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Conflict Detection Tools Impact on Controller Taskload - Fast time study

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TITLE : Conflict Detection Tools Impact on Controller Taskload

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Summary:

The fast time simulation reported in this document aims at assessing the potential benefits of conflict detection tools (MTCD, TCT) for planning and tactical use by the controllers. The study is focused on i) the investigation of taskload reduction and taskload re-allocation aspects and ii) the evaluation of the ratio between controller taskload reduction and accuracy of MTCD/TCT tools.

The modelled airspace contains 6 MUAC sectors and the 24h regulated CFMU traffic sample from 19 July 2005 was used as initial traffic. Results were compared with a baseline situation without use of conflict detection tools. Fast time results showed an average taskload reduction of 12% when MTCD only was used (that was consistent with FASTI previous results) and a taskload reduction of about 21% when both MTCD and TCT were active. Taskload was evenly distributed across the two controllers (~48% Planner and ~52% Tactical) when both MTCD and TCT were active, while taskload distribution without use of conflict detection tools was less balanced (~36% Planner and ~64% Tactical).
With respect to accuracy of the tools, initial results showed that for 2% variance for TCT and 10% variance for MTCD, impact on taskload seems small, contained around the ideal values.

The results may feed subsequent real time simulations and may provide inputs to a business case study

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LIST OF ABBREVIATIONS

ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
BADA	Base of Aircraft Data
CMA	Critical Manoeuvre Alert
CFMU	Central Flow Management Unit
EC	Executive Controller
E-OCVM	European – Operational Concept Validation Methodology
FASTI	First ATC Support Tools Implementation
FL	Flight Level
FTS	Fast Time Simulation
GSP	Group Sector Planner
MTCD	Medium Term Conflict Detection
MUAC	Maastricht Upper Area Control
PC	Planning Controller
RAMS	Reorganized ATC Mathematical Simulator
R/T	Radio Telephone
SESAR	Single European Sky ATM Research
STAR	Standard Terminal Arrival Route
TCT	Tactical Controller Tool

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1 FOREWORD

1.1 BACKGROUND

The objectives of the experiments is to carry out additional analysis using fast-time simulation of the feasibility and performance of the new ***First ATC Support Tools Implementation*** (FASTI) Programme concepts developed by EUROCONTROL.

Initially, during a first series of simulations, a preliminary analysis of Medium Term Conflict Detection (MTCD) for different ATC configurations, including the Group Sector Planner (GSP) using FASTI methodologies and support tools has been carried out ([6]). In light of the results from that analysis, it was decided to do a supplementary analysis focusing more on the benefits and impacts of using additional FASTI tools (MTCD and the Tactical Controller Tool - TCT) particularly on the workload for a traditional sector controller team of one Planning Controller (PC) and one Tactical (Radar/Executive) Controller (TC).

The experiments of the current study were performed partially under WP7 of the contract 'ATC Modelling Support' (TRS08-220328-T) by ISA Software (preparation and modifications of the fast time platform).

1.2 PURPOSE

The fast time simulation reported in this document aims to assess the potential benefits of conflict detection tools for the controllers (MTCD, TCT). The study is focused on i) the investigation of task load reduction aspects and ii) the evaluation of the ratio between controller taskload reduction and accuracy of MTCD/TCT tools. The results may feed subsequent real time simulations. Conversely, real time simulations were required as input ([7]) to analyse and define working methods associated to the TCT utilization, so as to define a relevant TCT model and a corresponding working method.

The simulations are based on realistic models and on traffic sample consistent with SESAR assumptions. They complement work already performed in the FASTI framework, featuring the opportunity to consolidate the results gathered through this previous work, to build a competitive fast time platform and to broaden them with the assessment of new concepts.

For comparison purposes this report includes results from the previous studies carried out by EEC ([6]) and in previous work done under FASTI activity ([5]) using the same traffic sample and the same airspace. This document provides the description of the experiments carried out and the results obtained so far. More specifically, the analysis report will describe the modelling environment used, define the scenarios and metrics and provide and illustrate the results.

2 DESCRIPTION OF EXPERIMENTAL CONCEPTS

2.1 FASTI PROGRAMME

The First ATC Support Tools Implementation (FASTI) Programme aims at highlighting the need for the co-ordinated implementation and rapid deployment of an initial set of controller support tools (see [3][4]). The programme will address short and medium term requirements but will also enable the introduction of further automation in ATC in the longer term. The objective of the programme is to co-ordinate the implementation and deployment of controller system support tools, as required, across Europe by 2012, in a harmonised way.

2.2 CONFLICT DETECTION TOOLS FOR PLANNING AND TACTICAL USE

The objectives of the experiments are to investigate the potential benefits and impacts of the revised controller teams and advanced decision-support tools considered in the FASTI concepts, including:

- <u>Medium Term Conflict Detection</u> (MTCD) is an automated decision-support tool that detects conflicts between aircraft trajectories up to 20 minutes in advance. Due to the trajectory uncertainty occurring within the MTCD's longer conflict look-ahead time, false conflicts (conflicts that are predicted but do not occur) and missed conflicts (conflicts that will occur but were not predicted) are expected to occur.
- <u>Tactical Controller Tool</u> (TCT) is an automated tool that allows the tactical controller (Radar/Executive) to detect and resolve conflicts up to 8 minutes in advance. In addition, the TCT provides a *Critical Manoeuvre Alert* function which indicates situations to the Tactical controller where a flight may enter into conflict *if it fails to carry out a pending manoeuvre (turn / level-off).*

FASTI concepts are described in more detail in [3][4].

3 EXPERIMENTAL APPROACH

3.1 EXPECTED EXPERIMENT OBJECTIVES, OUTCOMES AND HYPOTHESES

The FTS experiments' objectives cover the following areas:

- Evaluate potential benefits brought by conflict detection tools (MTCD +TCT) on controllers' taskload in MUAC environment;
- Assess the impact of conflict detection tools accuracy on the controller's taskload;
- Consolidate and refine previous results, obtained with FASTI simulations, through an approach considering both planning and tactical controllers' tasks;

The expected outcomes of this experiment are mainly as follows:

- An assessment of the impact of MTCD+TCT on controllers activity

- An evaluation of the resulting expected controller workload reduction.

Various hypotheses were made in this study:

Hypotheses on the horizon times for which the conflict detection tools are active are consistent with FASTI concept definitions:

- 20 minutes for MTCD;
- 8 minutes for TCT.

These values are fixed for all runs. Conflicts are detected and solved by Planner and Tactical, respectively, only inside these horizons.

Consistent with FASTI Programme assumptions and schedule, both fast time models for TCT and MTCD provide support for conflict detection only, while the resolution is managed by the tactical and planning controllers without advisories from the tools.

To model MTCD and TCT effects a similar method as the one used by previous FASTI fast time study was employed:

- The fast time platform models only the effects of the controller support tools and not a real implementation of the tools. Thus, the approach is rather conservative, but easier to implement and effective for relative comparison between various airspace organisations.

Critical Manoeuver Alert (CMA) effect was decided to be modelled and simulated since is one of the key elements of the support brought by the TCT tool, having a direct impact on task load by reducing monitoring activity and avoiding future problems (by e.g. a clearance to be sure that an a/c will conform to the plan). The assumption made here, in fast time, was that the tactical controller trusts its tool and will spend less time to check and monitor potential conflict situations that may occur in case of a miss-manoeuvres as these situations are detected, monitored and highlighted by the CMA function.

3.2 SIMULATION PLATFORM

3.2.1 Selected Simulation Tool: RAMS Plus

All traffic, airspace, controllers and procedures were simulated using the RAMS Plus fast-time ATM simulation tool. RAMS Plus simulates traffic from a macro-to-micro level (gate-to-gate movements) depending on the fidelity of the scenario input data, where a single scenario can contain as many flights, sectors, and airports as required to represent a local to global ATM environment.

3.2.2 Concept modelling and implementation

The effects of FASTI concepts were modelled using a combination of existing RAMS Plus functionality (for MTCD alone– as used in the previous experiments, see [6]) and specific enhancements to adapt the model to the concepts relating to the TCT:

1. MTCD conflict detection was implemented within RAMS Plus using a sliding 20 minute look-ahead window, linked principally with the RAMS Plus Planning Controller model, but also available to the Tactical Controller.
2. TCT conflict detection was implemented within RAMS Plus using an 8-minute look-ahead linked to the Tactical Controller. In case of conflicts identified by the RAMS Plus Tactical Controller which would exist further than 8-minutes away, these conflicts are rescheduled for consideration once they are within the TCT look-ahead window.
3. TCT "*Critical Manoeuvre Alert*" (CMA) functionality – used in the tool to signal critical manoeuvres for any flight in the airspace which '*if missed*' may result in a spatial conflict with nearby traffic was modelled using new features in the RAMS Plus tool, developed specifically for modelling TCT CMA functions. The TCT look-ahead was set to 3-minutes in the RAMS Model parameters for the scenario.
4. A customised conflict resolution rule-base was developed to ensure that CMA type 'conflicts' are not treated by the RAMS Plus controllers in the same way as traditional separation conflicts, and to emulate real-world Planning Controllers with MTCD in place, as well as Tactical Controllers with both MTCD and TCT available.
5. A facility for creating a varying percentage of false and missed conflicts was added to the MTCD model using the same approach as in WP2 experiments.
6. A number of new dynamic workload conditions and relationships were added to assist with workload estimation, and to include reductions in workload identified by EUROCONTROL operational experts, when CMA functionality was used in the TCT tool.

TCT and MTCD were modelled using enhancements to the normal RAMS Plus conflict detection.

It should be noted the distinction between the use of detection mode and resolution mode within the fast time platform. Whereas the detection mode was modified in order to reflect TCT and MTCD behaviours the existing conflict resolution part was 'assigned' to the fast time controllers' model.

Controller workload task weights for conflict detection and resolution were also reduced in scenarios where the controller would have the assistance of the MTCD and/or TCT decision support tools.

Note that RAMS Plus conflict detection detects conflicts when the second aircraft to be involved in the conflict enters the planning or Tactical controller's window; thus it may detect conflicts more than 8 (or 20) minutes in advance depending on the Planning and Tactical control horizons. However, for the project purposes, conflict detection horizon was limited to maximum 20 minutes.

3.2.3 False & Missed Alert Modelling and Trajectory Prediction Uncertainty

In the fast time platform both TCT and MTCD provide false alerts and missed conflicts. The main rationale to develop this feature was to simulate a realistic trajectory prediction and to evaluate the impact on the controller task load in order to be able to derive performance requirements, since the TCT is not defined as a safety critical tool. Safety related aspects are not a direct goal here, but the rate of errors is something to be clearly identified as a safety requirement but outside the scope of this study.

To incorporate error due to trajectory prediction uncertainty within the simulator, a ***False Alert*** and ***Missed Alert*** model was included such that MTCD and TCT tools modelled in the study have increasing inaccuracy as the time/distance to the conflict increases. Additionally, where one of the aircraft involved in the conflict is manoeuvred for another problem in advance of a predicted MTCD/TCT conflict, the situation foreseen may no longer exist (i.e., if another conflict occurs and one of the aircraft is moved to resolve that conflict).

The MTCD model in RAMS Plus provides a sliding conflict probe that extends for a 20-min horizon where conflicts within the scope of the probe are re-assessed every 5-mins (i.e. at T0, the probe considers potential conflicts from T0 to T0+20min, at T5= T0+5min the probe is from T5 to T5+20 minutes etc.). The TCT model applies the same principle as the MTCD, where the settings for TCT are an 8-min look-ahead probe, repeated in 2-minute cycles. It should be noted that the conflict probe cycles are applied to an existing potential conflict already detected and are different from the trajectory update rate which is the same as current radar update rate.

For each of the tools, trajectory prediction inaccuracy is modelled by including an error factor for the probe as shown in the example in the diagram below:

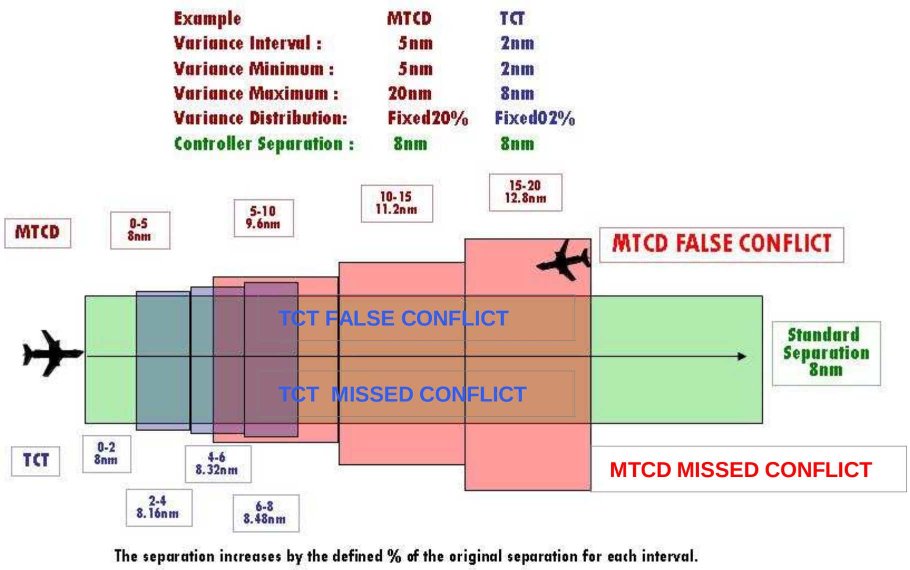

Figure 1: TCT, MTCD and False Alert models

As illustrated above, trajectory prediction uncertainty is modelled using a distribution which is applied to the controller separation being used for conflict analysis in increasing steps over the MTCD and TCT conflict probes. Each tool may have its own settings depending on their expected performance (MTCD having a lower accuracy) and for the purpose of this experiment, three trajectory prediction accuracy levels were considered in this study:

Level1 (no variance):

MTCD with 0% separation variance in steps of 5 with a maximum range of 20.

TCT with 0% separation variance in steps of 2 up to a maximum range of 8.

Level2 ('high accuracy')

MTCD with 10% variance in steps of 5 with a maximum range of 20.

TCT with 2% variance in steps of 2 up to a maximum range of 8.

Level3 ('low accuracy'):

MTCD with 20% variance in steps of 5 with a maximum range of 20.

TCT with 8% variance in steps of 2 up to a maximum range of 8.

The rate of errors can vary, going from a perfect detection (which is an ideal case even for the real world – i.e. a "perfect" TP) to less accurate levels. The current tested values for the TCT accuracy were a perfect rate (e.g. 0%), a 2% of false alerts at 8 minutes of horizon time and 8% (in order to see a clear trend in workload evolution). Due to lack of time, other combinations (as a perfect TCT + an inaccurate MTCD) were not tested.

However it should be noted that the perfect case is in the centre of the study. The missed and false alerts results are given for indication and can be used as a contribution for justification/support of specific values for safety requirements and tolerance of errors.

3.3 SCENARIO DESCRIPTION

3.3.1 Airspace

The airspace used in this study is that same as for previous study ([5][6])- comprising three MUAC en-route sectors (DD, MN and RR) each of which have been divided into two sectors each with a vertical split at FL335. This sector split was done to reduce the total workload particularly for the DD sector, the largest sector in the scenario, and to provide a more equitable test of the Group Planner concepts (tested in [6]).

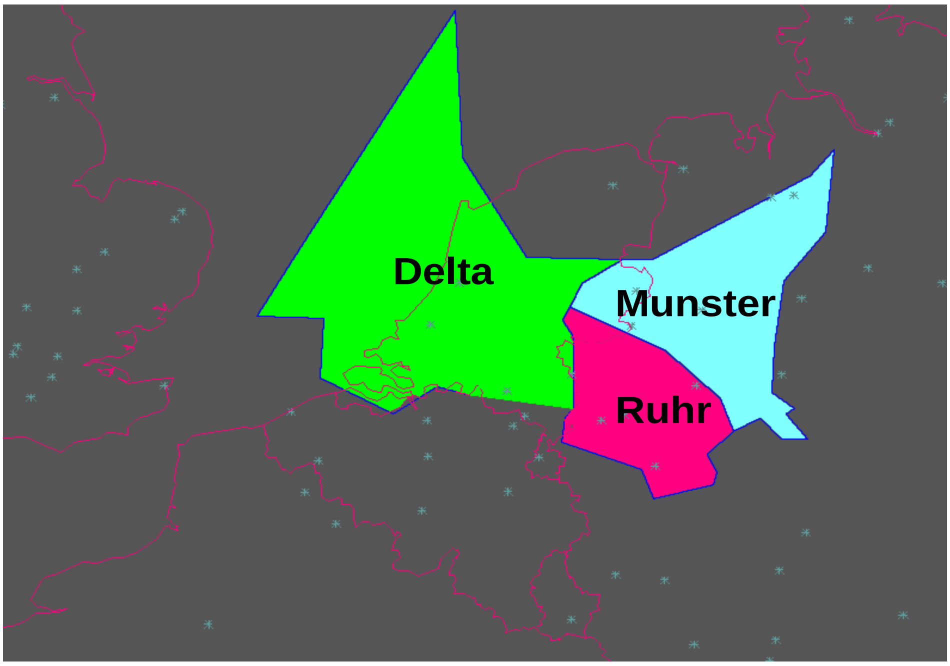

Figure 2 : Airspace

Table 1 below shows the name, floor and ceiling of the sectors measured in this analysis.

Sector	Floor	Ceiling
DDLO	245	335
DDHI	335	500
MNLO	245	335
MNHI	335	500
RULO	245	335
RUHI	335	500

Table 1. Sectors Measured

In addition to the MUAC sectors listed above, a number of adjacent "dummy" sectors were defined to enable MTCD conflict detection beyond the physical boundaries of the 6 measured sectors. The high altitude dummy sectors (FL245 and above) were defined as sectors belonging to MUAC (same centre) while the low altitude dummy sectors up to FL245 were defined as an external centre, thus providing a more realistic mix of inter- and intra-centre workload.

Simulation results for the dummy sectors were not included in the presented results.

3.3.2 Traffic

The traffic sample used in this analysis was provided by the FASTI Programme ([5]) and included a 24-hour traffic sample for the MUAC region based on 2005 traffic levels.

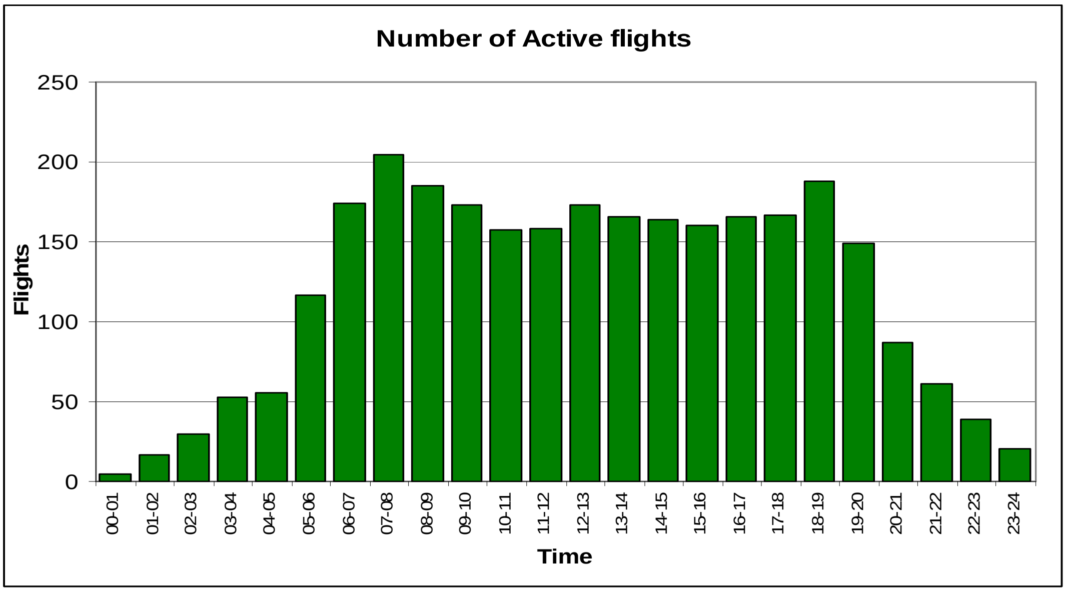

Figure 3: Hourly Traffic Load

No iterative analysis was used for this particular scenario, but the 24-hour traffic was used for each of the three settings of MTCD and TCT variance described in section 3.1.2.

3.4 CONTROLLER TASKLOAD MODEL

Baseline model for the task load definition is based on the recording of all control and co-ordination actions carried out between sectors by the tactical controller and/or planner. There are five main categories of tasks:

1. Flight data management tasks
2. Coordination tasks
3. Conflict search tasks
4. R/T Communication task and
5. Radar activity

This model is resulting from the NORVASE project used for an initial capacity study performed for MUAC. Designed by AENA, NORVASE model has also been used in CRDS fast-time studies. Its initial purpose was to establish criteria for determining ATM capability using standardised procedures and methods.

The baseline model was then modified by FASTI operational experts in two steps. Tasks and task weights have been adjusted to account for the assistance provided to the Planner Controller [5]and Group Planner controller [6] by MTCD. This model was implemented and adapted to RAMS platform in past experiment ([6]).

Then, for the purposes of this study The Tactical Controller tasks and taskload weights were adapted by FASTI operational experts and human factors experts to represent the Tactical

Controller with TCT active, and with the CMA functionality in place. Modifications were based on operational judgment and expertise combined with measurement from real-time simulation ([7][8]). This model was then translated in typical RAMS Plus Planner and Tactical controllers models. A number of the results in the following sections are based upon these taskload models.

3.5 TESTED ORGANISATION

3.5.1 Tested organisation: MTCD and TCT actives

As described previously the 24-hour traffic sample were used for the MUAC (6-sector) simulation scenario, with controller teams made up of 1 Planning and 1 Tactical controller with MTCD in place for the Planner and both MTCD and TCT in place for the Tactical:

- The **FASTI** scenario includes the **MTCD** model with a 20-min look-ahead for conflict alert repeated in 5-min cycles
- The **TCT** tool has an 8-minute Conflict Alert probe, repeated in 2-min cycles and Critical Maneuver Alert (CMA) functions active with a 3-min look-ahead.
- Task weights have been adjusted to account for the assistance provided to the controller by the MTCD and/or the TCT tool. (see 3.4)
- Trajectory prediction inaccuracy is modelled as described previous with three different pairs of parameter setting:
    a. Level 1: both MTCD and TCT with no variance (i.e. a perfect trajectory prediction)
    b. Level 2: MTCD 10% variance, TCT 2% variance
    c. Level 3: MTCD 20% variance, TCT 8% variance

Only results using Level 1 of accuracy (no variance) are compared with previous results, since all the previous fast time studies assumed a perfect trajectory prediction. Impact of inaccurate trajectory prediction (i.e. Level 2 and Level 3) will be separately assessed through random iterative runs.

3.5.2 Organisations used for comparison

For comparison purposes this report includes results from the previous studies carried out by EEC and in previous work done under FASTI activity – only for no variance in the trajectory prediction, and using the same traffic sample, as follows:

Baseline: MUAC (6 - sector) with controller teams made up of 1 Planning and 1 Tactical controller with no MTCD and no TCT - Results used for comparison are given in past experiments ([5])

Baseline + MTCD: (6 – sector) with controller teams made up of 1 Planning and 1 Tactical controller with MTCD in place for the Planner – Results used for comparison are given in past experiments ([5][6])

It should be noted that, even if the same traffic and airspace were implemented within RAMS for all three organisations, the aircraft performance model was improved from older BADA releases to the newest version of BADA 3.8 in this study. This leads to some inherent differences between simulations.

3.6 CHOICE OF METRICS AND MEASUREMENTS

The results will initially be evaluated according to the following metrics:

M1. Number of detected conflicts

M2. Controller taskload

Besides addressing directly the intended objectives of the concept, these metrics has commonly been used by other fast time and real time simulations. This choice thus makes it easy and straightforward to compare results amongst different projects.

Concerning the taskload metric, the results calculation is based on the measurement of the amount of time spent by controllers on a number of defined tasks, belonging to five main categories: conflict search, flight data management, co-ordination, R/T communication, and radar activity (monitoring) as defined in paragraph 3.4.

4 RESULTS

4.1 SUMMARY

In the first part this section provides results from the initial scenario (24-hours traffic for the 6 MUAC sectors, no variance for the tools) without any iterations being considered. In particular it looks at:

- o Traffic Loads in each sector over the 24-hour period
- o Critical Manoeuvre Alerts that would have been signalled to the Tactical Controller by the TCT tool
- o "Real" Conflicts identified in the simulation, and how they were resolved by the different Controllers
- o ATC Controller Taskload assessments, based on the adapted set of Controller Tasks taking account of CMA functionality and conflict detection support from the TCT tool.

In the second part, using the initial scenario, iterations are performed in order to asses the impact of tools accuracy variance. In particular it looks at:

- o How the False and Missed Alerts for each of the Controllers affects the total taskload.

4.2 TRAFFIC LOAD

Figure 4 shows the traffic loads over the 24-hour analysis period for the six MUAC sectors in the baseline scenarios. With the exception of Delta High, which shows several peaks over 40 flights per hour during the core period, most sectors reveal loads around 30 flights per hour.

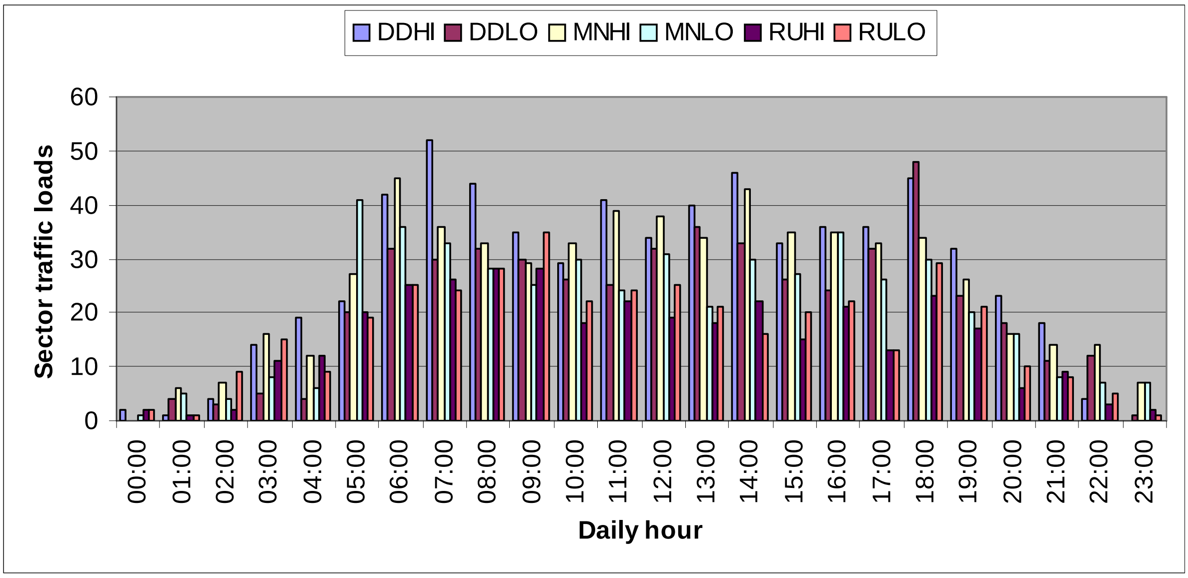

Figure 4 : Hourly Sector Traffic Load

4.3 CONFLICTS AND CRITICAL MANOEUVRE ALERTS

Figures 5 to 7 show the number of *"Real" Conflicts* and *Critical Manoeuvre Alerts* identified using the MTCD/TCT modelling in the 24-hour traffic period for each sector. The figures present ideal case when MTCD/TCT provides a perfect detection, i.e. no false alerts and no missed conflicts. Figure 5 shows the total number of conflicts and critical manoeuvre alerts per Sector (Tactical + Planner), whereas Figure 6 and 7 show hourly evolution of the conflicts.

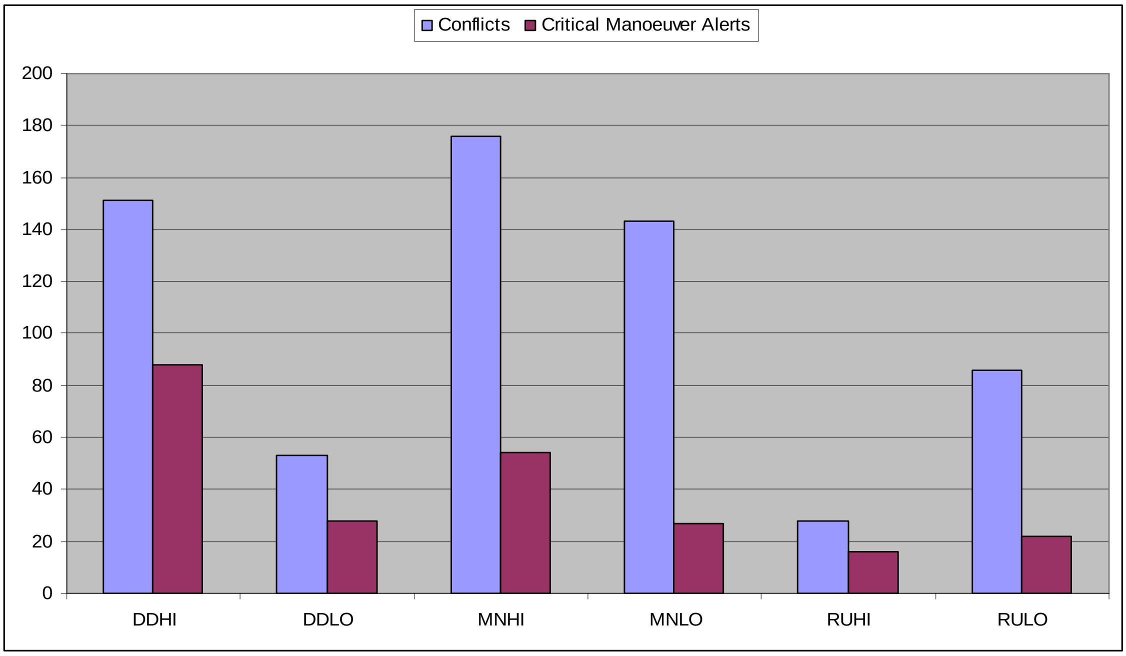

Figure 5: Total number of Potential Conflicts (Planner), Tactical Conflicts and Critical Manoeuvre Alerts

It should be noted that most of these potential conflicts are detected by the Planner Controller supported by MTCD, by checking entry / exit flight levels. Since the MTCD detection is based on planning trajectories only, the number of potential conflicts could be important. However only a reduced part become tactical conflicts solved by Tactical Controller within a horizon less than 8 minutes. As expected the critical manoeuvre alerts are mainly reported in sectors having many evolutive flights as Delta High and Munster High at peak hours (morning and afternoon).

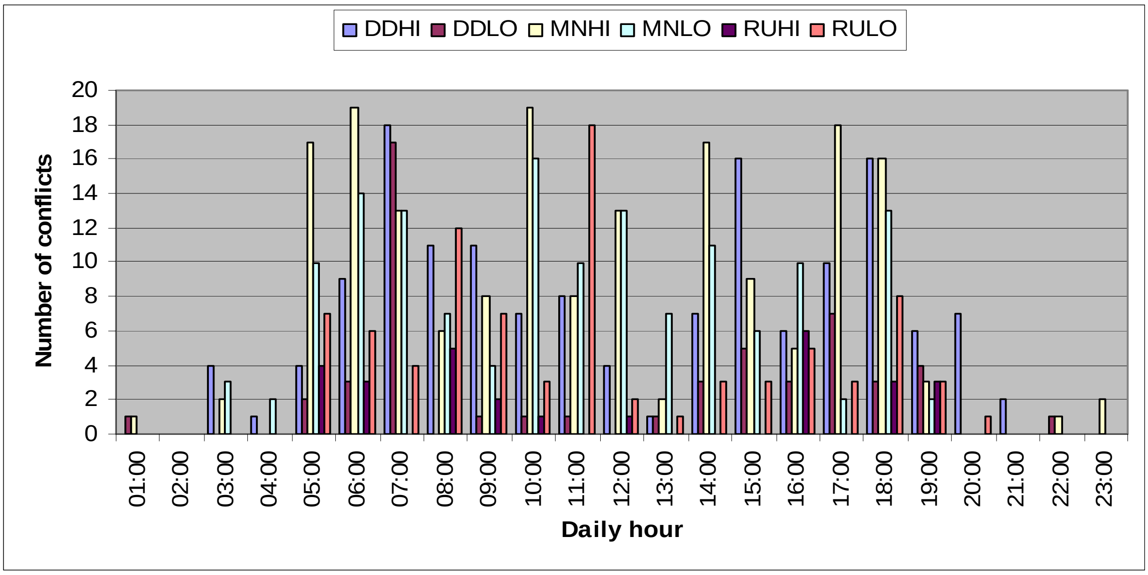

Figure 6: Hourly number of conflicts per sector

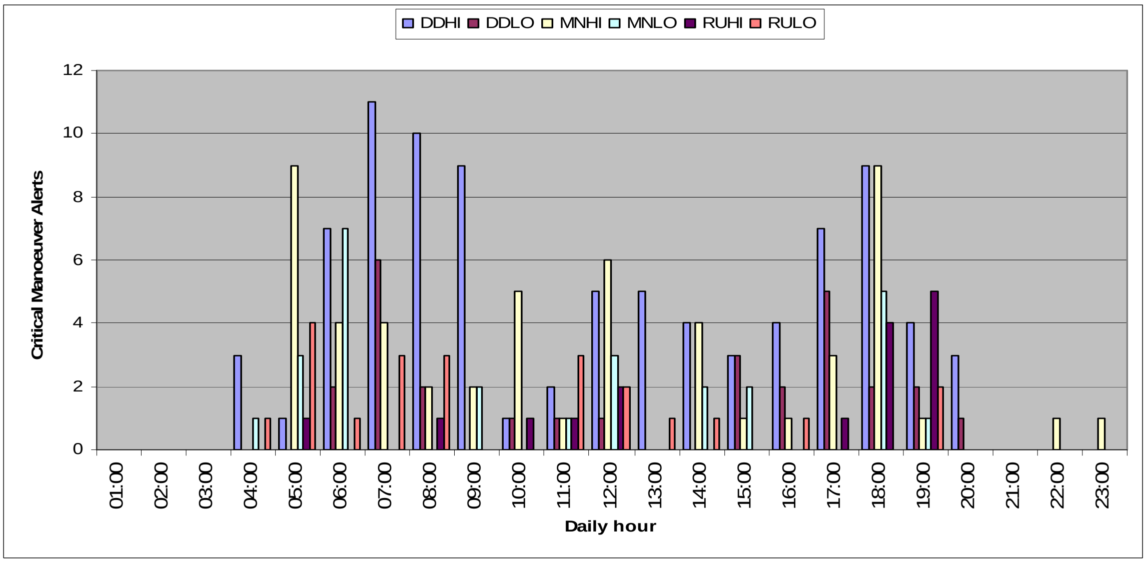

Figure 7: Hourly number of critical manoeuvre alerts per sector

4.4 CONTROLLER TASKLOAD RESULTS

This section presents controller taskload results for the controller teams working sectors with FASTI tools (MTCD & TCT with *Critical Maneuver Alerts* active) for the 24-hour traffic scenario.

4.4.1 Total Taskload for Controller Teams and Distribution of Taskload

The following charts (Figure 8, Figure 9, Figure 10) show for each organisation the division of total controller taskload by sector and controller in minutes over the entire 24-hour period, excluding the dummy sectors, which were not tabulated. Total taskload for all three organisations together is shown in Figure 11. In previous experiments with no additional FASTI tools (Baseline) or with MTCD only (Baseline + MTCD) , taskload figures reported were higher than when the TCT tool is also in place, as shown in the charts below, which include results from the previous studies carried out by EEC and in previous work done under FASTI activity.

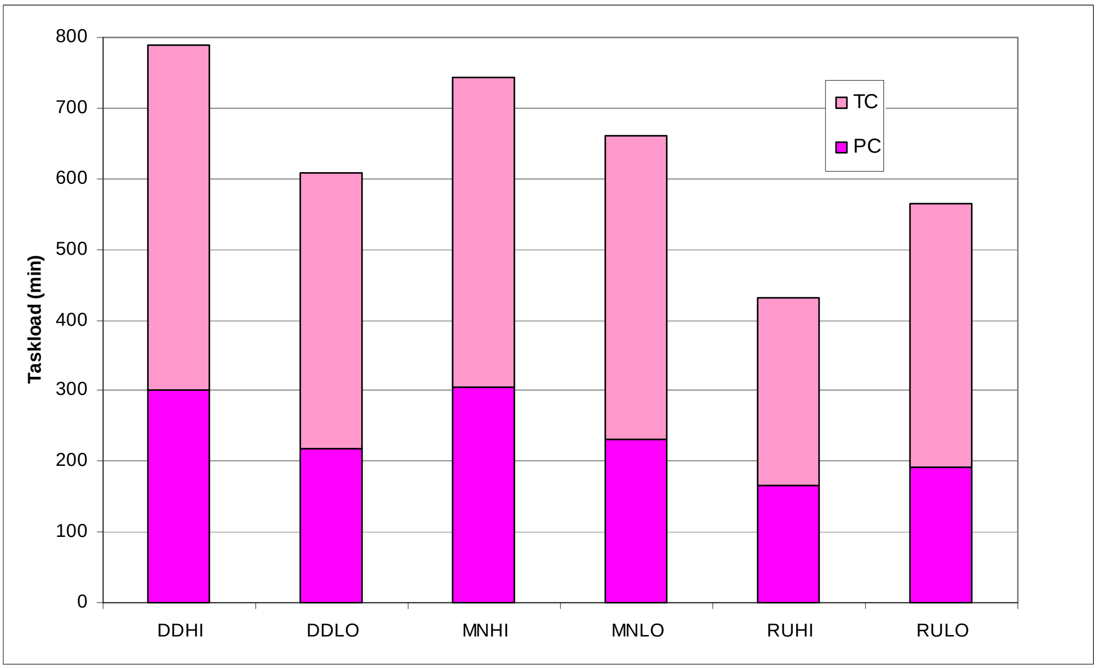

Figure 8: Total Taskload by Sector/Controller (Baseline: no MTCD, no TCT)

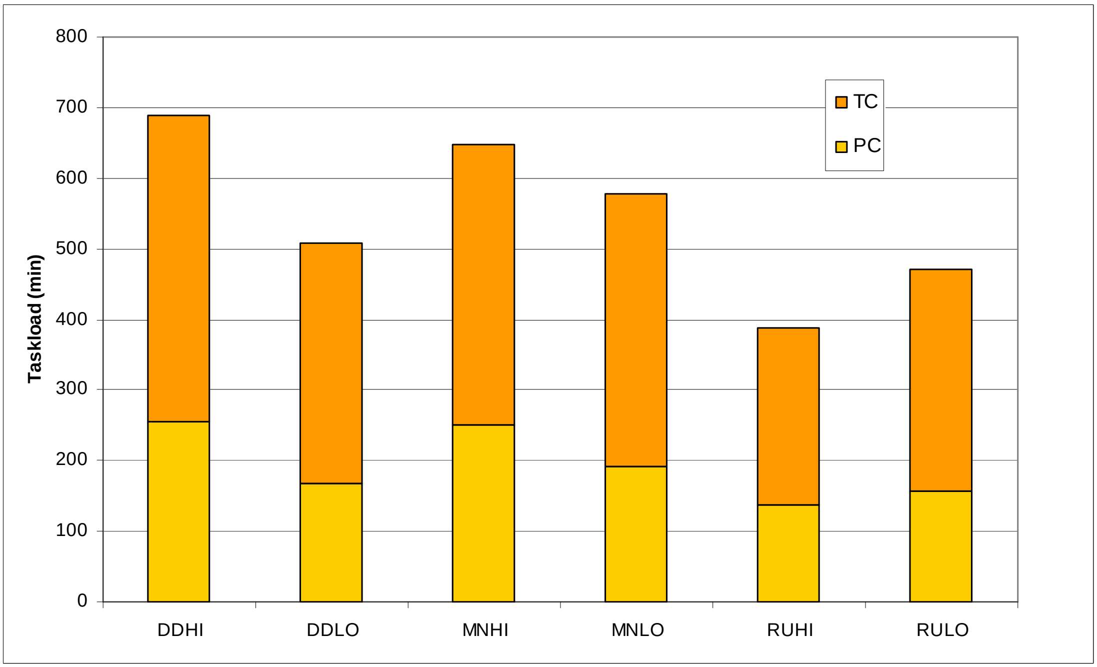

Figure 9: Total Taskload by Sector/Controller (Baseline + MTCD, no TCT)

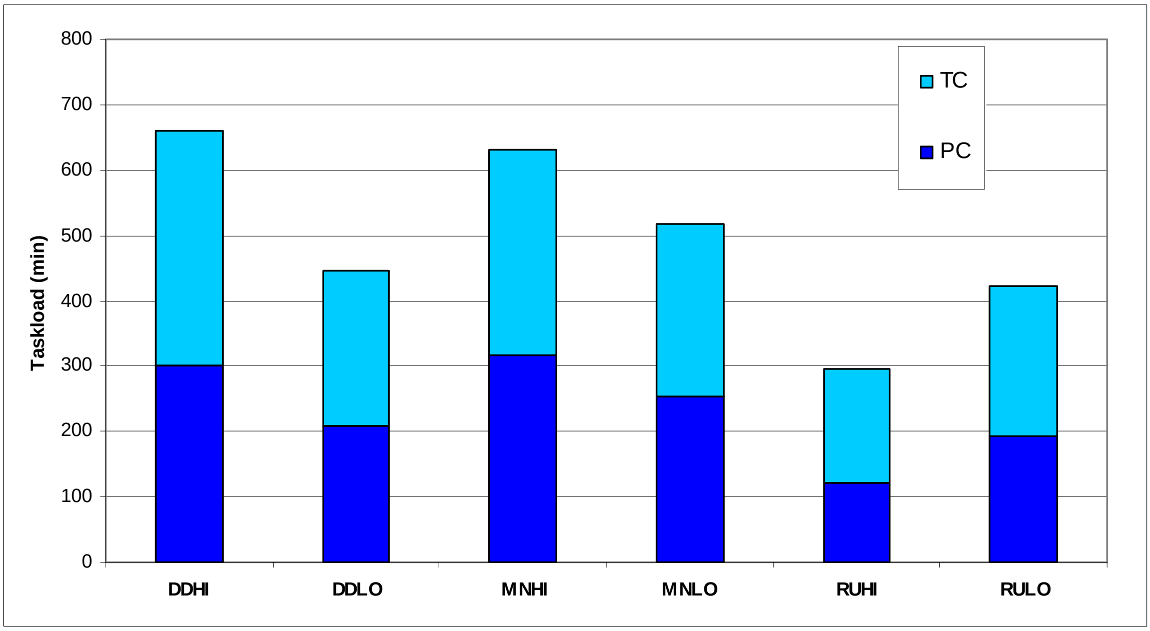

Figure 10: Total Taskload by Sector/Controller (Baseline + MTCD + TCT)

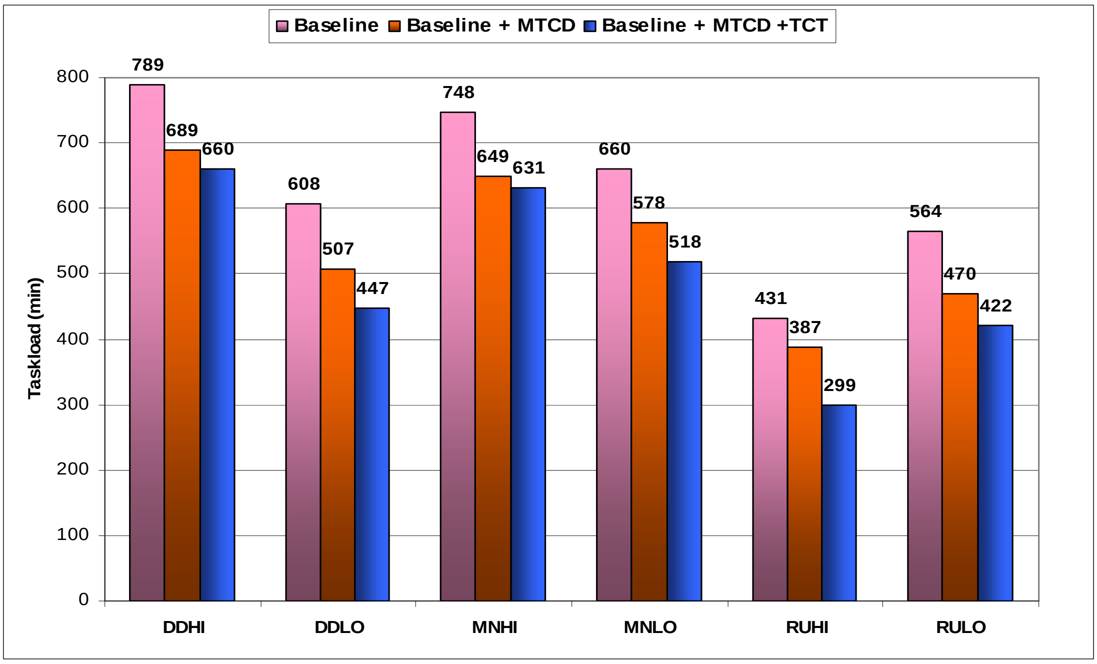

Figure 11: Comparison of total taskload by sector and organisation using FASTI tools

The results also show a good balance of taskload between the two controllers which is further confirmed in the following charts which show the % load for each of the controllers analysed in each of the three organisations. Figure 12, Figure 13, and Figure 14 show how the total distribution of taskload between Planner and Tactical (in percentage) varies as a function of organisations.

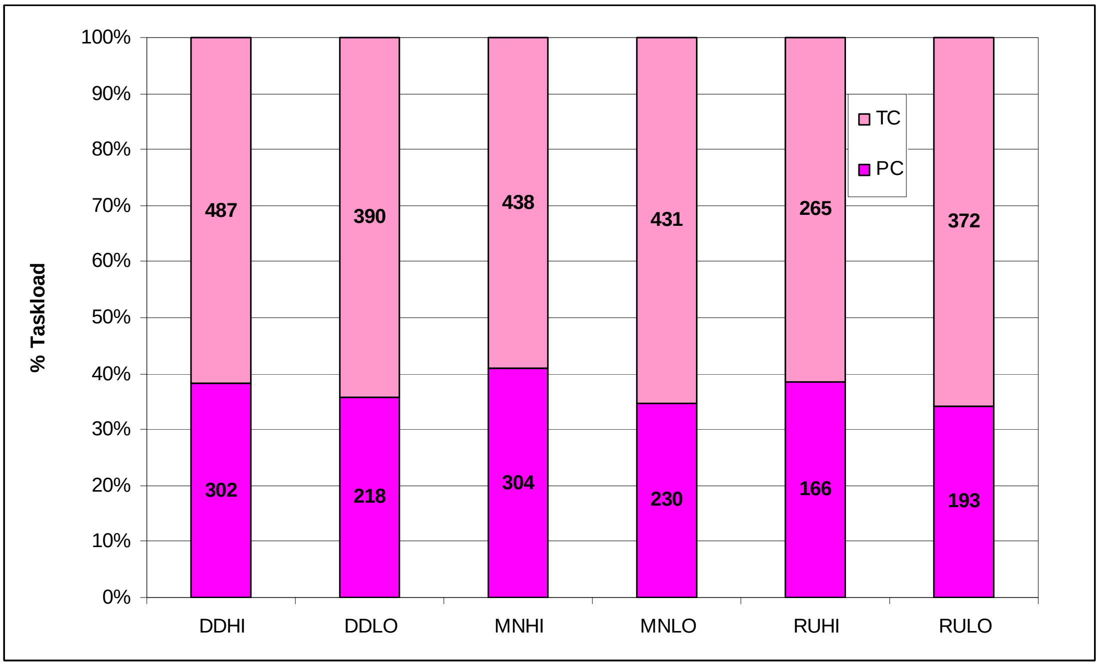

Figure 12: Distribution of Taskload (%) by Sector/Controller (Baseline, no MTCD, no TCT)

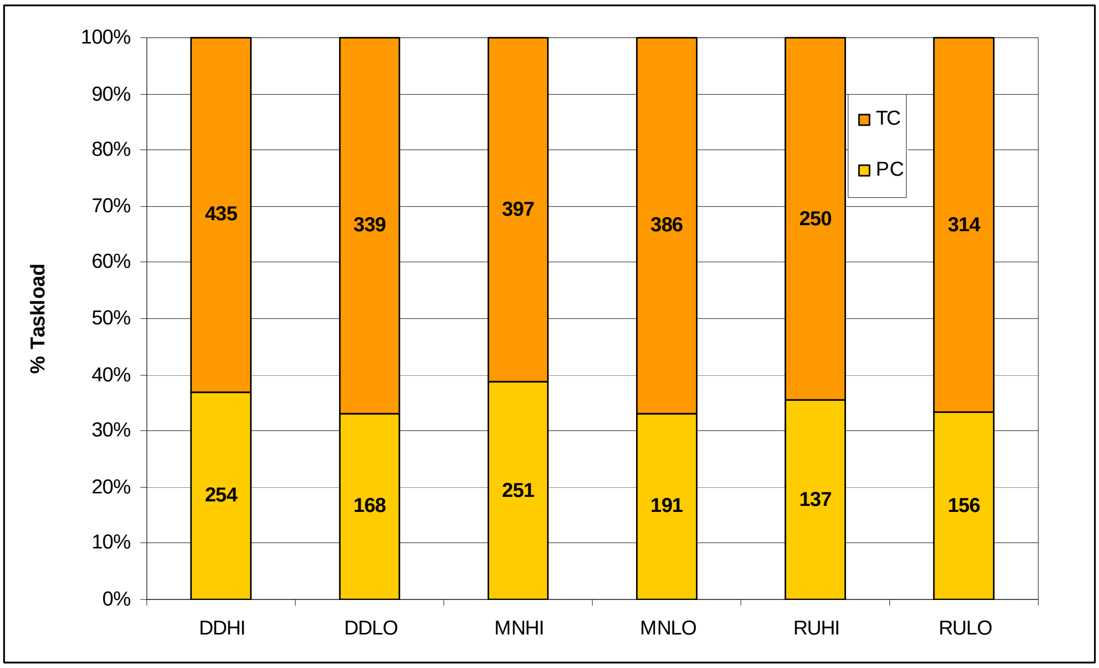

Figure 13: Distribution of Taskload (%) by Sector/Controller (Baseline + MTCD, no TCT)

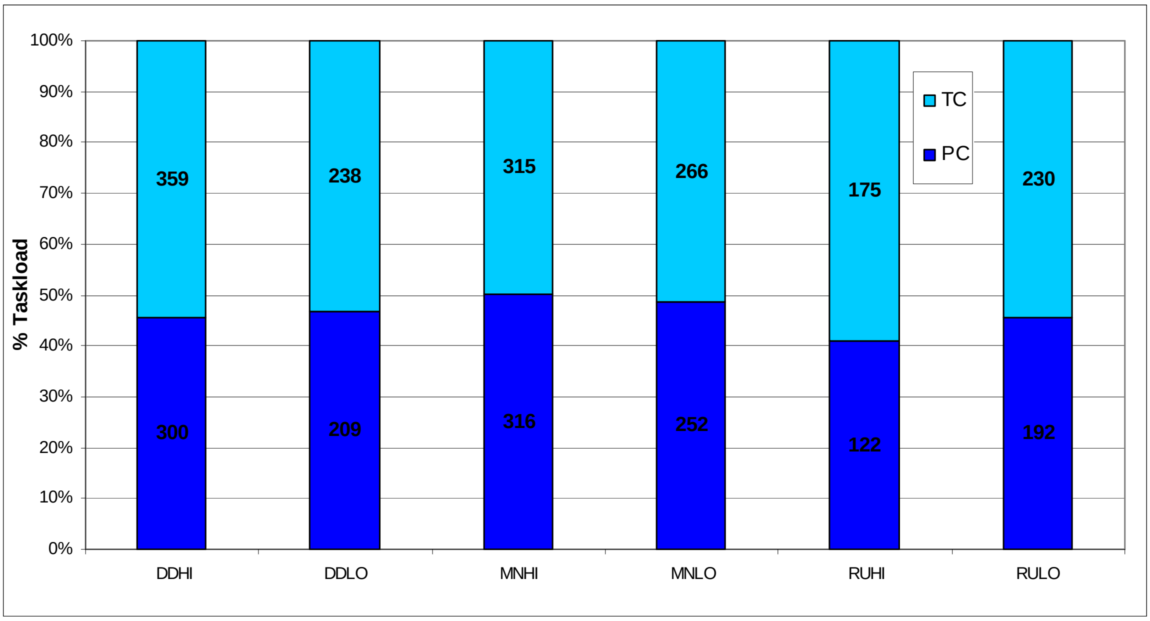

Figure 14: Distribution of Taskload (%) by Sector/Controller (Baseline + MTCD +TCT)

4.4.2 Taskload by Category for Controller Teams

Over the 24-hour period, the different categories of controller tasks as described by NORVASE model are distributed as shown in the following charts as function of sector and organisation:

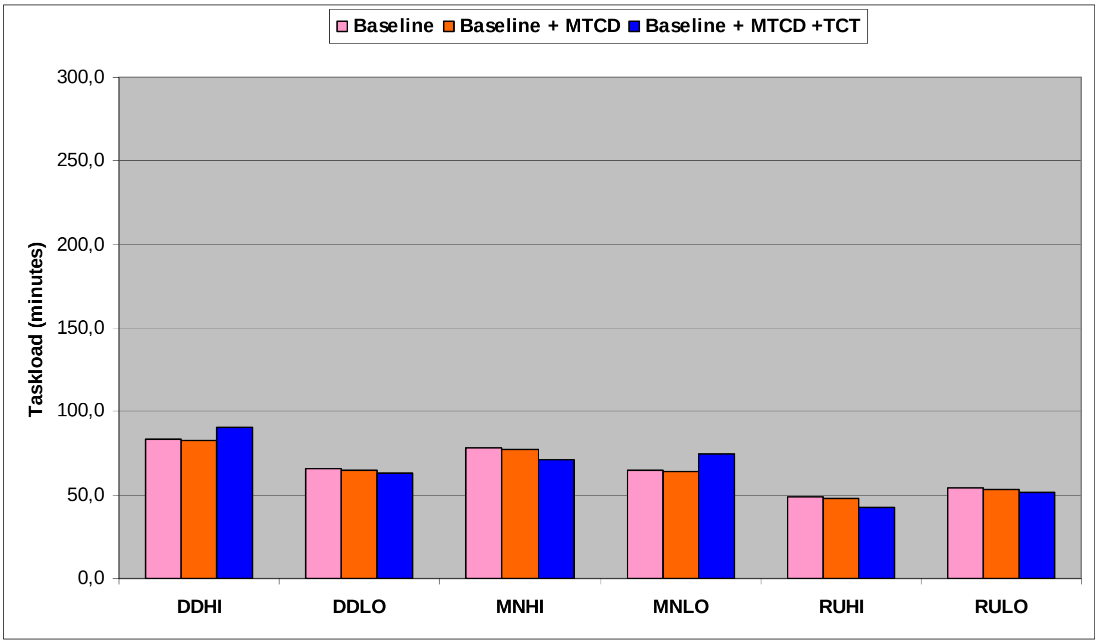

Figure 15: Flight Data Management taskload per Sector and organisation

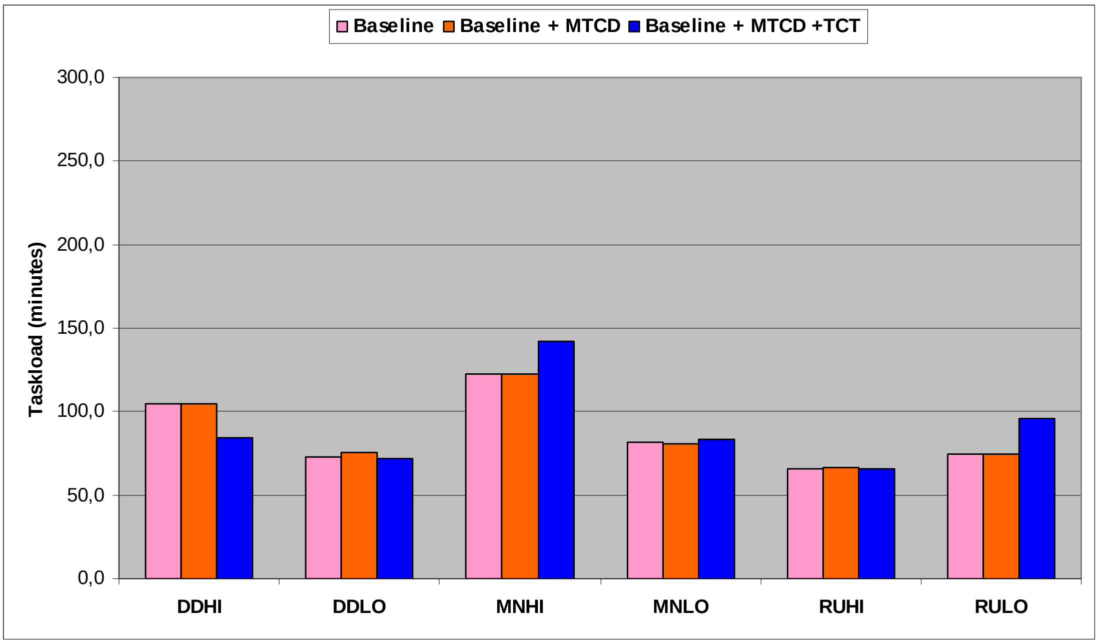

Figure 16: Coordination taskload per Sector and organisation

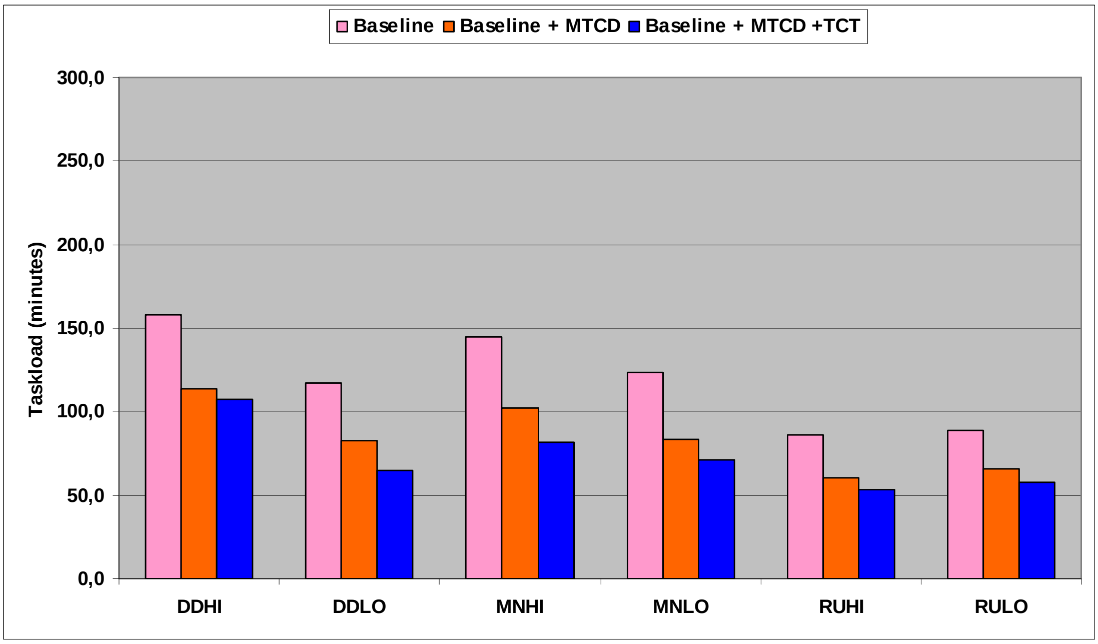

Figure 17: Conflict Search taskload per Sector and organisation

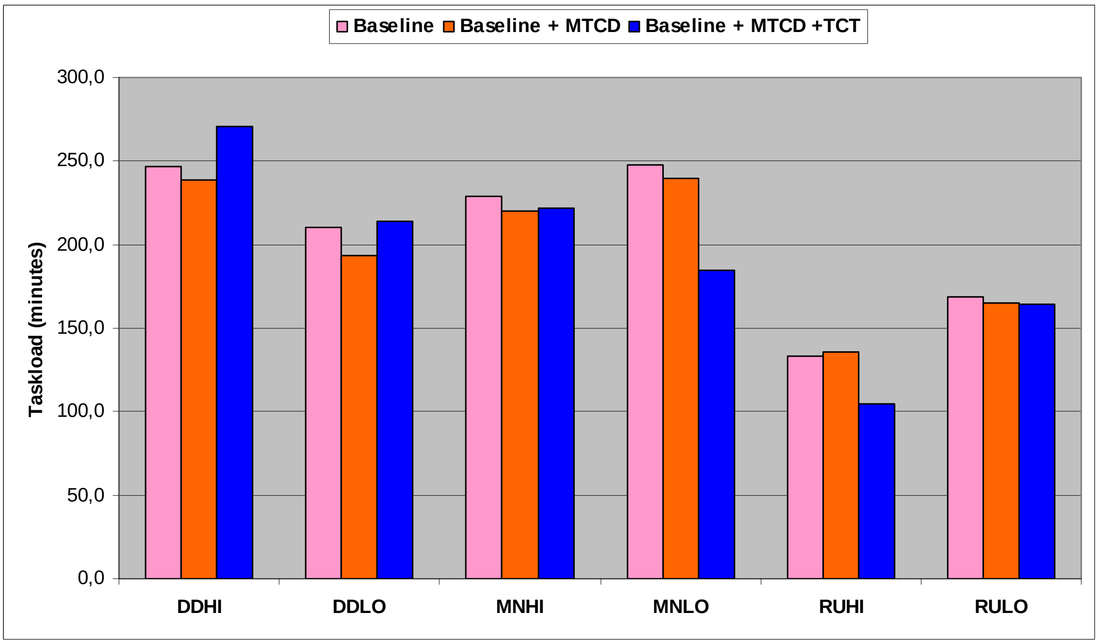

Figure 18: R/T Communication taskload per Sector and organisation

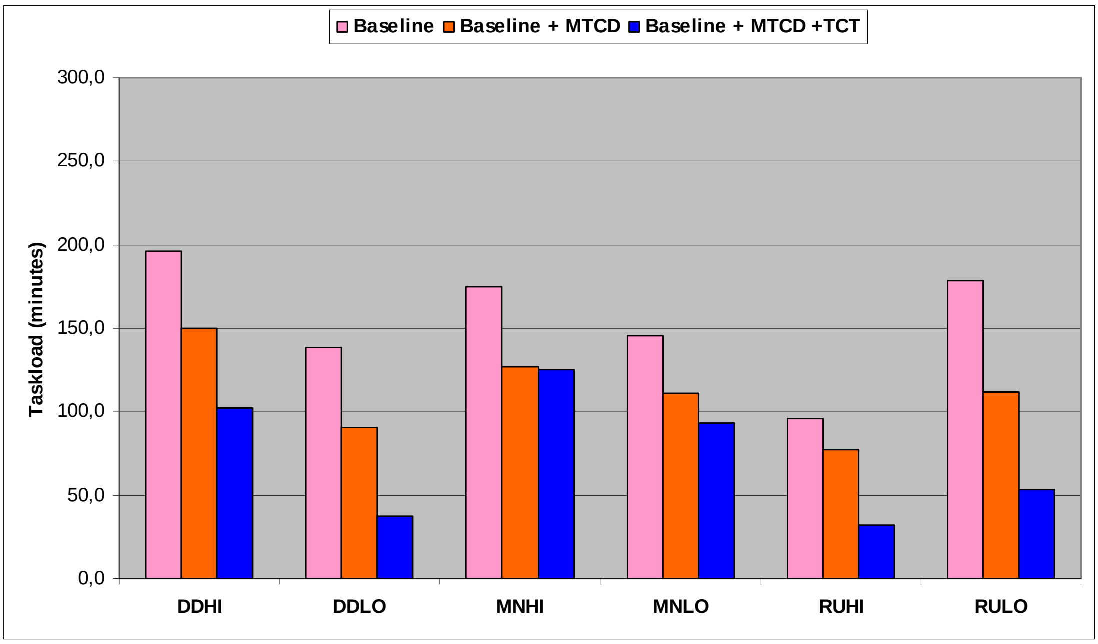

Figure 19: Radar Activity taskload per Sector and organisation

As noted in previous experiments, taskload is reduced when TCT is active across all sectors particularly within the Conflict Search (by ~39%) and Radar Activity (by ~52%) groups (i.e. those linked directly to conflict identification and resolution) whereas a small increase in taskload was noted for the coordination tasks, confirmed by operational observations. Flight Data Management Tasks were found to be similar for all organisations (as expected, because the same traffic sample was used, i.e. the same number of aircraft) while a small decrease in the R/T Communication tasks (6%) was noticed, this may be due to a better conflict detection & resolution management.

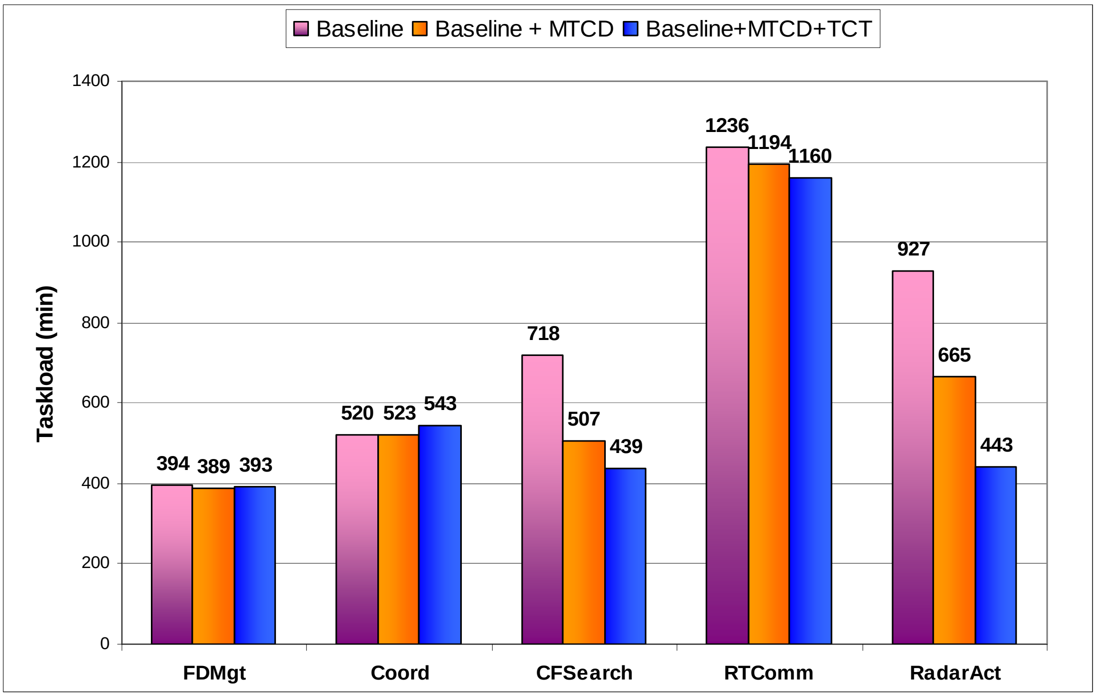

Figure 20: Comparison of total taskload by category and organisation using FASTI tools

4.5 SENSITIVITY ANALYSIS OF THE TOOLS ACCURACY

As indicated in previous sections, the conflict detection tools have initially been modelled as "perfect" – i.e. they do not generated false alerts and no conflict is missed. The models have been refined through the addition of errors (see 3.1.3). The single traffic scenario was used by carrying out multiple iterations to obtain a statistical significance of the analysis. For the two chosen levels of tools accuracy (see 3.2.3), the initial entry traffic was randomly perturbed within +/- 2 minutes with respect to the initial entry time. For each level 10 random iterations were performed.

The impact of false alerts and missed conflicts is illustrated in Figure 21, which gives the average ratio and standard deviation of additional taskload induced as a function of the false alerts rate. The analysis conducted indicates that:

- For 2% variance for TCT and 10% variance for MTCD, impact on taskload seems small, contained around the ideal values.
- Additional taskload induced by the existence of false alerts increases significantly when the false alerts rate grows beyond 8% for TCT- this could thus be targeted as a worst case performance figure for MTCD;
- A false alerts/missed conflicts rate of 20% MTCD and 8% TCT would literally withdraw the taskload reduction which was brought by MTCD/TCT usage

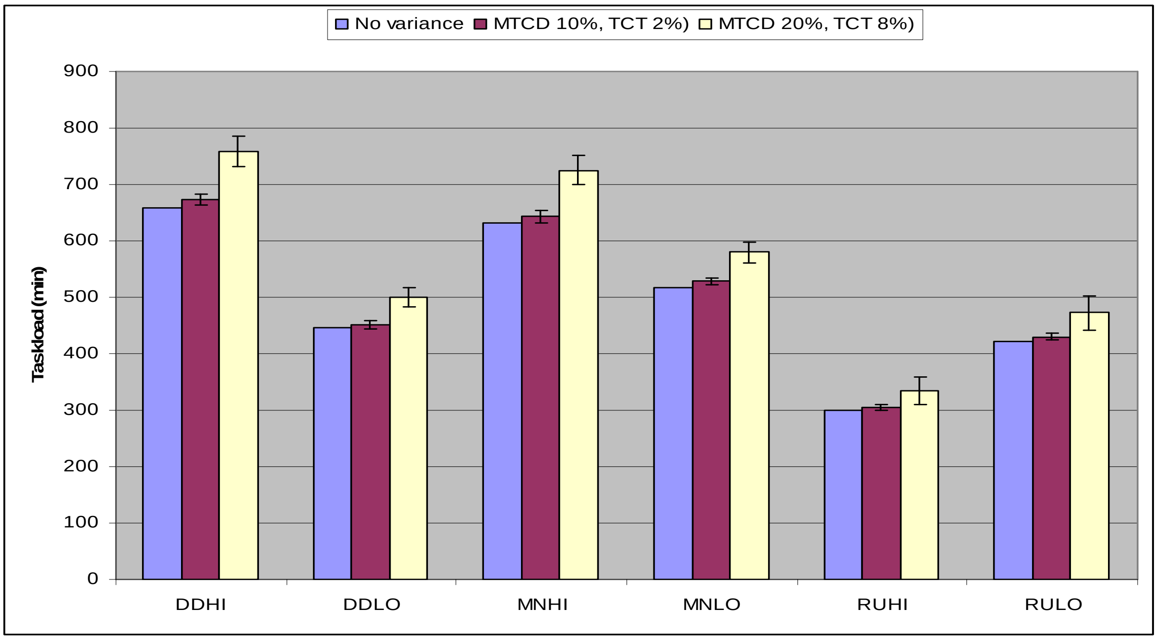

Figure 21: Taskload variation as function of false alerts and missed conflicts rates

However, given that only an initial single traffic scenario was used, we cannot discount any benefit that may be achieved without carrying out more traffic samples to increase the statistical significance of the analysis. Even if the traffic was perturbed by iterative iterations, since the same traffic sample was used, the number of conflicts and geographical localisation of these conflicts may not vary significantly between iterations.

5 CONCLUSIONS

The results indicate that the inclusion of the conflict detection tools (TCT as well as the MTCD) offers a further reduction of taskload for the classic PC/TC control team (see Table 2, comparison with baseline) but more over that the balance of taskload that is shared across the two controllers is evenly distributed, even in the sectors where many conflicts are identified (Figure 22, comparison with baseline). Note that the values in the table are rounded to the nearest integer.

	FDMgt	Coord	CFSearch	RTComm	RadarAct	Total
Baseline	394	520	718	1236	927	3795
Baseline + MTCD	389	523	507	1194	665	3278
Baseline + TCT+MTCD	393	543	439	1160	443	2979
Taskload reduction MTCD	1%	-1%	29%	3%	28%	14%
Taskload reduction MTCD + TCT	0%	-4%	39%	6%	52%	21%

Table 2. Summary of Taskload variation as function of organisation and category

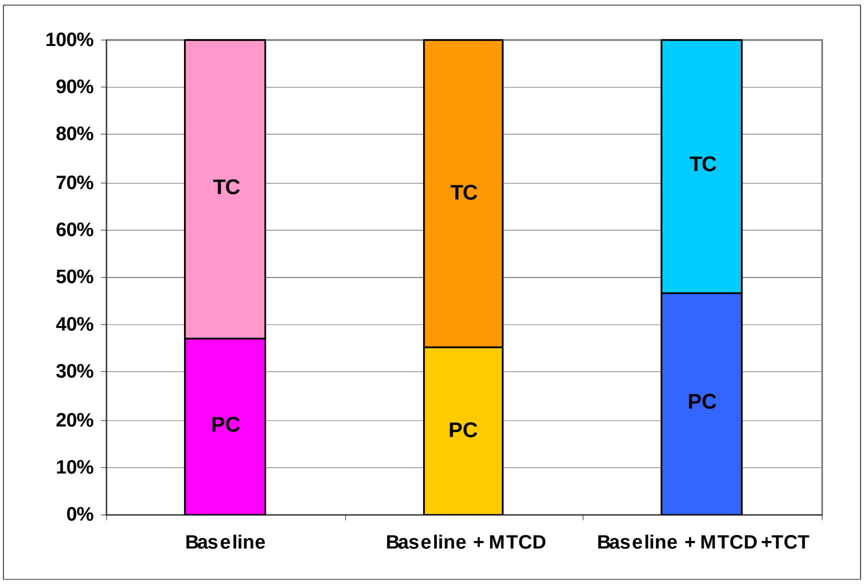

Figure 22: Distribution of total Taskload (%) by Organisation/Controller

At this stage of the project, the main conclusions derived from the experiments can be summarised as:

- Consistency with FASTI previous findings: the results obtained for the "Baseline+MTCD" configuration are very similar to those of FASTI programme regarding an equivalent environment: the measured task load reduction provided by MTCD with respect to the

"Baseline" (no detection tools) is in the order of 14%. This brings confidence to the results obtained for other configurations;

- In a "TCT+MTCD" environment, the overall task load is reduced by 21% with respect to the "Baseline" (no detection tools) and the taskload sharing between controllers looks more balanced in this new configuration (48% Planner and 52% Tactical).
- For accurate prediction of trajectories (i.e. a TCT rate of false alerts/missed conflicts = 2%, and MTCD rate) impact on taskload seems small, contained around the ideal values.

However, initial observations suggest that trajectory prediction inaccuracy for the TCT with the settings used in the different scenarios can result in false alerts which could be 25% higher than the number of real conflicts in the busier sectors. However, we would recommend further analysis of the actual impacts using multiple iterations as the model is somewhat dependant on the traffic organisation, so runs based on a single traffic sample will not provide statistically significant results.

5.1 RECOMMENDATIONS FOR FUTURE WORK

Considering the results obtained so far, it is recommended to go on with the project's subsequent steps, and in particular to focus on:

- Analysing the impact of the single use of TCT. As a pre-requisite for this, a detailed definition of TCT working alone methods will be required from operational experts;
- At the moment, the CMA contribution is included in the middle of the total TCT contribution. Further study could be to make separate runs with and without CMA to prove its utility;
- Refining the analysis of the false alerts/missed conflicts rates and its sharing between Tactical and Planner, with the objective to derive more detailed minimum performance requirements for the detection tools;
- Extending the analyses to traffic samples representative of SESAR forecasts for 2015 and 2020 and/or to other airspace than MUAC.

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