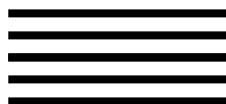


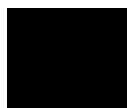
PROGRAMME FOR
HARMONISED AIR TRAFFIC
MANAGEMENT RESEARCH
IN EUROCONTROL



DOC 96-70-24



EUROPEAN ORGANISATION FOR THE SAFETY OF AIR NAVIGATION, EUROCONTROL



PD/1 FINAL REPORT
Annex D
Analysis of Questionnaires

PHARE/NATS/PD1-10.2/SSR;1.1



EUROCONTROL

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Date: January 1997

REVISION HISTORY

June 1996	Draft version 0
July 1996	Draft version 1 incorporating NATS review comments
September 1996 PD3CG	Draft version 2, with minor changes following review by
October 1996	Version 1.0, with minor changes, approved by the PCC
January 1997	Version 1.1, issued as a final document in Volume 2, approved by the PHARE Management Board

LIST OF CONTENTS

1. ANALYSIS OF QUESTIONNAIRES	6
1.1 PROCEDURE.....	6
1.2 PRESENTATION OF THE RESULTS	6
2. TRAINING AND SIMULATION ENVIRONMENT.....	8
3. HMI: DISPLAYS, DIALOGUES, INTERACTION.....	14
4. OPERATIONAL ASPECTS: TRAFFIC HANDLING, PROCEDURES	23
5. INDIVIDUAL TOOLS AND FUNCTIONS.....	39
5.1 DISCUSSION OF RESULTS	39
5.2 RESPONSES FROM BOTH PLANNING AND TACTICAL CONTROLLER.....	42
5.3 RESPONSES FROM PLANNING CONTROLLERS.....	48
5.4 RESPONSES FROM TACTICAL CONTROLLERS.....	55
6. GLOSSARY	57

LIST OF TABLES

Table 2-1 - Training and Simulation Environment; Summary of Questionnaire Results	9
Table 3-1 - HMI aspects; Summary of Questionnaire Results	16
Table 4-1 - Operational Aspects per ORG; Summary of Questionnaire Results	25
Table 5-1 - Individual Tools and Functions; Summary of Questionnaire Results	41

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1. ANALYSIS OF QUESTIONNAIRES

This annex to the PD/1 final report describes the procedures for the compilation and statistical analysis of the controllers' questionnaire responses, and presents the results in four thematically ordered sections:

- training and simulation environment;
- HMI: displays, dialogues, interaction;
- operational aspects: traffic handling, procedures;
- individual tools and functions.

1.1 PROCEDURE

All questionnaire items were presented to the controllers as statements, with controllers requested to check the appropriate level of the six-point rating scale below:

strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
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The responses obtained were analysed separately for each item.

As a first step, the frequency distribution of the responses in the six categories was compiled and plotted as a histogram.

Second, a statistical test was applied as an objective means to identify whether a significant trend of responses, to agree or to disagree, existed.

This was done using the Binomial Test, which is for testing two-class frequency distributions (binomial distributions). In our case, the two classes were formed by combining all responses on the left-hand (disagree) part of the scale against all combined responses on the right-hand (agree) part of the scale. The Binomial Test gives the probability of an observed proportion of the two frequencies, under the hypothesis that there is no true difference between the two. This hypothesis is equivalent with saying that there is no significant trend of responses on either side of the scale, and thus observed differences are caused by chance alone. The more different the two observed frequencies are, the smaller becomes this probability, and in case of a low probability of less than five per cent ($p < 0.05$) a significant trend (either to agree or to disagree) will be stated.

1.2 PRESENTATION OF THE RESULTS

The subsequent sections of this annex start with explanations of the main findings, thereby referring to the respective items. Written controller comments are incorporated in summary, as well as specific information about particular teams (weeks), if any remarkable observations of this kind were made. Summary tables at the end try to give some general overview.

Thereafter, the questionnaire items belonging to the section are listed. A uniform mode of presentation has been adopted for all items:

1. Statement text.
2. N ; number of responses obtained.

Distribution histogram.

Each histogram entry stands for a controller response, thereby allowing distinctions between T (tactical controllers) and P (planning controllers) as well as between sectors 10 and 11; e.g. T10 stands for a sector 10 tactical controller's response, P11 for a sector 11 planning controller's response, etc.

3. Binomial Distribution and Significance.

Top line: Overall binomial distribution of responses.

Second line: T = Sub-distribution of tactical controller responses.

Third line: P = Sub-distribution of planning controller responses.

Fourth line: 10 = Sub-distribution of sector 10 controller responses.

Fifth line: 11 = Sub-distribution of sector 11 controller responses.

In case of a statistically significant trend of the overall distribution or any sub-distribution the associated probability (less than 0.05) is given in the corresponding line.

A missing probability indication or "n.s." means that there was no significant agreement or disagreement in terms of the test criterion chosen here.

In case of significance, "+" indicates acceptance (or positive responses) for the PD/1 system or concept, whereas "-" indicates rejection/negative responses. Since in the questionnaire positive and negative statements had been mixed intentionally, the +/- signs are thought to be necessary for quick orientation. In several cases of non significant results where the significance limit of $p < 0.05$ was closely failed by one or two responses only and there may be an interesting, non-significant trend, "(+)" or "(-)" in brackets are used to indicate tendencies.

Note: the order of the questionnaire items has been re-arranged for reasons of presentation of the results.

2. TRAINING AND SIMULATION ENVIRONMENT

Starting with the work environment in general (item 1.1), the overall distribution of controller responses was not significant. Although there was a strong tendency to agree in saying it was comfortable (the significance limit was missed by one vote only) there were a few comments with slight complaints about seating (“would like better seating”; 2 comments), air condition (“too cold”; 2 comments) and the use of headsets (2 comments).

Distractions/disturbances from other activities in the control room (1.2) were not a matter of concern, the responses were highly significant positive. Except two controllers in weeks 1 and 2, all the rest negated any distractions.

Responding to the ISA (1.3) which apparently was requested noticeably enough (1.4) was not significantly accepted or rejected by the controller sample in total, but there appeared to be opposite tendencies for TCs who did rather rate ISA as distracting, and for PCs who did not. This can be seen from the bimodal distribution histogram as well as from the binomial frequencies for TCs and PCs.

Traffic samples (1.5) and the way in which feed sectors were simulated (1.6) were accepted in tendency, but not significantly. Comments indicated that the reasons preventing full acceptance were in case of item 1.5 some minor shortcomings in the aircraft performance models underlying the simulation (not really the traffic samples), in case of item 1.6, the fact that sometimes traffic had been released from feed sectors which was already in conflict.

Asking TCs about their interaction with the pseudo pilots (1.7, 1.8) resulted in positive responses which might have been even clearer if pseudo pilots would have been able “to have access to full flight plan data of their a/c” (a comment to item 1.8).

Controllers in total agreed significantly with saying they had enough training on the airspace and route structure (1.9), and tended to agree with the amount of training on tools and functions (1.10) and on the roles of TC and PC (1.11). In particular tactical controllers and sector 11 controllers were significantly positive in nearly all of their responses to the training issues.

Table 2-1 summarises the findings of this section. The vast majority of positive response tendencies and significances support the conclusion that the training and simulation conditions provided in PD/1 had been accepted sufficiently well by the participating controllers. This is also an important factor for increasing trust in the simulation results.

3. HMI: DISPLAYS, DIALOGUES, INTERACTION

Items 2.1 to 2.7 deal with some aspects of interacting with the PD/1 system.

In general, the interaction mechanisms were well accepted. Although there were some written comments, spread over various items of this section (in total six comments), which indicated that sometimes controllers experienced system response times that went down “too slow when the system was busy”, the concept and mechanisms for interacting with the system were widely approved.

The mouse was significantly accepted as a suitable interaction device (2.1), as were the window management techniques (2.2).

The features provided by the radar toolbox (2.3) were significantly accepted as giving enough flexibility. There was only a single comment suggesting as an additional feature “a button for F/L highlighting, e.g. when 350 is selected to highlight all a/c at F/L 350”.

The pop-up menus were accepted significantly, as regards handling them (2.4) as well as the number of options offered (2.5). There were two written comments from TCs under 2.4, criticising that pop-up menus require “much mouse movement” and that “default values were of limited use”. N.B.: item 2.4 was wrongly stated since no speed menu was offered in PD/1.

In 2.6, a significant majority of controllers agreed that electronic co-ordination was an improvement as compared to co-ordination by telephone.

Display aspects are covered under items 2.7 to 2.16 (general) and under items 2.17 and 2.18 (differentiated per ORGs).

The responses on the size of the screens were in total significantly positive (2.7).

Although the tactical controllers significantly agreed with the screen layout in general (2.8), an overall significant acceptance was not achieved. There appeared to be a close relation to item 2.9 (with clearly negative overall response on the readability of text) because written comments under both items mostly referred to potential difficulties with reading information which is presented in different colours on different backgrounds. Most frequently quoted here were mustard labels, red and pink text and associated difficulties with reading it e.g. in labels, but also CLW and HIPS were mentioned in this context.

On the other hand, the colour coding concept for indication of aircraft status was significantly highly accepted as being comprehensible and useful (items 2.10 and 2.11).

Abbreviations used were significantly highly accepted (2.12).

Item 2.13 indicates that the issue of discriminating 3-D and 4-D *capability* of aircraft was perhaps not optimally solved. This is reflected in a non significant bimodal distribution of responses, indicating that part of the controller group accepted the solution while another part rejected it (in fact, an aircraft symbol in PD/1 indicated the actual *mode* of 3-D or 4-D operation, but not the underlying *capability* which might have been useful e.g. in the case of a 4-D FMS-equipped aircraft operating in 3-D mode after a tactical intervention).

There was a non-significant tendency to accept the usefulness of information displayed through message-in/message-out windows (2.14) and the sector inbound list (2.15) in a routine

manner on the PVD. Although there were controllers saying they “hardly ever used” the message-in/message-out windows, as well as controllers denying any need for a SIL, the majority of controllers tended to appreciate both kinds of information.

A reverse tendency could be observed concerning STCA presentation (2.16) which was rejected by the majority of the participants. The comments written down indicated as the main reason “too many false alarms” or “mistakes” which could even “shock the controller” (six comments in total).

Two more items about displays and interaction were put under each of the three ORGs.

The controllers in total clearly felt that aircraft that should have been accessible to mouse clicks were sometimes not (2.17) under all ORGs. The negative responses were relatively strongest for ORG 0 where all sub-distributions were significant.

It appears that linking accessibility in the given way with the Advanced Information status of aircraft was not well accepted by the controllers.

The responses about becoming aware of important events on the screen (2.18) were in no case significant, i.e. neither clearly in favour nor clearly against the system. From the binomial distributions there might be seen a slight tendency to rate ORG 0 a little bit better than the advanced ORGs, particularly by the group of tactical controllers (see line T). There were a few written comments under this item, criticising in particular the CLW.

2.1	suitability of mouse				+
2.2	ease of window use				+
2.3	flexibility of radar toolbox				+
2.4	ease of pop-up menus				+
2.5	options on pop-up menus				+
2.6	electronic coordination				+
2.7	screen size				+
2.8	screen layout				(+); TC+
2.9	text easy to read				-
2.10	colour coding of labels				+
2.11	colour indication of aircraft status				+
2.12	meaning of abbreviations				+
2.13	clarity of 3-D/4-D status				0
2.14	content of message in/out windows				(+)
2.15	value of sector inbound list				(+)
2.16	presentation of STCA				(-)
	<i>HMI aspects per ORG</i>	ORG 0	ORG 1	ORG 2	
2.17	accessibility of aircraft to mouse clicks	-	-	-	
2.18	clarity on screen of important events	0	0	0	

2.7 The screen size is appropriate for daily work.

N=32

T10		T11		T10		P11		T10		P10		P10	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree								

Binomial Distribution; Significance

	7	:	25	p < .01	+
T	4	:	12		
P	3	:	13	p = .022	+
10	4	:	12		
11	3	:	13	p = .022	+

2.8 The screen layout in general should not be changed.

N=32

T10		T11		T10		P11		T10		P10		P10	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree								

Binomial Distribution; Significance

	10	:	22	n.s.(+)	
T	3	:	13	p = .022	+
P	7	:	9		
10	4	:	12		
11	6	:	10		

2.9 All text on the screen was easy to read.

N=31

T10		T11		T10		P11		T10		P10		P10	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree								

Binomial Distribution; Significance

	24	:	7	p < .01	-
T	10	:	5		
P	14	:	2	p = .004	-
10	12	:	4		
11	12	:	3	p = .036	-

2.13 The 3-D/4-D FMS capability of the aircraft was always easy to recognise.

N=32

T10									
T10	P10	T11	P11	T10	P10	T11	P11	T10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree				

Binomial Distribution; Significance		
	14	: 18
T	7	: 9
P	7	: 9
10	7	: 9
11	7	: 9

2.14 The information in the message-in / message-out windows was appropriate.

N=32

P11									
P11	T11	P10	T10	P11	T10	P10	T10	P10	T10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree				

Binomial Distribution; Significance		
	11	: 21
T	5	: 11
P	6	: 10
10	4	: 12
11	7	: 9

2.15 I don't really need the information given by the sector inbound list.

N=32

P10									
P10	T10	P10	T10	P10	T10	P10	T10	P10	T10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree				

Binomial Distribution; Significance		
	21	: 11
T	10	: 6
P	11	: 5
10	10	: 6
11	11	: 5

2.16 The short term conflict alert (STCA) was presented in a suitable way.

N=32

T11									
T11	P11	T10	P10	P11	T11	P11	T11	P11	T11
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree				

Binomial Distribution; Significance		
	20	: 12
T	10	: 6
P	10	: 6
10	11	: 5
11	9	: 7

2.18 All important events coming up on the screen could be recognised easily - ORG 0

N=32

Binomial Distribution; Significance

15 : 17 n.s.
 T 6 : 10
 P 9 : 7
 10 8 : 8
 11 7 : 9

P11							
P11		T11					
T11	P11	T11					
T10	P11	T11	P10	T11			
T10	P11	T10	P10	T11	P11		
P11	T10	P10	T10	P10	T11	P11	
T10	P10	T10	P10	T10	P10	T11	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree		

2.18 All important events coming up on the screen could be recognised easily - ORG 1

N=32

Binomial Distribution; Significance

19 : 13 n.s.
 T 10 : 6
 P 9 : 7
 10 11 : 5
 11 8 : 8

T11								
T11	P11	T11				P11		
T10	P11	T10	P11	T11	P11	P11		
P11	T10	P10	T10	P10	T11	P10	T11	P11
T11	P10	T10	P10	T10	P10	T11	P10	T10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree			

2.18 All important events coming up on the screen could be recognised easily - ORG 2

N=32

Binomial Distribution; Significance

19 : 13 n.s.
 T 11 : 5
 P 8 : 8
 10 11 : 5
 11 8 : 8

T11				T11			
T11	P11	T11	P11	T11	P11	P11	
T10	P11	T11	P11	T11	P11	P11	
T10	T10	P10	T10	P10	T11	P10	P10
T10	T10	P10	T10	P10	T10	P10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree		

4. OPERATIONAL ASPECTS: TRAFFIC HANDLING, PROCEDURES

Among the items of this section are those which addressed particular aspects of the controllers' practical work, and others which were rather suited to get insight into their views of the operational concept as a whole.

The first four items refer to some operational issues which can be treated in a more general manner, i.e. which were anticipated to be not specific for any particular ORG. The remainder of this section describes results obtained from identical items under the different ORGs of PD/1.

3.1 tried to capture data link effect on controller workload. Despite that there were some controllers who denied any reduction of their own workload, a significant proportion (three quarters) of the controller sample agreed in saying that data link reduced their workload.

This is in parallel to the NASA TLX figures (see Annex C) where workload was found to decrease with higher percentages of 4-D/datalink-equipped aircraft in the traffic mixes.

Nevertheless, controllers were a bit more reluctant to assess 4-D FMS aircraft as a benefit for their own work. Only in tendency (not significant) they would prefer all aircraft to be 4-D FMS equipped (item 3.2).

3.3 may perhaps spotlight the rationale beyond this attitude: when tactical controllers were asked whether it is acceptable to them that 4-D FMS aircraft fly as cleared (N.B. and planned conflict-free by the PC) previously, no uniform trend but a bimodal distribution of their responses came out. This reflects two opposite opinions, one group of TCs saying yes, another group saying no. Comments indicated that those saying no had difficulties to accept level changes and turns of aircraft, without explicit TC approval.

It seems that acceptance of flying without further communication depends heavily on proper teamwork of PC and TC in one sector. It guarantees, among others, that e.g. aircraft turns and level changes will not be perceived by the TC as unexpected or surprising events.

Under 3.4 controllers agreed significantly that clear sector responsibilities were given. However, a look at the PCs and TCs sub-distributions suggests that control authority was estimated as being more clear (TCs responses were significant) than planning authority (PCs responses were not significant).

Differentiated amongst ORGs, controllers were first asked about safe handling of traffic (3.5). Another item about keeping aircraft separated (3.6) followed later in the questionnaire. However, the responses showed that controllers obviously treated those two items as being completely equivalent, since the same pattern of responses could be observed. In both cases the reference system (ORG 0) was significantly accepted, the only three negative responses under 3.5 and four of the five negative responses under 3.6 came from one controller team in one particular week. The advanced ORGs were not accepted in that respect, there seemed to be even a slight but consistent trend to the opposite.

Presumably the perception of separation (for a controller the main issue of safety) was different in the advanced ORGs.

A pattern of responses which was similar to the safety and separation issues was found for the controller estimates of how well the system helped to “maintain the picture” (3.7).

Again, ORG 0 received overall approval (the highest by PCs), the advanced ORGs did not. Even negative trends were observed for ORG 1 and ORG 2.

On the other hand, the advanced ORGs were perceived to be relatively better in supporting conflict detection (3.8) and conflict resolution (3.9) than ORG 0. In ORG 0 conflict detection was rated with a negative tendency, conflict solving was significantly negative. A trend towards more favourable responses for the advanced ORGs could be observed, with the planning controllers contributing most to this.

The roles of tactical and planning controllers, namely the task partitioning between TC and PC (3.10) and the co-operation of TC and PC within a sector (3.11) were generally accepted as being clear and unproblematic. Significant positive overall responses were obtained under each ORG.

In 3.12 (co-ordination should have been possible earlier) significant negative responses were obtained for all ORGs. Controllers generally would have liked to co-ordinate traffic with other sectors earlier than the system sometimes allowed them to do. Again, only gradual differences between ORGs could be identified. It seems the co-ordination issue was aggravated in ORG 2.

Did the system allow the controllers to work according to their personal work style? In 3.13 overall responses about the reference system (ORG 0) were in tendency positive; sector 10 controllers responded significantly positive. A written comment saying it was “...not possible to work ahead when traffic is in the previous sector” gives a hint that this might have been a matter of concern particularly for controllers of sector 11 which is the smaller/narrower sector. Nevertheless, ORG 0 which was closest to the today’s operational procedures and conventional work style achieved much higher approval than the advanced ORGs. ORG 1 was disliked most, getting significantly negative responses. The ORG 2 responses were in tendency negative, too.

3.14 aimed at subjective controller capacity estimates, a significant number of controllers were confident that they could have handled even more traffic with the ORG 0 system. Again, as in the previous item about work style, sector 10 controllers in particular responded significantly positive. No such significant response distributions could be observed for ORG 1 and ORG 2.

Finally, in 3.15 controllers were asked to estimate their workload as compared to the today’s system. Although one might argue that “today’s system” is quite an imprecise term in this context, the controllers’ *relative* view of the ORGs revealed some markedly basic differences. ORG 1 received the most unfavourable significant negative overall estimates. As in the items above, sector 10 controllers played a prominent role here. In ORG 0 as well as in ORG 2 a considerably higher number of controllers gave better workload estimates, but the distributions were not significant.

This result fits perfectly with the ISA workload scores analyses (see Annex C). Average ISA scores were highest under ORG 1 as compared with ORG 0 and ORG 2 averages.

Table 4-1 summarises the results of the questionnaire items which allowed for certain operational aspects a comparison between the PD/1 ORGs. It shows that ORG 0, the ORG closest to current day procedures and with which the participants were most familiar, was preferred over the advanced system in terms of safety/separation, maintenance of the picture,

personal work style, and even the amount of traffic that the controllers felt confident to cope with. Although the controllers (planning controllers in particular) admitted that detection and solution of conflicts was better supported by the advanced system. Among the advanced system versions ORG 2 was accepted better than ORG 1. ORG 1 achieved the least favourable figures in terms of controller acceptance and subjective workload estimates.

	ORG 0	ORG 1	ORG 2
3.5 safe handling of traffic	+	0	0
3.6 keeping aircraft separated	+	0	0
3.7 maintaining the picture	+	0	0
3.8 conflict detection	(-) PC(-)	0 PC(+)	0 PC(+)
3.9 conflict solving	- PC(-)	0	0 PC(+)
3.10 PC/TC task partitioning	+	+	+
3.11 PC/TC co-operation	+	+	+
3.12 early co-ordination	-	-	-
3.13 work according to personal work style	(+) S. 10+	-	(-)
3.14 could have handled even more traffic	+ S. 10+	0	0
3.15 workload compared with today's system	0	- S. 10-	0

Table 4-1 - Operational Aspects per ORG; Summary of Questionnaire Results

3.6 It was always possible to keep aircraft well separated - ORG 0

N=32

										P11	Binomial Distribution; Significance						
										P11							
										T11	T	5	:	27	p < .001 +		
										T11	P	2	:	14	p = .004 +		
										T11	P	3	:	13	p = .022 +		
										T10	10	3	:	13	p = .022 +		
										T10	11	2	:	14	p = .004 +		
										T10							
										T11	T11	T10	P10	T11			
										P11	T11	P11	T10	P10	T11		
T10	P10	T11	P10	T10	P10	T10	P10	T10	P10	T10							
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree												

3.6 It was always possible to keep aircraft well separated - ORG 1

N=32

										Binomial Distribution; Significance									
										P11	18	:	14	n.s.					
										P11	T	8	:	8					
										P11	P	10	:	6					
										T11	10	10	:	6					
										T11	11	8	:	8					
										T11									
										T10	T11	P11	T10	P11					
										T10	P10	T11	P10	T11	P11	T10	P11		
										T10	P10	T10	P10	T10	P10	T10	P10		
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree														

3.6 It was always possible to keep aircraft well separated - ORG 2

N=32

										Binomial Distribution; Significance										
										T11	18	:	14	n.s.						
										T11	T	10	:	6						
										T10	P	8	:	8						
										T10	10	10	:	6						
										T10	11	8	:	8						
										T11										
										T10	P11	P11	T11	P10						
										T10	P10	T10	P10	T11	P11	T11	P10			
										T11	T10	P10	T10	P10	T10	P10	T10	P10		
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree															

3.7 “Maintaining the Picture” was supported well by the system - ORG 0

N=32

Binomial Distribution; Significance

	9	:	23	p < .05	+
T	6	:	10		
P	3	:	13	p = .022	+
10	4	:	12		
11	5	:	11		

				P11	T11				
		T11		P11	T11	P11			
		T11		P10	T11	P11			
		T11		P10	T10	P11			
	P11	T10		T11	P10	T10	P11	T11	P10
T10	P10	T10	P11	T10	P10	T10	P10	T10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree				

3.7 “Maintaining the Picture” was supported well by the system - ORG 1

N=32

Binomial Distribution; Significance

	20	:	12	n.s.
T	10	:	6	
P	10	:	6	
10	11	:	5	
11	9	:	7	

		T11	P11						
		T11	P11						
		T11	P11		T11				
		T10	P11		T11	P11		P11	
T11	P10	T10	P10	T10	P11	T11	P10	T11	P11
T10	P10	T10	P10	T10	P10	T10	P10	T10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree				

3.7 “Maintaining the Picture” was supported well by the system - ORG 2

N=32

Binomial Distribution; Significance

	20	:	12	n.s.
T	9	:	7	
P	11	:	5	
10	9	:	7	
11	11	:	5	

				P11					
		P11		T11		T11		P11	
		P11	T11	P11	T11	P11	T10	T11	P11
T11	P10	T11	P10	T10	P11	T10		T11	P10
T10	P10	T10	P10	T10	P10	T10	P10	T10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree				

3.8 Conflict detection was supported well by the system - ORG 0

N=32

	Binomial Distribution; Significance
P11	20 : 12 n.s.(-)
P11	
P11	T 9 : 7
P11	P 11 : 5 n.s.(-)
P11	10 9 : 7
T11 P11	11 11 : 5 n.s.(-)
T11 P10	
T11 P10 T11	
T11 P10 T10	
T11 P10 T10 P10	
T11 P10 T10 P10 T10 P10	
T11 P10 T10 P10 T10 P10 T10 P10	
T11 P10 T10 P10 T10 P10 T10 P10 T10 P10	
T11 P10 T10 P10 T10 P10 T10 P10 T10 P10 T10 P10	
strongly disagree	strongly agree

3.8 Conflict detection was supported well by the system - ORG 1

N=32

	Binomial Distribution; Significance
P11	15 : 17 n.s.
P11	
P11	T 10 : 6
P11	P 5 : 11 n.s.(+)
P11	10 7 : 9
P11	11 9 : 7
T10 T11	
T10 T11 P11	
T10 T11 P11 P11	
T10 T11 P11 P11 P11	
T10 T11 P11 P11 P11 P11	
T10 T11 P11 P11 P11 P11 P11	
T10 T11 P11 P11 P11 P11 P11 P11	
T10 T11 P11 P11 P11 P11 P11 P11 P11	
strongly disagree	strongly agree

3.8 Conflict detection was supported well by the system - ORG 2

N=32

	Binomial Distribution; Significance
P11	14 : 18 n.s.
P11	
P11	T 9 : 7
P11	P 5 : 11 n.s.(+)
P11	10 5 : 11 n.s.(+)
P11	11 9 : 7
T11	
T11 T11	
T11 T11 P11	
T10 T11 P11 P11	
T10 T11 P11 P11 P11	
T10 T11 P11 P11 P11 P11	
T10 T11 P11 P11 P11 P11 P11	
T10 T11 P11 P11 P11 P11 P11 P11	
T10 T11 P11 P11 P11 P11 P11 P11 P11	
strongly disagree	strongly agree

3.10 The task partitioning between TC and PC was not always clear - ORG 0

N=32

T11										
T11	P11									
T11	P11									
T11	P11									
T11	P11									
T10	P10									
T10	P10		P11				T11			
	P11	T10	P10		P10		P11	T10		
T10	P10	T10	P10	T10	P10	T11	P10	T10	P11	T11
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree					

Binomial Distribution; Significance

	24	:	8	p < .01 +
T	11	:	5	
P	13	:	3	p = .022 +
10	13	:	3	p = .022 +
11	11	:	5	

3.10 The task partitioning between TC and PC was not always clear - ORG 1

N=31

	P11									
	P11									
	P11									
	P11									
T11	P11									
T11	P11									
T11	P10									
T11	P10									
T11	P10					T11				
	T10	P10	T10	P11	T10			T11		
T11	P11	T10	P10	T10	P10	T10	P10	T10	P11	T11
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree					

Binomial Distribution; Significance

	24	:	7	p < .01 +
T	10	:	5	
P	14	:	2	p = .004 +
10	11	:	4	
11	13	:	3	p = .022 +

3.10 The task partitioning between TC and PC was not always clear - ORG 2

N=31

	P11									
	P11									
	P11									
T11	P11									
T11	P11									
T11	P10									
T11	P10									
T11	P10									
T10	P10									
	T10	P10	T11					T11		
	T10	P10	T10	P11				T11		
P11	T10	P10	T10	P10			P11	T10		
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree					

Binomial Distribution; Significance

	27	:	4	p < .001 +
T	12	:	3	p = .036 +
P	15	:	1	p < .001 +
10	14	:	1	p < .001 +
11	13	:	3	p = .022 +

3.11 The co-operation of TC and PC within a sector was not a problem - ORG 0

N=32

P11	T11	P10	T10	P10	T10	P10	T10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree			

Binomial Distribution; Significance

	3	:	29	p < .001 +
T	1	:	15	p < .001 +
P	2	:	14	p = .004 +
10	1	:	15	p < .001 +
11	2	:	14	p = .004 +

3.11 The co-operation of TC and PC within a sector was not a problem - ORG 1

N=32

P11	T11	P10	T10	P10	T10	P10	T10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree			

Binomial Distribution; Significance

	7	:	25	p < .01 +
T	3	:	13	p = .022 +
P	4	:	12	
10	3	:	13	p = .022 +
11	4	:	12	

3.11 The co-operation of TC and PC within a sector was not a problem - ORG 2

N=32

T11	P11	P10	T10	P10	T10	P10	T10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree			

Binomial Distribution; Significance

	8	:	24	p < .01 +
T	4	:	12	
P	4	:	12	
10	3	:	13	p = .022 +
11	5	:	11	

**3.13 Overall, the system allowed me to work according to my personal work style -
ORG 0**

N=32

Binomial Distribution; Significance

	12	:	20	n.s.(+)
T	5	:	11	
P	7	:	9	
10	3	:	13	p = .022 +
11	9	:	7	

					P11					
					P10	T11				
		T11	P11		P10	T11				
	P11	T11	P11	T11	P10	T10			T11	
	P11	T11	P11	T10	P10	T10	P10		T11	
T10	P11	T10	P10	T10	P10	T10	P10	T10	P11	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree					

**3.13 Overall, the system allowed me to work according to my personal work style -
ORG 1**

N=32

Binomial Distribution; Significance

	26	:	6	p < .001 -
T	14	:	2	p = .004 -
P	12	:	4	
10	13	:	3	p = .022 -
11	13	:	3	p = .022 -

		T11								
		T11	P11							
		T11	P11	T11						
		T11	P10	T11						
	P11	T10	P10	T10						
	P11	T10	P10	T10	P11		P11	T11	P11	
T10	P10	T10	P10	T10	P10		P10	T10	P10	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree					

**3.13 Overall, the system allowed me to work according to my personal work style -
ORG 2**

N=32

Binomial Distribution; Significance

	22	:	10	n.s.(-)
T	12	:	4	
P	10	:	6	
10	10	:	6	
11	12	:	4	

				T11						
			P11	T11						
		T11	P11	T11			P11			
	P11	T11	P10	T11			P11	T11		
T11	P11	T10	P10	T10	P11		P10	T10	P11	
T10	P10	T10	P10	T10	P10	T10	P10	T10	P10	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree					

3.14 I could have handled even more traffic with the system - ORG 0

N=32

Binomial Distribution; Significance

	8	:	24	p < .01 +
T	4	:	12	
P	4	:	12	
10	3	:	13	p = .022 +
11	5	:	11	

T11															
T11				P11				P11							
T11			P11			T11			P11						
T10			P11			T11			P10						
P11				T10		P10		T11		P10					
T10		T11		P11		T10		P10		T10		P10			
T10		P10		T11		P11		T10		P10		T10		P10	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree							strongly agree			

3.14 I could have handled even more traffic with the system - ORG 1

N=31

Binomial Distribution; Significance

	14	:	17	n.s.
T	7	:	9	
P	7	:	8	
10	10	:	5	
11	4	:	12	

T11																	
T11																	
T11																	
T11				P11													
T10			P11			T10			P11			P11					
T10		P10		T10		P11		T11		P10		T11		P10			
T10		P10		T10		P11		T11		P10		T11		P10		P11	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree							strongly agree					

3.14 I could have handled even more traffic with the system - ORG 2

N=32

Binomial Distribution; Significance

	14	:	18	n.s.
T	8	:	8	
P	6	:	10	
10	8	:	8	
11	6	:	10	

T11																			
T11				P11				P11											
T10			P11			T10			P11			P11							
P10		T10		P10		T11		T10		P10		T11		P10					
P10		T10		P10		T10		P11		T10		P10		T11		P10		P11	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree							strongly agree							

5. INDIVIDUAL TOOLS AND FUNCTIONS

5.1 DISCUSSION OF RESULTS

In order to assess controller views on the tools and functions that were specifically provided in the PD/1 system, a set of seven questionnaire items was used to assess for each of the tools whether it:

- was used frequently (4.1);
- was deemed relevant for a controller's work (4.2);
- was helpful in avoiding conflicts (4.3);
- reduced workload (4.4);
- fits with the ATC work (4.5);
- fits with personal work styles (4.6);
- should be improved (4.7).

The results are given first for the tools and functions on which both TC and PC responses were collected:

- a) the Conflict Risk Display (CRD);
- b) the Conflict Zoom Window (CZW);
- c) the Augmented Dynamic Flight Leg (ADFL).

Results are given for the tools aimed at PCs only:

- a) the Highly Integrated Problem Solver (HIPS);
- b) the Horizontal Assistance Window (HAW);
- c) the Vertical Assistance Window (VAW).

Results are also given for specific TC issues, in particular:

- a) the Communication List Window (CLW).

Table 5-1 gives a summary overview.

Among the tools available to both TC & PC, only for the ADFL did a significant number of controllers report they used it frequently (4.1c) and it was relevant for their work (4.2c), whereas this view was clearly rejected for the CZW (4.1b; 4.2.b), and no significances were obtained for the CRD (4.1a; 4.2a).

The ADFL was also significantly approved as being helpful for avoiding conflicts (4.3); no such significance was observed for CRD and CZW. The ADFL was seen as a useful means for reducing workload (4.4); this was significantly negated for CRD and CZW.

The items about interaction (4.5 and 4.6) were not asked for the CZW. The others, CRD and ADFL, were significantly accepted as fitting well with the ATC work (4.5a; 4.5c). Moreover, the ADFL alone was clearly appreciated for being convenient to personal work styles (4.6c).

Improvements were clearly deemed desirable for all three features (4.7a, b, c) but for quite different reasons. For instance, the written comments on the ADFL indicated that some controllers would have liked to make more extensive use of it than it was foreseen in PD/1. So, it was suggested "...to extend it to WPs (*waypoints*) outside of the sector", in order to "...use it to propose a trajectory in an other sector", which would be an enhancement of ADFL functionality rather than an improvement. In contrast to this, comments on the CRD e.g. sometimes quoted difficulties with its proper functioning ("...not working properly" reported by two TCs in two different weeks) as well as there was suggested by one controller that the "...time scale should be adjustable for smaller sectors."

Planning controller responses on "their" tools revealed clearly the very prominent role of the HIPS.

All PCs reported that the HIPS was used frequently (4.1d), relevant for their work (4.2d) and helpful to avoid conflicts (4.3d), whereas HAW and VAW were much less accepted or even rejected. A written controller comment which was typical says "...when you have HIPS, HAW and VAW are not used". Therefore, in the following the focus will be on the HIPS results.

In terms of workload reduction, the PCs rated the HIPS in tendency positive (4.4d).

Interacting with the HIPS was also tended to rate positively from the standpoint of ATC work (4.5d), but no such tendency was found when interaction with the HIPS was rated from the standpoint of personal work style (4.6d).

The PCs' significant agreement to say that improvements in the HIPS would be desirable (4.7d) appeared to have various reasons. Written comments revealed some general criticisms like "...it distracts from the radar" (i.e. from the PVD), "ADFL could be used..." (instead), "...waste of airspace", but also some specific points were made, e.g. to allow better "...identification of a/c which block altitudes", or "...it should be possible to leave exit /entry levels out of the trajectory".

Tactical controllers only were asked to assess the CLW. They reported to have used it frequently (4.1g) and that it was highly relevant for their work (4.2g). Both response distributions were significant.

No significances were found in controller responses on the CLW's usefulness for workload reduction (4.4g) and the kind of interaction with the CLW (4.5g and 4.6g). The distribution of the responses and some written comments indicated that two different views may have governed the TCs' assessment of the CLW: a positive view which was to concede in principle that a CLW "...is a main control tool in ORG 1 and 2", and a negative view which is to criticise particularly the consequences of the CLW's importance, e.g. "...the CLW distracts..." or "...the computer is controlling you."

Like all other tools and functions, improvements were deemed desirable for the CLW (4.7g). It appeared that a number of controllers would prefer a different composition of the messages.

	PCs and TCs			PCs only	TCs only		
	a) CRD	b) CZW	c) ADFL	d) HIPS	e) HAW	f) VAW	g) CLW
4.1 used frequently	0	-	+	+	-	(-)	+
4.2 relevant for my work	0	-	+	+	(-)	0	+
4.3 helpful to avoid conflicts	0	0	+	+	0	(+)	not asked
4.4 workload reduction	-	-	+	(+)	(-)	0	0
4.5 fits with ATC work	+	not asked	+	(+)	(+)	+	0
4.6 personal work style	0	not asked	+	0	(-)	0	0
4.7 improvements desirable	significant controller agreement for all tools and functions: yes, should be improved						

Table 5-1 - Individual Tools and Functions; Summary of Questionnaire Results

4.3a The information displayed in the CRD was helpful for avoiding conflicts.

N=32

Binomial Distribution; Significance

19 : 13 n.s.
 T 10 : 6
 P 9 : 7
 10 10 : 6
 11 9 : 7

T11	P11		T11		P11		T11		P11		
T10	T11	P10	T11	P11	T11	P10	T11	P10	T11	P11	
T10	P11	T11	P10	T10	P11	T11	P10	T11	P11		
T10	P11	T10	P10	T10	P10	T10	P10	T10	P11		P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree						

4.3b The information displayed in the CZW was helpful for avoiding conflicts.

N=28

Binomial Distribution; Significance

19 : 9 n.s.
 T 10 : 4
 P 9 : 5
 10 10 : 4
 11 9 : 5

		P11									
		P11	T11			P11					
		P11	T11			P11					
		T11	P11	T11			T11	P10			
T10	P10	T10	P10	T10			T11	P10			
T10	P10	T10	P10	T10	P11	T10	P10			T11	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree						

4.3c The information displayed in the ADFL was helpful for avoiding conflicts.

N=31

Binomial Distribution; Significance

5 : 26 p < .001 +
 T 3 : 12 p = .036 +
 P 2 : 14 p = .004 +
 10 2 : 14 p = .004 +
 11 3 : 12 p = .036 +

T10	T11	P11	T11	P10	T10	P10	T10	P10	T10	P10	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree						

4.4a The CRD was useful for reducing my workload.

N=32

	T11	P11							
	T11	P11							
	T11	P10							
	T10	P10	T11						
T11	T10	P10	T11	P11			P11		
T10	T10	P10	T11	P11			P11		P11
T10	P10	T10	P10	T10	P11	T10	P10	T11	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree				strongly agree	

Binomial Distribution; Significance

	25	:	7	p < .01 -
T	14	:	2	p = .004 -
P	11	:	5	
10	13	:	3	p = .022 -
11	12	:	4	

4.4b The CZW was useful for reducing my workload.

N=28

	T11	P11							
	T11	P11		P11					
T11	T10	P11		P11					
T10	P10	T10	P10	T11	P11	T11	P10	T11	
T10	P10	T10	P10	T11	P10	T10	P10	T10	P11
strongly disagree	disagree	slightly disagree	slightly agree	agree				strongly agree	

Binomial Distribution; Significance

	21	:	7	p < .05 -
T	10	:	4	
P	11	:	3	
10	10	:	4	
11	11	:	3	

4.4c The ADFL was useful for reducing my workload.

N=30

				T11					
				T11	T11	P11		P11	
				T10	T11	P11		P11	
				T10	P11	T11	P10	P11	
	T11	P10		T10	P11	T10	P10	P10	
	T10	P10		P11	T10	P10	T10	P10	T10
strongly disagree	disagree	slightly disagree	slightly agree	agree				strongly agree	

Binomial Distribution; Significance

	5	:	25	p < .001 +
T	2	:	12	p = .016 +
P	3	:	13	p = .022 +
10	3	:	13	p = .022 +
11	2	:	12	p = .016 +

4.5a The kind of interaction with the CRD does not fit well with the ATC work.

N=31										Binomial Distribution; Significance				
										22	:	9	p < .05	+
										T	:	3	p = .036	+
										P	:	6		
										10	:	7		
										11	:	2	p = .004	+

T11	P11	T11	P11	T11	P11	T10	P10	T10	P10	P11	T10	P10	T10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree									

4.5c The kind of interaction with the ADFL does not fit well with the ATC work.

N=30										Binomial Distribution; Significance				
										26	:	4	p < .001	+
										T	:	0	p < .001	+
										P	:	4		
										10	:	2	p = .004	+
										11	:	2	p = .016	+

T11	P11	T11	P11	T11	P11	T10	P10	T10	P10	P11	T10	P10	P10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree									

4.6a The kind of interaction with the CRD was suitable to my personal work style.

N=30										Binomial Distribution; Significance				
										14	:	16	n.s.	
										T	:	7		
										P	:	9		
										10	:	5		
										11	:	11		

T11	P11	T11	P11	T11	P11	T10	P10	T10	P10	T11	P11	T11	P10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree									

4.6c The kind of interaction with the ADFL was suitable to my personal work style.

N=30										Binomial Distribution; Significance				
										2	:	28	p < .001	+
										T	:	14	p < .001	+
										P	:	14	p = .004	+
										10	:	15	p < .001	+
										11	:	13	p = .002	+

P11	T11	P11	T11	P11	T10	P10	T10	P10	T11	P11	T10	P10	T10	P10	P11
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree										

4.7a Improvements in the CRD would be desirable.

N=32

		P10		T11		T10		P10		T10		P10	
	strongly disagree		disagree		slightly disagree		slightly agree		agree		strongly agree		

Binomial Distribution; Significance

	2	:	30	p < .001 -
T	1	:	15	p < .001 -
P	1	:	15	p < .001 -
10	1	:	15	p < .001 -
11	1	:	15	p < .001 -

4.7b Improvements in the CZW would be desirable.

N=27

		P10		T11		T10		P10		T10		P10	
	strongly disagree		disagree		slightly disagree		slightly agree		agree		strongly agree		

Binomial Distribution; Significance

	8	:	19	p < .05 -
T	4	:	9	
P	4	:	10	
10	4	:	10	
11	4	:	9	

4.7c Improvements in the ADFL would be desirable.

N=30

		P10		T11		T10		P10		T10		P10	
	strongly disagree		disagree		slightly disagree		slightly agree		agree		strongly agree		

Binomial Distribution; Significance

	4	:	26	p < .001 -
T	1	:	13	p = .002 -
P	3	:	13	p = .022 -
10	3	:	13	p = .022 -
11	1	:	13	p = .002 -

5.3 RESPONSES FROM PLANNING CONTROLLERS

4.1d I used the HIPS frequently.

P=16

Binomial Distribution; Significance
 P 0 : 16 p < .001 +

					P11
					P11
					P11
					P11
				P11	P10
				P11	P10
				P11	P10
				P11	P10
				P10	P10
				P10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.1e I used the HAW frequently.

P=16

Binomial Distribution; Significance
 P 13 : 3 p = .022 -

					P11
					P11
					P11
					P10
					P10
				P11	P11
				P10	P10
				P10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.1f I used the VAW frequently.

P=15

Binomial Distribution; Significance
 P 10 : 5 n.s.(-)

					P11
					P11
					P10
					P10
					P10
					P11
					P11
					P11
					P10
					P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.2d The HIPS was highly relevant for my work.

P=16

Binomial Distribution; Significance
P 1 : 15 p < .001 +

				P11	
				P11	
				P11	
				P11	
				P11	P11
				P10	P10
				P10	P10
				P10	P10
		P11	P11	P10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.2e The HAW was highly relevant for my work.

P=16

Binomial Distribution; Significance
P 12 : 4 n.s.(-)

		P11			
	P11	P10			
	P11	P10	P11	P11	
	P10	P10	P11	P10	
	P10	P10	P11	P10	P11
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.2f The VAW was highly relevant for my work.

P=15

Binomial Distribution; Significance
P 9 : 6 n.s.

		P11			
		P10			P11
		P10			P11
	P11	P10	P11	P11	P11
	P10	P10	P10	P11	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.3d The information displayed in the HIPS was helpful for avoiding conflicts.

P=16

P11
P11
P11
P11
P11
P11
P11
P11
P10
P10
P10
P10
P10
P11
P10
P10
P10

Binomial Distribution; Significance
P 0 : 16 p < .001 +

strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
-------------------	----------	-------------------	----------------	-------	----------------

4.3e The information displayed in the HAW was helpful for avoiding conflicts.

P=16

Binomial Distribution; Significance
P 10 : 6 n.s.

P11
P11
P11
P10
P10
P11
P10
P10
P10
P11
P10
P10
P10

strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
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4.3f The information displayed in the VAW was helpful for avoiding conflicts.

P=15

Binomial Distribution; Significance
P 4 : 11 n.s.(+)

P11
P11
P11
P10
P11
P11
P10
P10
P10
P10
P10
P10
P10
P10
P10
P11

strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
-------------------	----------	-------------------	----------------	-------	----------------

4.4d The HIPS was useful for reducing my workload.

P=16

Binomial Distribution; Significance
P 5 : 11 n.s.(+)

				P11	
				P11	P11
	P11			P10	P11
	P10		P11	P10	P11
P11	P10	P10	P10	P10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.4e The HAW was useful for reducing my workload.

P=13

Binomial Distribution; Significance
P 10 : 3 n.s.(-)

		P11	P11		
		P10	P11	P11	
	P11	P10	P10	P11	
	P10	P10	P10	P10	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.4f The VAW was useful for reducing my workload.

P=14

Binomial Distribution; Significance
P 7 : 7 n.s.

		P11		P11	
		P10		P11	
	P11	P10		P11	P11
	P10	P10	P10	P10	P11
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.5d The kind of interaction with the HIPS does not fit well with the ATC work.

P=15

Binomial Distribution; Significance
 P 11 : 4 n.s.(+)

	P11				
	P11				
	P11	P11			
	P11	P10			
	P10	P10		P10	
P11	P10	P10	P10	P10	P11
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.5e The kind of interaction with the HAW does not fit well with the ATC work.

P=13

Binomial Distribution; Significance
 P 10 : 3 n.s.(+)

		P11			
		P11			
		P11			
		P10			
		P10			
		P10			
	P11	P10	P11		
	P11	P10	P10	P10	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.5f The kind of interaction with the VAW does not fit well with the ATC work.

P=13

Binomial Distribution; Significance
 P 12 : 1 p = .004 +

		P11			
		P11			
		P10			
		P10			
	P11	P10			
	P11	P10			
	P11	P10			
	P11	P10		P10	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.6d The kind of interaction with the HIPS was suitable to my personal work style.

P=16

Binomial Distribution; Significance
P 7 : 9 n.s.

				P11	
				P11	
		P11		P11	
		P10	P10	P10	
P11	P10	P10	P10	P10	P11
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.6e The kind of interaction with the HAW was suitable to my personal work style.

P=14

Binomial Distribution; Significance
P 9 : 5 n.s.(-)

				P11	
				P11	
		P11		P11	
		P10	P10	P11	
P11	P10	P10	P10	P10	P11
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.6f The kind of interaction with the VAW was suitable to my personal work style.

P=14

Binomial Distribution; Significance
P 6 : 8 n.s.

				P11	
				P11	
				P11	
		P10		P11	
		P10	P10	P10	P11
P11	P10	P10	P10	P10	P11
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.7d Improvements in the HIPS would be desirable.

P=16

Binomial Distribution; Significance
 $P = 2 : 14 \quad p = .004 -$

				P11	P11
			P11	P11	P11
			P11	P10	P11
			P10	P10	P10
	P10	P11	P10	P10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.7e Improvements in the HAW would be desirable.

P=13

Binomial Distribution; Significance
 $P = 2 : 11 \quad P = .022 -$

				P11	P11
			P11	P11	P11
			P11	P10	P11
			P10	P10	P10
	P10	P11	P10	P10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

4.7f Improvements in the VAW would be desirable.

P=13

Binomial Distribution; Significance
 $P = 2 : 11 \quad p = .022 -$

				P11	
			P11	P11	
			P10	P10	
			P10	P10	P11
	P10	P11	P10	P10	P10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

5.4 RESPONSES FROM TACTICAL CONTROLLERS

4.1g I used the CLW frequently.

T=16

				T11	
				T11	
				T11	
				T11	
				T10	
				T10	
				T10	T11
				T10	T11
				T10	T11
				T10	T10
T10			T11		
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

Binomial Distribution; Significance
T 1 : 15 p < .001 +

4.2g The CLW was highly relevant for my work.

T=16

				T11	
				T11	
				T11	
				T11	T11
	T10			T10	T11
	T10		T11	T10	T11
	T10		T10	T10	T10
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

Binomial Distribution; Significance
T 3 : 13 p = .022 +

4.4g The CLW was useful for reducing my workload.

T=16

				T11	
				T11	
T11	T11		T11	T11	
T10	T10		T10	T11	
T10	T10	T10	T10	T10	
strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree

Binomial Distribution; Significance
T 9 : 7 n.s.

6. GLOSSARY

ADFL	augmented dynamic flight leg
ATC	air traffic control
CLW	communications list window
CRD	conflict risk display
CZW	conflict zoom window
F/L	flight level
FMS	flight management system
HAW	horizontal aid window
HIPS	highly interactive problem solver
HMI	human machine interface
ISA	instantaneous self assessment
n.s.	not significant
ORG	organisation
PC	planning controller
PVD	plan view display
STCA	short term conflict alert
TC	tactical controller
TLX	task load index
VAW	vertical aid window