

APPENDIX C

PD/1+ TRIAL RESULTS

C1 INTRODUCTION

This technical Appendix presents in full the results from the PD/1+ trial, conducted under WP6 of the NATS PD/3 IOCP. The results are summarised and discussed in the main body of the final report.

This appendix assumes familiarity with appendix B which describes the measurements made, the planned analysis, and the methodology applied during the analysis phase.

Section CC2 gives an indication of the scale and range of each measure employed in the PD/1+ trial analysis. Appendix B gives a thorough description of these measures.

Section CC3 contains the results of the statistical significance testing carried out, and includes relevant results and comments from the questionnaires, debriefs and comment sheets. Each low level objective of the PD/1+ trial (see appendix B) is addressed in turn.

C2 DESCRIPTIVE STATISTICS

Descriptive statistics, usually in the form of a graph, were produced for each analytic measure prior to the statistical tests being carried out. This was to give an indication of the size and range of each measure, and an initial comparison between the ORGs. A statistical difference cannot be inferred from the graphs alone. Note that in the case of some measures, only ORG1 and ORG2 were of interest, as they reflect some specific aspect of tool usage, or controller workload, that the GHMI and PATs modifications were intended to address.

An additional reason for producing descriptive statistics for each measure, was to avoid further statistical analysis if a measure was of little descriptive value. For example, when it was observed that attempts to use the HIPS speed problem solver (SPS) for aircraft without datalink were rare, such as one attempt every three exercises, there was little value in further analysing the measure.

The graphs that were produced are given in this section. Unless stated otherwise, the vertical bars on the graphs represent the 25th and 75th percentile range of the measure in question, and the centre point represents the median. The median is robust to skewness and can also be used for data which is ordinal. The range is represented using the 25th and 75th percentiles so the influence of outliers is eliminated.

C2.1 ISA

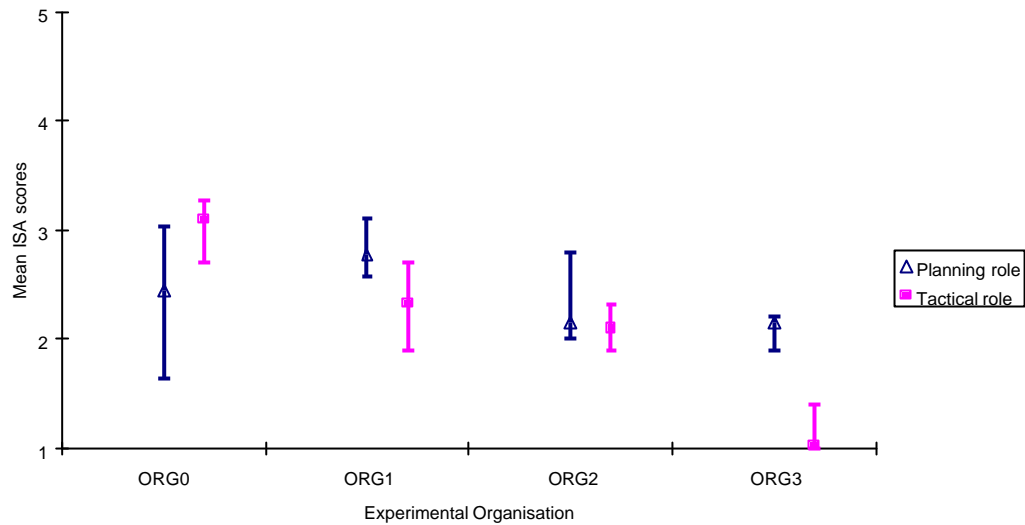


Figure C1 - Mean ISA for each ORG

Figure C1 shows the median of the mean ISA values, for each ORG and for each of the controller roles. Note that ISA values from only two of the planning controllers were available. One planner was lost to sickness before the completion of ORG1 and remained unavailable for ORGs 2 and 3. Comments made during the debrief sessions by a second planner led us to conclude that the ISA scores recorded did not accurately reflect the perceived workload. It appeared from observation that this controller had been selecting the nearest button (“under-utilised”) to stop the flashing. However the same controller’s TLX scores corresponded well with the debrief comments and hence were not excluded from the analysis.

Mean ISA has been presented here to be consistent with the results in the PD/1 Final Report. As there is a variation in the way that individual controllers interpret each ISA score, the mean ISA serves only to represent the trend between ORGs. The corresponding results from the PD/1 trial have been super-imposed on the chart below, to assist comparison. Note that there were many ways in which the PD/1 and PD/1+ trials differed, for example the traffic samples simulated, the individual controllers and the number of controllers. Figure C2 serves only to compare the trends in workload between the two trials and not the magnitude of changes in workload, hence the ISA scale has been omitted. Note that the PD/1 ORGs 0 and 2 (70%) correspond with the PD/1+ ORGs 0 and 1 respectively. The PD/1 results were from exercises with medium and high levels of traffic volume, whilst the PD/1+ results also include low levels of traffic volume.

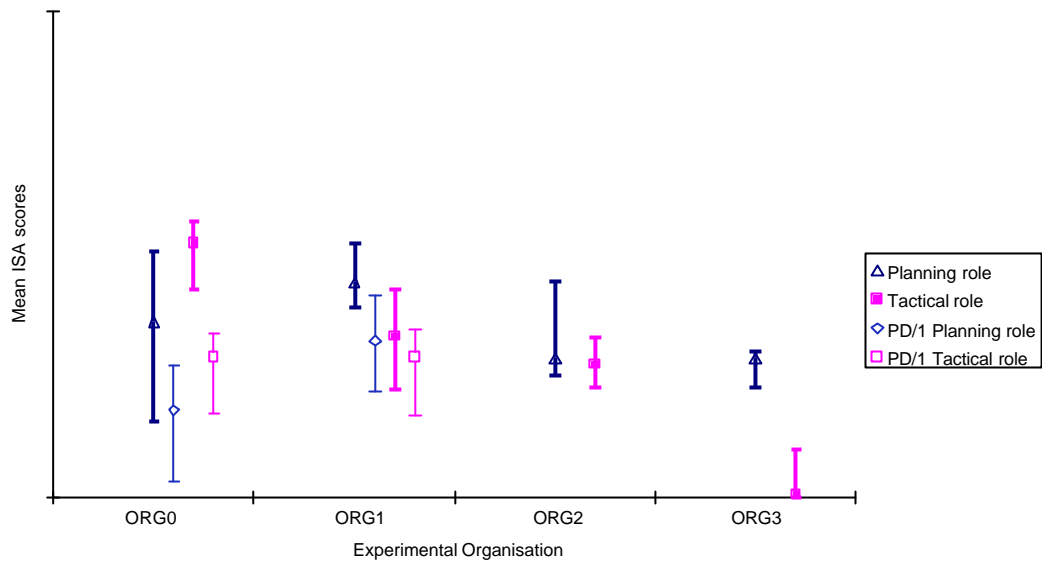


Figure C2 - Mean ISA for each ORG, including PD/1 ORG0 and PD/1 ORG2 (70%)

C2.2 TLX

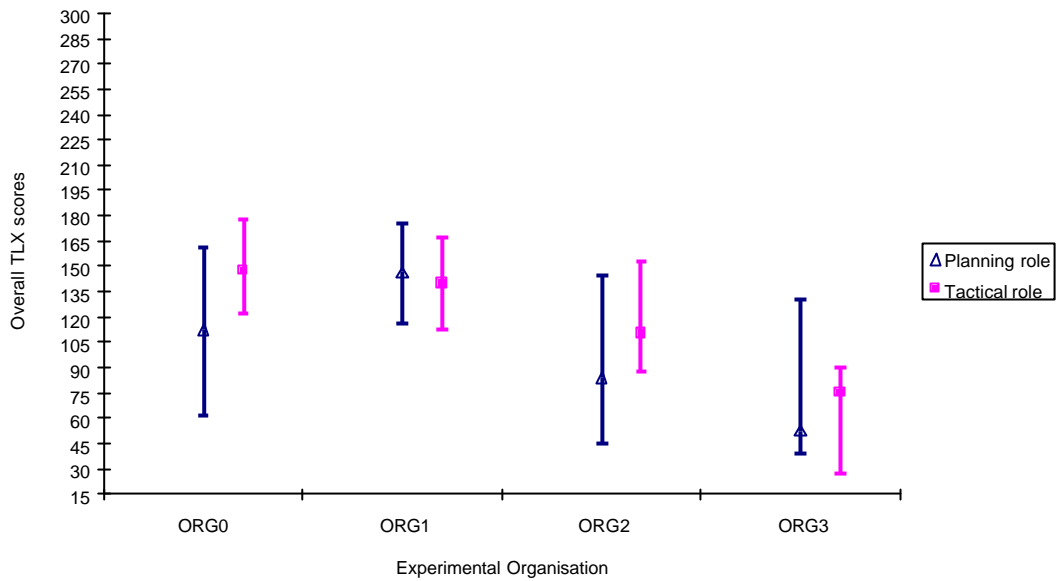


Figure C3 - Overall TLX for each ORG

Figure C3 shows the median of the overall TLX scores, for each ORG and for each of the controller roles. Note that overall TLX scores range from a possible minimum of 15 to a possible maximum of 300. Figure C4 and Figure C5 below show the medians of the TLX time pressure scores and TLX frustration experienced scores, which are components of the overall TLX subjective measure of workload. The TLX factor scores scale covers the range from 1 (minimum contribution of factor to workload) to 20 (maximum).

Note that TLX scores from only three of the four planning controllers were available, since one planner was lost due to sickness halfway through the trial.

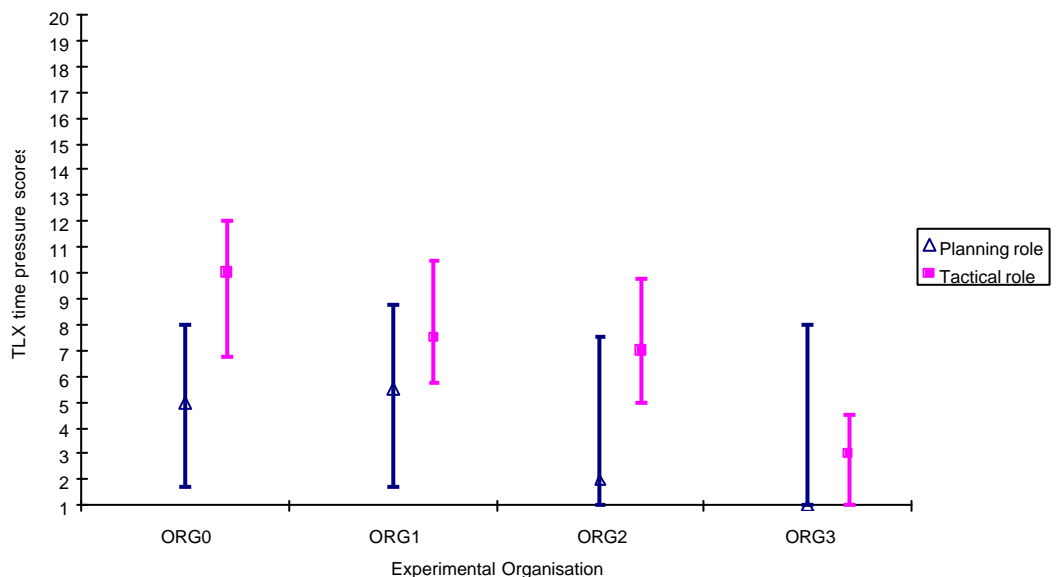


Figure C4 - TLX time pressure for each ORG

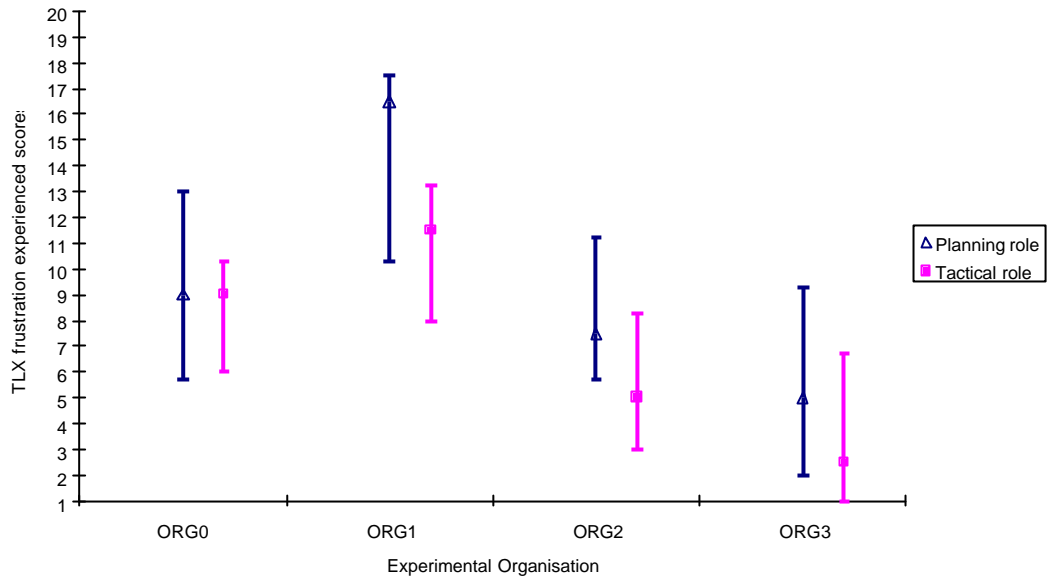


Figure C5 - TLX frustration experienced for each ORG

C2.3 Percentage of time spent using R/T

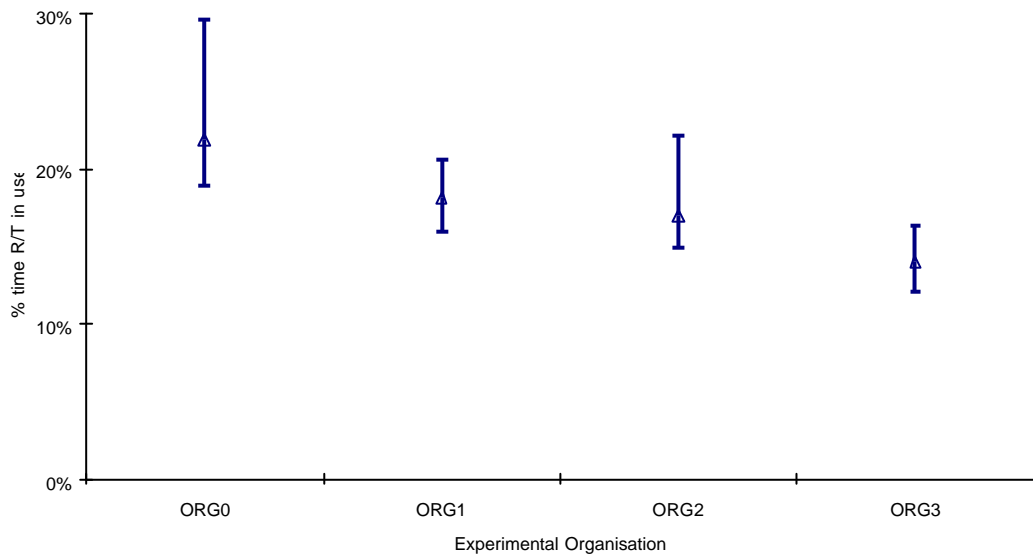


Figure C6 - Percentage of time spent using R/T for each ORG

Figure C6 shows the median values of the percentage of time spent using R/T per exercise for each ORG. This objective measure of workload applies to the tactical role only, and includes both transmitted and received R/T.

C2.4 Number of release alerts

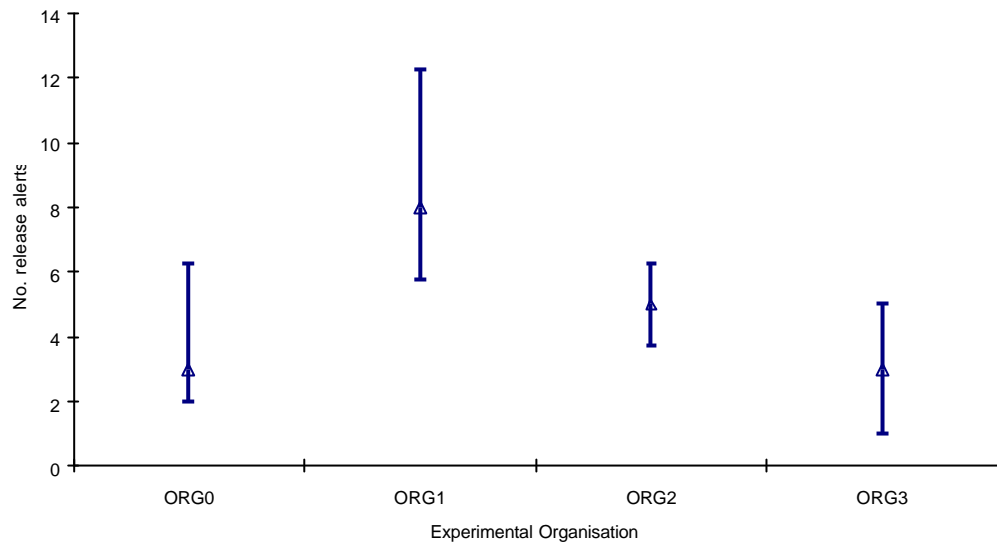


Figure C7 - Number of release alerts for each ORG

Figure C7 shows the median values of the number of release alerts per exercise for each ORG. This objective measure applies to the tactical role only.

C2.5 Time taken to register each aircraft

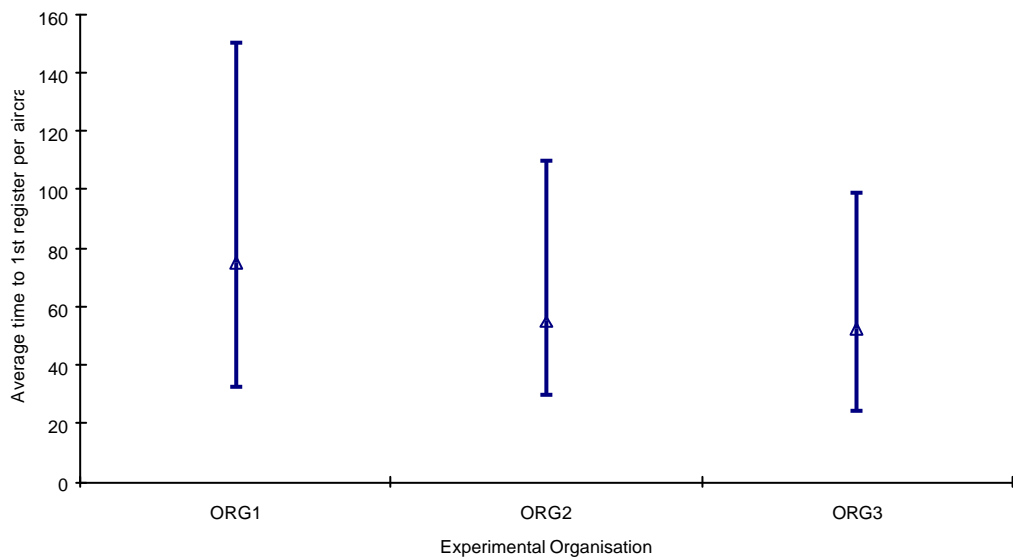


Figure C8 - Time taken to register each aircraft for each ORG

Figure C8 shows the median values of the average time taken from the aircraft entering the advanced information state, to the controller registering a trajectory for that aircraft. This objective measure of workload applies to the planning role only. This measure does not apply to ORG0, since the register process is not a feature of this ORG.

C2.6 Number of times per exercise that HIPS was used to modify a trajectory

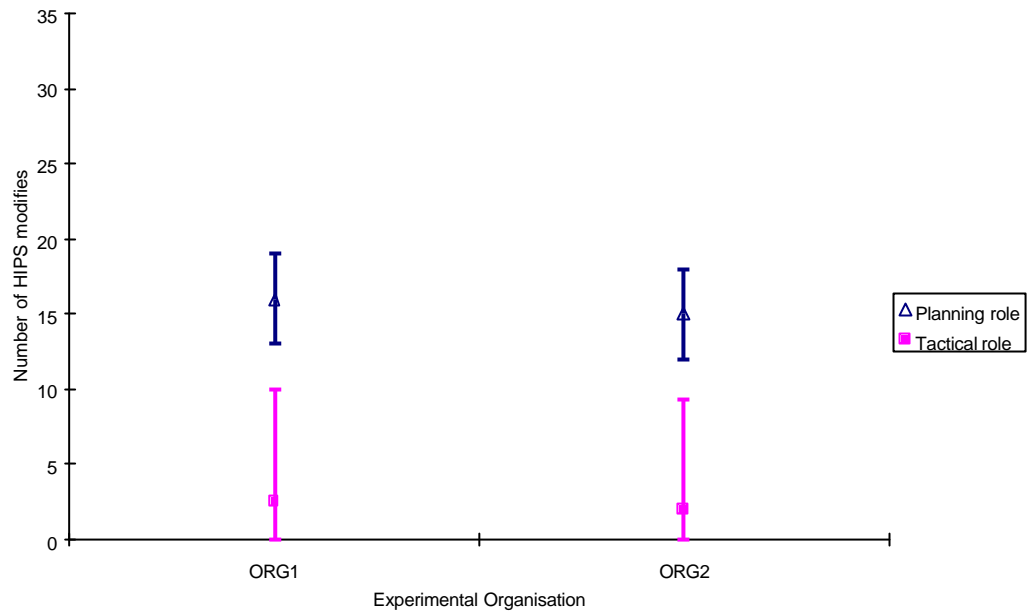


Figure C9 - Modifications using HIPS for ORGs 1 and 2

The process of making an edit to an aircraft trajectory, to validating and successfully registering it, is known as a trajectory modification. Each exercise a count was made of the number of times that HIPS was used to modify aircraft trajectories. Figure C9 shows the median values of this measure for ORG1 and ORG2, for each of the controller roles. This is an objective measure of the amount of usage of the HIPS tool.

C2.7 Number of times throughout the trial that ADFL was used to modify a trajectory

Role	Controller	ORG1	ORG2
Planner	b	3	3
	c	0	0
	f	1	5
	g		
Tactical	a	0	0
	d	0	0
	e	1	1
	h	0	0

Table C1 - Modifications using ADFL for ORGs 1 and 2

Table C1 shows the total number of times throughout the trial that ADFL was used to modify aircraft trajectories, for ORG1 and ORG2 and for each of the controllers. This is an objective measure of the amount of usage of the ADFL tool. The information has been

represented in tabular form, since occurrences of an aircraft's trajectory being modified using the ADFL were so rare.

C2.8 Number of times per exercise that ADFL was invoked

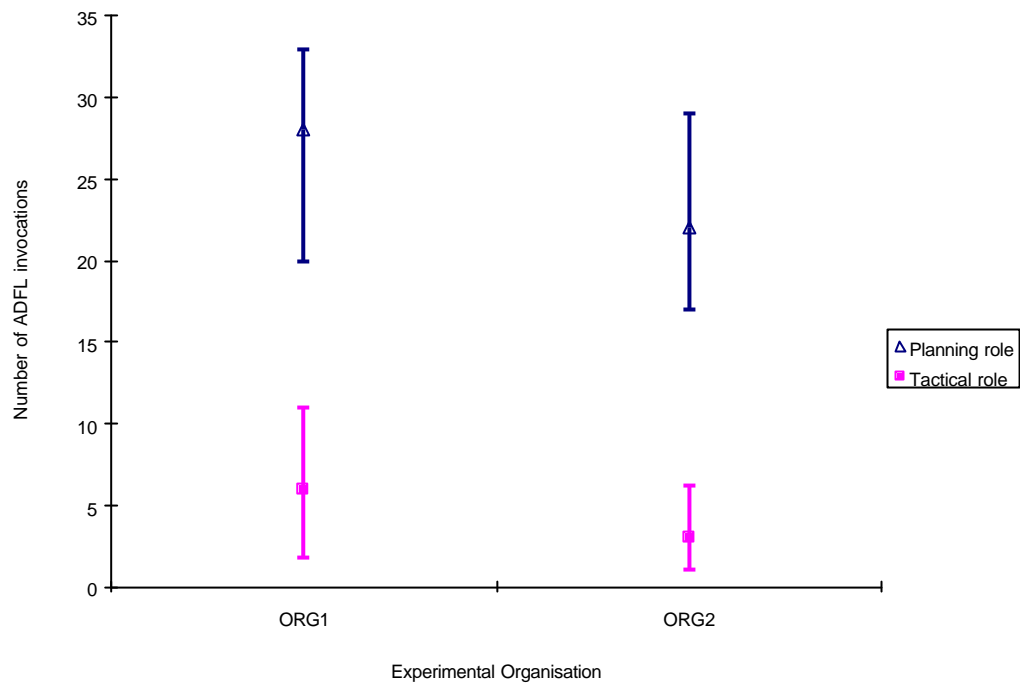


Figure C10 - Number of ADFL invocations for ORGs 1 and 2

Figure C10 shows the median number of times per exercise that the ADFL was invoked, compared between ORG1 and ORG2 for each of the controller roles. This is an objective measure of the amount of tool usage.

C2.9 Number of aircraft on frequency for ISA 3

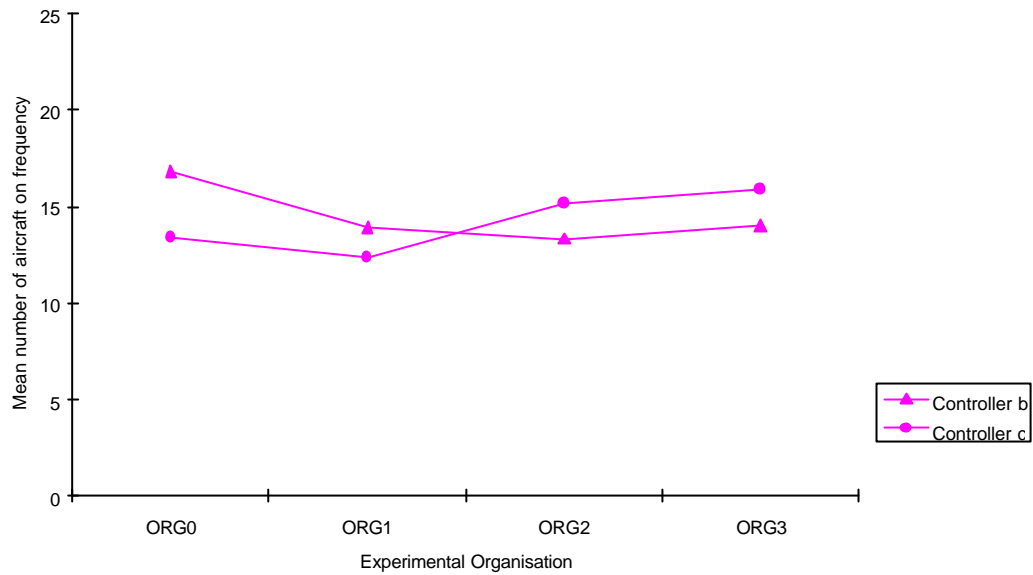


Figure C11 - Mean number of aircraft on frequency for ISA 3: planning controllers

Figure C11 and Figure C12 show the means of the number of aircraft on frequency each time a controller responded with ISA 3, for the planning role and the tactical role respectively. The values are compared between all four ORGs.

As mentioned in CC2.1, ISA values from only two of the planning controllers were available. Hence the measure is plotted for these planners alone.

The vertical arrows in Figure C12 indicate that the tactical controller had ISA responses in categories 1 and 2 only. The associated value is therefore the peak number of aircraft on frequency for that controller in that ORG.

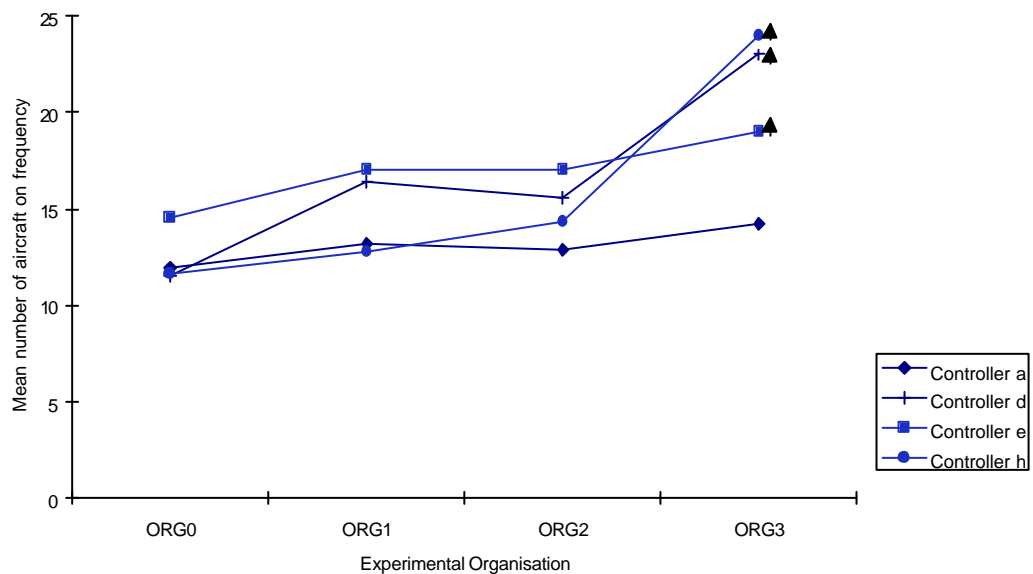


Figure C12 - Mean number of aircraft on frequency for ISA 3: tactical controllers

C2.10 Number of times an attempt was made to select trajectory of aircraft without datalink in the HIPS SPS

Role	Controller	ORG1	ORG2
Planner	b	3	0
	c	0	0
	f	2	0
	g		
Tactical	a	1	0
	d	0	0
	e	0	0
	h	0	0

Table C2 - Number of attempted HIPS SPS interactions for aircraft without datalink for ORGs 1 and 2

Table C2 shows the total number of times throughout the trial that an attempt was made to interact with the trajectory of an aircraft without datalink in the HIPS SPS. This information is compared between ORG1 and ORG2, for each of the controllers, and has been represented in tabular form because the attempts were so rare.

C2.11 Average number per exercise of attempted validations per successful trajectory modification

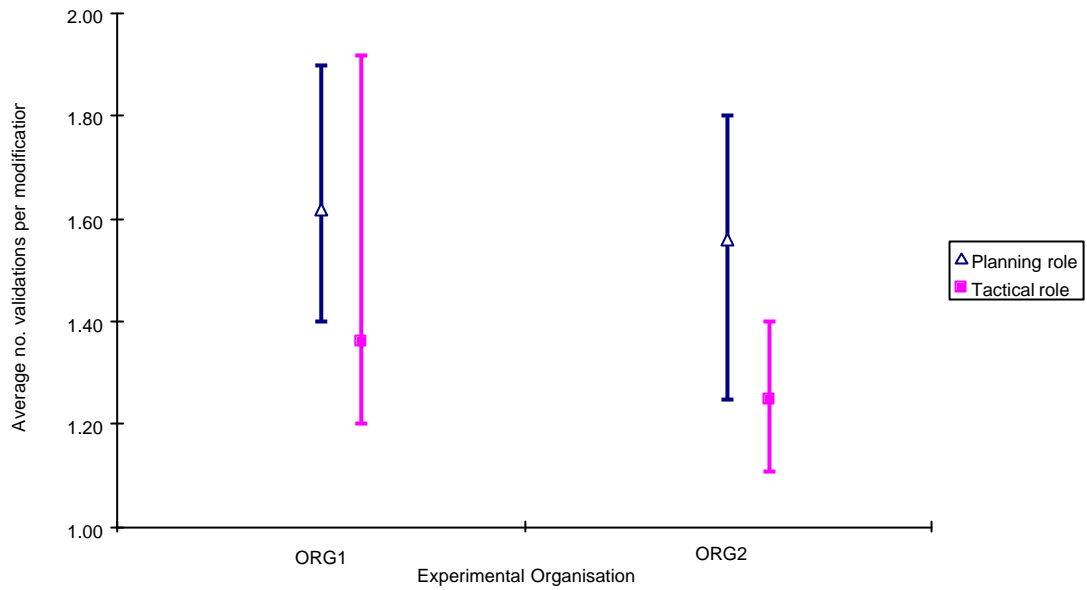


Figure C13 - Average number of validations per trajectory modification for ORGs 1 and 2

Each time an aircraft trajectory was edited, a count was made of the number of validations necessary before it was successfully registered, and this was averaged each exercise over the number of times a trajectory modification occurred. Figure C13 shows the medians of this measure, averaged over all the exercises in ORG1 and ORG2. The measure is analysed between controller roles, and is an objective measure of tool use efficiency.

C2.12 Average time taken per exercise to modify trajectory

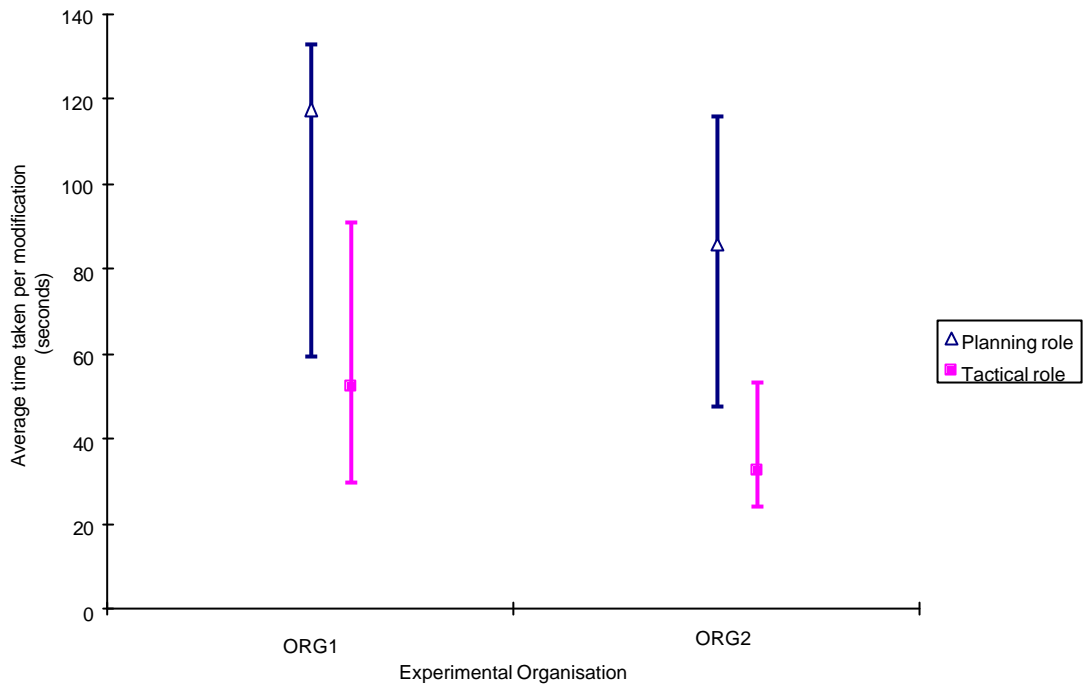


Figure C14 - Average time taken to modify trajectory for ORGs 1 and 2

Each exercise, when an aircraft trajectory was edited the time spent by the controller, from the initial edit to finally successfully registering that trajectory, was recorded and averaged over the number of trajectory modifications. Figure C14 shows the medians of this measure, averaged over all the exercises. The measure is compared between ORG1 and ORG2 for both controller roles, and is an objective measure of tool use efficiency.

C2.13 Percentage of aircraft registers with trajectory edited in each HIPS display

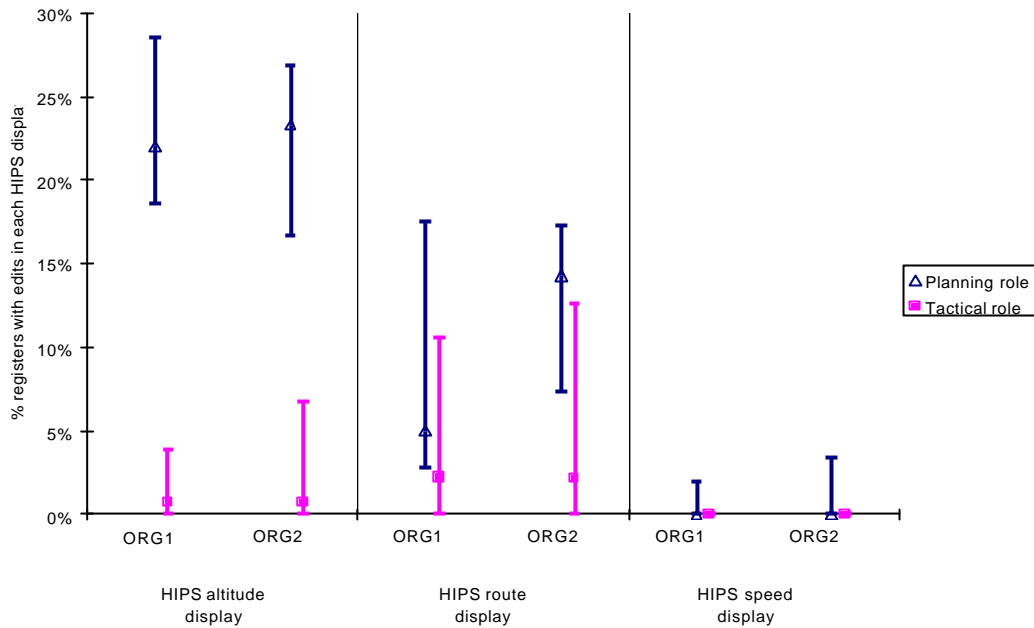


Figure C15 - Average percentage of aircraft registers with trajectory edited in each HIPS display for ORGs 1 and 2

The percentage of trajectory registers each exercise with the aircraft trajectory edited in HIPS, was analysed by the three displays. Figure C15 shows the median values of these measures, averaged over all the exercises. The measures are compared between ORG1 and ORG2 for each of the controller roles, and are an objective measure of tool usage.

C2.14 Percentage of aircraft registers with trajectory modified in the HIPS SPS

Role	Controller	ORG1, %	ORG2, %
Planner	b	0.72	0
	c	0.35	0
	f	4.06	5.09
	g		
Tactical	a	0.35	0.35
	d	0	0
	e	0	0
	h	0	0

Table C3 - Mean percentage of aircraft registers with speed edited in HIPS compared between ORGs 1 and 2

Table C3 shows the mean values of the percentage of trajectory registers where the aircraft speed was edited in HIPS. This objective measure of tool usage is compared between ORG1 and ORG2 for each of the controllers. It has been represented in tabular

form because modifications to the speed of aircraft were so rarely made, as Figure C15 shows.

C3 TRIAL RESULTS

This section presents the results from the statistical tests and questionnaires associated with each low level objective of the trial. These are summarised in the form of tables. Relevant observations made by the specialist observers and all appropriate comments from the questionnaires, debriefs and comment sheets have also been included. Where the comments originated from the questionnaires, the relevant question has been included to provide the context of the comment. The role and sector of the controller making the comment have also been included, but the fortnight is not indicated, so results from “S10 Tactical” for example, could have come from one of two controllers. Where controller comments are italicised, this indicates that the comment is a direct quotation.

Where statistical results are given for a certain measure, the notation $ORG_a > ORG_b$ indicates that the scores for ORG_a were significantly greater than those for ORG_b , with a significance level of 5%. Likewise, $ORG_a < ORG_b$ indicates significantly lower scores for ORG_a . By $ORG_a = ORG_b$, it is meant that there was no evidence of a statistically significant difference between ORG_a and ORG_b .

The median values for the two ORGs are also presented alongside the result to suggest the scale of the difference where a statistical difference between two ORGs has been observed, or if the difference observed appears to be large but is not statistically significant. The exception to this is the ISA measure, as the interpretation of each ISA score may vary between controllers, and hence can not be averaged. For objective measures, the percentage difference has also been calculated.

There is always a risk of false positives in these tests: with a significance level of 5%, it is to be expected that, on average, 1 in 20 tests where the null hypothesis was rejected is, in fact, a false positive. This means that the observed difference did indeed occur by chance and the null hypothesis should not have been rejected. The statistical tests employed were carefully chosen to minimise the risk of a “Type II error”, that is accepting the null hypothesis where in fact it should have been rejected. The null and alternative hypothesis for each low level objective are described in Appendix B.

Note that results from controller “g”, the sector 11 planner from the second fortnight of the trial, were lost due to sickness. As a result, the statistical analysis excluded the measures from this controller. Furthermore, this controller was unavailable to respond to the ORG1, ORG2 and ORG3 questionnaires. The letters a to h have been used to identify the individual controllers throughout the results, in order to preserve anonymity. See Table C4 below.

The results are summarised and discussed in the main body of the report.

Fortnight	Sector	Role	Controller
1	10	Tactical	a
		Planner	b
	11	Planner	c
		Tactical	d
2	10	Tactical	e
		Planner	f
	11	Planner	g
		Tactical	h

Table C4 - Controllers, sectors, roles and fortnights

C3.1 For each controller role, examine whether the PD/1 PATs and GHMI modifications, and additional training, have a positive impact on workload

Comparison of ISA scores

Planner	Sig 1-sided diff:	ORG1 > ORG2
Tactical	Sig 1-sided diff:	ORG1 > ORG2

As mentioned in section CC2.1, ISA values from only two of the planning controllers were available for statistical analysis. This applies throughout the results given for ISA. See Figure C1.

Comparison of TLX scores

Overall TLX scores:		ORG1 median	ORG2 median
Planner	ORG1 = ORG2	146.5	84
Tactical	ORG1 = ORG2	139.5	110.5

TLX time pressure scores:		ORG1 median	ORG2 median
Planner	ORG1 = ORG2	5.5	2
Tactical	ORG1 = ORG2	7.5	7

TLX frustration experienced scores:		ORG1 median	ORG2 median
Planner	ORG1 = ORG2	16.5	7.5
Tactical	Sig 1-sided diff: ORG1 > ORG2	11.5	5

PUMA

The PUMA analysis undertaken using data from the PD/1+ trial, consisted of a qualitative comparison of workload plot data for the sector 10 tactical and planning controllers between ORG1 and ORG2, and a comparison of the task types undertaken during the two different ORGs.

The workload plots were produced using the PUMA Workload Assessment Tool (WAT) and describe the workload of the tactical and planning controllers for the time interval used. A full description of the PUMA methodology applied on producing these plots from the video tapes is given in reference 8. The y-axis scale represents W/INDEX units, a unit of workload, and the x-axis represents time. See reference 15 for a full description of W/INDEX. Figure C16 and Figure C17 give the workload plots for the planning role, and Figure C18 and Figure C19 give the workload plots for the tactical role, in ORG1 and ORG2 respectively. It is important to note that the WAT output is not definitive, but is intended only to be used in a comparative manner.

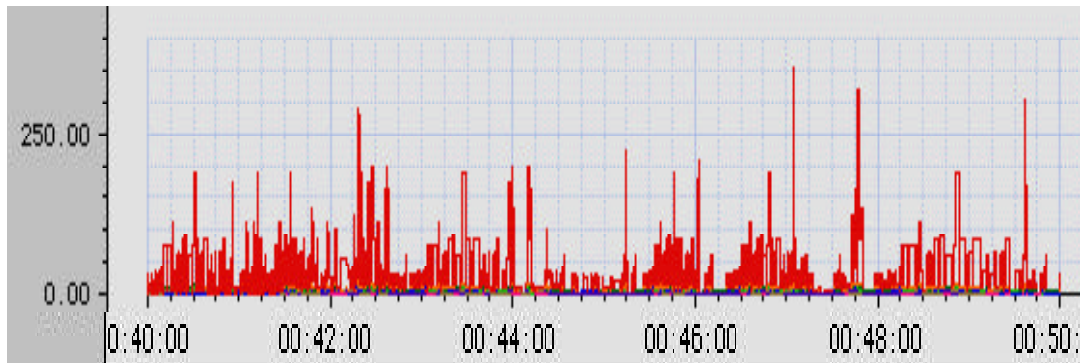


Figure C16 - PUMA WAT output - ORG1, planning controller

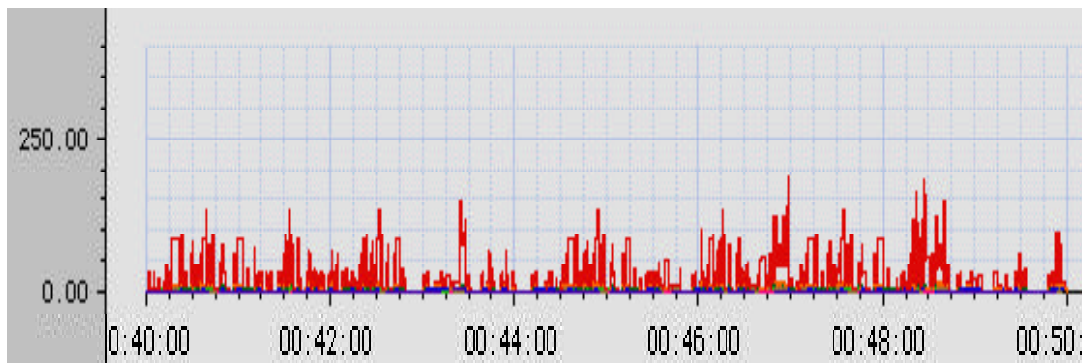


Figure C17 - PUMA WAT output - ORG2, planning controller

For the planning role, the apparent density of the workload plots decreases in general from ORG1 to ORG2. This greater plot density in ORG1 is representative of greater workload than in ORG2, being indicative of more tasks and hence actions being completed during the same unit of time. Initial impressions formed by the subject matter expert performing the video analysis, suggest this reduction in workload may be due to the reduction in the size of the HIPS no-go zones, since the planner took less time to plan aircraft trajectories. The level of the workload peaks in ORG2 is also reduced compared to those in ORG1. The very thin peaks in the plot, i.e. of one pixel thickness, are artefacts generated by the PUMA algorithm, however, and are characteristic of slight task overlap rather than greater workload.

During ORG1 the planning controller effected control of the sector using 11 types of task, whereas during ORG2 the same controller effected control using only 7 tasks. This is a general result and is not merely restricted to the time interval investigated. It shows a reduction in the tasks the controller is required to undertake in order to effectively control the sector. More importantly, the nature of the tasks differs significantly. The tasks are listed below in Table C5.

Task No.	ORG1	ORG2
1	Assess a/c route through sector	
2	Discuss ATC plan with tactical	
3	Housekeeping	
4	Plan a/c route simple	
5	Plan/register aircraft route (ADFL)	
6	Talk to tactical	
7	Monitoring	
8	Monitor tactical	
9	Co-ordinate with next sector	
10	Discuss ATC plan 3-way	
11	Discuss system problems	

Table C5 - Planning control tasks for ORG1 and ORG2

Between ORG1 and ORG2, the tasks not executed are those related to co-ordination. The removal of the need to ‘monitor the tactical controller’, the removal of the need to ‘co-ordinate’ and ‘discuss ATC plan 3-way’, i.e. discussion of the ATC plan with the tactical partner and a planner from another sector (effectively co-ordination again), shows a decrease in inter-sector communication. A reduction in verbal communication implies an effective increase in the amount of electronic co-ordination, or a reduction in the need to co-ordinate. This may simply be due to greater familiarity with the system, but analysis of the video evidence suggests that co-ordination was easier with the ORG2 interface.

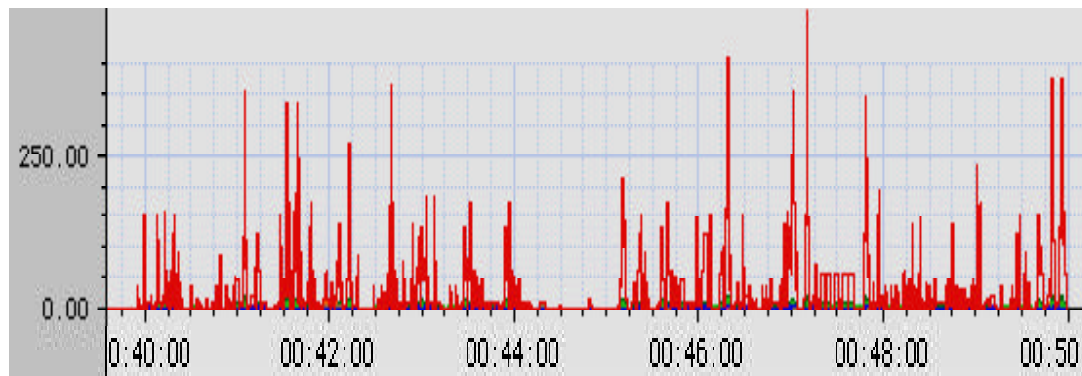


Figure C18 - PUMA WAT output - ORG1, tactical controller

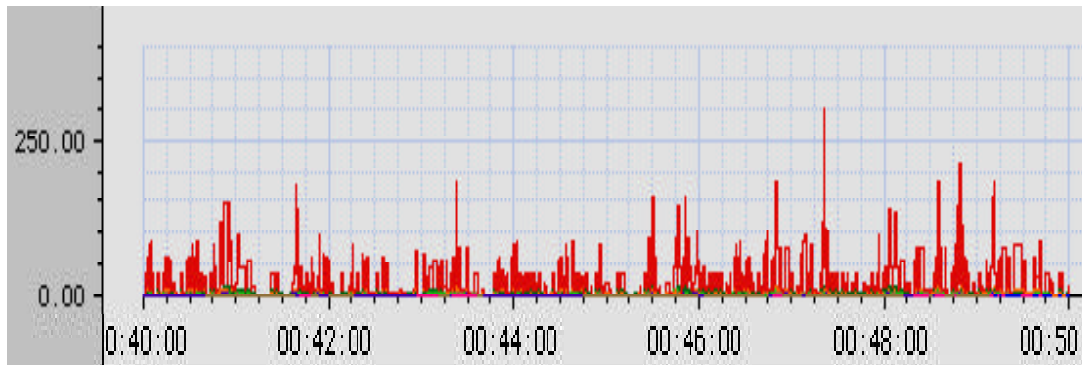


Figure C19 - PUMA WAT output - ORG2, tactical controller

Figure C18, the plot for ORG1, shows a slightly greater apparent plot density compared to ORG2 in Figure C19, indicative of a slightly lower workload for the tactical controller in ORG2. In general, the ORG2 plot shows a more consistent, slightly lower level of workload, with more efficient task sequencing. The two plots for the tactical role also show very different peaks in the workload between ORG1 and ORG2. The ORG1 plot shows a greater number of peaks, but as mentioned above, the very thin peaks in the plot are artefacts generated by the PUMA algorithm, however, and are characteristic of slight task overlap rather than greater workload.

The main feature of the ORG1 plot is the apparent period of inactivity shortly after 44 minutes. This area corresponds to a period when the tactical controller was making notes on a simulator problem, and as such is accurately reflected in the WAT plot as a period of low workload.

During ORG1 the tactical controller effected control of the sector using 14 types of task. In order to control the sector during ORG2, 17 tasks were undertaken; however, only some of the tasks were common to both ORGs. These tasks are listed in Table C6. The most important difference between the two sets is the task 'Assess route, make tactical intervention'. In this case the tactical controller was so concerned by the proposed separation offered by the HIPS trajectory that it was deemed necessary to intervene tactically. Furthermore, with the smaller HIPS no-go zones in ORG2 the tactical controller also found it necessary to discuss clearances in the CLW with the planner, as these occasionally appeared to breach separation minima. This observation was supported by comments that the participants made during debriefs, and it is possible that the need to discuss these CLW clearances resulted in increased workload for the tactical controller.

During ORG2 the tactical controller undertook the task to 'fix deviating a/c'. This was a short activity which removed the 'deviating a/c' indication from around the aircraft target. The tactical controller also undertook this activity during ORG1, although it was not observed during the video analysis.

Other than the differences described above, the change in control tasks between ORG1 and ORG2 was minimal, and represented different ways of undertaking the same tasks.

Task No.	ORG1	ORG2
1	Assume a/c at TDB	
2	Assess a/c route	
3	Discuss ATC plan	
4	Monitoring	
5	Query HIPS	
6	Review CLW content	
7	Release a/c at TDB	
8	Release a/c no HMI	Confirm a/c on freq
9	Housekeeping	Discuss and issue clearance
10	Co-ordinate with sector 11	Accept a/c on freq (pass clearance)
11	Issue CFL modification (CLW)	Fix deviating a/c
12	CFL modification, unable to access level box	Assess and modify a/c route
13	Issue CFL modification (TDB)	Assume a/c no call
14	Look away from suite	Assume a/c at SIL
15		Accept a/c on freq. miss call
16		Talk non-ATC relevant
17		Assess route, make tactical intervention

Table C6 - Tactical control tasks for ORG1 and ORG2

A difference in the style of control was directly observable from the video tapes: during ORG1 the tactical controller found it difficult to maintain control of the sector and undertake tasks in a composed manner; whilst during ORG2, the same controller had a planned and structured means of operating, and was able to control the sector effectively. This appears to suggest greater familiarity with the system in ORG2. The video evidence suggests, however, that the improvement in working style was not gradual as associated with increasing familiarity, but was a stepped increase, implying that there was a real improvement to the user interface.

During the PUMA debrief after the ORG2 exercise, one controller said, *“It’s a different traffic sample, that’s why it’s so much easier to control.”* The traffic sample was, in fact, identical in ORG2 to the one used in ORG1. Another controller said, *“You must have made huge changes to the user interface, because it’s so much easier to use.”*

Number of release alerts (tactical controller only)

			ORG1 median	ORG2 median	% difference
Tactical	Sig 1-sided diff:	ORG1 > ORG2	8	5	37.50%

R/T usage (tactical controller only)

Tactical	ORG1 = ORG2
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Time taken to register each aircraft (planning controller only)

			ORG1 median	ORG2 median	% difference
Planner	Sig 1-sided diff:	ORG1 > ORG2	74.90	54.86	26.76%

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG2 :

How do you believe the **tools** you were given during ORG2 affected your workload/time pressure/frustration (compared to ORG1)?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	Decrease	Decrease	No change
	c	Decrease	Decrease	Increase ¹
	f	Decrease	No change	Decrease
	g			
Tactical	a	No change	No change	Decrease
	d	No change	No change	No change
	e	Decrease	Decrease	No change
	h	Decrease	No change	No change

¹ See section C3.8 (p43) and section C3.13 (p58). Controller c felt that the scrolling in the HIPS displays and the size of the TST had become worse.

How do you believe the **interface** you used during ORG2 affected your workload/time pressure/frustration (compared to ORG1)?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	No change	No change	No change
	c	No change	Decrease	Increase ¹
	f	No change	No change	No change
	g			
Tactical	a	No change	Decrease	Decrease
	d	No change	No change	Decrease
	e	No change	No change	Decrease
	h	No change	No change	No change

What change between ORG1 and ORG2 represented the biggest improvement to the system?

Role	Controller	Change
Planner	b	<i>Smaller no-go zones</i>
	c	<i>Smaller no-go zones</i>
	f	<i>Smaller no-go zones</i>
	g	
Tactical	a	<i>Smaller no-go zones</i>
	d	<i>Removal of unnecessary CLW messages</i>
	e	<i>Removal of unnecessary CLW messages</i>
	h	<i>Removal of unnecessary CLW messages</i>

Were there any changes between ORG1 and ORG2 that you felt represented a decrease in the abilities of the system?

Role	Controller	Change
Planner	b	<i>None</i>
	c	<i>System not showing some conflictions</i>
	f	<i>None</i>
	g	
Tactical	a	<i>Scrolling in HIPS was difficult if window too small</i>
	d	<i>None</i>
	e	<i>TST being smaller</i>
	h	<i>None</i>

What good features did you encounter using the interface during ORG2?

S10 Tactical - *None really were more of a direct benefit, because the features were little different from ORG1. I believe that far too much attention is given to the interface and not enough to what the tools are meant to achieve.*

What problems or undesirable features (if any) did you notice with the interface during ORG2?

S10 Tactical - *Problems of interaction with TST as described, and of course with HIPS in general interaction is cumbersome, and inaccurate. "Snapping back" of fixes, scrolling inconsistencies, too many functions to achieve one minor result: All still substandard.*

If you believed that there was a difference in the ease with which you controlled traffic between ORG1 and ORG2, can you describe what the difference was?

S10 Planner - *The improvements in tools made the planning on the whole quicker.*

S11 Tactical - *Basically just read off messages in communications list. Monitor compliance and deviations. Most relaxing, in fact.*

S10 Tactical - *The system was faster and HIPS more reliable.*

S10 Tactical - *Basically, I simply think I've learnt to accept the limitations of the system, and have developed a technique of ignoring some things and working with lower expectations with others.*

S11 Planner - *I began to move around the system quicker because I am getting used to it.*

C3.2 For each controller role, examine whether the PD/1 PATs and GHMI modifications, plus additional training, have a positive impact on controller workload compared to the PD/1 baseline

Comparison of ISA scores

Planner	ORG0 = ORG2	
Tactical	Sig 2-sided diff:	ORG0 > ORG2

Note that for this low level objective the significance testing was 2-sided, because it was not possible to predict *a priori* whether ORG0 or ORG2 would have less workload.

Comparison of TLX scores

Overall TLX scores:		ORG0 median	ORG2 median
Planner	ORG0 = ORG2	112.5	84
Tactical	ORG0 = ORG2	147.5	110.5

TLX time pressure scores:		ORG0 median	ORG2 median
Planner	ORG0 = ORG2	5	2
Tactical	ORG0 = ORG2	10	7

TLX frustration experienced scores:		ORG0 median	ORG2 median
Planner	ORG0 = ORG2	9	7.5
Tactical	ORG0 = ORG2	9	5

Number of release alerts (tactical controller only)

Tactical	ORG0 = ORG2
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R/T usage (tactical controller only)

		ORG0 median	ORG2 median	% difference
Tactical	ORG0 = ORG2	21.87%	16.96%	22.45%

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG2:

How do you believe the **tools** you were given during ORG2 affected your workload/time pressure/frustration (compared to ORG0)?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	Decrease	Decrease	Increase
	c	Sig. decrease	Sig. decrease	Decrease
	f	Decrease	Decrease	Increase
	g			
Tactical	a	Decrease	Decrease	No change
	d	No change	No change	Increase
	e	Decrease	Decrease	No change
	h	Decrease	No change	No change

How do you believe the **interface** you used during ORG2 affected your workload/time pressure/frustration (compared to ORG0)?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	Increase	Increase	Increase
	c	No change	Decrease	No change
	f	Decrease	Decrease	Decrease
	g			
Tactical	a	Decrease	Decrease	Decrease
	d	Decrease	No change	Decrease
	e	No change	No change	No change
	h	Decrease	No change	No change

The following results have been taken from the questionnaire issued at the end of ORG3:

In the matched pair comparison, indicate the ORG you felt you were able to control most safely/orderly/expediently (between ORG0 and ORG2 only).

Role	Controller	Safely	Orderly	Expediently
Planner	b	ORG2	ORG2	ORG2
	c	ORG2	ORG2	ORG2
	f	ORG0	ORG0	ORG0
	g			
Tactical	a	ORG0	ORG0	ORG0
	d	ORG0	ORG0	ORG0
	e	ORG0	ORG2	ORG2
	h	ORG0	ORG0	ORG0

Mark the effect on your workload during ORG2, using ORG0 as your point of reference.

Role	Controller	Workload
Planner	b	Sig. Increase
	c	Decrease
	f	Decrease
	g	
Tactical	a	Decrease
	d	Decrease
	e	Decrease
	h	Decrease

C3.3 For each controller role, examine the difference in workload between the PD/1 baseline and the advanced PD/1 organisation before the additional training and modifications were made to the PATs and GHMI

Comparison of ISA scores

Planner	Sig 1-sided diff:	ORG0 < ORG1
Tactical	Sig 1-sided diff:	ORG0 > ORG1

Overall, the ISA scores recorded by the planning controllers in ORG0 were lower than those recorded in ORG1. The ISA scores recorded by the tactical controllers in ORG0 were higher than those recorded in ORG1. These differences are statistically significant.

Comparison of TLX scores

Overall TLX scores:			ORG0 median	ORG1 median
Planner	Sig 1-sided diff:	ORG0 < ORG1	112.5	146.5
Tactical	ORG0 = ORG1		147.5	139.5

TLX time pressure scores:			ORG0 median	ORG1 median
Planner	ORG0 = ORG1		5	5.5
Tactical	ORG0 = ORG1		10	7.5

TLX frustration experienced scores:			ORG0 median	ORG1 median
Planner	ORG0 = ORG1		9	16.5
Tactical	ORG0 = ORG1		9	11.5

Number of release alerts (tactical controller only)

			ORG0 median	ORG1 median	% difference
Tactical	Sig 1-sided diff:	ORG0 < ORG1	3	8	166.67%

R/T usage (tactical controller only)

			ORG0 median	ORG1 median	% difference
Tactical	Sig 1-sided diff:	ORG0 > ORG1	21.87%	18.10%	17.23%

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG1:

How do you believe the **tools** you were given during ORG1 affected your workload/time pressure/frustration (compared to ORG0)?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	Sig increase	increase	Sig increase
	c	Sig increase	Increase	Increase
	f	Sig decrease	Sig decrease	Sig increase
	g			
Tactical	a	Decrease	No change	Increase
	d	No change	No change	Increase
	e	Decrease	Decrease	No change
	h	Decrease	No change	No change

How do you believe the **interface** you used during ORG1 affected your workload/time pressure/frustration (compared to ORG0)?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	Sig increase	Sig increase	Sig increase
	c	No change	Increase	Increase
	f	Sig increase	Decrease	Sig increase
	g			
Tactical	a	No change	No change	No change
	d	Decrease	No change	No change
	e	Decrease	Increase	No change
	h	No change	No change	No change

What problems or undesirable features (if any) did you encounter with the interface during ORG1?

S10 Planner - *The interface led to considerable frustration, and added to workload. Because of the cumbersome nature of it, at times the best solution for the aircraft and systems was not chosen.*

What change between ORG0 and ORG1, in your opinion, represented the biggest improvement to the system?

S11 Tactical - *HIPS. More workload for the planner, less for tactical. However a mixture of aircraft with and without datalink equalised the workload - and spare capacity available for monitoring and problem resolving.*

S10 Planner - *The HIPS made the major change between the ORGs, and the role reversal with regards to workload for the planner and tactical. The HIPS inherent problems over-complicated relatively simple situations though.*

If you believed that there was a difference in the ease with which you controlled traffic between ORG0 and ORG1, can you describe what the difference was?

S10 Planner - *The use of datalink does permit a significant reduction in the tactical controller workload. In terms of control for the planner, it really is just a matter of looking at HIPS and working out a solution and registering it. In this case HIPS is better than the HAW and VAW/CRD combinations.*

Are there any other comments you have not already made that you feel are relevant about any aspects of ORG1, the simulation, traffic samples, the interface, the tools, etc.?

S10 Planner - *HIPS makes no attempt to provide a "picture" to either controller. If the tactical is not involved in planning how can he possibly cope with high traffic levels within his sector, when he doesn't know what the overall objectives are? The tactical is essentially "de-skilled" by the planner and HIPS. Even if he understood the situation, would he have the practised, honed abilities left to solve it?*

S10 Planner - *In ORG1 I nearly did not have "the picture" at times and there is a complete breakdown between aircraft type. This was very different from ORG0 - where I was able to pick up the tactical plan and support the tactical controller.*

S11 Tactical - *+75% traffic sample too much.*

The following results have been taken from the questionnaire issued at the end of ORG3:

In the matched pair comparison, indicate the ORG you felt you were able to control most safely/orderly/expediently (between ORG0 and ORG1 only).

Role	Controller	Safely	Orderly	Expediently
Planner	b	ORG1	ORG1	ORG1
	c	ORG1	ORG1	ORG1
	f	ORG0	ORG0	ORG0
	g			
Tactical	a	ORG0	ORG1	ORG0
	d	ORG0	ORG1	ORG0
	e	ORG0	ORG1	ORG0
	h	ORG0	ORG0	ORG0

C3.4 For each controller role, examine whether the PD/1 PATs and GHMI modifications, plus additional training, have a positive impact on the amount of tool use

Number of times HIPS was used to modify an aircraft trajectory

Planner	ORG1 = ORG2
Tactical	ORG1 = ORG2

Number of times ADFL was used to modify an aircraft trajectory

Planner	ORG1 = ORG2
Tactical	ORG1 = ORG2

Number of times ADFL was invoked

			ORG1 median	ORG2 median	% difference
Planner	Sig 1-sided diff:	ORG1 > ORG2	28	22	21.43%
Tactical	Sig 1-sided diff:	ORG1 > ORG2	6	3	50.00%

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG1:

Do you think you could have made more use of the tools you were given (in ORG1)?

Role	Controller	Could have used tools more?
Planner	b	No
	c	No
	f	Yes
	g	
Tactical	a	Yes
	d	Yes
	e	Yes
	h	Yes

The following results have been taken from the questionnaire issued at the end of ORG2:

Do you think you could have made more use of the tools you were given (in ORG2)?

Role	Controller	Could have used tools more?
Planner	b	No
	c	No
	f	Yes
	g	
Tactical	a	No
	d	Unsure
	e	No
	h	No

What tools (in ORG2) did you use more often (than in ORG1) as a result of the training?

Role	Controller	Which tool more?
Planner	b	<i>All</i>
	c	<i>None</i>
	f	<i>None</i>
	g	
Tactical	a	<i>ADFL</i>
	d	<i>HIPS</i>
	e	<i>None</i>
	h	<i>HIPS/CRD</i>

If you answered 'yes' as to whether you performed better in ORG2 compared to ORG1, was it due to greater experience or the additional training?

Role	Controller	Reason
Planner	b	Neither - changes in tools alone
	c	Greater experience
	f	Greater experience
	g	
Tactical	a	Unsure which ORG performed better in
	d	Unsure which ORG performed better in
	e	Greater experience
	h	Greater experience & additional training

Was the additional training you received before ORG2 valuable in teaching you to use the features of the workstation properly?

Role	Controller	Training valuable?
Planner	b	No
	c	No
	f	Yes
	g	
Tactical	a	Yes
	d	Yes
	e	Yes
	h	Yes

C3.5 For each controller role, examine the impact on workload of controlling purely datalink equipped aircraft

Comparison of ISA scores

Planner	Sig 1-sided diff:	ORG2 > ORG3
Tactical	Sig 1-sided diff:	ORG2 > ORG3

Comparison of TLX scores

Overall TLX scores:			ORG2 median	ORG3 median
Planner	ORG2 = ORG3		84	52.5
Tactical	Sig 1-sided diff:	ORG2 > ORG3	110.5	75

TLX time pressure scores:			ORG2 median	ORG3 median
Planner	ORG2 = ORG3		2	1
Tactical	Sig 1-sided diff:	ORG2 > ORG3	7	3

TLX frustration experienced scores:			ORG2 median	ORG3 median
Planner	ORG2 = ORG3		7.5	5
Tactical	ORG2 = ORG3		5	2.5

Number of release alerts (tactical controller only)

Tactical	ORG2 = ORG3
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R/T usage (tactical controller only)

			ORG2 median	ORG3 median	% difference
Tactical	Sig 1-sided diff:	ORG2 > ORG3	16.96%	14.02%	17.32%

Time taken to register each aircraft (planning controller only)

Planner	ORG2 = ORG3
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Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG3:

How do you believe the **tools** you were given during ORG3 affected your workload/time pressure/frustration (compared to ORG2)?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	Decrease	Decrease	Decrease
	c	No change	No change	Decrease
	f	No change	No change	Increase
	g			
Tactical	a	Decrease	No change	Decrease
	d	Sig decrease	No change	No change
	e	No change	No change	No change
	h	Sig decrease	Sig decrease	No change

How do you believe the **interface** you used during ORG3 affected your workload/time pressure/frustration (compared to ORG2)?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	No change	No change	No change
	c	Decrease	Decrease	No change
	f	No change	No change	No change
	g			
Tactical	a	No change	No change	Decrease
	d	Decrease	No change	Increase ²
	e	Decrease	No change	No change
	h	Decrease	Decrease	No change

In the matched pair comparison, indicate the ORG you felt you were able to control most safely/orderly/expediently (between ORG2 and ORG3 only).

Role	Controller	Safely	Orderly	Expediently
Planner	b	ORG3	ORG3	ORG3
	c	ORG3	ORG3	ORG3
	f	ORG3	ORG3	ORG3
	g			
Tactical	a	ORG3	ORG3	ORG3
	d	ORG2	ORG2	ORG3
	e	ORG3	ORG3	ORG3
	h	ORG3	ORG3	ORG3

² Controller frustrated at having nothing to do.

Did the use of tools facilitate your ability to control traffic?

- S10 Tactical - *Yes, a little bit. Purely because I had no impact on the general traffic situation except to re-input a couple of trajectories because the aircraft were indicating deviations.*
- S10 Planner - *Yes, a little bit. The tools speed coupled together with my increase in experience with them, this led to planning becoming quicker, enabling me to handle more traffic.*
- S11 Tactical - *No effect. I was not controlling traffic in this ORG - the planner does it all!!*
- S11 Tactical - *Yes, a little bit. Tactical controller not required to do much.*
- S11 Planner - *Yes, a lot. The tools are the key to controlling the aircraft. It is relatively easy with HIPS. Without it workload would be far higher.*

What change between ORG2 and ORG3, in your opinion, represented the biggest improvement to the system?

- S10 Tactical - *The absence of deviations for aircraft without datalink!*
- S10 Planner - *All aircraft being equipped with datalink.*
- S11 Tactical - *From a tactical controller's point of view it reduced his job to almost nil!!*
- S11 Tactical - *I didn't have to do much. R/T workload reduced.*
- S11 Planner - *Cutting out the tactical and therefore the risk of him not passing a message at the correct time.*

Are there any other comments you have not made already that you feel are relevant about any aspect of ORG3, the simulation, traffic samples, the interface, the decision support tools, etc?

- S10 Tactical - *I'm sure I'm learning the samples, and learning to accept the (large) limitations of the system and get the best out of it by working with/around it.*
- S10 Planner - *Much of my response to some of the traffic situations is a response to having seen the traffic samples previously...*

What changes to the system (between all ORGs) caused the biggest change in your workload?

- S10 Tactical - *The use of HIPS by the planner took away my need to "plan", resulting in a reduction of workload. However this also took away my ability to keep a mental picture so time saved was used trying to generate this picture of confidence.*
- S10 Tactical - *The long term planning ability and lack of R/T in ORG1 compared to ORG0. However I didn't feel safer using the HIPS than VAW/HAW after discovering the inconsistencies in conflict prediction.*
- S10 Planner - *All aircraft equipped with datalink: workload went down.*
- S10 Planner - *The enhancements to the usability of the GHMI. I cannot tell you how much extra workload the GHMI can generate.*
- S11 Tactical - *As the planner's job increases the tactical job reduces.*
- S11 Tactical - *ORG2, with most traffic equipped with datalink, the aircraft without datalink had to be controlled in a very exacting time frame.*
- S11 Planner - *Introduction of HIPS decreased my workload.*

Can you identify the differences in your thought processes when dealing with aircraft without datalink, as opposed to datalink equipped aircraft?

- S10 Tactical - *Aircraft without datalink require greater caution with regard to following CLW/HIPS quite as readily, because profiles/routes do not follow predicted paths.*
- S10 Planner - *With aircraft without datalink it was more relevant to use parallel headings therefore relying more on vertical separation.*

Did you feel that the division of responsibilities between the planner and the tactical controllers was equitable?

- S10 Planner - *The tactical in ORG3 is under-utilised!*

C3.6 For each controller role, examine whether the advanced PD/1 organisation including purely datalink equipped aircraft plus the additional training and the modifications to the PATs and GHMI (i.e. ORG3), has a positive impact on workload, compared to the PD/1 baseline system (ORG0)

Comparison of ISA scores

Planner	ORG0 = ORG3	
Tactical	Sig 1-sided diff:	ORG0 > ORG3

Comparison of TLX scores

Overall TLX scores:			ORG0 median	ORG3 median
Planner	ORG0 = ORG3		112.5	52.5
Tactical	Sig 1-sided diff:	ORG0 > ORG3	147.5	75

TLX time pressure scores:			ORG0 median	ORG3 median
Planner	ORG0 = ORG3		5	1
Tactical	Sig 1-sided diff:	ORG0 > ORG3	10	3

TLX frustration experienced scores:			ORG0 median	ORG3 median
Planner	ORG0 = ORG3		9	5
Tactical	Sig 1-sided diff:	ORG0 > ORG3	9	2.5

Number of release alerts (tactical controller only)

Tactical	ORG0 = ORG3
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R/T usage (tactical controller only)

			ORG0 median	ORG3 median	% difference
Tactical	Sig 1-sided diff:	ORG0 > ORG3	21.87%	14.02%	35.90%

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG3:

How do you believe the **tools** you were given during ORG3 affected your workload/time pressure/frustration (compared to ORG0)?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	Sig decrease	Sig decrease	Sig decrease
	c	Sig decrease	Sig decrease	Sig decrease
	f	Decrease	Decrease	Sig increase
	g			
Tactical	a	Decrease	Decrease	Increase
	d	Sig decrease	No change	Sig increase
	e	Sig decrease	Sig decrease	Decrease
	h	Sig decrease	Sig decrease	No change

How do you believe the **interface** you used during ORG3 affected your workload/time pressure/frustration (compared to ORG0)?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	Decrease	Decrease	No change
	c	Sig decrease	Sig decrease	Sig decrease
	f	Decrease	Decrease	Increase
	g			
Tactical	a	No change	No change	Decrease
	d	Sig decrease	No change	Sig increase
	e	Sig decrease	Sig decrease	Increase
	h	Sig decrease	Sig decrease	No change

In the matched pair comparison, indicate the ORG you felt you were able to control most safely/orderly/expediently (between ORG0 and ORG3).

Role	Controller	Safely	Orderly	Expediently
Planner	b	ORG3	ORG3	ORG3
	c	ORG3	ORG3	ORG3
	f	ORG0	ORG0	ORG3
	g			
Tactical	a	ORG0	ORG3	ORG0
	d	ORG0	ORG0	ORG3
	e	ORG0	ORG3	ORG3
	h	ORG3	ORG3	ORG3

Mark the effect on your workload during ORG3, using ORG0 as your point of reference.

Role	Controller	Workload
Planner	b	Increase
	c	Decrease
	f	Sig Decrease
	g	
Tactical	a	Sig Decrease
	d	Sig Decrease
	e	Sig Decrease
	h	Decrease

C3.7 Explore the relationship between controller workload and sector capacity

ISA versus number of aircraft on frequency

Results of statistical comparison of sustained aircraft capacity:

ORGs compared		Result
ORG0	ORG1	ORG0 = ORG1
ORG0	ORG2	ORG0 = ORG2
ORG0	ORG3	ORG0 = ORG3
ORG1	ORG2	ORG1 = ORG2
ORG1	ORG3	ORG1 = ORG3
ORG2	ORG3	ORG2 = ORG3

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG1:

How did your capacity to control aircraft in ORG1 compare with ORG0?

Role	Controller	Capacity
Planner	b	Decrease
	c	Increase
	f	Increase
	g	
Tactical	a	No change
	d	No change
	e	-
	h	No change

Debriefs, observations and comment sheets

ORG	Source	Comments
3	Debrief	<i>ORGs 2 and 3 balanced the tasks between the tactical controller and the planner.</i>
3	Debrief	<i>ORG1 is completely unworkable, a heap of junk.</i>
3	Debrief	<i>ORG2 and ORG3 are relatively efficient with certain levels of traffic, difficult to point out where this is, however we provide a control service and some traffic in ORGs 2 and 3 was out of control.</i>
3	Debrief	<i>Teamwork and perhaps safety compromised in ORGs 2 and 3.</i>
3	Debrief	<i>ORG0 balanced safety and efficiency.</i>
3	Debrief	<i>I liked ORG0 the most, because I am a controller and that is a controllable situation.</i>

C3.8 For each controller role, examine the impact on workload of improving the scrolling in the HIPS profile displays

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG2:

Please tick the box you believe best describes the movement within the HIPS display during ORG2.

Role	Controller	Movement within HIPS display
Planner	b	Has been improved
	c	Has become worse
	f	Has been improved
	g	
Tactical	a	No noticeable change
	d	No noticeable change
	e	Has been improved
	h	Has been improved

The movement within the HIPS display was modified between ORG1 and ORG2, how did this affect your workload/time pressure/frustration?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	Decrease	Decrease	No change
	c	Increase	Increase	Increase
	f	Decrease	No change	No change
	g			
Tactical	a	Decrease	Decrease	Decrease
	d	No change	No change	No change
	e	No change	Decrease	No change
	h	No change	No change	No change

What problems or undesirable features (if any) did you encounter when using tools during ORG2?

S10 Tactical - *Scrolling vertical planner erratic.*

S10 Planner - *The scrolling exit flight level on HIPS scrolls too quickly when there is a large change in levels, making it difficult to capture the required level.*

What good features did you encounter using the interface during ORG2?

S10 Tactical - *The scrolling of the profile makes life easier and quicker.*

What problems or undesirable features (if any) did you notice with the interface during ORG2?

S10 Planner - *The scrolling of the altitude problem solver is okay until you have a really "picky" interaction...*

Were there any changes between ORG1 and ORG2 that you felt represented a decrease in the abilities of this system?

S10 Tactical - *Scrolling vertical planner was hard to use with a small window.*

Debriefs, observations and comment sheets

ORG	Source	Comments
1	Comment sheet	<i>Difficulty experienced in picking up level in altitude problem solver.</i>
1	Comment sheet	<i>HIPS altitude problem solver: Scrolling makes it hard to capture the level.</i>
2	Observation	Scrolling in HIPS altitude problem solver is much harder on the eyes than in the previous ORGs.
2	Observation	Cursor moves down and everything shifts up.
2	Observation	Prefers the old way.
2	Observation	Sure gives you eye strain.
2	Observation	Scrolling on HIPS altitude problem solver is much too responsive for some aircraft.
2	Observation	Has trouble getting the HIPS altitude problem solver to stop scrolling at 24.
2	Debrief	<i>Hurts your eyes, 'Blurring effect'.</i>
2	Debrief	<i>It moves double the distance - as you move down, it moves up. You move too far and then you have to come back.</i>
2	Debrief	<i>'Random oscillation experienced for some aircraft'. These occasions very frustrating and detract from general usability.</i>
2	Debrief	<i>Improved as you got used to it.</i>
2	Debrief	<i>I preferred ORG1 where you moved up, moved off and waited for a second. Even the extra time which the scrolling saves in ORG2 is taken up with trying to re-focus and seeing whether you have hit the right level.</i>
2	Debrief	<i>When there are lots of levels and big level changes required, it was known to go a bit funny, but it was OK most of the time. It didn't have to be so accurate as you could drop it and it would snap at the nearest level allowing subsequent fine tuning. Preferred ORG2.</i>
2	Debrief	<i>Tends particularly to be the case with exit levels, they get overwritten.</i>
3	Observation	HIPS altitude problem solver seems to be scrolling OK.

C3.9 For each controller role, examine the impact on workload of ‘greying out’ the HIPS SPS for aircraft without datalink

Number of attempted interactions in the HIPS SPS for aircraft without datalink

Attempts to interact with aircraft without datalink in the HIPS SPS were too rare for statistical analysis to be worthwhile. See section CC2.10.

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG1:

What problems or undesirable features (if any) did you encounter when using tools during ORG1?

S10 Planner - *The time display just didn't seem to work, or work intensively, for example, a time constraint would be imposed, and would be accepted, but in fact not carried out. Why?*

What problems or undesirable features (if any) did you encounter when using the interface during ORG1?

S10 Tactical - *The "speed" HIPS interface didn't work.*

Can you make any suggestions for improving or modifying any of the aspects of the workstation or functions after ORG1?

S10 Planner - *HIPS SPS - do not use it.*

The following results have been taken from the questionnaire issued at the end of ORG2:

Please tick the box you believe best describes the HIPS SPS during ORG2.

Role	Controller	HIPS SPS
Planner	b	Has been improved
	c	No noticeable change
	f	Has been improved
	g	
Tactical	a	Has been improved
	d	Has been improved
	e	Has become worse
	h	Has been improved

The HIPS SPS was modified between ORG1 and ORG2, how did this affect your workload/time pressure/frustration?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	No change	No change	No change
	c	No change	No change	No change
	f	No change	No change	No change
	g			
Tactical	a	No change	Decrease	No change
	d	Decrease	No change	No change
	e	No change	No change	Decrease
	h	No change	No change	No change

The following results have been taken from the questionnaire issued at the end of ORG3:

Was the flight plan in HIPS easy to edit?

S10 Planner - *The GHMI really hindered what should be simple. The time display was utterly hopeless.*

Debriefs, observations and comment sheets

ORG	Source	Comments
1	Debrief	<i>Can't get the HIPS SPS to work.</i>
1	Debrief	<i>HIPS SPS not used much.</i>
1	Comment sheet	<i>If an aircraft is not equipped with datalink, why does the time window come up? There is an HMI issue here. Because if I have the window filled, I assume I can change the aircraft's speed (Time). It is really annoying to have to check OK when it tells me that the aircraft is not datalink equipped, and thus cannot accept a change, and the information shouldn't be there in the first place.</i>
2	Debrief	<i>HIPS SPS offers a constant speed to the next waypoint and not across the sector. This was a misunderstanding on the part of 10P.</i>
2	Debrief	<i>Would like HIPS SPS to be able to generate speed and time advisories.</i>
2	Debrief	<i>Would like planning control to override it.</i>
2	Debrief	<i>Speed control should be used to maintain separation not establish it.</i>
2	Debrief	<i>Tried to use HIPS SPS once in ORG1, but got lots of error messages and had to click them off, didn't get that in ORG2.</i>
2	Debrief	<i>Tactical controller uses HIPS SPS to maintain the picture.</i>
2	Debrief	<i>Tactical controller predominantly deals with aircraft without datalink and therefore doesn't need to use the window.</i>
2	Debrief	<i>Reinforces the distinction between aircraft with datalink and aircraft without.</i>
2	Debrief	<i>Very good, I don't get suckered in to using it.</i>
2	Debrief	<i>Didn't use it: didn't understand it at first, preferred vertical and lateral separation.</i>
3	Observation	<i>Enlarges HIPS SPS momentarily (mostly reduced to nil).</i>

C3.10 For each controller role, examine the impact on workload of forcing the optimisation of the PVD by having the planner and tactical control positions start up in an unusable configuration by default

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG2:

Did you find your own arrangements of windows in ORG2 to be better than the automatic configuration in ORG1?

Role	Controller	
Planner	b	Yes
	c	Yes
	f	Yes
	g	
Tactical	a	Yes
	d	Yes
	e	Yes
	h	Yes

Did you feel confident about moving and manipulating the windows on the screen into a configuration that best suited your way of working?

Role	Controller	
Planner	b	Yes
	c	Yes
	f	Yes
	g	
Tactical	a	Yes
	d	Yes
	e	Yes
	h	Yes

Please comment on moving and manipulating the windows on the screen.

S10 Tactical - *They're relatively easy to move about, overall I've got only satisfaction for the utilisation of the various windows. My only gripe would be that there are too many.*

S10 Planner - *The flexibility of the system enables you to manipulate the display with ease until you have found a suitable set-up which I think is very personal, related to your task.*

S11 Tactical - *I like everything to be in the same place every time I sit down. That way I can find it when I am busy - by reaction - and not have to search for it. I concentrate on the traffic first.*

The following results have been taken from the questionnaire issued at the end of ORG3:

In what way(s) did the interface help you to control traffic?

S10 Planner - *Being able to set up my display to my liking, led to more economical mouse movements.*

Debriefs, observations and comment sheets

ORG	Source	Comments
0	Observation	<i>For some reason I am missing the Message In bay messages.</i>
0	Observation	<i>Again, prompted by trainer to accept a proposal - moved MIW to a more prominent position to the right of the PVD - was previously at the bottom right corner of the screen.</i>
0	Observation	<i>Increased the height of PVD, more in keeping with the shape of the sector.</i>
2	Debrief	<i>Probably a good thing; makes people think where they want their window.</i>
2	Debrief	<i>Would like to be able to save their own preferences.</i>
2	Debrief	<i>Other defaults: label positioning on automatic, being able to alter the position of labels, to switch off the track vectors, save the size of the HIPS altitude problem solver (APS) and HIPS SPS.</i>
2	Debrief	<i>Individual set up: planner doesn't need PVD, depends on the size and shape of the sector and whether the controller is right handed or not.</i>
2	Debrief	<i>All managed to define arrangements that suited them.</i>
2	Debrief	<i>Preferred set up likely to change with time and experience.</i>
2	Debrief	<i>Would like to rationalise, there are too many sources of information. Same information through less sources. He feels that this is as a result of getting rid of electronic flight strips.</i>
2	Debrief	<i>Takes a couple of runs to define what you want out of the set up, once you have an idea, unlikely that you ever want to change it again.</i>
2	Debrief	<i>The default set up was very like what I would have set up anyway.</i>

C3.11 For each controller role, examine the impact on workload of filtering the CLW output to remove redundant messages and improving the legibility of the text

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG1:

What problems or undesirable features (if any) did you encounter when using tools during ORG1?

S10 Tactical - *Unhelpful messages again. CLW giving instructions pertaining to completely irrelevant normal navigation of aircraft.*

Can you make suggestions for improving or modifying any of the aspects of the workstation or functions after ORG1?

S10 Planner - *Enlarging the communications list window.*

S11 Tactical - *Communications list window - Remove unnecessary messages.*

The following results have been taken from the questionnaire issued at end of ORG2:

What good features did you encounter when using the tools during ORG2?

S10 Tactical - *Bolder type in the communications list.*

S10 Tactical - *The CLW is undoubtedly easier to read and to filter relevant information with the absence of superfluous messages.*

S11 Tactical - *Clearer labelling on communications list.*

Please tick the box you believe best describes the communications list window during ORG2.

Role	Controller	Comms. list window
Planner	b	Did not use
	c	Has been improved
	f	Has been improved
	g	
Tactical	a	Has been improved
	d	Has been improved
	e	Has been improved
	h	Has been improved

The communications list window was modified between ORG1 and ORG2, how did this affect your workload/time pressure/frustration?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	No change	No change	No change
	c	No change	No change	No change
	f	No change	No change	Decrease
	g			
Tactical	a	Decrease	No change	Decrease
	d	Decrease	Decrease	Decrease
	e	Sig decrease	Sig decrease	Sig decrease
	h	Decrease	No change	Decrease

Debriefs, observations and comment sheets

ORG	Source	Comments
1	Observation, comment sheet, debrief	<i>There are lots of spurious messages.</i>
1	Observation, comment sheet	<i>Deleted a line in the CLW because it was rubbish.</i>
1	Debrief	<i>Presentation is too small and contents are indistinct.</i>
2	Debrief	<i>Text and colour both noticeable improvements.</i>
2	Debrief	<i>Good that the redundant messages had been filtered out.</i>
2	Debrief	<i>The text was more legible.</i>
2	Debrief	<i>Both of the changes were very effective, I was pleased with the results.</i>
2	Debrief	<i>Has got rid of spurious messages, but has produced an additional problem, which is the confusion of instructions from current and future sectors. The spurious messages weren't dangerous, but the confusing messages potentially are.</i>
2	Debrief	<i>Need some kind of alarm to indicate when messages should be passed.</i>
2	Debrief	<i>Need a bigger clock.</i>
2	Debrief	<i>ORG1, there were more useless than useful messages, there were still about 10% useless messages in ORG2, e.g. messages which affect aircraft outside your airspace, can't do anything with them, have to get rid of them, because they affect the others.</i>
2	Debrief	<i>It is difficult for the tactical controller to pass on messages on time regardless of what he is doing. Better give him something to do and keep him happy.</i>
2	Debrief	<i>As planner, I occasionally check the CLW for last minute messages: it was more legible.</i>
3	Debrief	<i>Spent too much time trying to decipher the contents of the window. Even with the improvements, I still don't think it is useful.</i>

C3.12 For each controller role, examine the impact on the controller’s frustration of subduing the colour of the no-go zones in HIPS

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG2:

Please tick the box you believe best describes the colours in the HIPS displays during ORG2.

Role	Controller	Colours in HIPS
Planner	b	Have been improved
	c	No noticeable change
	f	Have been improved
	g	
Tactical	a	Have been improved
	d	Have been improved
	e	Have been improved
	h	Have been improved

The colours in the HIPS displays were modified between ORG1 and ORG2, how did this affect your frustration?

Role	Controller	Colours in HIPS
Planner	b	No change
	c	No change
	f	Decrease
	g	
Tactical	a	No change
	d	No change
	e	No change
	h	No change

What good features did you encounter when using the tools during ORG2?

S10 Tactical - *Improvements in HIPS conflict parameters and colours of the no-go zones.*

The following results have been taken from the questionnaire issued at the end of ORG3:

Are there any further comments you would like to make about the use of colour in HIPS and the PVD?

S10 Planner - *On numerous occasions one's eyes become very tired. An hour of this leaves you very fatigued.*

Debriefs, observations and comment sheets

ORG	Source	Comments
2	Debrief	<i>Didn't notice the changes.</i>
2	Debrief	<i>Didn't matter.</i>
2	Debrief	<i>Would rather not have the outline.</i>
2	Debrief	<i>Better.</i>
2	Debrief	<i>The duller the better.</i>
2	Debrief	<i>ORG1 always has the brightness low anyway.</i>
2	Debrief	<i>I could work with both.</i>

C3.13 For each controller role, examine the impact on workload of re-designing the Trajectory Support Tool

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG1:

Can you make any suggestions for improving or modifying any of the aspects of the workstation or functions after ORG1?

S10 Tactical - *TST is fiddly.*

The following results have been taken from the questionnaire issued at the end of ORG2:

What good features did you encounter when using the tools during ORG2?

S10 Tactical - *Smaller TST.*

What problems of undesirable features (if any) did you encounter when using tools during ORG2?

S10 Tactical - *I found the TST layout in ORG1 easier to use.*

S10 Tactical - *TST being reduced and button order changed seemed totally irrelevant and unhelpful. Why have the TST at all? Why have to validate AND register a trajectory?*

What problems or undesirable features (if any) did you notice with the interface during ORG2?

S10 Tactical - *Problems of interaction with the TST as described,...*

Were there any changes between ORG1 and ORG2 that you felt represented a decrease in the abilities of this system?

S10 Tactical - *TST being smaller could be considered counter-productive.*

Please tick the box you believe best describes the trajectory support tool during ORG2.

Role	Controller	Trajectory support tool
Planner	b	Has been improved
	c	Has become worse
	f	Has been improved
	g	
Tactical	a	Has become worse
	d	Has been improved
	e	Has become worse
	h	Has been improved

The trajectory support tool was modified between ORG1 and ORG2, how did this affect your workload/time pressure/frustration?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	No change	Decrease	No change
	c	Increase	Increase	Increase
	f	No change	No change	No change
	g			
Tactical	a	Increase	Increase	Increase
	d	No change	No change	No change
	e	No change	No change	No change
	h	No change	No change	No change

Debriefs, observations and comment sheets

ORG	Source	Comments
1	Observation	Closed TST to get a better look at the profile.
2	Debrief	<i>Size = retrograde step = too small.</i>
2	Debrief	<i>Liked the new size.</i>
2	Debrief	<i>Preferred the order of buttons.</i>
2	Debrief	<i>Would prefer to have a tool bar available with TST functionality available on HIPS. Use ADFL to range and bearing and if there is a problem refer to HIPS.</i>
2	Debrief	<i>Preferred the old set up.</i>
2	Debrief	<i>Kept waiting for the wrong button to become active (Learning effect?).</i>
2	Debrief	<i>Register is the key button, it should be separate from the others so as it can't be hit by accident.</i>
2	Debrief	<i>Would like a validate and register button.</i>
2	Debrief	<i>Font changes didn't seem to make any difference, not so much reading as pattern recognition.</i>
2	Debrief	<i>ORGI was easier to read, I was straining to see which button was which.</i>
2	Observation	Is not yet used to new arrangement of buttons: waits with mouse over wrong one.

C3.14 For each controller role, examine the impact on workload of amending the electronic proposal and counter-proposal facility

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG1:

Can you make any suggestions for improving or modifying the aspects of the workstation or functions after ORG1?

S10 Planner - *Message in/out windows incoming messages should be more obvious.*

S11 Tactical - *MI/MO: Too small.*

The following results have been taken from the questionnaire issued at the end of ORG2:

Please tick the box you believe best describes the message in/out windows during ORG2.

Role	Controller	Message in/out windows
Planner	b	Has been improved
	c	No noticeable change
	f	Has been improved
	g	
Tactical	a	Did not use
	d	Has been improved
	e	Did not use
	h	Did not use

The message in/out window was modified between ORG1 and ORG2, how did this affect your workload/time pressure/frustration?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	No change	Decrease	No change
	c	No change	No change	No change
	f	No change	No change	No change
	g			
Tactical	a	No change	No change	No change
	d	Decrease	Decrease	Decrease
	e	No change	No change	No change
	h	No change	No change	No change

Debriefs, observations and comment sheets

ORG	Source	Comments
1	Observation	The orange text is difficult to read, e.g. a failed proposal.
2	Debrief	11P Keeps the eyes on HIPS and rarely looks at MIW/MOW, can often miss incoming aircraft, picks them up on the PVD when he is alerted to the callsign which has gone orange. Which would then refer the controller back to MIW. MIW should flash to alert incoming messages.
2	Debrief	<i>Easier to read.</i>
2	Debrief	<i>Planner needs to have the accept message highlighted.</i>
2	Debrief	<i>Sector 11 planner finds it easier to spot incoming aircraft on the PVD. Needs a flash to alert.</i>
2	Debrief	Sector 10 planner positions MIW right at top, problems could be to do with position as sector 11 planner had MIW at the bottom.
2	Debrief	Tactical controllers hardly ever used them.
2	Debrief	<i>Much better.</i>
2	Debrief	Missing messages? One occasion, on changing the plan of a previously cleared aircraft there was a second message associated with the aircraft had completely changed. Tactical controller didn't notice and issued it. A one off? Should be an alarm to indicate otherwise the tactical controller will not notice.

C3.15 For each controller role, examine the impact on frustration of improving the point-out facility

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG1:

Can you make any suggestions for improving or modifying the aspects of the workstation or functions after ORG1?

S11 Tactical - *Pointing out: Brighter.*

The following results have been taken from the questionnaire issued at the end of ORG2:

Please tick the box you believe best describes the facilities for 'pointing out' during ORG2.

Role	Controller	Facilities for 'pointing out'
Planner	b	Did not use
	c	Has been improved
	f	Has been improved
	g	
Tactical	a	Has been improved
	d	Did not use
	e	Has been improved
	h	Has been improved

The facilities for 'pointing out' were modified between ORG1 and ORG2, how did this affect your workload/time pressure/frustration?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	No change	No change	No change
	c	No change	No change	No change
	f	No change	No change	No change
	g			
Tactical	a	No change	No change	No change
	d	No change	No change	No change
	e	No change	No change	No change
	h	Decrease	No change	Decrease

Debriefs, observations and comment sheets

ORG	Source	Comments
0,1	Training	<i>Easy to miss.</i>
2	Debrief	<i>Various comments about the colour: "Wonderful colour", "lovely", "disgusting", "off-putting".</i>
2	Debrief	<i>Highlighting is not useful, because you will talk anyway.</i>
2	Debrief	<i>Too bright.</i>
2	Debrief	<i>Best use it as an aide memoire, 'I'll get back to that'.</i>
2	Debrief	<i>Would like to have two colours available.</i>
2	Debrief	<i>Could be used for a reminder for tactical controller, but planner doesn't always need to see it. Could cancel it, of course, but that's extra work.</i>
2	Debrief	<i>Possible use as a point out between two sectors, highlight/call/that one.</i>

C3.16 For each controller role, examine the impact on workload of improving the validity of the no-go zones

Average number of attempted validations per successful trajectory modification

Planner	ORG1 = ORG2
Tactical	ORG1 = ORG2

Average time taken per trajectory modification

		ORG1 median	ORG2 median	% difference
Planner	ORG1 = ORG2	117.53	85.71	27.07%
Tactical	ORG1 = ORG2	24.23	15.24	37.12%

Note that there was a trend for the planners to take less time in ORG2 than in ORG1 to modify aircraft trajectories, but statistically significant at the 10% level only. The null hypothesis is still accepted.

Percentage of aircraft trajectory registers that were modified, analysed by each HIPS display

Horizontal problem solver:			ORG1 median	ORG2 median	% difference
Planner	Sig 1-sided diff:	ORG1 < ORG2	5.00%	14.29%	185.80%
Tactical	ORG1 = ORG2				

Altitude problem solver:

Planner	ORG1 = ORG2
Tactical	ORG1 = ORG2

Speed problem solver:

Since the SPS was used so rarely (see section CC2.14, on page 15), this measure is of little analytic value. Therefore there were insufficient data to carry out the statistical tests.

Questionnaires

The following results have been taken from the questionnaire issued at the end of ORG1:

What problems or undesirable features (if any) did you encounter when using the tools during ORG1?

S10 Planner - *The separation/risk areas are far too large.*

Can you make any suggestions for improving or modifying any of the aspects of the workstation or functions after ORG1?

S10 Tactical - *No-go zones parameters need to be reduced.*

S10 Tactical - *Make no-go zones far more accurate, and remove superfluous "behind-track" zones which are never going to be considered.*

Are there any other comments you have not already made that you feel are relevant about any aspects of ORG1, the simulation, traffic samples, the interface, the tools, etc?

S10 Planner - *No-go zones parameters too big. We use 5 miles and 1000 ft not 15 nms.*

The following results have been taken from the questionnaire issued at the end of ORG2:

What good features did you encounter when using the tools during ORG2?

S10 Tactical - *Improvements in HIPS conflict parameters and colours of the no-go zones.*

S10 Tactical - *Smaller no-go zones.*

S10 Planner - *The HIPS improvements the size of conflict and risk areas is a great improvement.*

S10 Planner - *The usability of the tools was generally improved. No single feature contributed to a reduction in workload, or ease of use. Except perhaps, the HIPS no-go zones were much easier to use.*

S11 Planner - *Reduction in no-go zones.*

Please tick the box you believe best describes the no-go zones within HIPS during ORG2.

Role	Controller	No-go zones within HIPS
Planner	b	Have been improved
	c	Have been improved
	f	Have been improved
	g	
Tactical	a	Have been improved
	d	Did not use
	e	Have been improved
	h	Have been improved

The no-go zones within HIPS were modified between ORG1 and ORG2, how did this affect your workload/time pressure/frustration?

Role	Controller	Overall workload	Time Pressure	Frustration Experienced
Planner	b	Decrease	Decrease	Decrease
	c	Decrease	Decrease	Decrease
	f	Decrease	No change	Decrease
	g			
Tactical	a	Decrease	Decrease	Decrease
	d	No change	No change	No change
	e	No change	No change	No change
	h	No change	No change	No change

What problems or undesirable features (if any) did you encounter when using tools during ORG2?

S11 Planner - *Conflicts not always shown on HIPS. Aircraft not shown or yellow no-go zones remaining so when they should be red.*

Debriefs, observations and comment sheets

ORG	Source	Comments
1	Observation	No-go zone in horizontal problem solver dictating a much wider separation than controllers would normally use - also confusing because the closest approach shown in CRD is 3 miles.
1	Observation	18 miles between two aircraft and one is only just outside the no-go zone of the other on the horizontal problem solver - this illustrates that the no-go zones are too big.
1	Comment sheet	<i>HIPS no-go zones much larger than associated conventional separation standards.</i>
1	Comment sheet	<i>HIPS no-go zones much too broad.</i>
1	Comment sheet	<i>The separation that HIPS uses contributes greatly to a reduction in capacity.</i>
2	Comment sheet	<i>Lack of red on HIPS! (worried that it doesn't show all conflicts)</i>
2	Comment sheet	<i>Conflict between 2 aircraft not highlighted as a risk even though descent profile passes through the other's risk box, i.e. showing as a yellow when it should be a red.</i>
2	Comment sheet	<i>The conflict parameters are much better, but they allow the planner to arrange for some very close passes. Was about to intervene when aircraft carried out manoeuvre. In reality, no-one would work like that.</i>
2	Observation	An airmiss was planned as conflict-free, there is no margin for error in HIPS now.
2	Debrief	<i>Using HIPS perfectly legally, there was a near thing, when a planned aircraft descended faster than was planned.</i>
2	Comment sheet	<i>HIPS is NOT reliable in this situation. It has created three airmisses in this one session just on sector 11 (not planned ones).</i>
2	Debrief	<i>Planner: a definite improvement. What's the point in having a 12 mile no-go zone when you are supposed to be using 5?</i>
2	Debrief	<i>ORG1: You knew you were planning correctly, but were still getting red conflicts.</i>
2	Debrief	<i>It is now more apparent when you cut it fine, there is no buffer zone.</i>
2	Debrief	<i>Don't care what the parameters are, as long as they are consistent.</i>

2	Debrief	<i>Separation can't be guaranteed for aircraft without datalink.</i>
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C3.17 For each controller role, examine the impact on workload of the extra training

This low level objective has been addressed in sections CC3.4 and CC3.10.

C3.18 For each controller role, examine whether the PD/1 PATs and GHMI modifications have had a positive impact on the usability compared to the PD/1 baseline

This objective has been addressed using the SUMI questionnaires, which quantitatively measure how usable the controllers found the PD/1+ ORGs. The controllers were asked to complete the questionnaires based on their experience of the ORGs during the trial period. The nature of SUMI is to reflect the usability of each ORG as a whole and therefore it is difficult to quantify the effect of the individual GHMI modifications. Discussion of the SUMI results appears in the main body of the report, and the interpretation concentrates on the GHMI and PATs modifications, where possible.

The results were processed by the SUMISCO analysis software, giving a rating for five aspects of the software (efficiency, likeability, helpfulness, control and learnability), as well as an overall global score.

The scales are arranged so that the standard for state-of-the-art commercial software is 50. Software rated above this is better than the state-of-the-art for quality of use, and software rated below 50 is poorer. Most “good” software will rate above 60 in most sub-scales, and any ratings below 40 usually indicate the need for remedial action. More detailed statistical analysis requires a minimum of ten controllers, whereas the PD/1+ trial had only eight and latterly seven, but this does not invalidate the findings noted here.

Table C7 to Table C10 below show how each individual controller rated the various aspects of the PD/1+ ORGs. The “SUMI” row of the table shows the overall score for each category; this is the median of the scores in that category. Note that due to sickness, controller g was unavailable to complete the SUMI questionnaires for ORGs 1, 2 and 3.

ORG0	Global	Efficiency	Affect	Help	Control	Learnability
Controller a	15	14	14	15	22	38
Controller b	33	27	29	29	42	62
Controller c	49	48	43	47	55	61
Controller d	43	50	41	44	44	55
Controller e	26	27	16	34	21	54
Controller f	20	16	25	11	42	28
Controller g	60	57	53	66	58	71
Controller h	44	32	60	57	35	50
SUMI	38	29.5	35	39	42	54.5

Table C7 - SUMI results for ORG0

ORG1	Global	Efficiency	Affect	Help	Control	Learnability
Controller a	22	17	11	31	20	34
Controller b	30	21	32	33	22	62
Controller c	43	41	47	41	45	66
Controller d	45	50	46	47	37	67
Controller e	19	20	16	22	27	40
Controller f	16	11	29	17	21	32
Controller g						
Controller h	47	38	64	60	35	35
SUMI	30	21	32	33	27	40

Table C8 - SUMI results for ORG1

ORG2	Global	Efficiency	Affect	Help	Control	Learnability
Controller a	19	11	14	32	14	36
Controller b	35	27	38	37	26	65
Controller c	51	38	41	60	56	66
Controller d	50	55	54	47	42	70
Controller e	24	24	22	31	24	47
Controller f	18	11	37	23	21	35
Controller g						
Controller h	47	44	67	57	33	38
SUMI	35	27	38	37	26	47

Table C9 - SUMI results for ORG2

ORG3	Global	Efficiency	Affect	Help	Control	Learnability
Controller a	27	17	21	46	24	44
Controller b	52	44	55	58	41	70
Controller c	51	41	51	60	51	69
Controller d	62	62	65	63	48	63
Controller e	25	24	19	41	23	60
Controller f	24	17	23	26	27	32
Controller g						
Controller h	59	47	71	65	48	57
SUMI	51	41	51	58	41	60

Table C10 - SUMI results for ORG3

The overall results for the four ORGs are summarised graphically in Figure C20 below, and are discussed in the remainder of this section.

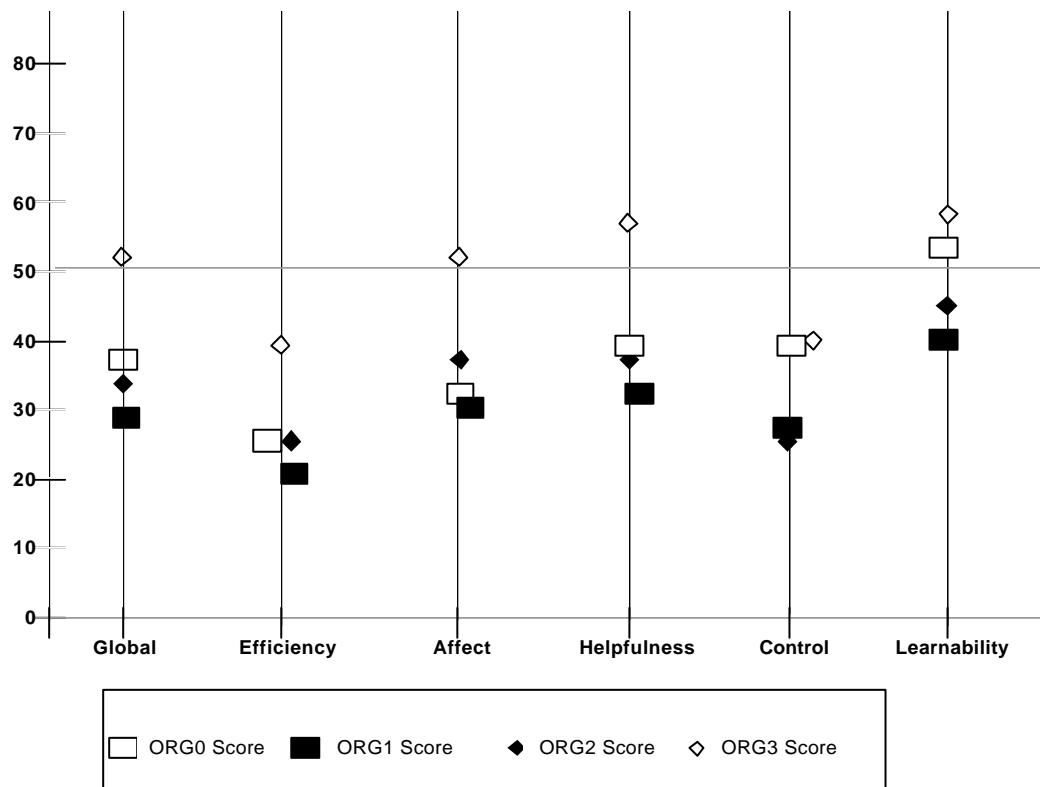


Figure C20 - Summary of SUMI scores

Interpretation of SUMI scores: Global

The global metric indicates the controllers' perception of the usability of the system overall, and, especially with the small sample size, is the most significant indicator of the six SUMI rankings.

The global score for each ORG was:

ORG0	38
ORG1	30
ORG2	35
ORG3	51

Software scoring between 50 and 60 on the global scale is, by definition, "above average," and the target for the global score for "state-of-the-art" commercial software should be 60 or more. ORG0, ORG1 and ORG2 rated as well below average. ORG3, at 51, was considered to be just above average.

Interpretation of SUMI scores: Efficiency

The efficiency metric measures the extent to which the controllers felt the software enabled tasks to be performed quickly, effectively and economically.

The efficiency score for each ORG was:

ORG0	29.5
ORG1	21
ORG2	27
ORG3	41

All the ORGs scored low, but ORG3 was acceptably efficient.

Interpretation of SUMI scores: Affect

The affect score is a measure of "likeability", or how much the controllers enjoyed interacting with the system. The affect score for each ORG was:

ORG0	35
ORG1	32
ORG2	38
ORG3	51

ORG0, ORG1 and ORG2 rated as well below average. ORG3, at 51, was considered to be just above average.

Interpretation of SUMI scores: Helpfulness

The helpfulness score reflects the impact of the visual cues and feedback offered. The helpfulness score for each ORG was:

ORG0	39
ORG1	33
ORG2	37
ORG3	58

In this category, ORG0 was classified within the “acceptable” range, ORGs 1 and 2 were well below average, and ORG3 at 58 was considered to be well above the average for state-of-the-art software with respect to helpfulness.

Interpretation of SUMI scores: Control

This score indicates how easy the controllers found it to make the software do what they wanted. This can be affected by factors such as complexity of task sequences, labelling of controls and system response times.

The control score for each ORG was:

ORG0	42
ORG1	27
ORG2	26
ORG3	41

ORG0 scored highest in this factor, yet still the controllers felt their level of control to be only just acceptable for ORG3.

Interpretation of SUMI scores: Learnability

The learnability score indicates how easy the controllers felt the system was to learn. The learnability score for each ORG was:

ORG0	54.5
ORG1	40
ORG2	47
ORG3	60

ORG0 and ORG3 scored well over 50, which indicates that they are above average for learnability and indeed ORG3 was considered excellent in this respect. ORGs 1 and 2 were acceptable in this category.

C3.19 Further investigation: learning effects

After completion of ORG3 at the end of the second fortnight, it was possible to run a further exercise using ORG1, EX204 in the exercise naming convention, to allow investigation of ‘learning effects’ on workload and tool usage efficiency, i.e. to address the question of whether the controllers found samples later in the fortnight easier purely because of greater familiarity with the system or simulated traffic.

EX204 was matched, in terms of traffic sample and three of the four controllers, with a previous ORG1 exercise, namely EX164. Controller g, the sector 11 planner in EX164, was unavailable to take part in EX204 due to sickness. In addition to losing controller g, further data were lost because, in the subsequent debrief, one of the other controllers claimed to have not taken the learning effect exercise seriously.

Comparison of ISA scores

The difference in ISA scores between EX164 and EX204 was statistically tested only for controller h, the sector 11 tactical controller, since ISA scores were not available from the other controllers. The difference was statistically significant, and showed that controller h perceived workload to be greater in EX164 than in EX204.

Comparison of TLX scores

It was not possible to test for a statistically significant difference in the overall TLX scores, or the TLX time pressure and TLX frustration experienced scores, due to the small amount of data available (only two data points for each exercise).

Percentage of time spent using R/T

Sector	EX164	EX204
11	19.23%	16.46%

Table C11 - Percentage of time R/T in use for EX164 and EX204

Table C11 shows that in sector 11, R/T was used more in EX164 than in EX204. The figures include both transmitted and received R/T.

Time taken to register each aircraft

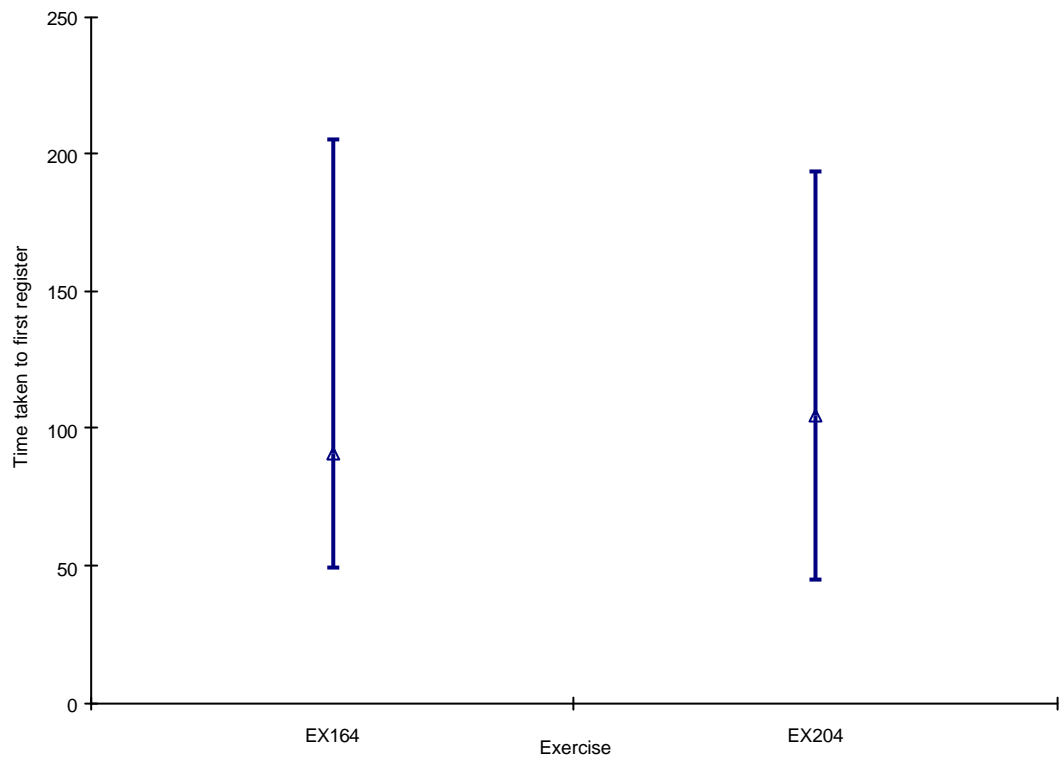


Figure C21 - Time taken to register each aircraft for EX164 and EX204

Figure C21 shows the median values of the time taken from the aircraft entering the advanced information state, to the controller registering a trajectory for that aircraft.

The values were tested using the Wilcoxon signed ranks test, with rows matched on a per aircraft basis, to determine if there was a difference between the two exercises. The difference was not statistically significant.

Average time taken to modify trajectory

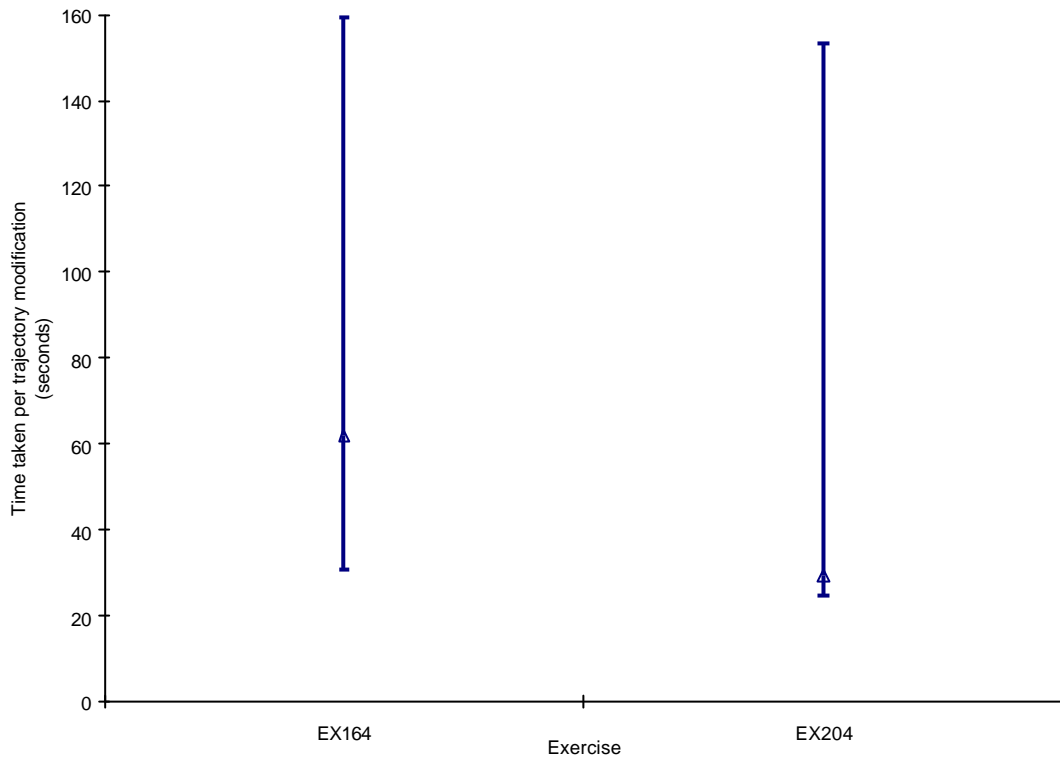


Figure C22 - Average time taken to modify trajectory for EX164 and EX204

Each time an aircraft trajectory was edited, the time spent by the controller from the initial edit to finally successfully registering that trajectory, was recorded for each exercise. Figure C22 shows the median and the 25th and 75th percentile range of this measure, known as ‘time spent per trajectory modification’, for each of the two exercises. The measure is compared between EX164 and EX204 for the sector 10 planning controller, and is an objective measure of tool use efficiency.

The controller performed trajectory modifications on twenty occasions during exercise EX164, and on nineteen occasions during EX204. The times taken per trajectory modification were compared between the two exercises using the Wilcoxon-Mann-Whitney test. Although on average time spent re-planning did decrease slightly, this difference was not statistically significant.