditions can be assessed in this time frame. The PC should also address exit planning when trajectory information is available.

4.5 Roles

A role can be defined in a number of ways:

- A function or part performed especially in a particular operation or process (dictionary).

The pattern of wants and goals, beliefs, feelings, attitudes, values and actions which members of a community expect should characterise the typical occupant of a position. Roles prescribe the behaviour expected of people in standard situations. [9] Krech, D., Crutchfield, R. S. and Ballachey, E.L. (1962) Individual in Society, McGraw Hill

ATCO roles in current sector teams are similar in a European context when considering the evaluation of MTCD. The addition of DST may change the role of one ATCO and subsequently will implicitly change the role of the other. Today the PC plays the part of a support role for the TC and this has resulted in accepted/expected norms in behaviour.

DST provides opportunity for change in task allocation and improved performance by the ATCO team. Collaborative activities associated with these changes require clarification of what the respective roles of the PC and TC will be, in a changed team environment.

4.5.1 *PC ROLE*

The provision of RPVD, MTCD Tools and SYSCO enhance the nature of assistance that the PC can provide to the TC. The PC will provide:

- Strategic ATM management/assistance;
- Tactical ATM management/assistance;
- Problem identification, monitoring and prioritisation assistance;
- Workload monitoring assistance.

4.5.2 *TC ROLE*

The executive status that the TC enjoys today will not be eroded by changes in the role of the PC. Tasks performed by the TC will not radically change from those of current ATCO teams. The DST will permit the TC to plan and prioritise earlier given the advantage of more organised traffic and advance warning of problems by both the PC and MTCD. The role of the TC remains relatively

unchanged but the sharing of the executive responsibility will necessitate *unambiguous* task allocation and definition.

In current ATM systems the TC behaviour is primarily “bottom-up” and the move or transition to a more “top-down” behaviour should not adversely affect the TC role.

4.6 Tasks

The areas of responsibility for PC and TC are the same but the areas of interest differ. In the application of DST the area of interest for the PC will be the pre-sector entry, entry, limited in-sector and sector exit.

- Pre-sector entry traffic is equivalent to the current day “pending” air traffic.
- Entry, in-sector and exit conditions are equivalent to current day “active” air traffic.

Pending traffic is assessed from the information available from electronic flight data and MTCD, and requirements for co-ordinations are satisfied by use of telephone/intercom or a third party.

ATM and the associated tasks that will result from DST shall be specified for the safe and efficient use of MTCD Tools.

4.6.1 *PC Tasks*

Traffic information when presented will be assessed for problem content, which will be available from the PCPD and RPVD. The PC will decide to intervene, or not, with the purpose of *strategic ATM* to reduce problem content, monitor problem(s) and TC workload and provide problem resolution or warning advisory for the TC. This function of the PC is achieved by:

- Monitoring the RPVD, SIL, MIW, MOW and PCPD;
- Co-ordination using SYSCO or telephone/intercom;
- Plan, prioritise and implement resolutions to air traffic problems;
- Allocating problems to the TC and advising the TC of problems (implicit or explicit actions);
- System updating.

Training issue – a work method shall be identified for problem identification, assessment, analysis, solution testing and proposals or co-ordination

The role of the PC necessarily dictates the associated tasks, which are:

- Monitor the Sector Inbound List (SIL) to detect proposed traffic – this permits the PC to view trajectories (flight legs) for aircraft if a *quick look* is required;
- Monitor PCPD to identify problems – PC views MTCD problems and interacts to assess impact on overall air situation;
- Use system tools, where necessary, to assess the need for intervention or monitoring – classify each problem and decide which course of action must be followed, either co-ordinate a change to Entry conditions (FL or route), pass the problem to the TC or intervene in a tactical manner (co-ordinate headings, speed control or routing with offering sector);
- Monitor message windows;
- Monitor workload of the TC and where peaks or bottlenecks are evident ensure every effort is made to reduce traffic complexity by reducing problem content of relevant traffic. The provision of tactical assistance may be necessary and co-ordination will have to be achieved between

PC and TC *(Note: PC may view TC Problem Display)* to ensure that the *Team* function safely and efficiently in an effective manner;
- Ensure, in so far as is reasonably practicable, strategic management of air traffic through the sector by monitoring, assessing problem content and intervening where prudent and feasible;
- Provide requested assistance to the TC;
- Ascertain preferred trajectories and comply with aircraft (customer) requirements where possible;
- Ensure that the requirements for ACT transmissions are achieved and co-ordinate where necessary by use of SYSCO or telephone/intercom;
- Assess exit conditions and co-ordinate, where necessary, with the downstream sector to resolve exit problems. The objective will be to ensure a conflict free traffic configuration at sector exit ;
- Ensure, at all times, that the system is updated by modifications to trajectories where required;
- Detect system and TC errors;
- Monitor system performance to ensure operational status;

4.6.2 *TC Tasks*

Monitoring, safety analyses of the air situation and problem resolution are the main tasks of the TC in current environments. The addition of DST provides opportunity for the TC to more easily identify risks of separation loss or air traffic problems.

The TC shall:

- Maintain a safe and efficient flow of air traffic in the sector;
- Maintain awareness of the air situation by use of RPVD, SIL, MIW and MOW window(s);
- Identify existence and nature of potential problems from TCPD data and notification by the PC;
- Manage R/T communications;
- Co-ordinate, where necessary, with the PC, adjacent sectors and centres;
- Update the system where necessary;
- Plan, prioritise and implement resolutions to problems with traffic;
- Integrate traffic in a safe and expeditious manner;
- Optimise airspace use with a “customer satisfaction” focus, where workload permits.

The TC shall have control and awareness of the sector air situation, at all times. The impact of PC planning should provide the TC with:

- Strategically organised traffic
- Awareness of problem content (TCPD provides problem display also)
- ACT requirements to be achieved

Tactical intervention results from a need to resolve conflicts and will be achieved by use of R/T. The primary objective of the TC is to *ensure safety of all traffic at all times*. The other objectives of the TC are:

- TC shall ensure that two R/T communications are established with each aircraft at entry;
- Efficiency – which will be achieved by timely implementation of optimum safe tactical solutions while taking cognisance of the impact of proposed interventions on the overall planning;
- Expeditiousness – satisfy the preferred trajectory (Route and Flight Level) requirements of all aircraft;
- Ensure that the system is updated at all times;
- Monitoring TCPD and RPVD for identification of Problems and NCWs;
- Co-ordinate with the PC to maintain safe and efficient operations;
- Monitor air situation to maintain a mental picture of traffic scenario in the event of unforeseen occurrences;
- Detect system and PC errors;
- Monitor system performance to ensure operational status;
- TC shall ensure that all aircraft are transferred at transfer time *(Note: Transfer warnings);*

4.6.3 *PC/TC Task-Overlap*

The area of interest of the PC that overlaps with that of the TC will be at the Exit boundary and to some degree in-sector and to a lesser extent at sector Entry. This necessarily, implies that there will be some co-ordination between the PC and TC and also some sharing of responsibility.

Specific task-overlap:

- PC when addressing exit problems may detect non-compliance with constraints and this might require tactical intervention – co-ordinate with TC or intervene;
- Co-ordination with downstream sector may be required and this can be achieved by either ATCO – if TC is busy PC co-ordinates;
- TC may allocate some specific R/T responsibility to the PC (e.g. Check-in, Transfer etc.);
- PC while assessing solution(s) may consult with the TC for his/her preference.

(Note: It is feasible to consider that the identification of more task-sharing opportunities may occur from experience in the use of MTCD)

4.7 Working Methods

The provision of guidance in the methods of work for MTCD use should allow for the task sharing between ATCOs.

(Note: HMI modifications prior to commencement of EATCHIP III A_Bis may impact on the working methods of one or both ATCOs)

4.7.1 *PC Working Method*

The consideration of how to integrate DST into the current ATCO working method forms a basis for description of a modified working method. The PC shall continue to work as before but utilise the assistance provided by the system to enhance his/her effectiveness in assisting the TC. The PC is primarily concerned with sector entry and with sector exit and some in-sector problems.

Method

- Assimilate environmental information (Equipment status etc.);
- Scan Sector Inbound List (SIL) and identify content and its implications (Flight strip equivalent). View aircraft trajectories (flight legs) through the sector;
- Check Message In Window (MIW);
- Check PC Problem Display (PCPD) and identify problem content and nature;
- Assess problem content of PCPD and investigate selected problem (if one exists);
- If required, evoke Problem Zoom Display (CZW or Filter?) and analyse;
- Investigate further – Lookahead and/or Vertical Aid Window;
- Delete, suppress the problem or formulate a solution, assessing in-sector impact and co-ordinate sector entry change or pass problem to TC;
- Assist the TC if required;
- Monitor air situation and construct “the picture”;
- Check “in-sector” problem potential and TC workload;
- Plan sector exit conditions;
- Update the system;
- Check sector exit problem potential and intervene where necessary (Co-ordinate with TC or downstream sector – SYSCO). This will require a problem free solution;
- Return to SIL and repeat the process.

4.7.2 *TC Working Method*

The impact of the PC strategic management of traffic for the TC will not radically change the established safe and effective working method of the TC as it is today. The objective is to extract maximum benefit from the provision of DST for the PC and the resultant assistance for the TC.

Method

- Assimilate environmental information (Equipment status etc.);
- Scan Sector Inbound List (SIL) and identify content and its implications (Flight strip equivalent). View aircraft trajectories (flight legs) through the sector;
- Check in new traffic on R/T;
- Check Message In Window (MIW);
- View the TCPD and assess content;
- Prioritise work by analysis of problem(s) taking account of impact on sector traffic (air situation);
- TC should be aware of probable R/T workload when planning future work;
- Effect solutions – either proposed/co-ordinated by the PC or formulate an effective and safe solution;
- Implement solution(s) - R/T and update system;
- Assess exit constraints and intervene to ensure compliance (ACT and Tactical intervention);
- Co-ordinate where necessary – PC and downstream sectors;
- Transfer traffic or wait for Transfer warnings;
- Assess PC workload;
- Where workload permits optimise for “customer” preferred requirements – route and flight level;
- Monitor for system and PC errors;
- Return to SIL and TCPD.

4.8 System Up-date

Trajectory Prediction relies on updates from the controllers. To ensure that the system is constantly updated it must be emphasised that the ACTO is responsible for provision of this data to the system. The importance can be highlighted in terms of the quality and accuracy of MTCD prediction being dependent on validity of TP calculation from “up to date” data.

4.9 MTCD Display

HMI requirements for MTCD should provide for an information display, which shall be intuitive, understandable, unambiguous, easily detectable, compatible with ATCO logic and accurate. The differences in cultural, social and operational backgrounds of the system user in ATM is such that the realistic approach to HMI development has to be, in the main, generic.

The most important requirement is that safety of air traffic is not compromised in any way. The goal of safety enhancement should be encompassed in HMI considerations. The change from hardware (strips, pens etc.) use to Information Display Systems (IDS) for ATCOs will be a progressive procedure. In the context of problem analysis and management the use of HMI for the presentation of MTCD data to the ATCO, necessitates, for the present:

- high degree of compatibility with current ATCO method of work in artefact use
- high degree of compatibility with current ATCO logic
- high degree of compatibility with current ATCO interpretations of strip management and analysis
- unambiguous information display
- information that is pertinent to the problem(s) under consideration
- accurate information, in so far as is reasonably practicable
- all information that should be displayed
- display of information in a timely manner

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