CONTROLLER ROLES - TIME TO CHANGE

Robert GRAHAM, **Alan MARSDEN, Isabelle PICHANCOURT, Franck DOWLING**

EUROCONTROL Experimental Centre
Bretigny–sur-Orge
France

robert.graham@eurocontrol.fr

alan.marsden@eurocontrol.fr

isabelle.pichancourt@eurocontrol.fr

franck.dowling@eurocontrol.fr

SUMMARY

This paper presents concepts and initial simulation results put forward by C3T (Controller Tools and Transition Trials [1]) a study project, whose aim is to define, develop and evaluate controller roles, tasks and working methods suited to the introduction of ATM Decision Support Tools (DST) and data link communication. The project is in support of the EUROCONTROL ATM2000^{+} strategy [2] and will apply both model and real-time simulation techniques.

To address the need for change, C3T has identified a number of operational improvements linked to technology expectations including:

1. Task sharing, with the planning controller (PC) organising tactical controller (TC) activity;

2. PC Empowerment[1], using predefined alternate clearances (PAC), system assisted co-ordination (SYSCO) and data link (CPDLC) to resolve problems and deliver clearances early;

[1] Empowerment means facilitating PC definition of tactical problem resolutions.

3. *Multi sector planning, reducing complexity and density, balancing traffic load and planning traffic flows over several sectors;*

4. Delegation, from controller to pilot for specific separation assurance;

5. Trajectory negotiation permits contracting agreed constraints for which there is a high expectation of achievement.

This paper discusses results arising from a model based and a real time simulation of a number of planning controller empowerment scenarios.

CONTROLLER TOOLS AND TRANSITION TRIALS – C3T

C3T aims to identify benefits accrued to airspace users, service providers and controllers from the proposed concepts and to define a pragmatic implementation of its findings.

The need for change is clear; capacity walls have been reached in numerous sectors in core European airspace and traditional methods of providing extra capacity are almost exhausted (sector split, more controllers, improved procedures etc.)

An opportunity exists for operational staff to embrace technology and forge it to their own requirements. The motivation for C3T study is based on the expectation that:

- Task sharing will balance workload in the sector through validation and prioritisation of problems by the planner for the tactical controller;

- Cost in workload to the controller (especially the tactical) and in economics to the airline will be reduced through early problem resolution;

- Delegation to the pilot of separation assurance will increase airspace capacity through reduced controller workload;

- Data link communication (CPDLC) will facilitate advance delivery of problem resolutions by planning controllers, and enable trajectory negotiation.

We empower the planning controller (PC) to define problem resolutions through use of conflict probing (CP); system supported co-ordination (SYSCO [3]) and advanced Human Machine Interaction (HMI). Resolutions are proposed to the TC of the offering sector via SYSCO or in the form of an alternate clearance to the own sector TC for execution or rejection in real time.

Operational Concepts – Planning and Tactical

C3T project employ results of a number of research projects whose global aim has been the development of modified control practices and decision support tools (DST). Major contributors to C3T include EATCHIP III [4], ERATO [5], PHARE [18], FACTS, [6] URET [12], and CTAS [13], and these are briefly introduced below:

EATCHIP III

EATCHIP III has proposed a series of real-time simulations to evaluate System Supported and Civil/Military Co-ordination [7] and "Added Functions" i.e. Monitoring Aids MONA [8], Medium Term Conflict Detection MTCD [9], Safety Nets SNET [10] and Air/Ground DATALINK [16]

ERATO

ERATO is a decision support tool whose concept of operation is based on cognitive model of the principal tasks of the controller – situation awareness development, detection, and resolution of conflicts. ERATO aims at assisting the controller in the decision making process associated with these tasks, principally by presenting the most pertinent information in a timely manner to the controller, who remains the decision making authority.

PHARE

PHARE provided for the development of a future ATM concept that supported the introduction of Multi-Sector Planning (MSP) and Air/Ground integration. *This role included reduction of traffic complexity and sector load balancing*

FACTS

The UK Future Area Control Tools Support programme is developing and evaluating a series of controller support tools using trajectory prediction and medium term conflict prediction. The controller tools evaluated include a fully electronic co-ordination capability and planning and tactical controller tools. These have been well received by the controllers participating in simulation trials.

URET

URET includes a Conflict Probe facility which checks flight plan trajectories for strategic conflicts and a Trial Planning function which allows the controller to check a desired flight plan amendment for potential conflicts before a clearance is issued.

System classifies Conflicts according to their occurrence probability and provides a notification time helping the controller to better organise tasks and optimise time management.

CTAS

CTAS has been developed to support conflict detection and resolution in the form of a Conflict Prediction and Trial Planning tool for field test evaluation. This includes a conflict detection function which estimates conflict probability and a trial planning function that allows the controller to check the efficiency of a desired resolution.

C3T STUDY CONCEPTS

A number of operational improvements are necessary to move the PC from today's ATC to an empowered PC using data link technology to transmit pre-planned

clearances to the pilot, and ultimately the introduction of an MSP role covering several sectors.

The C3T improvements evaluated for PC and TC in the model-based simulation are:

Task Sharing

Concept: PC evaluates and resolves entry and exit problems and limited in-sector resolution proposals (Cleared Flight Level and Direct route). The TC role is similar to today.

Technology: EATCHIP III [+] Tool-set. (i.e. SNET, CP (including filtering function and prioritisation of problem according to the resolution time), MONA, SYSCO)

When: 2007.

Expectation: A 20% capacity increase.

Empowerment

Concept: PC uses tools to identify and resolve problems excluding problems requiring TC intervention (e.g. radar vectoring). The PC Pre-defined Alternate (deferred) Clearance (PAC) is distributed through SYSCO or proposed directly to the TC through the HMI. The TC may reject, change or execute the PAC based on judgement of the current situation.

The TC role is directed to validation of the PAC and to complex problem resolution more easily determined by the human being. The PAC is linked to CPDLC for delivery at aircraft sector log-on.

Technology: EATCHIP III Tool-set with TED (Trajectory editor) and CPDLC (Controller-Pilot Data link communication)

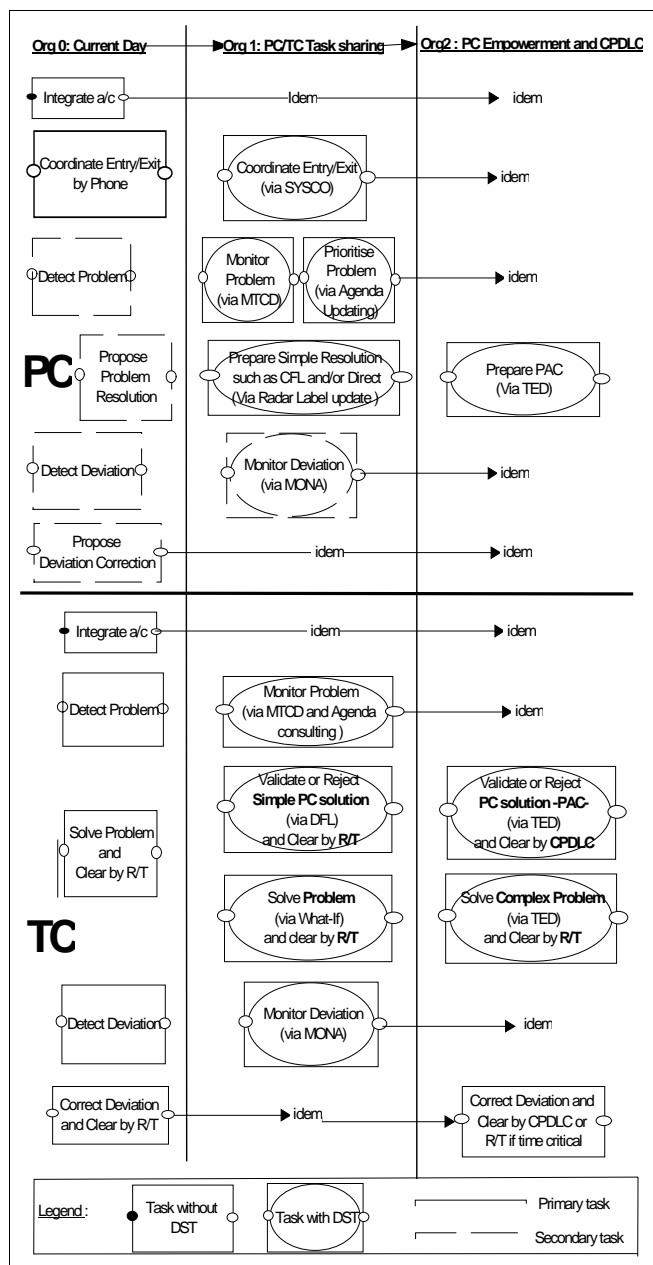*When*: 2010 – 2015.

Expectation: A 40% capacity increase.

Figure 1: PC / TC roles and tasks

MODEL BASED STUDY - HYPOTHESIS

The model simulations had to evaluate the potential for reduction in controller workload and improved capacity through increased task sharing between the sector TC and PC. The task of defining problem resolutions (excluding tactical radar control) is delegated to the PC;

This study assumed that CP, MONA, SYSCO, Trajectory Editor (TED) and CPDLC for delivery of predefined clearance proposals would be available.

Improved task sharing can be achieved between sector team members through proposed problem resolutions and organising TC intervention in time resulting in increased capacity at an acceptable cost through productivity gains.

The use of System Supported Co-ordination (SYSCO) and CPDLC with the empowered PC role will increase sector capacity without a significant increase in sector team workload. *(ensuring asynchronous communication between Ground and Ground and between Air and Ground.)*

MODEL BASED STUDY SCENARIOS

Both PC/TC task sharing and Empowered PC with CPDLC were evaluated which, with the baseline, provided three study scenarios, referred to as organisations (see figure 1).

The baseline operational parameters employed within the fast time model were derived from a EUROCONTROL study of Polish airspace validated by Polish ATC staff. A traffic sample equating to a 24-hour period in 1997 was augmented by 100% for the purposes of this study. The performance of the Polish airspace and procedures under this future traffic volume was used as the baseline.

PCTC Organisations

Organisation 0 - Baseline

Two controllers (PC & TC) staff each sector. The ATC environment assumed radar, paper strip displays with R/T and telephone used for clearance delivery and co-ordination.

Organisation 1 – Task Sharing

The sector configuration remained the same, however, controller tasks were amended to model task sharing between the TC and PC.

This organisation assumed that both conflict detection and clearance monitoring were the responsibility of the system. (via CP and MONA)

Certain conflict types were deemed as being the responsibility of the PC for resolution proposal including solutions involving direct route, planned level changes. SYSCO was assumed for co-ordinating changes with the

appropriate sectors for TC delivery. Within the model, a reduced TC cost (task execution time) was simulated as a result of the simplification of the conflict resolution task to that of clearance validation and delivery. It was considered that the PC cost would remain consistent with existing radar resolution tasks.

Organisation 2 – Empowerment

The controller tasks were reallocated so that only radar vectoring tasks remained with the TC. This task sharing assumed SYSCO and CPDLC would be available and that a graphical trajectory-editing tool (TED) would also be available to the PC. It was assumed that the output from this tool would be translated into either a co-ordination message to the sector N-1 or N+1, or a CPDLC message posted to the sector TC. The TC would validate and apply the clearance when the concerned aircraft logged on and was assumed.

The evolution of the roles of both the TC and PC are indicated in figure 1.

RAMS MODEL

Operation

The fast-time model used in this study was the Re-organised ATC Mathematical Simulator RAMS [11]. This model has been developed within EUROCONTROL and is used extensively in airspace and procedure development studies both within European Administrations and by the US FAA.

RAMS operates by taking individual controller tasks and their execution times, and applying them to resolution of predicted conflict situations and also standard ATC procedures such as co-ordination, assume and transfer of control. Task execution times are translated into an overall working time, which is further translated, into a workload classification of "moderate", "heavy" or "severe". The tasks simulated for this study are categorised below:

- Co-ordination;

- Flight data management;

- Routine r/t communication;

- Radar (Monitoring contract adherence),

- Conflict Search;

- Conflict resolution.

Random effects such as weather, system failures, non-standard operations and emergencies were not simulated.

Traffic Sample

The Poland Fast Time simulation study from which the baseline scenario was derived used a traffic sample from 1997. For this study, the traffic sample was augmented by 100%.

Sector Capacity Assessment

The capacity estimation provided by RAMS is defined as the maximum number of flights that can enter a specified control area in a defined period whilst maintaining an acceptable level of controller workload. This maximum is the Heavy Load Threshold (HLT).

The HLT value selected for Radar Controller position is 70% which corresponds to 42 minutes measured working time in one hour, leaving 18 minutes for other tasks not defined within the model.

MODEL BASED STUDY PRELIMINARY RESULTS

Organisation 0 - Baseline

Figure 2 indicates the workload (% time performing specific tasks) over the busiest three-hour period within the baseline organisation for the chosen traffic sample (1997 100 augmented %). Four of the sectors used in the study are upper sectors (FL320 and above) whereas sector SUW extended from Ground to Unlimited.
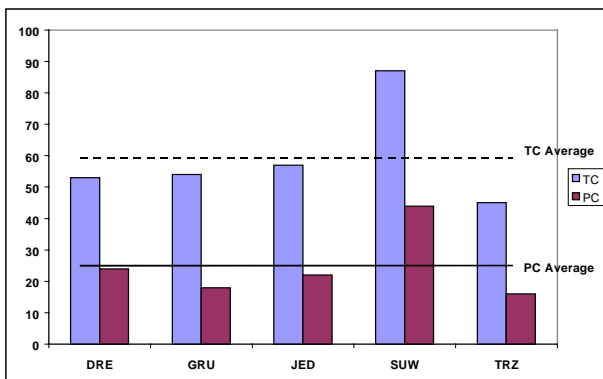

Figure 2: Workload in baseline organisation

Traditionally within RAMS studies, a workload over a three-hour period in excess of 40% is deemed "Heavy" and in excess of 50% is referred to as "Severe". Figure 2 highlights the extremes of workload for the TC and PC of each sector.

Organisation 1 – Task sharing

Within this organisation the task times associated with telephone co-ordination (PC task) were reduced in order to reflect the availability of SYSCO. The physical tasks associated with flight data management (strip manipulation) were deleted and the task times made consistent with the task of manipulating, reading and assimilating electronic information. Routine r/t communication task execution times were modified in order to reflect the availability of shared information between air and ground systems.

Tasks associated with radar surveillance were not significantly modified since the controller is still required to build and maintain the same level of situational awareness as with the baseline scenario. The system does assist the controller in areas such as clearance monitoring
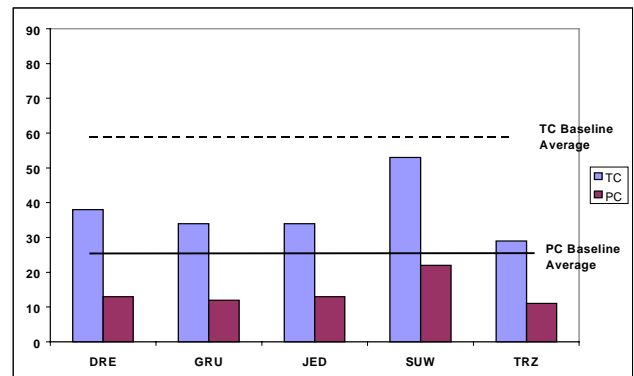

Figure 3: Workload in organisation 1

Conflict search tasks remained unchanged although additional tasks were assigned including conflict resolution evaluation and proposition (PC) and evaluation and application of the "solution" (TC). Figure 3 shows the change in workload associated with task sharing.
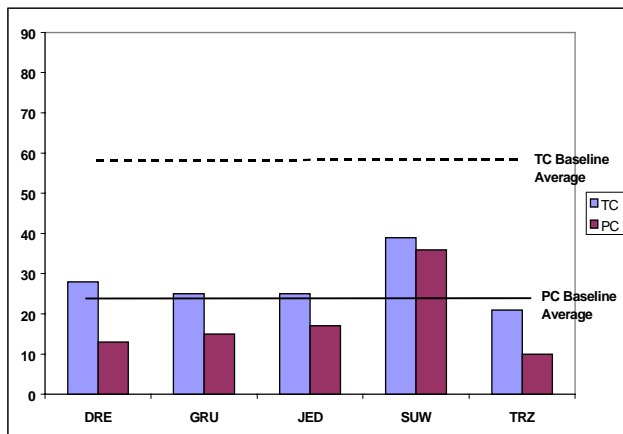
Organisation 2 – Empowerment

Figure 4: Workload in organisation 2

The task times associated with co-ordination and flight data management remained consistent with those used in task-sharing. Figure 4 shows the change in workload associated with early problem resolution (empowerment) by the PC.

Other task changes included:

- Communication - times were modified to reflect the availability of CPDLC for transmission of the PC proposed PAC;

- PAC definition - an additional task was assigned to the PC;

- Radar surveillance – times were reduced slightly to reflect the availability of TED and MONA, and improved aircraft conformance;

- Conflict resolution – times were slightly reduced for the PC since the availability of TED with "feed-back" should reduce the time taken to construct conflict-free trajectories.

Sector Capacity Analysis

The analysis of sector capacity was performed for each of the sectors and each of the study organisations. Figure 5 shows that in the baseline scenario, the capacity is indicated to be approximately 37 aircraft per hour in this sector and under task sharing the capacity would potentially rise to a value in excess of 50 aircraft per hour.

For the PC empowerment scenario, the workload figures were not sufficiently high to produce a reliable capacity estimate.
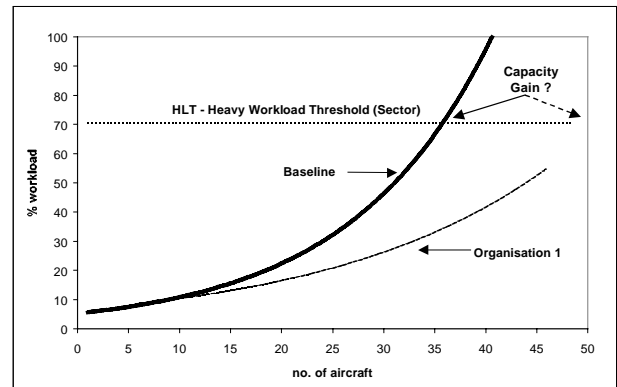

Figure 5: Capacity estimates in baseline and organisation 1

REAL TIME SIMULATION HYPOTHESES

The EUROCONTROL MTCD real time simulation was used by C3T to understand initial ideas concerning Task Sharing. This simulation used the EATCHIP tool set which includes SNET, MONA, MTCD (CP) and a limited version of SYSCO supporting only flight level co-ordination.

The primary <u>objectives</u> were to evaluate controller confidence towards MTCD and the impact of MTCD on Controller Roles, tasks and working methods.

The concept of operation was based on a layered filtering of conflict information as follows:

- MTCD detects problems;
- MONA detects non-compliance by aircraft of clearance (deviation) and advises on imminent actions e.g. Top of Descent, Frequency change etc.
- The PC –
  ⇨ Validates the conflict (is it real?);
  ⇨ If no - low light;
  ⇨ If yes - can I resolve it?
     ⇨ If yes -use SYSCO to propose solution (or telephone);
     ⇨ If no - is there urgency/severity? (E.g. less than 8 nm)
     ⇨ If yes put a warning for TC
     ⇨ If no transfer earlier/ delegate to TC
.
- MTCD provides an on-line configurable pre-warning (e.g. 5 min);

- The TC uses the conflict list (including delegated and late detected conflicts) to prioritise work, but the role and working method is generally unchanged;
- The PC is not tasked to specifically monitor the conflict resolution and/or clearance or critical delay for sake of safety;
- STCA provides last warning option (e.g. 90 sec);
- The PC may verbally warn the TC about a conflict or an a/c to be treated with priority and may provide assistance to the TC by updating the system on TC request.

REAL TIME SIMULATION - PRELIMINARY RESULTS

Unfortunately, at this early stage of simulation analysis, the results discussion is mainly based on the subjective data provided by controllers through questionnaires and debriefing, and from Human Factors observation.

Subjective data on perceived workload by each controller (ISA _Instantaneous Subjective Analysis every 2 minutes of an exercise) and objective data on traffic load and Controller data input have been recorded.

The simulation hypotheses that the use of SYSCO and DST would reduce the PC workload and impact positively on TC workload were not confirmed.

However, all participants agreed that the DST reduced PC workload.

It was considered that TC workload was not reduced, however, controllers worked scenarios with a 20% traffic increase without a perceived change in workload. This was confirmed by the ISA analysis.

Controllers were frustrated by the fact that SYSCO only permitted boundary level change co-ordination. They found the facility of system assisted co-ordination to be very good and wanted this to include Direct and Speed to reduce the telephone co-ordination.

C3T hypotheses concerning task sharing are confirmed:

Controllers said that the EATCHIP tool set enabled them to more readily plan and resolve Sector Entry conflicts. Planning controllers perceived this to be time saving in conflict detection, providing more time to assist and monitor the TC.

Participants agreed that DST supported the PC to plan "in-sector" and sector exit conflict resolutions in advance.

Initial analysis shows that the EATCHIP tools support PC intervention more easily when traffic is stable than evolving; in these situations the PC preferred to delegate problem resolution to the TC.

When a conflict was urgent or severe, PC put a warning on the conflict to attract the TC's attention. However, the simulation did not permit the PC to organise the TC work apart from the PC to TC delegation of problems, which were prioritised by the system according to time and severity. Such an eventuality would permit the PC to reduce the TC time pressure provoked by the warning, by prioritising the TC intervention time.

The use of a conflict pre-warning displayed in the radar label was considered to be very useful. This was generally configured to provide a warning less than 5 minutes before the start of a problem, reminding the TC to plan a resolution.

The PC monitored "in-sector" conflicts and verbally co-ordinated solutions with the TC, when work load permitted.

Participant's confidence with the DST evolved with time. This resulted in a request to view conflicts in the next sector. The objective was to improve service by ensuring that co-ordination would be accepted and by anticipating problems within an area of interest comprising current and next sector.

Results provided an insight to the task of traffic picture building. This requires the controller to be aware of the current traffic situation, future situation, and future workload. Some controllers used the Sector Inbound Lists and Conflict lists as future workload indicator.

Nevertheless, some limitations remain.

- The simulation showed that there is a need for a filter, which checks conflicts before displaying them to the controller. This would include borderline separations where variations in speed provoke intermittent conflict prediction and display.

- Controllers were concerned about trajectory prediction for aircraft in evolution and did not have much confidence in system indications for such traffic.

  It was felt that simple rules' such as climb as soon as possible and descend as late as possible are no longer sufficient. The use of a trajectory editor may improve the trajectory matching with the planned or actual clearances issued.

It should be noted that controllers did not feel challenged by the traffic during the simulation exercises despite a traffic increase of 20% between high and low samples.

CONCLUSIONS

The motivation for C3T is based on the expectations that:

1. Task sharing will balance workload in the sector through validation and prioritisation of problems by the planner for the tactical controller;

2. Cost in workload to the controller (especially the tactical) and in economics to the airline will be reduced through early problem resolution;

3. Delegation to the pilot of separation assurance will increase airspace capacity through reduced controller workload;

4. Data link communication (CPDLC) will facilitate advance delivery of problem resolutions by planning controllers, and enable trajectory negotiation.

Airline economics were not part of these studies.

The model based simulation study concentrated on 1, 2 and 3 and was conducted in order to explore a number of hypotheses relating to the potential for reduced controller workload resulting from task sharing and PC empowerment. The EATCHIP III real-time simulation was conducted in order to validate the MTCD concept and investigate DST impact on working methods, tasks and roles; for C3T this included aspects of 1 and 2.

The results are considered to be encouraging for the introduction of task sharing and planning controller empowerment.

Concerning the hypothesis *"Improved task sharing can be achieved between sector team members..."*

The results in fast time simulation have demonstrated that the introduction of task sharing and PC empowerment may lead to reduced sector team workload with associated capacity benefits. The TC workload is seen to reduce in each of the organisations as PC involvement in conflict resolution increases. The PC workload is seen to reduce in task sharing, as a result of the introduction of SYSCO and modification of flight data management tasks, although increases in PC Empowerment as a result of the delegation of conflict resolution tasks. The PC workload remains at an acceptable level. There is a more balanced distribution of workload between the TC and PC.

"The use of SYSCO and CPDLC with the empowered PC role will increase sector capacity..."

The model capacity analysis performed demonstrated potential for capacity increase within the task-sharing scenario in excess of 35%. This figure is higher than initial expectations and now needs to be validated in real-simulation where more reliable information concerning workload and capacity issues will be gathered. (Note that in EATCHIP 3a-bis real time simulation, Controllers worked scenarios with a 20% traffic increase without a perceived change in workload.)

This study has used an existing fast time scenario as its baseline to provide a high level of confidence in the individual ATC tasks and their duration as well as the airspace and traffic samples. The development of the task timings for the task sharing and PC empowerment scenarios was performed using expert judgement as to the likely effect on tasks as a result of modified procedures and equipment availability. The results are sensitive to these timings.

In C3T real time simulation the next concept and scenario to be investigated, will be

- PC with ability to edit the trajectory and to test if these alternative are conflict free

- With full SYSCO version, PC will solve any Entry conflict. This PC empowerment should be accepted without any doubt.

- On the other hand, the ability to prepare and implement in-sector conflict solution merits an in-depth validation process. .

The concept of PC Empowerment opens up issues such as training and team-working which will need to be addressed when considering the Human Factors issues associated with the roles of the controller in the future in the face of increased automation.

C3T will simulate a PC Empowerment scenario related to the CORA project (EUROCONTROL - Conflict Resolution Assistant). It is hoped that this will be an iterative loop of real-time and fast-time studies where more detailed task timing information from real time study will be "fed back" into fast-time.

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