Validation Report (VALR)

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Abstract

This document provides the Validation Report (VALR) for validation activity EXE-04.07.08-VP-304 (QW2), a real-time simulation which took place in Feb/March 2012, conducted in the context of project P04.07.08. The activity addresses OFA 03.03.04 (Sector Team operations) and Operational Improvement (OI) CM-0301 (Sector Team Operations Adapted to New Roles for Tactical and Planning), and aimed to validate the Multi-Sector Planning (iMSP) concept at the E-OCVM V3 level (pre-industrial development & integration), and also provide an initial investigation (V1/V2 scope/feasibility) into Single Person Operations (SPO) concept.

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Executive summary

This document provides the Validation Report (VALR) for the V3 maturity validation activity EXE-04.07.08-VP-304 (iFACTS Quick Win), a real-time simulation which took place in Feb/March 2012, conducted in the context of project P04.07.08, which is defined in the P04.07.08 Validation Plan (ValP)[6]. The validation exercise addresses OFA 03.03.04 (Sector Team operations) and Operational Improvement (OI) CM-0301 (Sector Team Operations Adapted to New Roles for Tactical and Planning), extracted from the ATM Master Plan (European ATM master plan portal).

This, the third in a series of three simulations, aimed to validate iMSP (a one Planner to two Tacticals team structure based on the NERC-iFACTS concept) at the E-OCVM V3 level (pre-industrial development & integration) in order to demonstrate that the developed concepts and enablers work coherently together and are capable of delivering the required benefits. In addition to Multi-Sector Planner operations, this activity provided an initial investigation (V1/V2 scope/feasibility) into the Single Person Operations concept on the NERC-iFACTS platform, where a single controller operates the sector(s) undertaking both the tactical and planning tasks, supported by the iMSP toolbox. As such a more subjective review of iMSP-tool efficacy in the Single Person Operation role has been undertaken.

The simulation provided the opportunity to exercise the Multi-Sector Planner concept and simulated an operational baseline (one Planner to one Tactical) against which a quantitative assessment could be made as well as enabling the participants to baseline their subjective assessment. The same enhanced Planner tools were also exercised in a one Planner to one Tactical environment to assess the feasibility of an early operational implementation for the enhanced Planner tools in order to provide an early benefit to operations. Also, with the addition of Integrated Coordination, the tools were exercised in the combined Planner and Tactical role.

The inevitable limited exposure of many of the participants during the relatively short simulation significantly impacted the quantitative assessment. Analysis showed that the participants' responses changed for the better over the duration of the simulation, particularly with regards to user acceptance of the iMSP concept, and showed that those participants with previous experience of some elements of the tools and concept prior to this activity performed much better, almost exclusively recording lower workload and better situational awareness. Software fixes in the first few days of the activity also improved user acceptance.

The participants all reported the MTCD-enhanced Look-See/What-If co-ordination support functionality was a significant improvement over current NERC Look-See/What-If, enabling them to assess offers more quickly in both a 'one Planner to one Tactical' and 'one Planner to two Tactical' (Multi-Sector Planner) environment. Despite the significant reduction in aircraft highlighted as being of coordination interest, the participants unanimously agreed that MTCD-enhanced Look-see/What-If did not miss any relevant interactions, highlighting all necessary problems to the Planner for consideration.

The participants concurred that taking into account coordination actions that the Planner had taken to resolve interactions (such as requesting that the offering sector lock an aircraft onto a heading) was of significant benefit. The Instruction Palette Coordination functionality (which enabled the Planner or Tactical to enter coordination constraints into the system), Coordination Point-Outs and Integrated Coordination Auto-Accept Conflict Detection were all rated highly. The enhanced Planner tools supported many tasks better than the current NERC tools for some of the participants, and the quantitative analysis gave an indication of a reduction in Planner workload.

Given the appropriate traffic conditions, the one Planner to two Tacticals configuration was seen to work where the Tactical in a bandboxed arrangement was overloaded; and where Planners in a split configuration were under-utilised. The one Planner to two Tacticals configuration provided a scenario where all controllers reported a comfortable level of workload. These observations were mainly during runs where participants had previous experience of the iMSP concept, though towards the end of the activity the subjective feedback from all participants was fairly positive. Further, it is likely that increased exposure to the role would have made a difference to the quantitative assessment of the Multi-Sector Planner concept, and provided a more accurate picture of the range of traffic levels where the 1P-2T configuration is appropriate.

However, the participants repeatedly reported that only being able to monitor the R/T frequency for one of their Tacticals would be a significant factor in reducing the Multi-Sector Planner's situational awareness. Although the iMSP concept had little impact on the Tactical role, the Tacticals did raise concerns that they would not have the support of a 'dedicated' Planner should a non-nominal situation occur (such as an emergency).

The results indicate that the workload, situational awareness and user acceptance of the Single Person Operations concept could all be satisfactory given the appropriate level of traffic. The concept of Integrated Coordination was considered to be useful in the Single Person Operations environment by all the participants, with five of the participants rating it as essential. The Dynamic Electronic Flight Strip auto-drop functionality was also considered by the majority of participants to be essential to Single Person Operations. However, there were safety concerns raised over the increased risk of errors when there are incoming R/T transmissions whilst making phone calls, and the absence of immediate support during abnormal events.

Subjectively the participants reported improved support to the core Planner tasks, a view borne out by the objective data, and as such felt that there would be a significant benefit across the unit in the current 1P-1T team structure of an early implementation of the Planner tools, particularly the MTCD-enhanced Look-See/What If, Auto-Accept Conflict Detection highlight, and Dynamic Electronic Flight Strips, on the NERC-iFACTS platform (subject to suitable refinement of the tools in line with the recommendations). As such it is recommended that NATS enters into an implementation programme at the London Area Control Centre. The study also recommends that a wider evaluation should be undertaken to verify the workload benefit.

The programme also needs to engage the Controller community in the development of the Multi-Sector Planning and Single Person Operations environments. Procedures, methods of operation, and system mitigations should be identified that address areas of concern such as roles and responsibilities, R/T monitoring, seating position, and support during emergencies and failures in order that the 1P-2T and Single Person Operations staffing configurations are accepted into the Operation.

1 Introduction

1.1 Purpose of the document

This document provides the Validation Report (VALR) for EXE-04.07.08-VP-304 (QW2) conducted in the context of project P04.07.08, which is defined in the P04.07.08 Validation Plan (ValP)[6]. The validation exercise addresses OFA 03.03.04 (Sector Team operations) and Operational Improvement (OI) CM-0301 (Sector Team Operations Adapted to New Roles for Tactical and Planning), extracted from the ATM Master Plan (European ATM master plan portal).

This real-time simulation aimed to validate the iMSP concept at the E-OCVM V3 level (pre-industrial development & integration) in order to demonstrate that the developed concepts and enablers work coherently together and are capable of delivering the required benefits. This activity also provided an initial investigation (V1/V2 scope/feasibility) into Single Person Operations (SPO) concept on the NERC-iFACTS platform, where a single controller operates the sector(s) undertaking both the tactical and planning tasks, supported by the iMSP toolbox. As such a more subjective review of iMSP-tool efficacy in the SPO role has been undertaken.

1.2 Intended readership

The intended audience for this document is:

- Participants in various tasks in P04.07.08, including OSED development, costs and benefits assessment, SPR and subsequent validation tasks;
- Operational Federating Coordinating Project P04.02 which is responsible for the validation consolidation tasks;
- Other Operational Sub-Package contributing project, particularly P04.07.02;
- P05.09, responsible for the specifications of integrated CWP;
- Transversal projects (WP16, B and C) for performance assessments;
- Although no direct interactions are foreseen with WP03, the present validation plans may also be of interest to the WP03 leader.

1.3 Structure of the document

Section 1 (this section) describes the purpose and scope of the document, the intended audience, and gives an explanation of the abbreviations and acronyms used throughout the document.

Section 2 describes the scope of the validation and a summary of the validation exercise.

Section 3 describes the conduct of validation exercise including the preparation, execution and deviations away from the planned activities.

Section 4 describes the validation exercise results. It includes a detailed analysis of the results including a description of the confidence in results.

Section 5 states all the conclusions and recommendations from the validation exercise.

Section 6 lists all the applicable and reference documents.

1.4 Glossary of Terms

Term	Definition
Bandboxing and Splitting	The process of combining or separating sectors within a Local Area Group to be controlled by a team of one Planner and one Tactical.
Incomm(ing)/	The process of electronically identifying that an aircraft is 'in communication

Term	Definition
Outcom(ing)	with'/'no longer in communication with' a particular Tactical controller.

1.5 Acronyms and Terminology

Term	Definition
ACC	Area Control Centre
ADD	Architecture Definition Document
ATM	Air Traffic Management
CAP	Closest Point of Approach
CD&R	Conflict Detection and Resolution
DTY	Daventry (LAG) comprising sectors S27, S32, S28 and S34
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
EFS	Electronic Flight Strip (Planner's)
E-OCVM	European Operational Concept Validation Methodology
HMI	Human-Machine Interface
iFACTS	Interim Future Area Control Tools Support
IFL	Internal (boundary) Flight Level
IRS	Interface Requirements Specification
INTEROP	Interoperability Requirements
LACC	London Area Control Centre
LAD	Level assessment Display
LAG	Local Area Group
LKS	Lakes (LAG) comprising sectors S3, S4 and S7
MSP	Multi-Sector Planner
MTCD	Medium Term Conflict Detection
NERC	New En-Route Centre (also refers to the architecture of the LACC system)
NFL	Entry Flight Level
NSEA	North Sea (LAG) comprising sectors S10 and S11

Term	Definition
OFA	Operational Focus Areas
OSED	Operational Service and Environment Definition
RTS	Real-Time Simulation (Simulator)
R/T	Radio-telephony
SA	Situational Awareness / Standing Agreement
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SJU Agency.
SPO	Single Person Operations
SPR	Safety and Performance Requirements
SUT	System Under Test
TAD	Technical Architecture Description
TDB	Track Data Block
TMA	Terminal Manoeuvring Area
TS	Technical Specification
VALP	Validation Plan
VALR	Validation Report
VALS	Validation Strategy
VP	Verification Plan
VR	Verification Report
VS	Verification Strategy
XFL	Exit Flight Level

2 Context of the Validation

This project will provide validated concepts (in the form of validation reports) and requirements (in the form of OSEDs) for both MOps and controller tools from which it will be possible for industry to develop the separation management and goal achievement tools (being developed by other level three projects in sWPs 4.7 and 5.7) to support the differing controller team organisations of one Planner to two Tacticals (MSP) and SPO operations.

As such, the output contributes directly to the ATM Service SVC06 (Conflict Management), phase 06 (Cruise). The corresponding project in WP 5 (P5.7.3) contributes to phases 05 (Climb) and 07 (Descent) of ATM Service SVC06.

Operational Focus Area (OFA)	OFA Target (Increase in Airspace Capacity)	Related Performance Requirement
Sector Team Operations	0,16%	REQ-04.02-DOD-PRF2.0003

2.1 Concept Overview

Validation Exercise ID and Title	EXE-04.07.08-VP-304 (Quick Win #2) MSP based on sector coordination
Leading organization	NATS
Validation exercise objectives	Assess the acceptability and benefits of the Multi-Sector Planner concept (1P-2T) and tools for a quick win on the NERC-iFACTS system.
Rationale	New opportunities for the utilisation of operational staff – including new roles for the Tactical and Planner Controllers within the team- are offered along with the increasing sophistication of medium-tem conflict detection tools.
Supporting DOD / Operational Scenario / Use Case	N/A
OFA addressed	03.03.04
OI steps addressed	CM-0301 – Sector Team Operations Adapted to New Roles for Tactical and Planning
Enablers addressed	HUM172-01, HUM172-02, HUM172-03, HUM172-04, HUM172-06, HUM172-07 HUM173-04, HUM173-05 PRO-046a
Applicable Operational Context	EnRoute
Expected results per KPA	**Capacity**: Reduced ATCO workload, better usage of ATCOs work force, distribution of workload among ATCOs' teams.

	Capacity: Less need for tactical intervention leads to a reduction in controller workload. Capacity could therefore increase as a function of reduced workload per flight. **Capacity, Safety**: The maintenance of capacity and safety are paramount when considering the human factors aspects associated with harmonized controller actions. **Cost Effectiveness**: Improvement in ability to resource to demand, providing significant reduction in costs associated with staff overheads. **Safety**: Potential conflicts within a medium-term time horizon will be identified and solved, minimised need for tactical intervention.
Validation Technique	Real-Time Simulation
Dependent Validation Exercises	EXE-04.07.02-VP-172

Table 1: Concept Overview

In order for the reader to understand the operational and system context for the concepts under validation in this exercise it is necessary to set out a short history of the work from its original inception. This introduction will address several aspects: the background and status of the wider MSP concept development from which iMSP was derived; the initial target operational environment and its constraints; a summary of the iMSP concept and associated automated support tools; and the influence it is expected that the iMSP development will have on the wider development of the MSP concepts within SESAR projects P4.7.8 and P5.7.3.

2.1.1 Project Background

Within NATS there has been a programme of R&D development for advanced support tools and a complementary operational concept in order to enhance the efficiency of Area Control operations since the late 1990s. The FACTS (Future Area Control Tools Support) project developed an initial core set of controller tools supporting both the decision making and monitoring aspects of the air traffic control task (both tactical and planning) based upon the underlying functions of Trajectory Prediction (TP), Medium Term Conflict Detection (MTCD) and Flight Path (sometimes known as Conformance) Monitoring (FPM). From this initial phase of concept development a first implementation project was initiated for the deployment of the tactical tools into the London Area Control Centre (LACC) based upon the architecture of the (then) New En-Route Centre (NERC) at Swanwick, a deployment known as Interim FACTS or iFACTS. Having completed the R&D phases of development of the iFACTS concept (as distinct to the FACTS concept owing to its reliance on the NERC architecture) in 2003, the iFACTS system went operational across all LACC sectors in 2011 and is therefore the current operational system.

Whilst the implementation project to deliver iFACTS into the LACC Operation was underway, the R&D development under the wider FACTS programme continued and broadened its remit from the core separation provision concept and support tools to begin to address the roles and responsibilities of the Controller Team with a view to the development of concepts that would allow a more flexible team structure than the typical Planner-Tactical pair (known as '1P-1T' – one Planner to one Tactical). In particular, the division of separation responsibility between Planner and Tactical and, for a team structure of more than one Tactical Controller to one Planner ('1P-nTs'), the division of separation responsibility between those several Tacticals was the key concept issue, the underlying tools and FDP allowing more dynamic distribution of the necessary flight data and problem information (e.g. aircraft conflicts) between the controllers in the team. This concept is what generally referred to as Multi-Sector Planner (although it is not the only concept to be known by that title).

Over two phases of early concept development, an approach to MSP was devised in which the Tactical controllers within the MSP sector-group worked together to achieve the exit conditions that the Planner had set at the boundary of the whole group – a method of working that was called Collaborative Control. One of the significant issues that influenced this approach was the early realization that it was not feasible to expect the Planner to be responsible for agreeing not only the entry and exit co-ordinations for each flight at the overall boundaries of the sector-group but also any at the "internal" boundaries between the sectors operated by each Tactical; neither was it desirable simply to transfer the work associated with planning across those boundaries to the Tactical controllers. Thus, one of the fundamental tenets of Collaborative Control is that co-ordination between Tactical controllers need only be agreed in those situations where a particular separation or traffic management problem exists, otherwise flights can be transferred from sector to sector without prior co-ordination (this method of operation is contingent on the correct information being distributed to each Tactical by the support tools as previously mentioned).

Although the Collaborative Control concept requires further development and concept validation (and forms the primary subject of a Step 1 thread within P4.7.8) it was clear that there was the potential for significant benefit to be derived from an MSP operation. As a result of the early promise shown by MSP and the (then) imminent commencement of iFACTS operations at LACC it was proposed that a first deployment of an interim MSP concept should be developed based on iFACTS and the current NERC architecture (i.e. the legacy FDP system) allowing the controllers to be organized into either the traditional 1P-1T or a new 1P-2T sector team structure – this development was known as Interim MSP ('iMSP').

2.1.2 Operational Context – London Area Control

In order to understand the environment in which iMSP is expected to operate, a brief description of the LACC iFACTS operation and system is set out below to provide some context. The London ACC is responsible for the provision of air traffic services for the airspace within the London FIR with the exception of the London and Manchester TMAs which are controlled by the London Terminal Control Centre and Prestwick Centre respectively. The LACC airspace is divided into approximately 30 sectors which are arranged into 5 Local Area Groups (LAGs): North, South, East, West and Central; each LAG is overseen by a Local Area Supervisor (LAS).

A Sector Team comprises a Planner controller (PC) and a Tactical controller (TC) and may have a dedicated Air Traffic Assistant or share an Assistant with other sectors (depending on the nature of the sector, particularly its interfaces with other ACCs and aerodromes). The team will be responsible for at least one and often, depending on traffic levels, several sectors which can be combined in a number of standard "bandboxed" configurations. These configurations are defined so that the typical range of traffic flows are able to be catered for and may allow a given sector to be combined in a number of different ways (e.g. a lateral bandbox with a geographically neighbouring sector or a vertical bandbox with a sector above or below). Bandboxes are always groups of contiguous sectors (i.e. there are never incidences of completely isolated sectors under the control of the same team) and, generally (though not exclusively), will only include sectors from the same LAG (i.e. the minimum number of live teams will be five – one for each LAG; this being the typical organization during night periods). The decision on when to bandbox (combine) or split (separate) sectors into and out of these groups is generally a shared responsibility between the LAS and the Planner(s) of the teams involved and will be made as a result of the predicted traffic loading (either from the flow management sector loading data or observed traffic on the radar)whilst taking account of issues such as adverse weather conditions, whether training is being undertaken, available staffing (and, hence, available sector validations), legal and desirable maximum time between rest periods etc. The judgement of when to bandbox or split sectors is not always easy and, although not terribly critical when combining (as this tends to occur as traffic levels are dropping), can be crucial to a safe operation when splitting since, if left too late, it can become difficult to undertake the splitting process (particularly from the point of view of the Tactical Controller) once the traffic level has actually reached an undesirably high level – splitting early, in anticipation, is always the preferred method of operation. Of course, to split a group of sectors from one team to two requires two controllers (the new Planner and new Tactical) to be available and present at the sector suite in order for the handovers to be taken and the new sector to be "opened". In terms of its relationship with the MSP concept, it is worth mentioning that there is no operational task associated with co-ordination between sectors that are in a bandboxed group – only the entry and exit boundaries of the whole bandboxed group have co-ordination agreements set for

them (at least as far as the controllers are concerned – from a system functional perspective the "internal" boundaries do get levels assigned across them so that the co-ordination sequence is complete; this is usually invisible to the controllers and generally only becomes operationally pertinent during the actual bandboxing and splitting processes).

2.1.3 LACC Planner Controller Role

The Planner controller has the responsibility to agree sector entry and exit conditions for flights with neighbouring sector teams (or centres, aerodromes, military units etc.) and to ensure that the goals he is setting for his Tactical (in terms of achieving the agreed co-ordinations, for example) are realistic given the overall traffic conditions and will not induce unacceptably high levels of workload for the Tactical. Additionally, the Planner is expected to provide support to the Tactical when plans and agreements require amendment and to act as a second set of eyes and ears (Planners are expected to monitor the radar and to listen to the sector frequency when possible given other tasks such as telephone calls) and making the Tactical aware of any developing situations which may require tactical intervention and of incorrect clearance readbacks that may have been missed by the Tactical.

In addition to the introduction of the Planner-Tactical team structure, one of the most significant changes to the method of operation when London Area Control moved from West Drayton to the New En-route Centre at Swanwick in 2002 was the replacement of an entirely manual co-ordination process from sector to sector (i.e. agreements made through telephone conversation) to a system-supported electronic co-ordination model. Not only was this intended to reduce significantly the need for routine telephone calls, but it was also to regulate the arrival of entry co-ordination offers at a particular sector through the use of adaptable co-ordination timers. In the old, manual, system a flight would be co-ordinated in a "cascade" through virtually the whole of London airspace when the first sector received the entry message (e.g. via OLDI) – each sector "Chief" (the predecessor of the Planner) would contact the next almost immediately after agreeing the flight into the sector to get an exit level that was agreed with the receiving sector. One result of this was that sectors would tend to have co-ordinated agreements on their entry (and exit) conditions of flights a long time before they were estimated to arrive at the sector and, crucially, well before a reasonably stable or complete picture of the likely traffic problems could be built leading to a consequently high level of revision to those agreements as the situation evolved – this was seen as a significant cause of workload across the unit. The electronic process introduced by NERC was predicated on the idea that offers would be sent automatically from offering to receiving sector in a more timely fashion governed by a set of timers and co-ordination points along the route of the flight. In this manner, although a Planner may *set* the exit level from the sector as soon as he has accepted the flight into the sector (in fact, that method of operating is encouraged as it gives the Tactical at least an initial target to plan for), the *offer* message will not be sent on to the next sector for consideration until a time (typically about 8 minutes) before the flight is estimated to reach a point on or near the sector boundary between the two sectors (controllers are able to force the offer to go sooner if that is operationally desirable, and may also, if necessary, delay the automatic offer-on, however these are relatively rare interventions). In this way, co-ordination advances ahead of a flight at a shorter time horizon and in a more controlled fashion by "tuning" (through the adaptation data) the arrival times of offers into a sector so that the offers flights on interacting flows are received in a more logical order with a consequent reduction in later revisions to co-ordination (and, hence, lower average workload across the unit).

The electronic system allows controllers to send, agree, revise, reject and withdraw co-ordination offers and maintains a sector-sequence for all flights which can be exploited by other aspects of the system (such as controller tools). The most fundamental tool supported by electronic co-ordination is the identification of the set of 'foreground flights' for a particular sector. Although there are a number of subtleties to this, in general foreground flights at a sector are those flights for whom the previous sector has set an exit co-ordination that identifies that sector as the receiving sector (even though the electronic offer-on event may not yet have been triggered by the timers). A flight remains foreground until, after it has been offered and accepted by the sector and has subsequently contacted the sector and eventually been transferred on to the next, it passes a point some way beyond the exit boundary when its foreground status is removed. Flights that are not foreground are known as 'background flights' (or may not even be flights 'known' to the NERC system, e.g. General Aviation flights outside controlled airspace or flights whose flight plans mean that they are not expected to penetrate LACC airspace, which are termed 'unknown flights'). For the controller (both Planner and Tactical), the benefits of classifying flights as having foreground or background status include the fact that, on the

radar screen, the radar position symbols and track data blocks (TDBs) of foreground flights can be displayed in a different colour to background (and unknown) flights making it significantly easier for the controller to distinguish between the various tracks (helping to reduce 'clutter' on the primary situation display).

Although the electronic co-ordination system itself is a piece of functionality that works in the background, it is important that the controller has access to the status of the process for each flight and has dialogues through which to enter the necessary data (e.g. co-ordination levels) and to trigger the necessary controller-initiated events (e.g. accepting an offer). To this end, a number of co-ordination bays, each populated by a set of electronic flight strips (EFS), are provided, the most important two being the Offered Bay and the Accepted Bay. Normally, a flight will only have a single EFS associated with it – duplicate strips are produced only in particular unusual situations. As the names suggest, an EFS for a flight for which an electronic offer has been received at a sector will be displayed in the Offered Bay and for those flights which have been accepted into the sector either explicitly by the Planner or automatically by the system (in the case of aircraft that are entering the sector under a standing agreement or via the OLDI process – these are known as 'auto-accepts') the EFS will be displayed in the Accepted Bay. The EFS (in whichever bay) is the primary element through which the Planner interacts with the flight and provides access to the various entry and exit co-ordination dialogue windows and to the tools provided to support the Planner in the decision-making process. The figure below shows examples of the Offered and Accepted Bays in use at LACC.

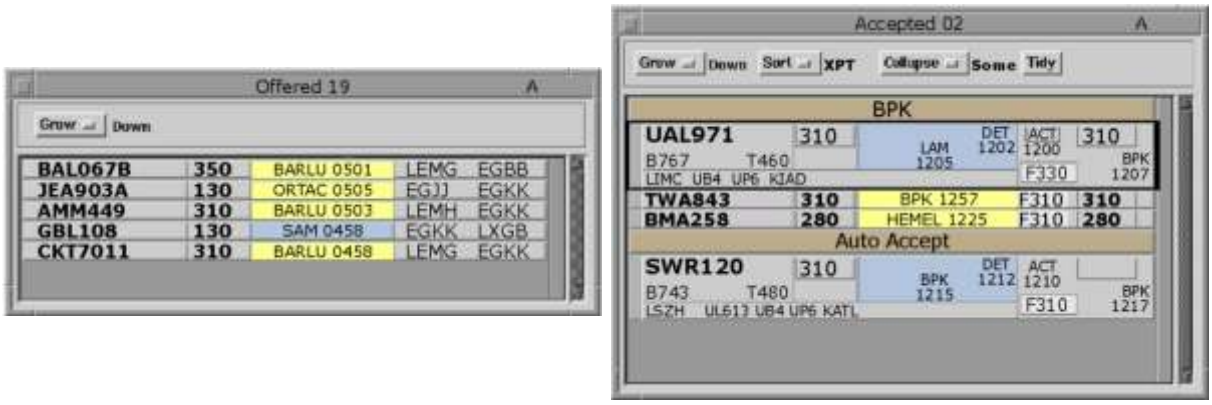


Figure 1 LACC Offered and Accepted Bays and Electronic Flight Strips
(showing 'collapsed' and 'full' strips)

To provide support to the Planner in his entry and exit co-ordination tasks, tools taking advantage of the electronic co-ordination introduced with NERC are available; these are known as Look-See and What-If. These two functions work in broadly similar ways; the main difference between them being that Look-See is only ever performed on the entry level (NFL) offered by the previous team when the flight is first considered by the receiving team (i.e. it is applied only to the offered NFL), for all other situations such as testing an alternative NFL (in order to send a revision) or the determination of a suitable exit level (XFL) the Planner makes use of What-If. In both cases, the level associated with the subject flight (be that an NFL or an XFL) is compared with the entry and exit levels of all other flights that have been offered to or accepted at the receiving team (including flights that are under the control of that team). If the NFL and/or XFL of the flight matches the level being probed, the flight is highlighted to the Planner (on the radar display and in the EFSs in the Offered and Accepted Bays). It is then left to the Planner to identify those flights from the highlighted set that actually may pose a problem and to make a decision based on that assessment. The following figure shows part of a situation display and an Accepted Bay during a Look-See probe with the flights identified as potential co-ordination problems to the subject flight highlighted with light blue TDB borders and EFS fields.

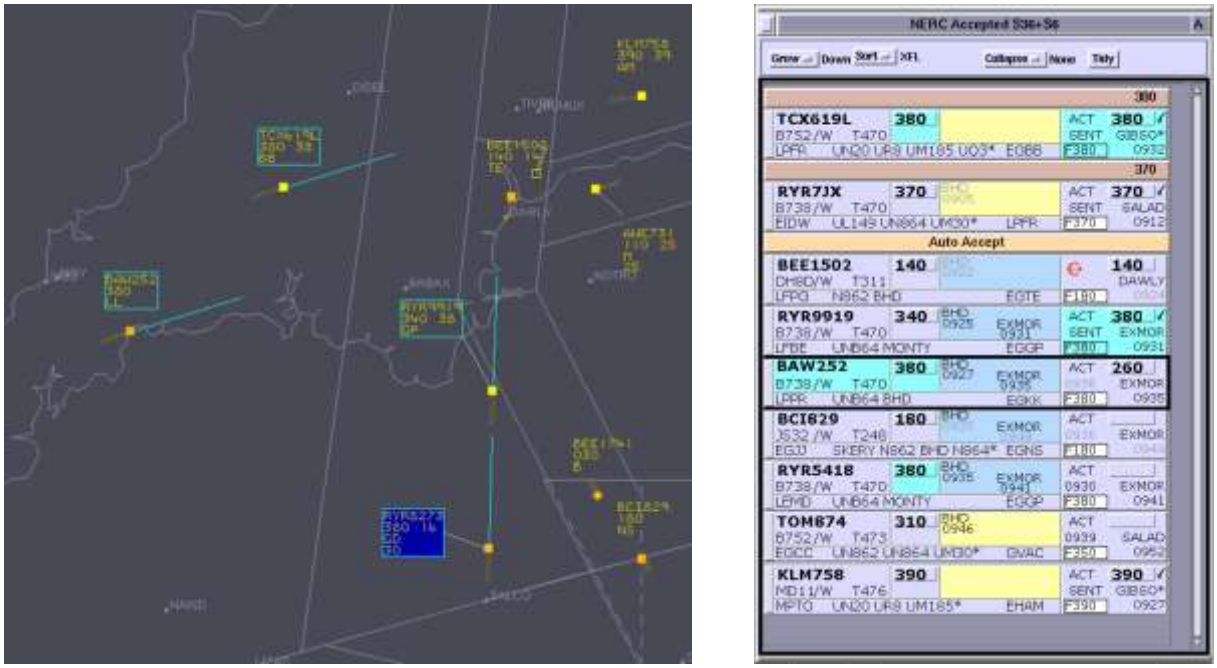


Figure 2 LACC Look-See / What-If highlights on main situation display and in EFSs

Prior to the introduction of the iFACTS tactical toolset, the Planner would make significant use of the paper flight progress strip (PFS) data display to help maintain his picture of the current and pending traffic as well as to provide a focus for discussion and recording agreements and plans with the Tactical. When the whole of LACC was converted to iFACTS the paper flight strips were no longer required and ceased to be printed; rather all workstations, whether for Tactical or Planner, now allow access to the whole suite of iFACTS tools. Although primarily designed for supporting the role of the Tactical controller, the tools are also used by the Planner particularly when making judgements that are significantly affected by the (future) tactical situation (such as determining suitable sector exit levels in more complex traffic conditions with multiple tactical problems to resolve, or monitoring the current situation to identify remedial actions that need to be taken if previously agreed co-ordinations begin to look difficult to achieve). It is worth clarifying that the NERC Planner support tools discussed above (Look-See etc.) were not changed by the introduction of iFACTS (the exception being that, as iFACTS requires the entry into the system of changes of communication status and of all tactical instructions and clearances, the TDBs at both the tactical and planner positions are able to display somewhat enhanced flight data).

Although the iMSP concept developed in this project is significantly aimed at enhancing the role of the Planner, there is inevitably an impact on the Tactical controller (the most obvious being the loss of a dedicated Planner in the controller team). That fact, together with the Planner's use of the iFACTS system (and that the tools that have been developed to support the 1P-2T operation are developments of iFACTS-like functionality) mean that an overview of the LACC Tactical role and the main aspects of the iFACTS toolset are also needed to gain a complete understanding of the iMSP concept under validation in this exercise; the following section sets out such an overview.

2.1.4 LACC Tactical Controller Role and iFACTS Support Tools

In common with many operations, the role of the Tactical controller is to achieve the goals set by the Planner whilst maintaining assured separation between flights (both those under his control and flights either yet to contact the sector or recently transferred on to the next team). In the LACC operation the Tactical devises a "tactical plan" to achieve those goals and endeavours as far as possible to offer the most desirable profiles to flights; thus, unrestricted climb as early as possible for outbounds and unrestricted descent as late as possible for inbounds with all flights given the most economical routing through the sector airspace is the target the Tactical aims for – deviations from this being made only where separation assurance dictates. In order to do this, the Tactical controller

has a suite of iFACTS tools to aid the decision-making and situation-monitoring aspects of the overall task.

The iFACTS tactical tools are based upon three core underlying functions: Trajectory Prediction (TP), Medium Term Conflict Detection (MTCD) and Flight Path Monitoring (FPM); together these are known as the 'Core Engine'. A complete set of tactical trajectories is generated at each workstation in the sector team, one for each of the foreground flights for that team. The tactical trajectory represents either the predicted behaviour of the aircraft should it continue on its current clearance (if the flight is under the control of the sector or recently transferred to the next sector) or, for the flights that have not yet been transferred to the sector and are still under the control of the previous sector or centre, the behaviour assuming the flight will enter the sector at the co-ordinated entry level(s).

For situation-monitoring support, these tactical trajectories are probed against each other by MTCD to determine whether any 'interactions' are predicted over the next fifteen minutes (the trajectories are a little longer than this to allow interactions towards the end of the trajectories to be better characterized). An interaction is classified by its severity based upon the predicted horizontal closest approach distance while vertical separation is predicted not to be maintained and takes account, not only of the core trajectory points, but also of the uncertainty associated with the prediction (both are calculated by TP) – in general, the uncertainty growth is open-loop and is calculated from the identified error / tolerance ranges on the key input parameters to the TP (e.g. aircraft mass, predicted meteorological conditions, unrestricted speed range, etc.). It is a key point to note that predicted interactions are not necessarily 'conflicts' (losses of separation) as it is not only situations where the necessary separation is not predicted to be achieved that are identified, other pairs of flights which are expected to come within a distance of interest of each other are also identified, classified and displayed to the controller as they are still pertinent to the separation assurance responsibilities of the Tactical.

For decision-making support, a number of speculative (sometimes known as 'tactical what-if?') trajectories are built for a selected flight which model alternative clearances in the vertical and/or horizontal which are probed (again by MTCD) against the tactical trajectories of the other foreground flights. This capability allows the Tactical Controller to see the interactions that would be predicted should a particular clearance be issued and to identify those interacting flights that need to be considered in order to clear the subject flight to its sector exit goal (position and level).

The iFACTS system presents the interaction information for both situation-monitoring and decision-support through a graphical HMI using common symbology and colours, most of which is contained within windows with some aspects able to be superimposed temporarily onto the radar situation display (e.g. to identify the geography and geometry of the predicted interaction). Examples of the various tools are shown below.

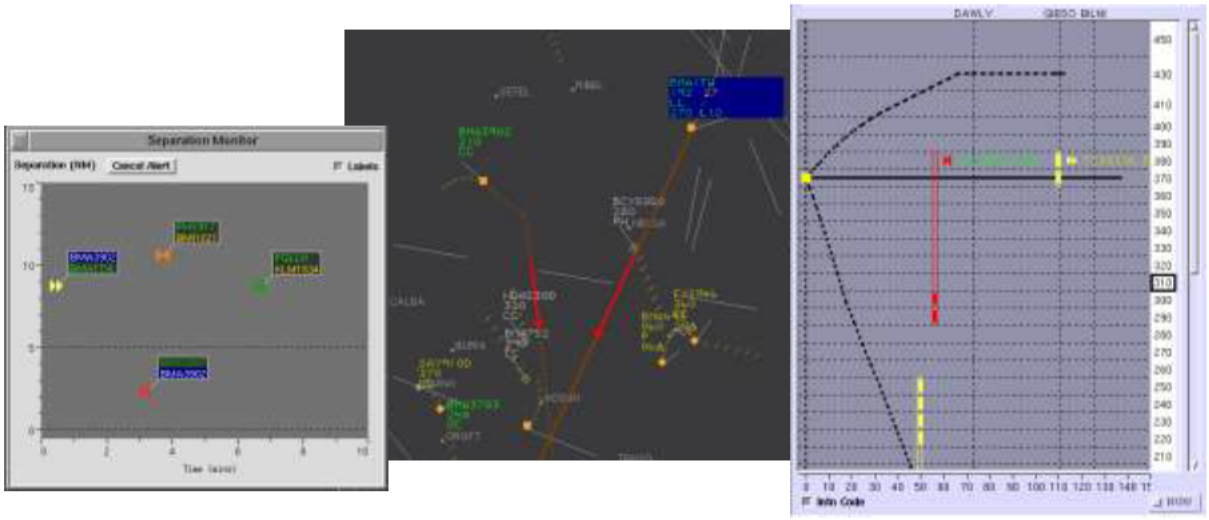


Figure 3 Examples of iFACTS tactical tools
(Separation Monitor, Tactical Interaction Vectors and the Level Assessment Display)

Owing to the reliance on predicted trajectories by the controller in the planning and execution of the tactical tasks, the FPM function (sometimes alternatively known as 'conformance monitoring') provides the Controller with crucial feedback of the conformance of each flight to the original prediction (and is refreshed when a new instruction is issued to a flight). In both the vertical and lateral dimensions, FPM triggers a visual alert should the aircraft be observed to be deviating outside the tolerances allowed in a particular plane and, in most circumstances, also generates a "deviation trajectory" which helps the controller identify any short-term interactions that have been generated as a result of the deviation (e.g. should the flight climb beyond the entered cleared level, a vertical deviation trajectory will be generated and probed to find any potential, previously unexpected, interactions as a result of the 'level bust'). It is worth noting that a deviation may be as a result of the flight not conforming to its clearance (a 'genuine' deviation), an input error by the controller (e.g. mis-entering a cleared flight level), or the situation developing in a manner not originally predicted (such as in the case of an aircraft correctly following the instructed radar heading but experiencing a wind that is not consistent with the predicted meteorological conditions and drifting away from the predicted path).

2.1.5 iMSP Concept and SESAR P4.7.8 Step 1 Quick Win

As mentioned above, previous early development phases of a MSP concept suggested that significant operational benefit could be gained through such a concept. With the more advanced concept of Collaborative Control reliant on the underlying FDP system upgrade and targeted at an iTEC implementation, a piece of work was initiated to investigate whether a more limited MSP concept could be developed for operational implementation and deployment in a shorter timeframe as an upgrade to the LACC iFACTS system. The iMSP concept development was therefore undertaken with this target in mind and with a number of constraints imposed upon it:

- the concept should be deployable on the NERC-iFACTS system at LACC;
- the concept would be limited to a one Planner to two Tacticals (1P-2T) team arrangement;
- although it would not be expected that all potential pairs of sectors could be operated as 1P-2T simultaneously across the LACC operation, the concept should be applicable to a wide variety of sector types and should cope with normal traffic levels (i.e. not only light or night-time traffic);
- minimal change should be required to the iFACTS Tactical tools, although it is accepted that support tools for the Planner may need to be developed;
- minimal change should be required to the architecture of the NERC system;
- minimal change to the roles, responsibilities and tasks of the Planner and Tactical controllers using iFACTS;
- the concept should not be inconsistent with the envisaged target MSP concept ("Full MSP") and should be a stepping-stone towards the future deployments.

The early phases of development for iMSP determined a number of concept criteria which were felt to be consistent with these constraints and which became, effectively, the criteria against which the objectives of the subsequent validation activities were set:

- the role, responsibilities and tasks of the Tactical controller operating in a 1P-2T mode will be as similar as possible to that of standard 1P-1T operation;
- the "internal boundary" between the two sectors (or sector groups) within a 1P-2T combination will be a co-ordinated boundary (i.e. there will be an explicit exit level from one sector and entry level into the next across the internal boundary for flights that are expected to traverse both sectors); the internal boundary may be lateral or vertical and may be set automatically from an appropriate sector adaptation file (in the case of a standing agreement, for example);
- although the specific nature of certain tasks may change, in general the role and responsibilities of the Planner controller when responsible for two Tactical controllers will be as similar as possible to those when operating in the 1P-1T mode;
- it will be primarily the responsibility of the Planner to set the co-ordination at the internal boundary, however all members of the controller team should have the ability to set and/or amend the level(s) and any supplementary co-ordination conditions;

- the Planner will not be expected to monitor both sector (i.e. Tactical) frequencies coincidentally when operating in 1P-2T mode, but will have access to both;
- as a result of having responsibility for traffic across two sectors (or groups of sectors), tools to support the Planner in the identification of acceptable entry co-ordination offers and the selection of appropriate exit levels will be required;
- as far as possible, additional support for the Planner will be provided through enhancement of the current toolset rather than the introduction of completely new tools and HMI.

The iMSP concept, as developed as a Quick Win thread of work within P4.7.8 for SESAR concept Step 1 (time-based operations), can therefore be summarized as one in which the Planner is responsible for the sectors under the control of two Tactical controllers, the common boundary between them being one across which a co-ordination agreement must be put in place either explicitly (generally by the Planner) or from a standard operational procedure (e.g. a standing agreement). Enhancements to the NERC planning tools (including Look-See, What-If, electronic strips etc.) have been developed in order to increase the efficiency of the planning and decision-making processes in order that the workload of the Planner in a 1P-2T team structure remains within acceptable limits at traffic levels that are comfortable, but not especially low, for the Tacticals.

In the context of the wider development of MSP concepts within P4.7.8, the iMSP concept is seen as a first step towards the more advanced (both from an operational and technical point of view) Collaborative Control concept in which internal boundaries (there may be more than one) need not be co-ordinated by procedure. Key operational concerns and issues associated with the move from a dedicated to a shared Planner such as support to the Tactical, monitoring the tactical situation, anticipation of situations that require remedial intervention and revision, and the perceived safety issues associated with the second controller listening to each frequency have all to be addressed without the additional impact of a significant change to the division of separation responsibilities of the controllers in the team. The on-going development of the more advanced MSP concepts in the later threads of the Project will gain valuable insight into these issues and guidance as to how they can be best addressed.

Three phases of development and validation were planned for the iMSP concept (the first of these preceded the start of P4.7.8 and focussed on the development of the support tools for the Planner). The latter two, a V2 exercise ‘iMSP2’ (EXE-04.07.08-VP-157) [7] was held in Dec 2010 and the Release 2 V3 exercise ‘iMSP3’ (EXE-04.07.08-VP-304) in March ’12 both included the enhanced planner tools and the 1P-2T operation (the latter also investigated a variation on the team structure with a single controller solely responsible for the sector i.e. Single Person Operations).

At the core of the iMSP concept is the proposal that there exists a level of traffic complexity that exceeds the capacity levels of the single team of two controllers (one Planner and one Tactical) in a bandboxed configuration, yet does not fully utilise the capacity of the four controllers in a split configuration (two sectors each controller by a Planner and a Tactical). When it is the workload of the Tactical that forces the split to maintain safe and acceptable levels of workload, the Planner may still be able to manage their task load comfortably at this point. The Multi-Sector Planner concept of 1P-2T with enhanced planner tools support is proposed as a concept that could bridge this gap. There may also be an opportunity during quieter traffic situations for a single controller (SPO) to perform the role of both Planner and Tactical using the enhanced toolset. The diagram below presents a schematic of this view – note however that the relationship between workload and traffic level is far from the simple one suggested by the picture and that it is purely to illustrate how the iMSP (and SPO) configurations could be exploited as traffic levels rise and fall.

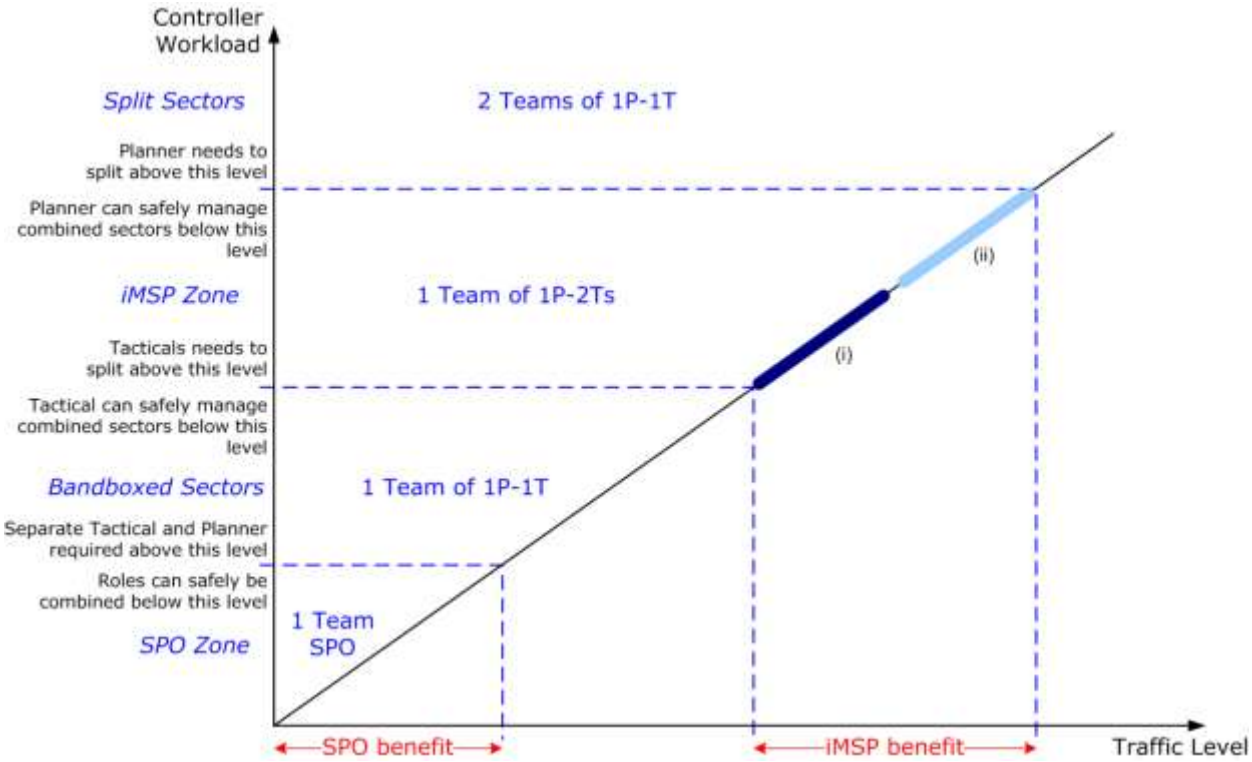


Figure 4 Sector staffing arrangements and traffic levels

In order to validate that the iMSP concept has applicability over a suitable range of traffic levels, the V3 exercise described in this report focussed on assessing the responses of the controllers in two important regions of this graph. In particular, the workload/traffic levels represented by the two blue shaded zones were of interest as they depict:

(i) periods where the traffic level and complexity was deemed to be sufficiently high that the bandboxed Tactical position was required to be split, and

(ii) periods where, although the two Tactical controllers felt that traffic levels were sufficiently high that they could not operate bandboxed, the two Planners felt that they could safely combine the sectors onto a single Planner position.

The range of traffic flows and levels over which these two situations pertain represents the potential operating envelope of the iMSP (1P-2Ts) team structure. A similar analysis can be applied to the interface between the 1P-1T and SPO modes.

In the following sections, an overview of the concept and associated tools as they were validated in iMSP2 (V2 maturity) is set out followed by a summary of the findings in the real-time validation exercise. Following that, the changes made to address the issues raised in that validation, as well as some outstanding aspects that were deferred to the later phase which, together, constituted the concept and tools to be validated in this exercise are described in some detail.

2.1.6 iMSP2 (V2) Phase Concept and Tools Description

This section will describe in detail the status of the concept and support tools that were developed and validated in the iMSP2 phase of work (the validation was at V2 maturity). The core concept will be seen to vary very little between phase 2 and phase 3, however the detail of the tools designed to support the Planner (and Tacticals) applying that concept mature significantly as a result of the V2 real-time validation.

As summarized earlier, the iMSP concept is one in which the normal requirement to agree a co-ordination at the internal boundary between the two tactical-sectors remains so that, from the point of view of either Tactical Controller, there is an entry co-ordination and an exit co-ordination for every

flight regardless of whether it will traverse just one of the tactical-sectors or both (in this document "tactical-sector" will be used as a short-hand term to describe the volume of airspace that is the responsibility of a single Tactical Controller and may comprise one or more airspace sectors). The diagram below helps to clarify these aspects of the concept and shows the two tactical-sectors within a multi-sector (a term that will be used to describe the airspace for which the Multi-Sector Planner has responsibility and which comprises the two tactical-sectors).

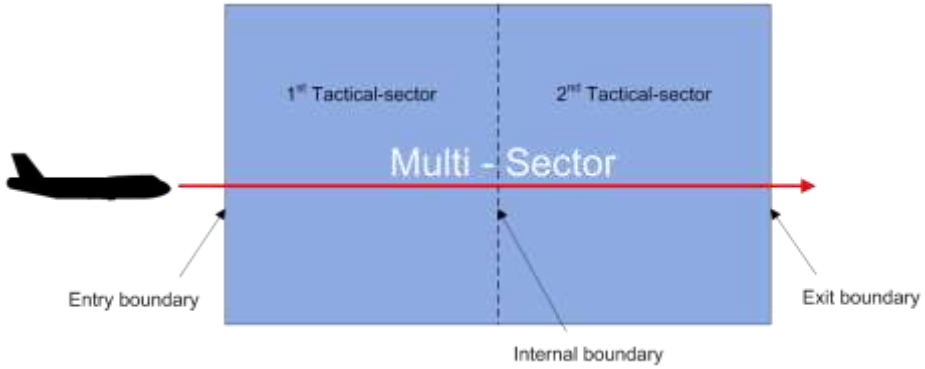


Figure 5 Tactical Sectors

The significant difference between the entry/exit boundaries into and out of the multi-sector and the internal boundary within the multi-sector is that, whereas the Planner for the multi-sector must come to an agreement with another Planner for the entry/exit boundaries, at the internal boundary he is aware of, and responsible for, the traffic on both sides of the internal boundary and is therefore in a position to dictate a suitable co-ordination level – in effect, he is both the offering *and* receiving Planner. In the iMSP concept, this fact is exploited to reduce the workload associated with setting the internal-boundary co-ordination since the normal electronic dialogue (select – offer – review – accept) that applies to the other sector boundaries is no longer relevant and the Planner can simply enter the desired level for the system to treat that as an agreed co-ordination. In fact, right up until the aircraft is transferred from Tactical 1 to Tactical 2, the Planner (or either Tactical) can amend the internal-boundary level simply by selecting a different one – no revision dialogue is necessary (it is accepted that, if the aircraft is near the boundary, verbal co-ordination is likely to be effected between Tacticals before the boundary level is amended – this is standard operating procedure in that scenario). Significantly, from the point of view of the Tactical controllers, there is a co-ordinated level at the exit boundary of tactical-sector 1 and a co-ordinated level at the entry boundary of tactical-sector 2 – the flight has exactly the same co-ordination agreements (and transfer of control and communications procedures, which are dependent on the nature of the co-ordination) as the other flights which are traversing only one of the tactical-sectors.

There are several potential benefits that could be realized through the Planner's overall responsibility for the multi-sector group. From the point of view of his role as a workload regulator, the Planner will be able to select a 'planning profile' through the airspace (the planning profile being the coarse vertical profile defined by the entry – internal – exit boundary levels along the expected track of the aircraft) which helps to balance the expected induced complexity (the level of 'difficulty' the Planner imposes on the Tactical through his selection of target exit co-ordinations) across the two tactical-sectors and to respond more readily as the actual workload of the Tacticals becomes apparent through the initial selection and subsequent amendment of the internal boundary. From the perspective of the airspace users, a similar process can be employed to ensure that the planning profile allows the aircraft to fly a trajectory that is less restricted (or, at least, that any restrictions to the flown trajectory constrain it as little as possible from its desired profile). In reality, the Planner must (as always) balance these two goals of safe sector workload and quality of service, but it is expected that the ability to set a planning profile across a larger volume of airspace has the potential to enhance that aspect of his role.

Of course, the nature of the sectors and traffic flows will be very significant in the way in which the Planner manages the internal boundary. A boundary between two laterally abutting sectors is quite different to one between vertical ones as there is significantly more choice over the co-ordination in the former than the latter. In the same way, pairs of tactical-sectors where the traffic flows are very segregated and few flights traverse both (i.e. few flights cross the internal boundary) sets quite a

different operational challenge for the Planner compared with sectors where there is a high proportion of flights that route through both tactical-sectors. The most significant difference between these scenarios is likely to be the number of flights for whom the Multi-Sector Planner will have responsibility (and, therefore, the amount of co-ordination and monitoring workload). In the former case, the Tacticals will have very distinct sets of traffic and the Planner will therefore be dealing with two sectors' worth of aircraft, whilst in the latter, although each Tactical may experience just as high traffic levels, the Planner will be responsible for a proportionately lower number of flights. It is exactly these variations in the nature of the flows and sector arrangements that will dictate at what levels of traffic particular pairings of sectors will be viable for operation in the 1P-2T mode (i.e. where along the traffic/workload line in Figure 4 the margins between the bandboxed, MSP, and split configurations lie).

2.1.6.1 Enhanced Look-See / What-If

Despite the fact that the Planner's task for dealing with co-ordination across the internal boundary is a more straightforward one than the dialogue with other Teams at the entry and exit boundaries, there is clearly more co-ordination workload for a Planner in 1P-2T team than a normal 1P-1T. In order to address this, it was proposed that enhancements be made to the NERC planning tools (as described in Section 2.1.3) such that they more efficiently identified 'planning problems' that needed resolution. Specifically, the purely level-matching NERC Look-See and What-If were enhanced with a planning variation of TP and MTCD (using the underlying core engine of iFACTS, but tailoring the trajectories and probing logic to the co-ordination task rather than the tactical separation assurance process). The expectation of the MTCD-enhanced Look-See and What-If capability is that it should significantly reduce the number of flights that are identified as potential problems to the Planner when assessing and selecting entry and exit (and internal) boundary co-ordination levels and that it should be available both to 1P-2T and 1P-1T teams (i.e. all LACC teams will benefit regardless of their structure).

The enhanced Look-See and What-If tools are underpinned by a set of 'co-ordination trajectories' that are created for each relevant flight at the workstations of a given sector team. For a 1P-1T team, the relevant flight set is the set of foreground flights for the Team; for a 1P-2T team, the relevant flight set is the combination of the foreground flights at tactical-sector 1 and tactical-sector 2 (in fact, this defines the planning-sector foreground flight set). The figure below helps to clarify this where the Planner is responsible for tactical-sector 1 and tactical-sector 2.

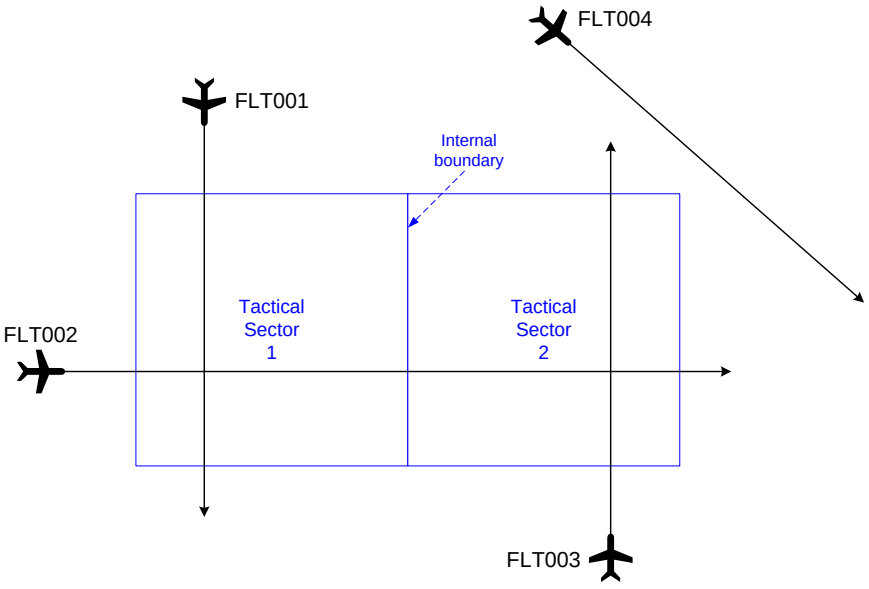


Figure 6 Planner Responsibility

In the figure, the foreground flights at tactical-sector 1 are FLT001 and FLT002 and at tactical-sector 2 they are FLT002 and FLT003; however, the planning-sector foreground flight set is FLT001, FLT002 and FLT003. FLT004 is a background flight at all of the positions in the team (but may be foreground at another LACC team).

Co-ordination trajectories are built at the various entry and exit levels (which may be single levels or ranges of levels in the case of co-ordinated climbs and descents) for all of the planning-sector foreground flights and are refreshed on a cyclic basis (every radar update). A co-ordination trajectory associated with the boundary co-ordination for a particular flight is truncated so that it only penetrates through an appropriate section of the airspace as depicted in the diagram below (which shows two laterally abutting sectors; similar rules are used to define how vertical boundaries are dealt with).

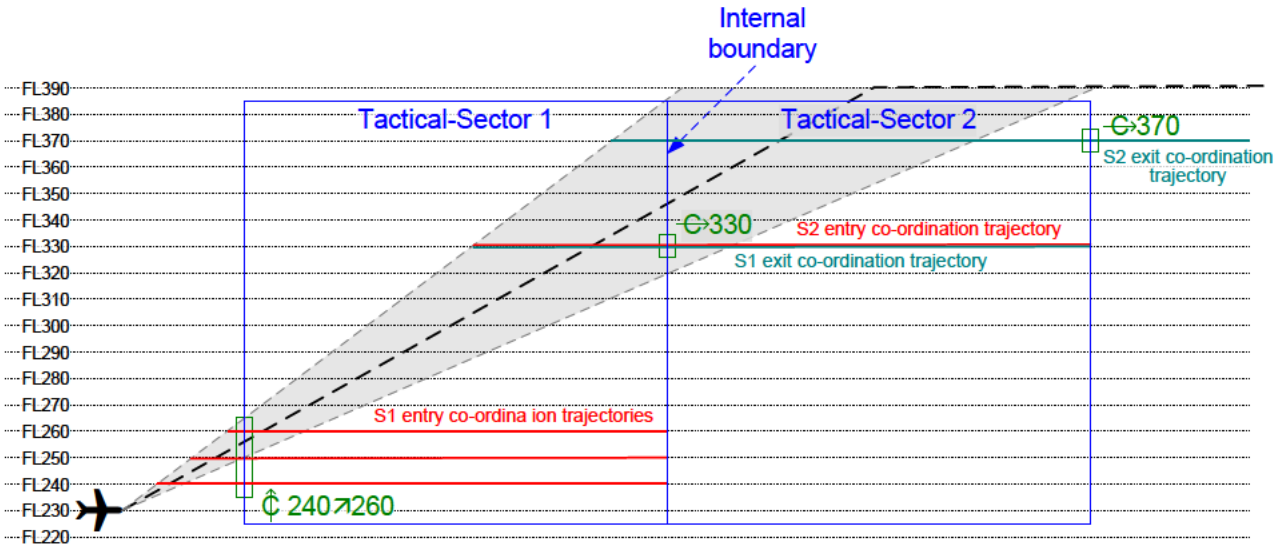


Figure 7 Coordination Trajectories

From the diagram, it can be seen that the starting points for entry and exit co-ordination trajectories are determined from the high-performance edge of the uncertainty zone (the grey shaded region) around the nominal (unconstrained) planning profile depicted as a dashed black line (which is derived from a trajectory based on the flight plan).

When the Planner initiates a Look-See (on the offered entry level into tactical-sector 1) or a What-If (on an alternative entry level or to identify a suitable internal boundary or exit level) for a subject flight, a co-ordination trajectory built at that level for that flight is probed by MTCD against all of the co-ordination trajectories for the other 'environmental' flights that are planning-sector foreground. Only flights that interact at a common level and are determined by MTCD to be closer than an adaptable separation threshold (e.g. 15Nm) at closest approach will be reported by the core MTCD algorithm as potential planning interactions. Subsequently, logic to filter the output further based on a set of air traffic rules is applied so that only those problems that make operational sense to the Controller are actually sent to the HMI for display. These ATC rules take account of operational practices such as whose responsibility is it to provide separation between two flights (e.g. two flights offered by the same sector that nominally are predicted to fall below the planning separation threshold distance are not reported to the receiving sector, when they undertake a Look-See for example, on the basis that it is the offering sector's responsibility to apply separation between the flights prior to transferring to the receiving sector); thus, although MTCD might detect a planning interaction, the Look-See HMI will not display the environmental flight as a problem. Thus, in comparison to the baseline NERC Look-See and What-If, significantly fewer flights are expected to be identified as potential planning problems to the Planner allowing him to focus on resolution rather than needing first to identify the real problems from a large highlighted set of flights. No change was made in the manner in which the results of the enhanced Look-See/What-If were presented; highlights were applied to the TDBs and the appropriate fields within the EFSs of the identified flights (see

Figure 10 for an example of the HMI).

2.1.6.2 Planner Interaction Vectors

In order to enhance the Planner's understanding of the various planning problems identified during the enhanced Look-See and What-If probes, additional HMI was designed to allow the superimposition of a plan-view depiction of the trajectories and geometry of the interactions for each

of the interacting flights. The baseline NERC Planner is able to display vector lines for the flights involved in a Look-See/What-If probe, however these vector lines are simply linear extrapolations of the current speed and direction of the aircraft from the most recent radar updates (see

Figure 10). The Planner Interaction Vectors are similar to the iFACTS Tactical Interaction Vectors however their trajectories and interactions are based on the planning (co-ordination) trajectories rather than the tactical trajectory and show not only the predicted ground path of the trajectories of the aircraft involved but also the positions of loss of predicted separation and closest approach (for the Planner, the loss of separation is based on the planning threshold of 15Nm and not the minimum radar separation standard). An example of the Planner Interaction Vectors can be seen in

Figure 8.

Figure 8 Planner Interaction Vector display during Enhanced Look-See/What-If

As shown in the figure, several vectors can be displayed simultaneously (as many as there are interacting flights) so, to help the Planner discriminate between each one, a simple mouse-focus operation enables the Planner to highlight each pair of vectors in turn (the others being low-lighted) as shown below.

Figure 9 Highlighted Vector Pair

From the Planner Interaction Vectors, the Planner is more able to judge the various tactical problems that are predicted to arise from a particular planning decision and can alter the boundary co-ordination or bring the situation to the Tactical controller's attention as appropriate (clearly the action will depend on many factors including traffic level, the position and severity of the interaction, the tactical complexity etc.).

2.1.6.3 Three-Field Strips

It can be seen in Figure 1 and Figure 2 that the Planner's Accepted Bay shows two co-ordination levels, the entry flight-level and the exit flight-level. For the normal 1P-1T configuration and for flights which only traverse one tactical-sector in the 1P-2T structure, there are only these two co-ordinations applicable to the flight. However, in the 1P-2T configuration, for flights which are expected to traverse both tactical-sectors a third co-ordination level exists – that of the internal boundary. In order to accommodate the input and display of the internal boundary level, minor changes were made to the EFS so that all three co-ordinations could be displayed; this HMI was known as the Three-Field Strip and an example is shown below in

Figure 10.

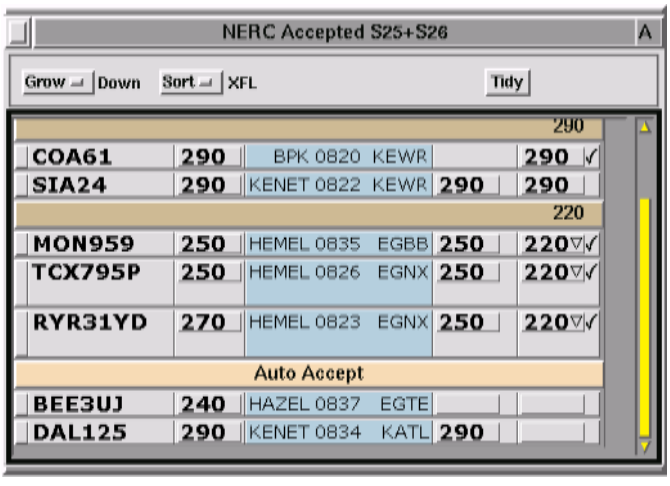


Figure 10 Planner Accepted Bay showing three-field strips (entry, internal, exit boundaries)

It can be seen that only the strips for certain flights have three level fields (e.g. SIA24 in the diagram) whereas others show just two (e.g. COA61). The system automatically determines whether a flight will cross the internal boundary (and, hence, require a three-field strip) based upon the route of the aircraft and the level set as the overall exit co-ordination (which may imply that the flight must climb

from a lower into a higher sector). The internal boundary level may be edited (updated) right up to the point when the flight is marked as out of communication ('outcomm') at the first tactical-sector and it is possible for the Planner or either Tactical to make that change (it is expected that, as the aircraft approaches the internal boundary, co-ordination will have been agreed verbally between the controllers before the internal level is updated).

2.1.6.4 Track Data Blocks

The track data block (TDB) in iFACTS is exactly the same at the Tactical and Planner positions. Various data are displayed to the Controller communication state (through the colour of the text) as well as the identification, current and exit levels, route code and clearances for the flight; deviation alerts are also presented on the TDB when triggered (an example of the iFACTS TDB is shown below displaying the RYR31YD callsign, actual flight level from Mode C of 250, exit co-ordination of FL220 down to the sector below and a route code "NX" meaning a destination of East Midlands Airport; the bright green text denoting a flight that is in communication).

Figure 11 iFACTS Track Data Block

For a Planner in a 1P-2T configuration, the internal boundary co-ordination level becomes an important additional piece of data and was added to the second line of the TDB between brackets (for those flights traversing the internal boundary); an example is shown below for a Birmingham inbound flights (denoted by the 'BB' route code) in which the internal boundary co-ordination is set to FL220 (a lateral boundary) and the exit level FL200 down to the sector below. Although the Planner TDB displays the two co-ordination levels, the TDB at each tactical workstation continues only to show the level pertinent to their particular exit boundary since the internal boundary is the exit boundary for tactical-sector 1 and the entry boundary for tactical-sector 2.

Figure 12 Track Data Block showing internal boundary level

Additionally, the Planner's TDB displays the communication state for the combination of sectors rather than (as at a tactical-sector) for just a single sector. In this way, the Planner is aware of whether the flight is in communication with either of the Tacticals (and is able to display further information in the TDB to identify which one explicitly – however that information is also presented elsewhere so is of lower importance in the TDB).

2.1.6.5 Planner Views

Generally, the Planner in a 1P-2T configuration is presented with the complete set of information for both tactical-sectors. For example, the interactions displayed in the Separation Monitor and the Level Assessment Display (as depicted in Figure 3) at the planner position are the combination of those at each of the tactical positions as are the radar tracks and TDBs displayed as foreground to the Planner. Generally, this wider picture of the traffic situation is what the Planner needs to undertake the core tasks of co-ordination and traffic management, however there are situations in which the Planner might need to focus on one or other of the tactical-sectors for a period (e.g. to understand a particular problem one of the Tactical controllers is requesting support to resolve or to help judge the balance of workload and complexity between the two Tacticals). In order to support these aspects of the Planner task, an HMI function to focus on one or other Tactical traffic was developed ('Planner Views') and which could be accessed as a switch on the radar palette (to select a view for an extended period) or as a keyboard initiated quick-look when a brief invocation of the view is required (the view only lasting as long as the corresponding keyboard key is held down).

When a Planner View of a particular Tactical is selected (identified as 'Left Tactical' and 'Right Tactical'), the TDBs at the planner position are changed to help differentiate those of the selected tactical sector from the rest. Additionally, the set of interactions that are displayed to the Planner in the iFACTS tactical tools (the Separation Monitor and the Level Assessment Display) is also divided between those pertinent to the selected tactical sector and the others with the HMI distinguishing between them (e.g. the labels of the interactions not pertinent to the selected tactical sector lose their labels for the duration of the Planner View in the SM).

2.1.6.6 Integrated Co-ordination

Integrated Co-ordination is an element of functionality derived from the proposed iTEC system that integrates an automated MTCD process into the assessment of the suitability of co-ordination offers. In its full (iTEC) form, Integrated Co-ordination (IC) is expected both to assess entry co-ordination offers and to select suitable exit boundary levels for onward co-ordination – the Planner only dealing with those entry and exit problems for which IC can find no suitable solution. In iMSP, only the offer at the entry boundary is subject to an IC process. In iMSP2 all offers received (including standing agreement and OLDI) triggered a single-shot (i.e. one-off) MTCD IC assessment at the moment the offer arrived. Since IC uses the same parameters as the enhanced Look-See to determine whether there are planning interactions, this was, effectively, the same as the system running a background Look-See at the moment of receipt of the offer. If no pertinent problems were found, the flight was automatically accepted into the sector without the Planner being involved; however in those cases where the IC probe identified one or more pertinent interactions, the flight was referred to the Planner for assessment (after which the flight was dealt with as any other – the Planner could accept, revise or reject the co-ordination as appropriate).

Currently at LACC certain co-ordination offers (e.g. standing agreements and OLDI entry co-ordinations) are automatically accepted into a sector without a requirement for the Planner to intervene. The Integrated Co-ordination function effectively extends this auto-accept concept to all offers provided there are no conflicting flights (at their entry and/or exit levels). It is worth noting that IC only triggers a single MTCD probe and that there is no on-going monitoring of the co-ordinations which is still the responsibility of the Planner. When a flight is offered, a strip would normally appear in the Offered Bay until the Planner selects that flight as the subject of a Look-See when it moves from the Offered to the Accepted Bay so it can be assessed against the other co-ordinated flights. With IC, should the flight be found to be conflict-free when the offer arrives, the strip will appear immediately under the Auto-Accept designator within the Accepted Bay. Those flights which are found by IC to have at least one pertinent planning interaction when the offer arrives are the only flights that generate a strip in the Referred Bay (the equivalent of the Offered Bay) for the Planner to assess.

2.1.7 Conclusions and Recommendations from iMSP2

The iMSP2 validation activity gave the controller group a first look at how a bespoke Planner trajectory/prediction capability could help to enhance the Planner tools currently available at LACC; it also gave some insight into the potential of such enhancements to reduce incrementally the workload of some Planner tasks. This was a first look at MSP for LACC (using the LUS/LMS sector group). At this point very little effort was available to refine the tools as presented at the front end of the system. This was due to the considerable amount of software change employed to prepare the NERC emulation for the system infrastructure changes (albeit the maturity of the tools design was acceptable for this level of validation). It should be noted that the system design that went forward into iMSP2 was purposefully adaptive; as such controller feedback provided by this activity could be accommodated within the time constraints imposed by the project and prototyped in the final (iMSP3) activity.

The iMSP2 validation activity concluded that Integrated Coordination had a detrimental effect on the Multi-Sector Planners' situational awareness, but was potentially more acceptable on sectors with a high proportion of standing agreement traffic that is auto-accepted in current LACC. In fact, a point that was noted by the participants was the potential for a safety benefit through IC probing and identifying for review OLDI and, to a lesser extent, SA flights that were found by MTCD to be in conflict with other traffic. The reduction in situational awareness was partly owing to the fact that, although IC would only accept flights automatically that were found to be conflict-free at their offered

entry level, the suitability of that level in terms of the management of the sector traffic might have been less optimal (e.g. automatically accepting a London TMA inbound flight above a UK overflight and causing unnecessary tactical complexity and workload which the Planner would have eliminated had he assessed both offers). It was recommended that IC be further developed to enable it to account for, and improve, situational awareness.

During periods when both Tactical sectors had relatively high traffic loading, the Multi-Sector Planner's Accepted Bay contained a considerable number of electronic flight strips, contributing to the Multi-Sector Planners' perceived high workload. It was recommended that procedures and tool support for dealing with the large number of strips in the Accepted Bay should be developed.

Further, the participants all reported that it would be a significant improvement to the MTCD-enhanced Look-See/What-If tool if the planning trajectories took into account coordination actions that the Planner had taken to resolve interactions, such as agreeing that the offering sector lock an aircraft onto a heading. It was recommended that the MTCD-enhanced Look-See/What-If should be developed to take account of lateral coordination agreements.

2.1.8 Tools Development for iMSP3 (V3)

The following sections describe the tools developed or revised in order to address the recommendations resulting from EXE-157 (iMSP2).

2.1.8.1 Sector Specific Probing

In order that the results of the Planner's probes for entry and exit co-ordination (Look-See and What-If) are of most benefit to the decision-making process, the 'raw' results from MTCD are filtered with a number of generic and then sector-specific rules which align to general and local (sector) practices before the remaining set is made known the Planner – in this way, an element of "air traffic reality" is injected into the tools which aims to ensure they align with the way in which the Controllers apply operational procedures and practices and are, therefore, more operationally acceptable to the Controllers. The (operational) iFACTS tactical tools include such rules and it upon these that sets of similar logic has been defined and encoded for the Planner tools under evaluation in this exercise.

The generic filtering applies a set of rules which could be considered to reflect the standard procedures for the co-ordination and transfer of flights between sectors throughout the London ACC (and are likely to be similar in other Centres). Typical examples of filters are, for example, two flights offered at the same level from the same previous sector need not be shown as a planning interaction at the receiving sector as it is always the responsibility of the offering sector (Tactical) controller to establish separation between the two flights (either lateral using headings, or longitudinal using speed control) prior to transfer to the receiving sector. More sophisticated rules are applied when considering the 1P-2T planning interactions in order to reflect the significance of the internal boundary in providing separation between flights in each of the two tactical sectors.

The sector-specific probing logic is set up in adaptation tables applicable to each sector (or sector group). Through these tables, particular traffic situations can be identified as ones for which the Planner is responsible (and, therefore, needs to be made aware of any planning interactions that occur) and those for which the Planner is not responsible (and, therefore, the system should suppress the indication of such problems). For example, in the Lakes (S3, S4, S7) group, the Planner is generally not responsible for providing planning separation between flights exiting the Lakes group to different receiving sectors unless those receiving sectors are the Daventry group (S27 / S32) for one flight and the West End group (S5 / S35) for the other which, owing to the proximity of the routes at the exit boundary to these sectors, do require the Planner to ensure the exit conditions set take account of the flight on the other route – in this specific case the probing will identify potential problems to the Planner.

2.1.8.2 Planner Context

The identification of Planner Context flights was designed to support the sector management element of the Planner's role. These 'environmental' flights may not be involved in an interaction with the subject flight based on the current clearance or existing co-ordination levels but may need to be considered by the Planner when making co-ordination choices for the Planning sector to mitigate

Tactical workload as they represent potential problems which the Tactical will have to resolve due to their anticipated vertical and lateral profiles. The set of traffic considered as potential Planner Context flights includes flights from the time they are targeted for co-ordination into the planning sector by the previous (offering) sector (i.e. prior to the arrival of the electronic offer). Logic associated with the phase of flight and the relationship between the current level of the aircraft to the requested, entry and exit (if that is know) levels determines the range of levels over which the flight is expected to operate within a given sector and, hence, the level range that a flight is considered for Planner Context.

The Planner Context tool was developed following the iMSP2 simulation exercise where the Planner in a 1P-2T team reported feeling a reduced awareness of the Tacticals' workload and traffic situation. It is not designed specifically to aid the co-ordination task but to help the Planner gain understanding of the induced Tactical workload as a result of the co-ordination goals that he is setting. Every time a Look-See or What-If is invoked, the contextual traffic between NFL and XFL (or an alternative suitable range should the XFL not yet be set) is highlighted with the aim of identifying to the Planner the set of flights that may lead to tactical complexity (tactical problems and resolution tasks). It was also anticipated that the context flight set when triggered with the enhanced Look-See/What-If functionality will provide a consolidated view of all possible MTCD issues (including planner and tactical) the subject flight may encounter as it transits the sector. As such the Planner may decide to monitor a subset of anticipated tactical problems identified by the tool. Figure 13 shows an example of the (deliberately subtle) HMI for the identification of Planner Context flights (a yellow shading (for eastbound flights) or blue shading (for westbound flights) behind the first two lines of the TDB).

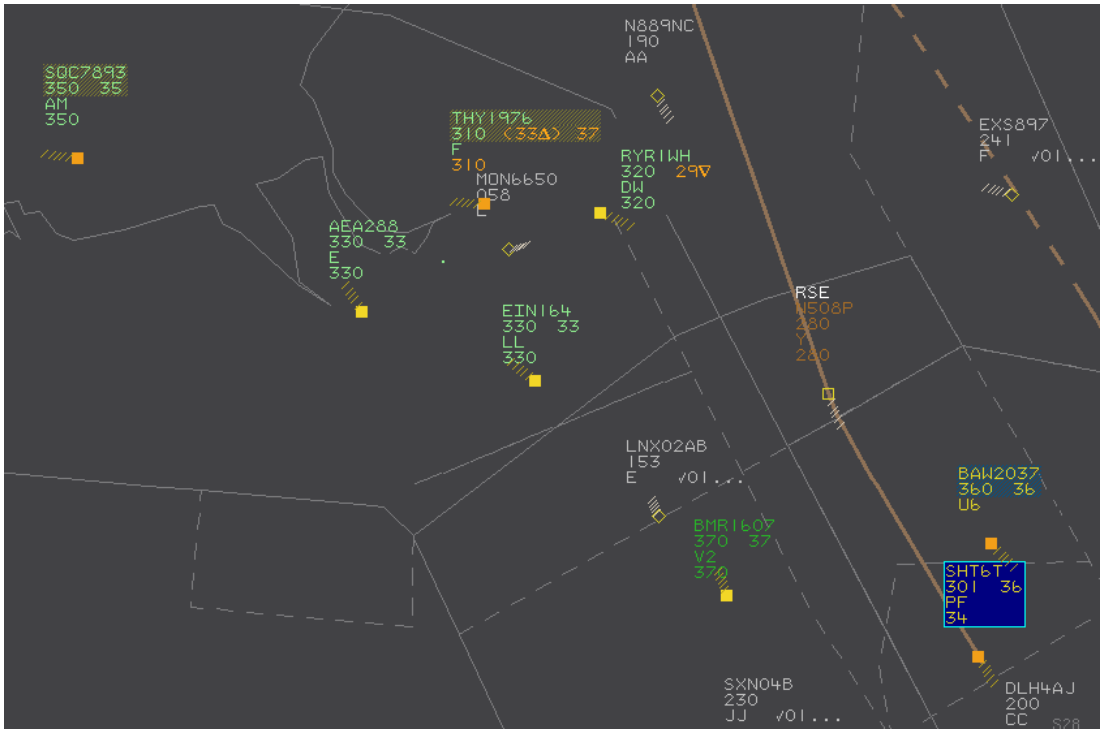


Figure 13 Example of Planner Context

2.1.8.3 Dynamic EFS

The current LACC Accepted Bay is designed to support the primary co-ordination tasks of the Planner allowing controllers to undertake co-ordination actions, evaluate the workload of the sector and maintain situational awareness. An electronic flight strip (EFS) moves into the Accepted Bay (from the Offered Bay) when the Planner initiates a Look-See on the offered entry level for that flight or, in the case of automatically accepted flights (e.g. standing agreements and flights entering from another centre over an OLDI boundary) at the time the offer is received and the flight is auto-accepted into the sector. At some point after acceptance at the entry boundary, the Planner considers an appropriate exit level (unless the flight is leaving the sector under a standing agreement or over an OLDI boundary, in which case the level is automatically allocated by the system) using the What-If function and sets the level in the EFS (which will then be offered when the aircraft is a parameter time from the

sector exit boundary or, in the case of vertical co-ordinations to a sector above or below, one minute after the exit level is set).At LACC, the EFSs are kept in the Accepted Bay until the Planner instigates a manual drop or presses the 'Tidy' button and the flight is no longer of co-ordination interest to the sector (i.e. marked for delete or withdrawn). The generally applied method of operation is to drop the EFS once the offer has been accepted by the next sector (the Planner is made aware of this by a tick displayed by the XFL in the strip).

For the Planner in a 1P-2T team (with more than a single sector's set of EFS, and potentially as many strips as two independent sectors depending on the particular traffic flows through the sectors), 'housekeeping' (i.e. the management of the strips) of the Accepted Bay was seen to become a significant task in itself during the iMSP2 validation exercise just because of the sheer number of strips. To help to alleviate the work associated with keeping the Accepted Bay to a manageable number of strips (and, therefore, to make it useful to the Planner rather than purely a cause of work with little benefit) the 'Dynamic EFS' functionality was developed. The behaviour of EFS in the Accepted Bay involved 'automated drop' and 'auto-recover' events which were aimed to maintain a manageable number of strips in the bay to enable the Planner to focus on only those EFS requiring attention. In this way, the Accepted Bay was seen to become more of a task-oriented list (although not a pure task bay) rather than simply a traffic-oriented one.

Strips become eligible for auto-drop when it is considered that there are no outstanding co-ordination tasks (according to a set of rules, with several exceptions to ensure that the EFS for a flight with key information is not removed from the bay). The actual removal of the strips is still triggered by the Planner pressing the Tidy button, so EFS are only ever removed from the bay through an explicit Planner initiated action (it should be noted that this functionality was changed during the simulation itself in response to the Controllers' comments – initially the strips were also removed automatically in response to several events such as accepting an offer and other user-triggered events that currently result in a reordering of EFS in the bay, and it was part-way through the activity when the system was changed so that the explicit tidy action by the Planner was required). Strips that have been auto-dropped are automatically recovered when they need the Planner's attention (for example when a flight is hooked, or highlighted by a Look-See or a co-ordination offer has been revised or rejected by the next sector etc.). In general, a strip displayed in the Accepted Bay with Dynamic EFS implies that there is some assessment, decision or action required by the Planner; when that has been accomplished, the strip is removed (or becomes eligible for removal when the Planner next tidies the bay).

2.1.8.4 Co-ordination Interaction Point-Out

Current the NERC-iFACTS system enables two flights involved in a tactical interaction to be highlighted on the display through the Interaction Point-Out functionality. This functionality has been extended to enable the Planner to communicate planning interactions to either one or both tacticals. The Co-ordination Interaction menu is invoked by a press-and-hold on the highlighted NFL, IFL or XFL of an EFS field highlighted during a Look-See/What-If. At the Tactical workstation(s), the track data blocks (TDBs) of the two flights are highlighted with a yellow border and, if the mouse cursor is moved over either one of the TDBs, the planning interaction is superimposed on the radar display. Once the Tactical has noted the situation, the point-out can be removed. It is expected that the Planner would use this functionality to highlight an issue to the Tactical prior to the Planner discussing the situation with the Tactical, particularly in the 1P-2T configuration if the problem concerns the Tactical controller seated further from the Planner.

2.1.8.5 Tactical Co-ordination Constraints

To enable the entry of co-ordination constraints which can be used to influence both the planning and tactical trajectories, the iFACTS Tactical Instruction Palette was modified to allow the user to input navigational or speed co-ordination data without affecting the current clearance of a flight (and without forcing the flight to become 'incomm' with the sector). The functionality also provides the Tactical controller (or Planner) with the ability to make changes to the entry and exit co-ordination levels (e.g. those associated with tactical releases) without the need to interact with the EFS, a possible limitation to the feasibility of the Single Person Operations concept (though the Planner and Tactical will still be able to change co-ordination levels in the usual way through the NERC Planner Tools). The users were able to move between standard Tactical input mode and co-ordination function mode by

checking/un-checking a 'COORD' checkbox on the Tactical Instruction Palette, the HMI indicating the mode change to the user.

Planning and tactical trajectories, which would otherwise be based upon the expected (cleared) route of the flight at a sector not yet controlling that flight (i.e. a downstream sector), are modified to take into account the constraints entered in the entry co-ordination, e.g. to follow a radar heading. In this way, both the predicted tactical and planning situation better reflects what will actually happen and the output of MTCD is improved. An extension of flight-path monitoring is applied to these tactical constraints to alert the offering sector Planner should the constraint not be issued as a clearance by the Tactical in a timely manner and, at the receiving sector, the controllers are alerted should the situation involving the flight with the tactical constraint applied deteriorates then the Tactical and Planner controllers are alerted.

2.1.8.6 Integrated Coordination (Auto-Accept Conflict Detection Highlight)

As mentioned in the summary of the outcome of the iMSP2 exercise, the Integrated Co-ordination functionality caused some degradation in the Planner's understanding of the traffic situation, primarily as they were unaware when safe, but operationally non-ideal, entry boundary co-ordinations were automatically agreed by the system. In this exercise, the IC functionality was modified so that, instead of automatically accepting any flights, it simply performed an MTCD check (effectively a background Look-See) on offers that fall into the current auto-accept set (standing agreements and OLDI transfers) at the time they were accepted into the sector. Those which were found to have a planning interaction were identified to the Planner by highlighting the entry flight level field on the EFS as shown below (the flights with a purple NFL have been found to be in Planner conflict by the IC MTCD check). The Planner could then decide whether or not those flights should have their entry co-ordination reviewed and, if necessary, revised.

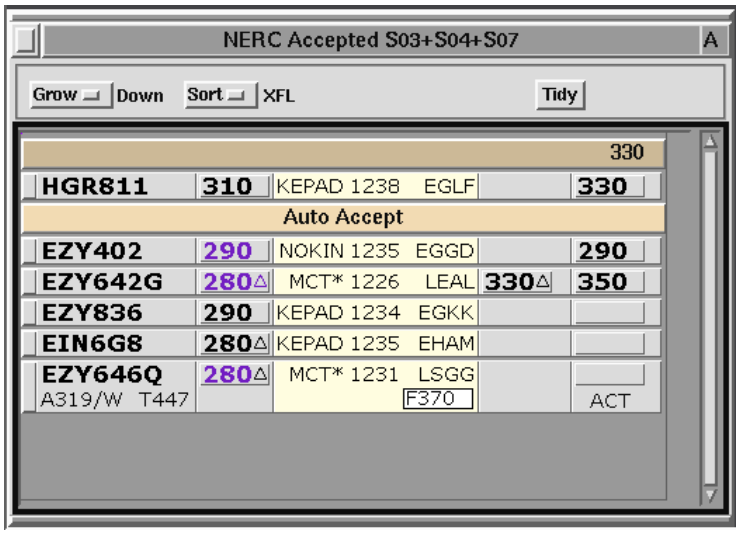


Figure 14 Example of IC 'Auto-Accept Conflict Detection' highlight

Only in the Single Person Operations mode (i.e. a single controller operating as a combined Tactical and Planner) was the original IC function enabled (accepting flights into the sector if no planning interaction was detected when the offer was received) on the basis that the traffic picture built by the SPO was a tactical one and any co-ordinations that were safe but undesirable (e.g. an inbound above an overflight) could be detected and resolved as part of the tactical assimilation of the traffic. In both scenarios, IC remains a single-shot assessment and is not intended to monitor whether the planning (co-ordination) situation has deteriorated; that task remaining the responsibility of the Planner (or the SPO).

2.2 Summary of Validation Exercise/s

2.2.1 Summary of Expected Exercise/s outcomes

Stakeholder/ Customer/ Other SESAR Project	External/ Internal to the Project	Involvement	Performance expectations	Validation objectives
ANSP	Internal	NATS, DSNA, AENA contribute directly to the project.	Obtain assurances that the Controller Team Organisation concepts and associated tools (e.g. for MSP) will benefit ATM operations and align with their developmental strategies at a national level / regional basis.	Develop consistent and coherent MSP concepts that are applicable to the different ATC En Route environments. Demonstrate benefits to ATM operations in terms of capacity, cost-effectiveness, efficiency and safety. Demonstrate that potential limitations are identified and mitigation means proposed.
ANSP	External to the projects (Internal to SESAR Programme)	DFS have requested a 'reviewer' role which has been agreed by all partners.	Obtain assurances that the Controller Team Organisation concepts and associated tools (e.g. for MSP) will benefit ATM operations and align with their developmental strategies at a national level / regional basis.	Gain confidence that the concepts and tools will also be fit-for-purpose for the A6 ANSPs not directly involved in the project.
Ground Industry	External to the projects (Internal to SESAR Programme)		Ensure that ATM systems are developed in support of the MSP related concepts. Specifically provide the link with P10.4.1 to ensure that the conversion of operational requirements to system requirements is complete and correct.	Develop a consistent and coherent concept description enabling the development of system specifications. Ensure consistency between operational and system requirements description. Ensure complete and correct requirements capture.
Military	External		Ensure that military aviation 'buys in' to the new concepts and are able to influence developments to ensure their needs (efficiency, mission	Ensure military aviation needs are correctly captured.

			effectiveness and flexibility) are met	
SESAR JU	Internal		Ensure that P4.7.8 is contributing to overall SESAR objectives. Ensure that P4.7.8 is adhering to the processes as outlined in the SEMP.	Develop consistent and coherent MSP concepts that are applicable to the different ATC En Route environments and are consistent with the overarching SESAR concepts. Demonstrate benefits to ATM operations in terms of capacity, cost-effectiveness, efficiency and safety. Demonstrate that potential limitations are identified and mitigation means proposed.
sWP4.2/5.2	External to the projects (Internal to SESAR Programme)		Ensure that output from the project is consistent with the overarching En Route Concept.	Develop consistent and coherent MSP concepts that are applicable to the different ATC En Route environments and are consistent with the overarching SESAR concepts. Demonstrate benefits to ATM operations in terms of capacity, cost-effectiveness, efficiency and safety. Demonstrate that potential limitations are identified and mitigation means proposed.
All projects in sWP 4.7/5.7	External to the projects (Internal to SESAR Programme)		Ensure that output from the project is consistent with the overarching En Route Trajectory and Separation Management Concept.	Develop consistent and coherent MSP concepts that are applicable to the different ATC En Route environments and are consistent with the overarching SESAR concepts. Demonstrate benefits to ATM operations in terms of capacity, cost-effectiveness, efficiency and safety. Demonstrate that potential limitations are identified and mitigation

				means proposed.

Figure 15 Stakeholders Performance Expectations

2.2.2 Benefit mechanisms investigated

The benefit mechanisms investigated are presented in the following diagram.

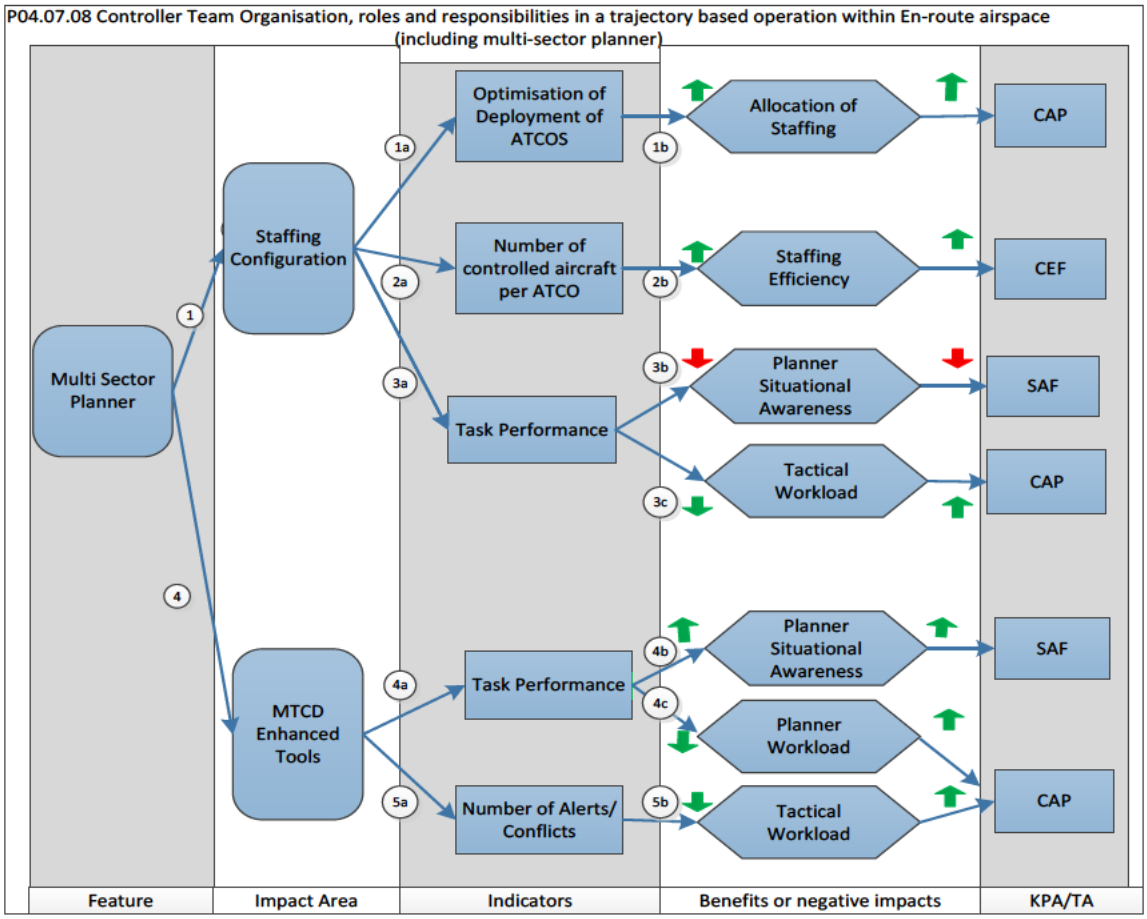


Figure 16 Benefit Mechanism

Feature Description: Multi Sector Planner

(1) The staffing configuration options will expand. For operations between bandboxed (1P-1T) and split (2(1P-1T)), the option of 1P-2T will be available.

(1a) More staffing options resulting in a more flexible usage of the controller workforce,

(1b) Since staffing configurations are not restricted to 1P-1T, this enables an increase in capacity through the application of 1P-2T when otherwise the sector would need to be split. Further, controllers on a watch freed up by being able to run MSP on an ad-hoc basis could be used to open up more sectors, which links to Capacity (related KPI – 73% increase by 2020; 3-fold increase in the longer term).

(2a) There is an opportunity to attain the same number of controlled aircraft in a 1P-2T configuration as a split 2(1P-1T) configuration.

(2b) This will make more efficient use of resources and potentially reduce the number of controllers required per watch, which links to Cost Efficiency (contributing to the SESAR KPI of reducing the Gate-to-Gate costs by 50% per flight).

(3a) Having a shared Planner could impact on Task Performance (workload, situational awareness, user acceptance)

(3b) A single controller monitoring R/T could reduce Planner situational awareness. Reduced situational awareness, if below an acceptable level, would have a negative impact on Safety KPA.

(3c) There is also a potential need to issue fewer clearances because of the more direct routes and fewer level caps, thereby reducing Tactical controller workload, which links to Capacity KPA. This could also provide a corresponding benefit on the cockpit side as a result of having to respond to fewer ATC instructions.

(4) Enhanced tools have been developed to support the MSP which includes MTCD-Enhanced Look-see/What-If which highlights flights only of coordination interest to the Planner, a tactical clearance probe when a Look-See/What-If is invoked, and Planner Context traffic highlighted to show Tactical workload.

(4a) The enhanced Planner tools aim to have a positive impact on Task Performance (workload, situational awareness, user acceptance)

(4b) The Interaction Vectors and Planner context may provide the Planner with an increased level of situational awareness (SA is at least maintained at increasing traffic levels), and IC checking of OLDI and SA flights for conflicts which might otherwise be overlooked by the Planner; links to the Safety KPA.

(4c) By only highlighting flights that are of coordination interest when the Planner controller conducts a Look-See/What-If, planning aircraft in/out of the sector can potentially be made quicker, thereby reducing Planner workload, which links to the Capacity KPA.

(5a) Potential conflicts may be identified and resolved earlier.

(5b) Solving conflicts earlier may result in a reduction in Tactical workload; links to the Capacity KPA.

Impacted Stakeholders: SESAR JU, SWP4.2/5.2, All projects in sWP 4.7/5.7, ANSPs, Ground Industry, Military.

Data Sources: Bedford/ISA Workload, CARS User Acceptance, China Lakes Situational Awareness, Data Logs (e.g. LOS, Offer and Accept), Observations, Questionnaires, Debriefs.

2.2.3 Summary of Validation Objectives and success criteria

SWP4.2 has been tasked to be the Coordinating Federating Project. The 4.2 Validation Strategy [8] states that the purpose of the V2 and V3 Validation Exercises is to assess the feasibility, the benefits and the limitations anticipated from different Controller Team Organisations in an **En Route context.**

In summary, the objectives need to address the following areas:

- To establish the feasibility of the iMSP (1P-2T) concept, including whether the implementation of the tools support is acceptable, identification of how the tools provided are being used and the impact of the team structure and tools support on tactical and planner controller roles and responsibilities.
- To identify the operational benefits (outside of more efficient and flexibility in sector manning) that may be associated with the deployment of the iMSP concept of operations into area control on the LACC NERC-iFACTS platform.
- To gain an understanding of the supporting and limiting factors of the operating environment that may be associated with the viability of the iMSP concept.
- To investigate the feasibility of the SPO concept, identifying how the provided tools are being used and any areas and tasks requiring improved tools support.

The following validation objectives are taken from the 4.2 Validation Strategy [8].

Identifier	OBJ-04.02-VALS-0001.0141
Objective	To validate the feasibility of sector team operations with MSP positions in Step 1, when one super planner replaces planners from some CWP (where the Executive Controller is left alone) for contiguous sectors in En Route context.

Identifier	Success Criterion
CRT-04.02-VALS-0001.0141	The migration of some Planners CWP into one Super Planner CWP and vice-versa is technically feasible: No suspension of ATC service Smooth transfer and transition No degradation of the ATC service
CRT-04.02-VALS-0001.1141	A Super-Planner is able to face across several contiguous sectors with low and medium traffic densities for achieving the planner roles and responsibilities for medium term, planning and coordination tasks: • to check, about 15 minutes before the flight is entering, the planned trajectory of aircraft intending to enter his control area for potential separation risk, • to co-ordinate entry/exit conditions leading to conflict-free trajectories • to give assistance to the respective Executive Controllers for tactical flight control accordingly.
CRT-04.02-VALS-0001.2141	The Executive Controllers don't feel either degradation or a loss of confidence regarding the working together with a Super Planner, in the context of low and medium traffic densities.
CRT-04.02-VALS-0001.3141	The handover when switching from several planners to one Super-Planner or from one Super Planner to several Planners is operationally possible and smooth enough, in the context of low and medium traffic densities.

Identifier	OBJ-04.02-VALS-0001.0142
Objective	To validate/assess the performances and benefits of sector team operations with MSP positions in Step 1, when one Super Planner replace planners from some CWP (where the Executive Controller is left alone) for contiguous sectors in En Route context. To demonstrate in particular sector team operations with MSP positions contribute at OFA level to the increase in airspace capacity by at least 0.16% compared to IP1 baseline.

Identifier	Success Criterion
CRT-04.02-VALS-0001.0142	Planning and Tactical controllers subscribe to the ability to switch to a Super Planner configuration in the context of low and medium traffic densities.

CRT-04.02-VALS-0001.1142	A MSP configuration based on a Super Planner contributes significantly to the reduction of the controller workload for the Planning Controller and the Executive Controller, in the context of low and medium traffic densities.
CRT-04.02-VALS-0001.2142	A MSP configuration based on a Super Planner shows a better usage of ATCOs work force, a better distribution of workload among ATCOs' team, in the context of low and medium traffic densities.
CRT-04.02-VALS-0001.3142	A MSP configuration based on a Super Planner facilitates significantly harmonized controller actions, in the context of low and medium traffic densities.
CRT-04.02-VALS-0001.4142	A MSP configuration based on a Super Planner improves the identification and resolution of potential conflicts within the medium-term time horizon, thus minimizes significantly the need for tactical intervention, in the context of low and medium traffic densities.
CRT-04.02-VALS-0001.5142	A MSP configuration based on a Super Planner benefits Cost Effectiveness KPA as it shows the ability to resource to demand in the context of low and medium traffic densities.
CRT-04.02-VALS-0001.6142	A MSP configuration based on a Super Planner benefits Capacity KPA as it shows the ability to cope with an increased air traffic demand compared with the low and medium traffic densities of reference. Benefits are proven superior to limitations both in quantity and in impact (assessed performances at least as good as performance targets) and aligned with the validation targets defined above.
CRT-04.02-VALS-0001.7142	A MSP configuration based on a Super Planner benefits Safety KPA as it shows the capability to reduce the occurrence of air traffic accidents in the context of low and medium traffic densities.
CRT-04.02-VALS-0001.8142	A MSP configuration based on a Super Planner benefits Predictability and Efficiency KPA by contributing to a better adherence to arrival schedules in the context of low and medium traffic densities.

Table 2: Validation Objective layout

The objectives from the 4.2 Validation Strategy [8] will be addressed by the following low level objectives:

[OBJ]

Identifier	OBJ-04.07.08-VALP-0304.0001
Objective	To assess the operational acceptability of the MSP concept under assessment in appropriate traffic conditions

[OBJ Trace]

		REQ-04.07.08-OSED-0001.1001	
		REQ-04.07.08-OSED-0001.1002	
		REQ-04.07.08-OSED-0001.1003	
		REQ-04.07.08-OSED-0001.1004	
		REQ-04.07.08-OSED-0001.1005	
		REQ-04.07.08-OSED-0001.1006	
		REQ-04.07.08-OSED-0001.1007	
		REQ-04.07.08-OSED-0001.0008	
		REQ-04.07.08-OSED-0001.0009	
		REQ-04.07.08-OSED-0001.0010	
		REQ-04.07.08-OSED-0001.0011	
		REQ-04.07.08-OSED-0001.0012	
		OFA03.03.04	

[OBJ Suc]

Identifier	Success Criterion
CRT-04.07.08-VALP-0304.1001	Multi-Sector Planner working principles are acceptable to ATCO participants in appropriate traffic conditions.
CRT-04.07.08-VALP-0304.2001	The support tools for the MSP are acceptable to ATCO participants in appropriate traffic conditions.

CRT-04.07.08-VALP-0304.3001	The MSP concept and associated tools are compatible with existing tools
CRT-04.07.08-VALP-0304.4001	Any change to controllers' roles and responsibilities is acceptable

[OBJ]

Identifier	OBJ-04.07.08-VALP-0304.0002
Objective	To assess the impact of the MSP concept under assessment on Human Performance, in appropriate traffic conditions

[OBJ Trace]

		REQ-04.07.08-OSED-0001.1001	
		REQ-04.07.08-OSED-0001.1002	
		REQ-04.07.08-OSED-0001.1003	
		REQ-04.07.08-OSED-0001.1004	
		REQ-04.07.08-OSED-0001.1005	
		REQ-04.07.08-OSED-0001.1006	
		REQ-04.07.08-OSED-0001.1007	
		REQ-04.07.08-OSED-0001.0008	
		REQ-04.07.08-OSED-0001.0009	
		REQ-04.07.08-OSED-0001.0010	
		REQ-04.07.08-OSED-0001.0011	
		REQ-04.07.08-OSED-0001.0012	
		OFA03.03.04	

[OBJ Suc]

Identifier	Success Criterion
CRT-04.07.08-VALP-0304.1002	The situational awareness of the MSP and associated Tacticals is acceptable (in appropriate traffic conditions).
CRT-04.07.08-VALP-0304.2002	Workload for both the Tactical and Planner controllers is maintained within an appropriately acceptable level under the Multi-Sector Planner Concept for the same traffic levels requiring split operations.

[OBJ]

Identifier	OBJ-04.07.08-VALP-0304.0003
Objective	To assess the impact of the MSP concept under assessment on level of safety in appropriate traffic conditions

[OBJ Trace]

		REQ-04.07.08-OSED-0001.1001	
		REQ-04.07.08-OSED-0001.1002	
		REQ-04.07.08-OSED-0001.1003	
		REQ-04.07.08-OSED-0001.1004	
		REQ-04.07.08-OSED-0001.1005	
		REQ-04.07.08-OSED-0001.1006	
		REQ-04.07.08-OSED-0001.1007	
		REQ-04.07.08-OSED-0001.0008	
		REQ-04.07.08-OSED-0001.0009	
		REQ-04.07.08-OSED-0001.0010	
		REQ-04.07.08-OSED-0001.0011	
		REQ-04.07.08-OSED-0001.0012	
		OFA03.03.04	

[OBJ Suc]

Identifier	Success Criterion
CRT-04.07.08-VALP-0304.1003	The Multi-Sector Planner concept has no negative impact on the controllers' perceived level of safety (in appropriate traffic conditions).
CRT-04.07.08-VALP-0304.2003	Multi-Sector Planner concept has no negative impact on the actual level of safety (in appropriate traffic conditions).

[OBJ]

Identifier	OBJ-04.07.08-VALP-0304.0004
Objective	To assess the operational acceptability of the enhanced Planner tools.

[OBJ Trace]

		OFA03.03.04	

[OBJ Suc]

Identifier	Success Criterion
CRT-04.07.08-VALP-0304.1004	The enhanced Planner tools are acceptable to ATCO participants.
CRT-04.07.08-VALP-0304.2004	The enhanced Planner tools are compatible with existing tools

[OBJ]

Identifier	OBJ-04.07.08-VALP-0304.0005
Objective	To assess the impact of the enhanced Planner tools on Human Performance

[OBJ Trace]

		OFA03.03.04	

[OBJ Suc]

Identifier	Success Criterion
CRT-04.07.08-VALP-0304.1005	The situational awareness of the Planner and associated Tacticals is acceptable
CRT-04.07.08-VALP-0304.2005	The enhanced Planner tools reduce Planner workload.
CRT-04.07.08-VALP-0304.3005	The enhanced Planner tools improve Planner task performance.

[OBJ]

Identifier	OBJ-04.07.08-VALP-0304.0006
Objective	To assess the impact of the enhanced Planner tools on level of safety in appropriate traffic conditions

[OBJ Trace]

		OFA03.03.04	

[OBJ Suc]

Identifier	Success Criterion
CRT-04.07.08-VALP-0304.1006	The enhanced Planner tools have no negative impact on the controllers' perceived level of safety
CRT-04.07.08-VALP-0304.2006	The enhanced Planner tools have no negative impact on the actual level of safety.

The following additional objectives will be assessed at an appropriate V2 level:

[OBJ]

Identifier	OBJ-04.07.08-VALP-0304.0007
Objective	To assess the operational acceptability of the SPO concept under assessment.

[OBJ Trace]

		OFA03.03.04	

[OBJ Suc]

Identifier	Success Criterion

CRT-04.07.08-VALP-0304.1007	SPO working principles are acceptable to ATCO participants.
CRT-04.07.08-VALP-0304.2007	The support tools for the SPO are acceptable to ATCO participants

[OBJ]

Identifier	OBJ-04.07.08-VALP-0304.0008
Objective	To assess the impact of the SPO concept on Human Performance (in appropriate traffic conditions)

[OBJ Trace]

		OFA03.03.04	

[OBJ Suc]

Identifier	Success Criterion
CRT-04.07.08-VALP-0304.1008	Workload for the SPO is maintained within an appropriately acceptable level.
CRT-04.07.08-VALP-0304.2008	In appropriate traffic conditions the task performance of the SPO is acceptable
CRT-04.07.08-VALP-0304.3008	In appropriate traffic conditions the situational awareness of the SPO is acceptable.

[OBJ]

Identifier	OBJ-04.07.08-VALP-0304.0009
Objective	To assess the impact of the SPO concept on level of safety in appropriate traffic conditions

[OBJ Trace]

		OFA03.03.04	

[OBJ Suc]

Identifier	Success Criterion
CRT-04.07.08-VALP-0304.1009	SPO Concept has no negative impact on the controllers' perceived level of safety.
CRT-04.07.08-VALP-0304.2009	SPO has no negative impact on the level of safety.

2.2.3.1 Choice of metrics and indicators

The following are the expected validation outcomes as detailed in the 04.02 Validation Strategy [8]:

- Sensitivity analysis/trade-off (working methods, work sharing, workload);
- Operational feasibility and acceptability from controllers;
- Technical feasibility (e.g. R/T, data-link, ACC configuration & CWP flexibility);
- Performance assessment (prove benefits) in terms of capacity (reduced workload for controllers, better usage of ATCOs work force, better distribution of workload among ATCOs' teams, and more harmonized controller actions) and safety (harmonized controller actions, better work sharing minimizing the need for tactical intervention, reduced workload).

A mixture of subjective and objective metrics/indicators was used to assess the objectives, as detailed below.

Quantitative Data	
Human Performance Metrics	Human Performance metrics, namely the Bedford Workload Rating scale, China Lakes Situational Awareness scale and CARS User Acceptance

	scale, will be distributed to the controllers at the end of each run. These give the controllers a 10 point scale to rate their performance in different areas. (see Appendix B for descriptions of these metrics)
Instantaneous Self Assessment (ISA)	ISA 'panels' will be provided at all measured positions so that an indication of the controllers' perceived workload can be obtained at 2-minute intervals. A real-time display of the ISA responses will be available in the simulator room. (see Appendix B for a descriptions of ISA scores)
Data Recording	Standard scientific recordings (R/T, phones, pseudo pilot inputs and track histories) will be made for each measured position. All interactions with the HMI during any simulation run will be recorded and resulting iMSP tools information (including Integrated Coordination, Look-See/What-If highlights etc).
RT Utilisation	Details of R/T use is logged and processed to give the number of calls and percentage of time each controller spends using R/T (transmitting and receiving). Data is recorded for each two minute time-slice throughout a run.
Loss of Separation Analysis	Details of all losses of separation, involving at least one measured sector, can be presented in tabular form. The separation standards applied will be 5nm/1000'. Further in-depth conflict analysis will be carried out, where appropriate.
Safety Observations	Participants will be asked to raise a Safety Observation if they identify any safety issue or concern during the simulation which they feel could impact upon the safety of the proposed operation within NATS or with any adjacent agency affected by the proposed changes. Any observations made will be forwarded to the customer who will be responsible for responding to any observations raised. The information will be used to supplement data collected during debriefs.
ACP Interventions	Data will be collected and analysed relating to all pseudo pilot 'intervention' messages i.e. all inputs that will alter an aircraft's flight profile in terms of speed, level and heading.
Aircraft on Frequency	The traffic loading for each measured sector, will be reported in both tabular and graphic format. The information provided will include the following information: • Initial number on frequency • Number of aircraft joining frequency • Number of aircraft leaving frequency • Residual number on frequency at end of period • Average number on frequency • Peak number on frequency • Number of aircraft joining per hour • Number of aircraft handled per hour • Number of aircraft handled for each 15 minute period • Graphical display of number on frequency against time

Qualitative Data	
Observations	Observation of the participants will be conducted throughout the simulation. Particular areas relating to the questionnaires, or any other areas identified through debriefs will be focused on.
Questionnaires	A questionnaire will be issued at the end of the exercise. It will be used to record the opinions and feelings of participants with respect to the impact of the concept. The answers to questions will be analysed to assess information provided relevant to the objectives. Answers to questions will be summarised to give a consensus opinion.
Debriefs	One to one debriefs will take place at the end of each run between participant and observer, to elicit information to supplement the observations and to record the opinions and feelings of participants with respect to the impact of the concept during the preceding run. The answers to questions will be analysed to assess information provided relevant to the objectives. The questions posed to the controllers may evolve over the course of the exercise to take advantage of the controllers' increasing knowledge of the concept and tools. Towards the end of the exercise the controllers will be asked more conceptual questions and there will be more questions designed to assess the performance of the concept. Group debriefs will also be scheduled into the simulation timetable and will be used to clarify and supplement the questionnaire responses. There may also be debriefs on an ad hoc basis if required. The information collected will support the relevant objectives.

KPA	Quantitative Metric/Indicators	Qualitative Metric/Indicators
Human Performance	Workload, Situational Awareness, User Acceptance	Questionnaires Observations Debriefs
	Aircraft on Frequency	
Safety	Loss of Separation Analysis	Questionnaires, Observations

2.2.4 Summary of Validation Scenarios

The Validation scenarios as specified by the 04.02 Validation Strategy [8] are detailed below.

Identifier	SCN-04.02-VALS-0001.0141
Scenario	En Route ATSU equipped with a MSP position acting as a super planner on contiguous sectors, giving priority to proving the feasibility of the concept, in the context of low and medium traffic densities. (Step 1 / Phase V2).
Variants	Low traffic density, medium traffic density Traffic with free routing flights Two and more contiguous sectors MSP position activation / de-activation MSP position grouping / de-grouping

Relationship	Linked Element Type	Identifier	Compliance
<JUSTIFIES>	<V&V Objective>	OBJ-04.02-VALS-0001.0141	N/A
<DERIVES FROM>	<Architecture element>	TBD	N/A
<ASSOCIATED TO>	<ATM Phase>	En Route / Execution	N/A

Identifier	SCN-04.02-VALS-0001.0142
Scenario	En Route ATSU equipped with a MSP position acting as a super planner on contiguous sectors, giving priority to proving the performances of the concept, in the context of low and medium traffic densities. (Step 1 / Phase V3).
Variants	Low traffic density, medium traffic density Traffic with free routing flights Two and more contiguous sectors MSP position activation / de-activation MSP position grouping / de-grouping

		OBJ-04.02-VALS-0001.0142	

The following specific scenarios were thus developed to address the objectives detailed 2.2.3 in addition to performing a preliminary consideration of Single Person Operations.

Identifier	Description
SCN-04.07.08-VALP-003-0010	1P-2T with enhanced Planner toolset
SCN-04.07.08-VALP-003-0020	1P-1T (Bandboxed) with enhanced Planner toolset
SCN-04.07.08-VALP-003-0030	1P-1T (Bandboxed) with NERC-iFACTS toolset (baseline Planner tools)
SCN-04.07.08-VALP-003-0040	1P-1T (Split) with enhanced Planner toolset
SCN-04.07.08-VALP-003-0050	1P-1T (Split) with NERC-iFACTS toolset (baseline Planner tools)
SCN-04.07.08-VALP-003-0060	SPO with enhanced Planner toolset and Integrated Coordination
SCN-04.07.08-VALP-003-0070	SPO with NERC-iFACTS toolset (baseline Planner tools)

2.2.5 Summary of Assumptions

2.2.5.1 Exercise Assumptions

The following assumptions were identified:

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
ASS-04.07.08-VP304 – 01	Sector Valid Participants	Human Performance	It was assumed that ATCOs were valid on the sectors they were staffing	Required for accurate assessment	En Route	Human Performance	Expert Opinion	N/A	Primary Project	High
ASS-04.07.08-VP304 – 02	Feed sector operator familiarity	Human Performance	It was assumed that Feed sector operators would be familiar with operational interface of feed sector operations.	Required to provide realism	En Route	Human Performance	Expert Opinion	N/A	Primary Project	Medium
ASS-04.07.08-VP304 - 03	Adjacent Sector Scenarios	Human Performance	It was assumed that the scenarios exercised in adjacent sectors would not impact the measurements	Required for accurate assessment	En Route	Human Performance	Expert Opinion	N/A	Primary Project	

Additionally, the following assumptions are taken from the 04.02 Validation Strategy [8].

Validation Assumption Code	Validation Assumption Description	Sources
ASM-04.02-VALS-0001.0701	The ATC Procedures related to Multi Sector Planning have been deployed, involving protocol for coordinating through several sectors, use of sector tools, and providing suggested trajectory changes (to eliminate conflicts and complexity) to the appropriate sector Executive Controller.	PRO-046a
ASM-04.02-VALS-0001.0702	The mandatory ground-ground automated coordination processes are implemented (electronic coordination capabilities are a prerequisite to further automation of controllers' tasks).	ESSIP ITY-COTR
ASM-04.02-VALS-0001.0703	The use of MTCD and conformance monitoring functions and associated operational procedures is approved.	ESSIP-ATC12
ASM-04.02-VALS-0001.0705	Mode S elementary surveillance is implemented in specified airspace	ESSIP SUR02

Table 3: Validation Assumptions

2.2.6 Choice of methods and techniques

Supported Metric / Indicator	Platform / Tool	Method or Technique
Task Performance	ACE (see 3.1.3)	RTS
Safety	ACE (see 3.1.3)	RTS

Table 4: Methods and Techniques

2.2.7 Validation Exercises List and dependencies

Validation activity EXE-04.07.08-VP-157 is a predecessor of this exercise; EXE-04.07.08-VP-587 and EXE-04.07.02-VP-172 are dependencies.

3 Conduct of Validation Exercise

3.1 Exercises Preparation

3.1.1 Experimental Design

The assessment is expected to confirm that, at appropriate traffic levels, the workload of a single Planner is acceptable even though that of the associated Tactical requires a split. A pair-wise comparison will be made of the Multi-Sector Planner staffing configuration (1P-2T) against that of a single Planner staffing configuration (1P-1T) of both a 'bandboxed' sector (in this case when the entire sector group is staffed by a Planner and Tactical team) and a 'split' sector (where each sector within a sector group is staffed by a Planner and Tactical). The aim is to;

i) examine periods where the '**bandboxed'** sector was considered sufficiently busy for the Tacticals to split,

ii) examine periods where the two Tacticals of a '**split'** sector reported that the split was appropriate from a tactical perspective, yet the corresponding Planners were 'under utilised'.

See **(i)** and **(ii)** in Figure 18 for an indication of the traffic levels appropriate to the relative application of the MSP concept.

Alongside workload as a measure of the acceptability of the concept, situational awareness and user acceptance must also fall within acceptable limits. Situational awareness is of particular importance for the MSP concept since it is expected that there will be some change in Planner situational awareness as a result of supporting two Tacticals.

The table below summarises the scenarios used to assess the objectives relating to the MSP concept (OBJ-04.07.08-VALP-0304.0001 to OBJ-04.07.08-VALP-0304.0003). The scenarios compared to assess items (i) and (ii) above are indicated.

(i)

Baseline Scenario	Solution Scenario #1	Baseline Scenario
SCN-04.07.08-VALP-003-0030	SCN-04.07.08-VALP-003-0010	SCN-04.07.08-VALP-003-0050
Bandboxed Sector	Multi-Sector	**Split** Sector
1P-1T (2 ATCOs)	**1P-2T** (3 ATCOs)	**1P-1T** (4 ATCOs)
NERC Planner tools*	**Enhanced** Planner tools	**NERC** Planner tools*

(*operational baseline)

(ii)

Further, to examine the impact of the MTCD-enhancements to the iFACTS tools independent of the 1P-2T staffing configuration (OBJ-04.07.08-VALP-0304.0004 to OBJ-04.07.08-VALP-0304.0006), the baseline runs from comparison (i) and (ii) above were also run with the enhanced Planner tools (using the same staffing configuration of 1P-1T). This is summarised in the table below.

Baseline Scenario (as above)	Solution Scenario #2
SCN-04.07.08-VALP-003-0030 SCN-04.07.08-VALP-003-0050	SCN-04.07.08-VALP-003-0020 SCN-04.07.08-VALP-003-0040
Bandboxed and Split	Bandboxed and Split

1P-1T	1P-1T
NERC Planner tools	**Enhanced** Planner tools

Any differences observed in the workload, situational awareness and user acceptance should be a consequence of the toolset. Note however that the traffic samples in this activity were designed to exercise the transition period between bandboxing and splitting, and as such the traffic composition may not aptly challenge the Planner in the 1P-1T configuration.

To investigate the feasibility of a combined Tactical and Planner role (i.e. Single Person Operations) OBJ-04.07.08-VALP-0304.0007 to OBJ-04.07.08-VALP-0304.0009) those runs in the 1P-1T configuration with enhanced Planner tools (Solution Scenario #2 above) were also run in an SPO configuration, as summarised in the table below. Again note that as the traffic samples were designed to examine the Multi-Sector Planner concept, they may be too challenging for the SPO.

Solution Scenario #2 (as above, bandboxed only)	Solution Scenario #3
SCN-04.07.08-VALP-003-0020	SCN-04.07.08-VALP-003-0060
1P-1T	SPO (combined T and P)
Enhanced Planner tools	Enhanced Planner tools incl. **Integrated Coordination**

3.1.2 Airspace and Staffing Configurations

Three sector groups were measured during the simulation, and each was run in either a bandboxed configuration, or 'split' into a maximum of two sectors.

- Lakes (LKS), comprising S3+S7 (Lakes Lower) and S4 (Lakes Upper)
- Daventry (DTY), comprising S27+S32 (Daventry Southbound) and S28+S34 (Daventry Northbound)
- North Sea (NSEA), comprising S10 (North Sea Lower) and S11 (North Sea Upper).

Maps of the three sector groups are given in Appendix C.

When two sectors within a group were combined into a 'multi-sector' they were staffed by one Planner and two Tactical controllers (1P-2T). The sectors not combined into a multi-sector were either staffed by one Planner and one Tactical (i.e. current Ops staffing configuration) in both a bandboxed and split configuration, a combined Planner and Tactical (SPO), or a single feed controller.

During each measured run, different scenarios (as detailed above) were exercised across the three measured sector groups. Each sector group was allocated one of the staffing configurations (1P-1T, 1P-2T or SPO), resulting in a total of eight combinations of sector staffing configurations (see Appendix D). The rationale behind having a relatively large number of different combinations of staffing configurations is to maximise the number of opportunities to expose participants to the iMSP concept (which will be exercised during all but one staffing configuration) whilst maintaining the staffing requirements to a maximum of eight operational controllers.

Further, each combination of staffing configuration was exercised with the NERC Planner tools and with the enhanced Planner tools (with the addition of IC for the SPO), though a different concept could be allocated to each sector group for a run. Thus, a total of 16 different staffing/tools configurations were created (see Appendix E – note that the 'ALT' configurations (e.g. '1 ALT') used the same staffing configuration as the similarly numbered pair (e.g. '1'); though different Planner tools were used).

Eight traffic samples were used during the simulation. Four base samples were modified to create a further four samples, which were slightly more challenging than the base samples although had

similar traffic volume (i.e. the complexity was increased rather than the traffic density). Note that within the simulation environment it can be difficult to replicate those circumstances which the iMSP concept can ideally support; providing a sufficient level of Tactical workload to necessitate two Tacticals, but which could be supported by a single Planner. Further, as many auxiliary tasks were either not simulated (e.g. those due to military traffic), or were only simulated to a minimal level (e.g. phone calls), to compensate, the traffic samples volumes were somewhat increased over current day. However, whilst positive feedback was received on the realism of the traffic samples, there was one sample (2D) where the LKS Tactical subjectively reported that the workload was low enough for the sectors to remain bandboxed.

In order for an appropriate like for like comparison to be drawn between configurations, traffic samples were specific to a 'set' of configurations (e.g. samples 1B and 1D were only exercised on configurations 1, 2, 1 ALT and 2 ALT) as shown in the table below.

Traffic Sample	Staffing/Tools Configurations			
1B, 1D	1	2	1 ALT	2 ALT
2B, 2D	3	4	3 ALT	4 ALT
3B, 3D	5	6	5 ALT	6 ALT
4A, 4B	7	8	7 ALT	8 ALT

Figure 17 Traffic Samples

In developing the experimental design and traffic sample needs, SPO was not considered in the context of the experimental design; rather the SPO concept was exercised where participant staffing levels dictated.

3.1.3 Simulation Environment

This exercise used the London Area Control (LAC) real-time simulator located at NATS' Corporate and Technical Centre, Fareham, UK. The simulator uses the ACE platform which allows high-fidelity simulation of NATS operations with prototype tools. Full data recording including flight data, track histories, comms data, controller instructions and controller interactions with the HMI are available.

Up to eight controller working positions hosted the measured sectors. Although the multi-sector was staffed by three controllers, there were four workstations available. The Tactical controllers either sat next to each other on the middle two workstations, and the Planner sat at an end workstation (but was able to move between either end workstation at will), or the Planner sat between the two Tactical controllers.

Five pseudo pilots supported the measured sectors. Up to ten feed positions simulated the airspace surrounding the measured sectors, with aircraft controlled by the automatic track generator (ATG) functionality (emulating pseudo pilot). As an example, the layout of the simulator for one of the staffing configurations is shown in Appendix F.

3.2 Exercises Execution

Exercise ID	Exercise Title	Actual Exercise execution start date	Actual Exercise execution end date	Actual Exercise start analysis date	Actual Exercise end date
EXE-04.07.08-VP-304	MSP based on sector Coordination	26/02/2012	11/03/2012	14/03/2012	31/09/2012

Table 5: Exercises execution/analysis dates

The validation exercise was conducted during twelve days over the period from 26th February to 11th March 2012. The first two days of the twelve day activity were dedicated to training and familiarisation of the iMSP concept (though one participant was not able to attend) which included briefings and simulation runs. The remaining ten days were assigned to measured runs, including 'delta' runs. 'Delta' runs were scheduled to provide the opportunity to experiment with different parameter settings

and enable additional controller rotations, and although measurements were taken during most of the delta runs, these were not appropriately 'matched' to any other runs.

A total of 43 out of a scheduled 44 runs were executed.

3.3 Deviations from the planned activities

3.3.1 Deviations with respect to the Validation Strategy

It was not possible to switch between staffing configurations during a run and therefore the following objectives from the Validation Strategy [8] which pertain to this could not be addressed during this validation activity:

Identifier	Success Criterion
CRT-04.02-VALS-0001.0141	The migration of some Planners CWP into one super planner CWP and vice-versa is technically feasible: No suspension of ATC service Smooth transfer and transition No degradation of the ATC service
CRT-04.02-VALS-0001.3141	The handover when switching from several planners to one Super Planner or from one Super Planner to several Planners is operationally possible and smooth enough, in the context of low and medium traffic densities.

Further, arrival schedules were not considered, and as such the following objective from the Validation Strategy was not addressed.

CRT-04.02-VALS-0001.8142	A MSP configuration based on a Super Planner benefits Predictability and Efficiency KPA by contributing to a better adherence to arrival schedules in the context of low and medium traffic densities.

3.3.2 Deviations with respect to the Validation Plan

3.3.2.1 Number of Measured Runs

With a maximum of two Multi-Sector Planner positions being simulated during each run, and all eight participants needing to be exposed to the MSP role, each participant completed at most 3 runs in the Multi-Sector Planner position during the two-day training period (although three of the eight participants had previous experience of some aspects of iMSP concept). Software issues during the first couple of days of the activity (through training and into 'measured' runs) also significantly hindered the controllers learning of some aspects of the system.

It became apparent during the activity (day eight) that the participants felt that they were not getting sufficient exposure to either the Multi-Sector Planner role or the enhanced Planner tools in the 1P-1T configuration (due in part to the need to capture baseline data during the activity). Also, feedback during the activity suggested that the Planners for the Daventry sectors were making minimal use of the enhanced Planner tools in a 1P-1T configuration and this exacerbated their feeling that they were not having enough exposure to the tools. Observations made during the later runs supported the view that the participants were still learning the tools. As this would affect their ability to make a subjective assessment, it was considered appropriate to modify the experimental design and run with enhanced Planner tools in all positions, rotating the controllers as necessary, for all remaining runs to increase the participants' exposure to the tools (resulting in a total of twelve 'delta' runs, two of which incorporated a rotation of participants part-way through the run.)

This decision reduced the number of 'measured' runs that contributed to the analysis and hence the amount of quantitative data collected to determine the benefits of the iMSP concept over current day operations. Further, to enable more 'rotation' of the participants, on some measured runs a non-sector valid controller staffed a Tactical position.

Thus, a total of 31 of the 36 planned measured runs were executed. Note that as different scenarios were exercised across the sector groups during a run, data from each run contributed to a more than one objective.

Further, a matched pair of runs may produce multiple matched pairs of data relating to individual sector groups.

To address objectives OBJ-04.07.08-VALP-0304.0001 to OBJ-04.07.08-VALP-0304.0003:

10 matched pairs of runs were executed resulting in:

- 10 matched pairs of data relating to split sectors (i) [1]
- 8 matched pairs of data relating to bandboxed sectors(ii)

To address objectives OBJ-04.07.08-VALP-0304.0004 to OBJ-04.07.08-VALP-0304.0006:

11 matched pairs of runs were executed resulting in:

- 26 matched pairs of data over all sectors

To address objectives OBJ-04.07.08-VALP-0304.0007 to OBJ-04.07.08-VALP-0304.0009:

6 matched pairs of runs were executed resulting in:

- 9 matched pairs of data over all sectors

3.3.2.2 Software

The software build delivery programme continued to deliver improvements to the iMSP system during the first tranche of the simulation activity. These improvements focused on refining the stability of the controller HMI front end and improving the timeliness of probe events executed and displayed by the system. There was one change made to the Dynamic EFS functionality towards the end of the first tranche. This modification reduced the number of events capable of triggering an EFS 'tidy' event. This change was anticipated by the tools team and as such the adjustment was implemented overnight with no subsequent disruption to the validation study.

The context flight functionality did not perform as expected. Upon execution of a Look-See/What-If the display of conflicting flights based on the coordination trajectories was displayed within 1-2 seconds on the situation display (and other associated tools). This was deemed adequate for this validation activity. It was observed that the related context flight set could take up to 25 seconds before being displayed on the situation display (by which time the controller had terminated the Look-See/What-If and as such the context flights, if any, would never be shown). This is expected to have a detrimental effect on the impact, usability and necessity of the context flight display as recorded by the controllers.

The iMSP toolset is built on the NERC emulation. Components such as Force Offer and Track Point-Out do not behave as per the current operational system. With respect to Track Point-Out if any enhanced tools features such as Planner Interaction Point-Out failed to perform as expected (as was the case) the Planner was still unable to point out the interaction to their Tactical as they would do today. On the emulation platform, changes to the flight plan such as changes to the RFL will not derive a new penetration sequence. It was noted that these omissions do have a notable impact on a busy sector Planner (especially the MSP); indeed there were several instances during the validation study where the Planner was distracted for some minutes by these issues and subsequently recorded elevated ISA scores as a result. The internal boundary coordination process between Tacticals in an MSP group demonstrated some stability problems. Once again this resulted in the MSP controller being distracted by an element of the system specifically designed to require minimal attention.

3.3.2.3 Learning Effect

As a result of the limited attainable level of exposure of the participants to the iMSP concept over the duration of the exercise, exacerbated by system bugs, the participants were still learning and

[1] One matched pair was subsequently removed from the analysis due to significant software problems reported during the exercise.

experimenting with the tools and concept towards the end of the exercise; this was recorded in the one-to-one debriefs at the end of the runs.

Further, at the end of each run, the participants were asked for their subjective view on the staffing configuration that would have been appropriate for the traffic within an operational context (i.e. split or bandboxed), and the appropriateness of the staffing configuration that was exercised (to include 1P-2T and SPO). It became apparent that those participants with previous experience to elements of the iMSP concept (as mentioned in 3.3.2.1) were reporting manageable traffic levels for the MSP for the same traffic samples where those without previous experience considered that it was too busy for the MSP.

Appendix G presents an examination of human performance indicators (Bedford Workload and China Lakes Situational Awareness) for traffic samples which were exercised by both a participant with previous experience of the iMSP concept and a participant with no previous experience. This showed that the 'average' and 'peak' workload was rated 'satisfactory' by those participants with previous experience, but was rated 'not satisfactory' for those participants with no previous experience. Analysis also showed that situational awareness was considerably better for those with previous experience, shifting situational awareness into the 'acceptable' region in all but one case.

In summary, the affect of the involvement of three of the participants in previous MSP activities was quite evident. The subjective scores recorded by the other five participants are, in part, reflections of their inexperience. Therefore it should not be concluded that a sector and level of traffic exercised could not be managed by a Multi-Sector Planner, but rather that it could not be managed by an MSP with limited exposure to the role.

Further, Figure 18 presents the CARS user acceptance scores over both the iMSP2 (EXE-172) and iMSP3 (EXE-304) simulations. It can be seen that user acceptance scores in general increase with increased exposure. In fact, all the human performance indicators were rated higher by all participants at end of simulation than at the beginning.

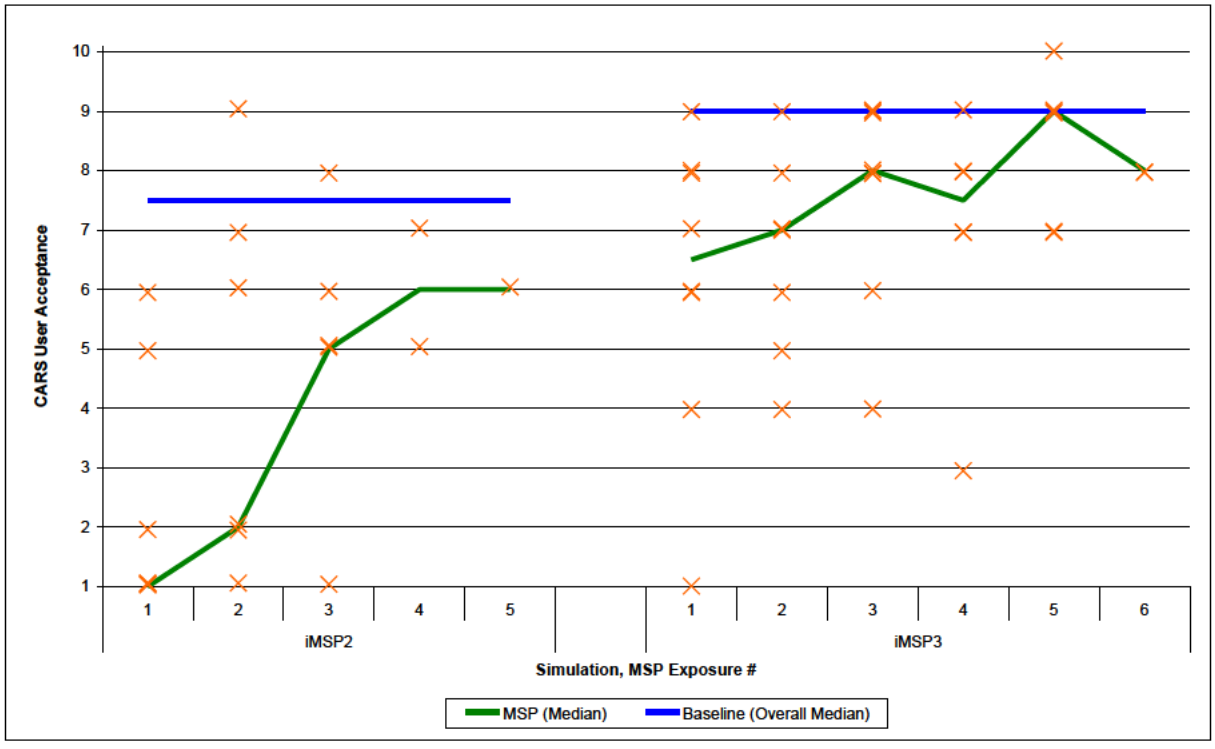


Figure 18 Effect of Exposure to Concept

Hence the familiarity of the participants with the tools, particularly in the early sessions, should be taken into account when assessing the simulation data and the controllers' feedback as the controllers' 'performance' is unlikely to have reached a plateau.

4 Exercises Results

4.1 Summary of Exercises Results

The results of the Validation activity are summarised in the following table. Note that the status of the validation objectives in some cases refers the reader to the associated Recommendation (R1-R6).

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
EXE-04.07.08-VP-304	OBJ-04.07.08-VALP-0304.0004	Acceptability of enhanced Planner tools	CRT-04.07.08-VALP-0304.1004	The enhanced Planner tools are acceptable to ATCO participants.	CARS rated as 'satisfactory' (<=3) on the majority of occasions, and no scores > 5 (moderate objectionable deficiencies) for both the Planner and Tactical. (OK) Questionnaires: Participants rated usefulness of key tools very highly in 1P-1T environment. (OK)	OK
			CRT-04.07.08-VALP-0304.2004	The enhanced Planner tools are compatible with existing tools	Questionnaires/Observations: Only one issue raised regarding confusion over mode of operation for Instruction Palette Coordination Functionality. (OK)	
EXE-04.07.08-VP-304	OBJ-04.07.08-VALP-0304.0005	Human Performance – enhanced Planner tools	CRT-04.07.08-VALP-0304.1005	The situational awareness of the Planner and associated Tacticals is acceptable	China Lakes: SA of Planner and Tactical similar to SA with NERC Planner tools, and in the majority of runs was rated 'acceptable and satisfactory' rated (i.e. <='3'). (OK)	OK
			CRT-04.07.08-VALP-0304.2005	The enhanced Planner tools reduce Planner workload.	Debriefs/Questionnaires: Participants unanimously agreed that the enhanced Planner tools would provide benefits in terms of Planner workload. (OK) The objective metrics also gave an indication of a reduction in Planner workload. (OK)	
			CRT-04.07.08-VALP-0304.3005	The enhanced Planner tools improve Planner task performance.	Debriefs/Questionnaires: enhanced tools supported most participants at least as well and often better than the NERC Planner tools. (OK)	

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
EXE-04.07.08-VP-304	OBJ-04.07.08-VALP-0304.0006	Safety Levels – enhanced Planner tools	CRT-04.07.08-VALP-0304.1006	The enhanced Planner tools have no negative impact on the controllers' perceived level of safety	Questionnaires: No issues highlighted (also China Lakes SA of Planner and Tactical for majority of runs was rated 'acceptable and satisfactory' (i.e. <='3')). (OK)	OK
			CRT-04.07.08-VALP-0304.2006	The enhanced Planner tools have no negative impact on the actual level of safety.	Full safety assessment not undertaken, though no risk bearing losses of separation were recorded. (OK)	
EXE-04.07.08-VP-304	OBJ-04.07.08-VALP-0304.0001	Acceptability of MSP Concept	CRT-04.07.08-VALP-0304.1001	Multi-Sector Planner working principles are acceptable to ATCO participants in appropriate traffic conditions.	CARS: For runs where controllers reported that traffic levels were appropriate to MSP (requiring split operations today), score does not exceed '5' (i.e. moderately objectionable deficiencies). (OK) In same such runs, Tactical scores 'acceptable' (i.e. <=3). (OK) Questionnaire: six of the eight participants (including all with previous experience of iMSP) reported that MSP concept was viable. (OK)	OK
			CRT-04.07.08-VALP-0304.2001	The support tools for the MSP are acceptable to ATCO participants in appropriate traffic conditions.	Questionnaires: Participants rated usefulness of key tools very highly in 1P-2T environment. Further development of Dynamic EFS to improve support for prioritisation of tasks. (OK)	
			CRT-04.07.08-VALP-0304.3001	The MSP concept and associated tools are compatible with existing tools	No issues pertaining to MSP specific tools. (OK) (see CRT-04.07.08-VALP-0304.2004 also)	

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
			CRT-04.07.08-VALP-0304.4001	Any change to controllers' roles and responsibilities is acceptable	Questionnaires/Debriefs: Tacticals raised concern regarding a single controller monitoring R/T. (OK)	
EXE-04.07.08-VP-304	OBJ-04.07.08-VALP-0304.0002	Human Performance - MSP Concept	CRT-04.07.08-VALP-0304.1002	The situational awareness of the MSP and associated Tacticals is acceptable (in appropriate traffic conditions).	China Lakes: For 7 of 8 runs where controllers reported that traffic levels were appropriate to MSP (i.e. requiring split operations today), SA rated 'acceptable and satisfactory' for MSP and Tactical, the exception rating at '4' (acceptable but not satisfactory). (OK) In same such runs, Tactical rated SA 'acceptable' (i.e. <=3) (OK)	OK
			CRT-04.07.08-VALP-0304.2002	Workload for both the Tactical and Planner controllers is maintained within an appropriately acceptable level under the Multi-Sector Planner Concept for the same traffic levels requiring split operations.	For runs where controllers reported that traffic levels were appropriate to MSP (i.e. requiring split operations today): ISA: average workload rated as '3' (i.e. comfortable') (OK) Bedford: average workload rated <=4 (i.e. at worst, 'tolerable'). (OK)	
EXE-04.07.08-VP-304	OBJ-04.07.08-VALP-0304.0003	Safety Levels - MSP Concept	CRT-04.07.08-VALP-0304.1003	The Multi-Sector Planner concept has no negative impact on the controllers' perceived level of safety (in appropriate traffic conditions).	Debrief/Questionnaires: Tacticals raised concern regarding a single controller monitoring R/T. (OK)	OK
			CRT-04.07.08-VALP-0304.2003	Multi-Sector Planner concept has no negative impact on the actual level of safety (in appropriate traffic conditions).	Full safety assessment not undertaken, though no risk bearing losses of separation were recorded. (OK)	

Exercise ID	Validation Objective ID	Validation Objective Title	Success Criterion ID	Success Criterion	Exercise Results	Validation Objective Status
EXE-04.07.08-VP-304	OBJ-04.07.08-VALP-0304.0007	Acceptability of SPO Concept	CRT-04.07.08-VALP-0304.1007	SPO working principles are acceptable to ATCO participants.	CARS: over all runs score did not exceed 5 (i.e. moderately objectionable deficiencies, and often rated <=3, i.e. *'satisfactory without improvement'*. (OK) Questionnaire: majority view that SPO concept was viable. (OK)	OK
			CRT-04.07.08-VALP-0304.2007	The support tools for the SPO are acceptable to ATCO participants	See CRT-04.07.08-VALP-0304.2004 Questionnaires: Participants rated usefulness of key tools very highly in SPO environment. (OK)	
EXE-04.07.08-VP-304	OBJ-04.07.08-VALP-0304.0008	Human Performance – SPO Concept	CRT-04.07.08-VALP-0304.1008	Workload for the SPO is maintained within an appropriately acceptable level.	Traffic levels exercised were in excess of levels anticipated for SPO operations	n/a
			CRT-04.07.08-VALP-0304.2008	In appropriate traffic conditions the task performance of the SPO is acceptable	Traffic levels exercised were in excess of levels anticipated for SPO operations	
			CRT-04.07.08-VALP-0304.3008	In appropriate traffic conditions the situational awareness of the SPO is acceptable.	Traffic levels exercised were in excess of levels anticipated for SPO operations	
EXE-04.07.08-VP-304	OBJ-04.07.08-VALP-0304.0009	Safety Levels - SPO Concept	CRT-04.07.08-VALP-0304.1009	SPO Concept has no negative impact on the controllers' perceived level of safety.	Debrief/Questionnaires: Concern raised regarding a single controller monitoring R/T and lack of immediate support for non-nominal situations (e.g. emergencies). (OK)	OK
			CRT-04.07.08-VALP-0304.2009	SPO has no negative impact on the level of safety.	Full safety assessment not undertaken, though no risk bearing losses of separation were recorded in non-matched exercises. (OK)	

Table 6: Summary of Validation Exercises Results

4.1.1 Results on concept clarification

This exercise addresses a relatively mature concept in terms of the enhanced Planner tools in support of Multi-Sector Planning.

4.1.2 Results per KPA

Human Performance

The participants unanimously agreed that the enhanced Planner tools would provide benefits in terms of Planner workload, and there was an indication of a reduction in workload for objective metrics in the 1P-1T configuration. Workload for both the Tactical and Planner controllers was maintained within an appropriately acceptable level under the Multi-Sector Planner Concept, for which the participants subjectively reported would require split operations today.

Safety

No safety issues were highlighted with regards to the introduction of the enhanced Planner tools, though for 1P-2T and SPO staffing configurations concern was raised regarding a single controller monitoring R/T, and for SPO operations that there was a lack of immediate support for non-nominal situations (e.g. emergencies).

4.1.3 Results impacting regulation and standardisation initiatives

Regulation and standardisation issues were not addressed explicitly in the V3 exercises; however, it is not anticipated that there would be significant impact on these from the introduction of the concept.

4.2 Analysis of Exercises Results

4.2.1 Analysis

The sectors chosen for this simulation, Daventry (DTY), Lakes (LKS) and North Sea (NSEA) have different characteristics and as such data will be presented for each individual sector group where appropriate.

All system data analysis excludes the ‘run-in time’ of 10 minutes and ‘run down time’ of 5 minutes.

Analysis was undertaken using the comparative data from appropriately matched runs. The matched pairs of data are identified by sector group (i.e. DTY, LKS and NSE), and assigned a unique letter to identify separate matched pairs (i.e. DTY (B)).

Three methods of comparative analysis were used:

- Histograms showing the Median values.
- ‘Box and Whisker’ charts showing the Median, Upper and Lower first quartile (25th percentile), and the Maximum and Minimum scores recorded for each measure. The box represents the Upper and Lower first quartiles with the Median shown as a horizontal line inside the box, and the maximum and minimum shown as the ‘whiskers’.
- Wilcoxon Signed Ranks Test for Statistical Significance. Wilcoxon signed-rank statistical testing has been applied to the results of the comparison of the 1P-1T configuration with enhanced Planner tools to that with NERC Planner tools. This testing highlights any significant (5%) differences in groups of matched pairs, and accounts for the size of the difference. Tables for this analysis are not provided within the report; rather statistical significance is reported in the supportive text to the ‘Box and Whisker’ charts to indicate the importance of the results.

The data for one of the matched pairs of runs [NSEA (D)] was excluded from the analysis because significant problems were experienced with the functionality which compromised the run. Data from another matched pair [DTY (E)] was also excluded from any comparative analysis because there was a controller mismatch.

4.2.1.1 Generic Tools Use and Usability

This section provides a general overview of the use and usability of the enhanced tools, and is a precursor to the results discussion for each of the staffing configurations of 1P-2T, 1P-1T and SPO which are individually addressed under the relevant objective (though where appropriate, data may be presented specific to a staffing configuration). Should there be any deviation from the general feedback for a specific role, it will be discussed in the section under the relevant objective.

MTCD-Enhanced Look-See/What-If

During each run with MTCD-enhanced Look-See/What-If functionality, the data logs also recorded those aircraft which would be highlighted by the corresponding NERC Look-See/What-If function. Therefore it is possible to make a direct comparison of the number of flights highlighted by each tool. Note that here the dataset comprises of all measured runs, from all scenarios exercised (see 3.1.1), and also that multi-level coordinations have been excluded from this analysis.

Figure 19 shows the difference between the number of aircraft highlighted by the MTCD-enhanced Look-See and the NERC Look-See for each sector group. The graph shows that the MTCD-enhanced Look-See highlighted fewer aircraft; up to 17 fewer aircraft, demonstrating that the MTCD-enhanced Look-See provides a significant improvement over the NERC Look-See (which is highlighting a high proportion of aircraft that are not of coordination interest to the 'Planner' – i.e. false positives). Significantly, Controllers confirmed that all the necessary 'problems' were detected and indicated to the Planner (i.e. there were no false negatives reported during the activity).

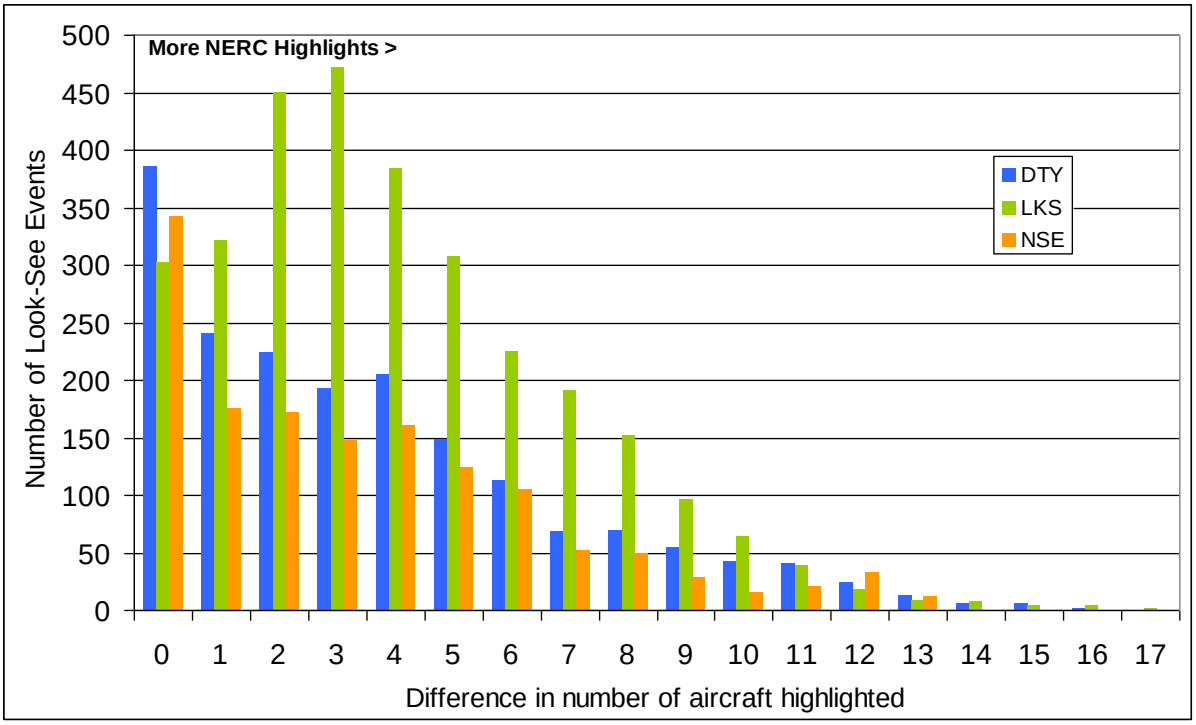


Figure 19 Performance of 'Look-See' tool

Analysis shows that the impact of the MTCD-enhanced Look-See was different between sector groups; DTY and NSEA follow similar distributions, with a peak at '0', whereas for LKS the difference peaks at '3'. This suggests that the MTCD-enhanced Look-See, though usefully highlighting less aircraft than current NERC for all sector groups, had an even greater impact on LKS sector.

Similar to the analysis of Look-See, analysis showed that the MTCD-enhanced What-If highlighted significantly fewer aircraft (a median of 3 less aircraft highlighted for a What-If on an NFL and 4 less aircraft for a what-If on the XFL), demonstrating that the MTCD-enhanced What-If provides a large improvement over the NERC What-If (Appendix H, A.1.1). Despite the significant reduction in aircraft highlighted as being of coordination interest, the participants unanimously agreed that MTCD-enhanced Look-see/What-If did not miss any relevant interactions (i.e. no false negatives were detected).

The controllers were encouraged to manually 'assure' Planner interactions if they thought that a particular interaction was of no interest to them. This functionality was used infrequently by the controllers and they only assured one type of interaction (NFL for a descending flight against an XFL for a climbing flight).

In current NERC, controllers use vector lines (based on linear extrapolation of the current radar ground velocity) to assess whether aircraft highlighted by a Look-See/What-If are likely to pose a genuine problem. These vector lines are automatically invoked as part of the NERC Look-See, and the length (extrapolation time) manually adjusted (as appropriate) to gain a better understanding of the traffic situation. The greater the amount of time spent modifying the vector lines, the greater the increase in workload. When an MTCD-enhanced Look-See/What-If is invoked, Planner Interaction Vectors based on the predicted trajectories and taking account of route and aircraft performance are shown (rather than vector lines) to automatically provide this context, though Planner Interaction Vectors and vector lines can also be manually invoked as required.

Analysis of the amount of time that the Planner makes adjustments to the vector lines (Appendix H, A.1.2) shows that the Planner's with the enhanced tools (i.e. Coordination Interaction Vectors) spend significantly less time using vector lines, contributing to a reduction in workload.

Integrated Coordination Auto-Accept Conflict Detection

Based on feedback from the iMSP2 simulation, the training runs commenced with a planning separation of 15Nm, that is, any interactions between aircraft that were predicted to be less than 15Nm were highlighted to the Planner. However, since the iMSP2 activity iFACTS has undergone operational implementation, and feedback from the participants was that a planning separation of 20Nm would be more appropriate. The reason behind using 20Nm was that the Planner would be alerted to interactions which may lie just outside of iFACTS' detection parameters (the Separation Monitor only displays interactions with a CPA of up to 15Nm). This additional margin should prevent situations where Planning tools had not detected an interaction but later, after the flight has been accepted into the sector, Tactical interactions are detected. The planning separation was changed from 15Nm to 20Nm from the second day of measured runs.

The IC Auto-Accept Conflict Detection was highlighting (in purple) on average 14% of eligible offers (i.e. either Standing Agreement (SA) or OLDI) in LKS, and 4% in NSEA (see Figure 20 for a breakdown of the average number per run of each type of offer accepted). No automatically accepted offers were highlighted in DTY, as DTY does not have an OLDI boundary (Planner interactions between two Standing Agreements were filtered). During the entire simulation only one Standing Agreement was highlighted (a flight from PC East into S10 conflicted with a flight from EHAA which had been given a coordinated climb into S10). All other offers were manually accepted (Man Acc).

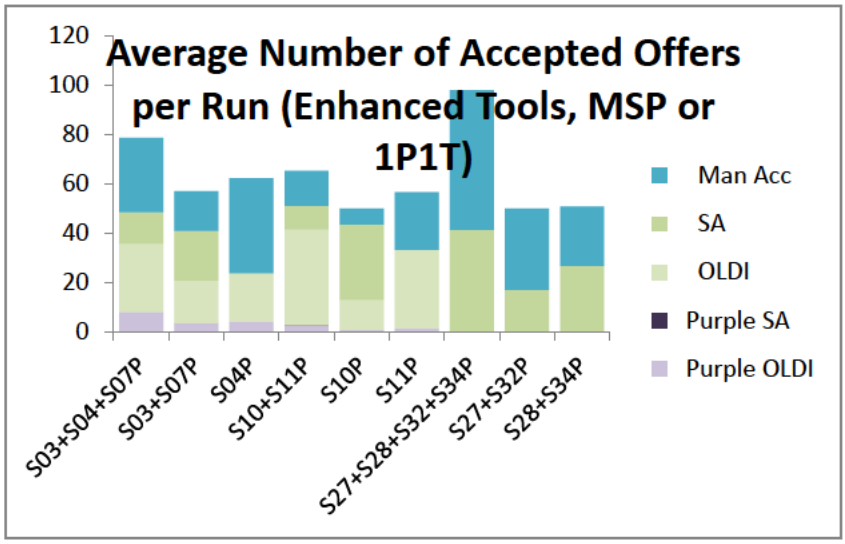


Figure 20 Number of Offers Accepted

When an auto-accepted offer was highlighted, the controllers often hooked the strip (inducing a Look-See) to view the interaction. The Planners could then either act on the highlighted flight, or the

environmental flight (displayed in the Look-See). The Planners responded by revising NFLs, applying Coordination Constraints, sending Planner Interaction Point-Outs and/or 'cocking' the strips.

However the issue was raised that the IC Auto-Accept Conflict Detection highlight only provides a snapshot in time, and is not dynamic in updating as the situation changes. Further, two participants, having found the tool to be useful, reported that it was not 'attention getting' enough.

Dynamic EFS

'Dynamic EFS' functionality was developed to support the MSP with housekeeping of the Accepted Bay. The behaviour of EFS in the Accepted Bay aimed to reduce the number of strips in the bay to enable the Planner to focus on only those EFS requiring attention.

Over all matched pairs and all sectors the median number of EFS in the Accepted Bay drops from 15 to 3 when the Dynamic EFS tool is in use, although this figure varied slightly between sector groups (Figure 21). Appendix H (A.1.3) shows the number of EFS in the Accepted Bay during a snapshot in time for those runs with enhanced Planner tools (and hence Dynamic EFS), and those without. It is clear that the Dynamic EFS tool considerably reduces the number of EFS in the Accepted Bay.

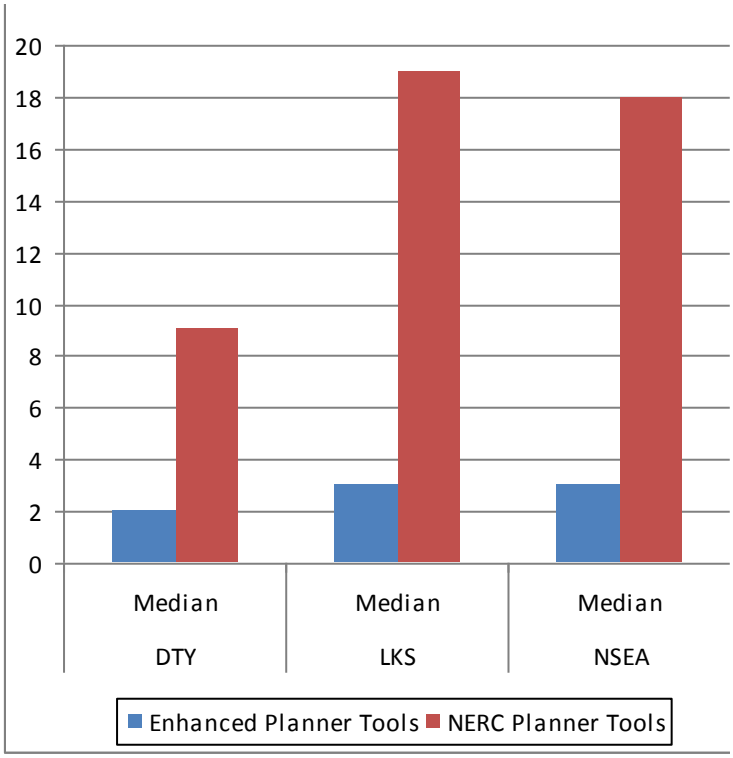


Figure 21 Median Number of EFS in Accepted Bay

However over the first half of the simulation it became evident that the participants found the frequent updating of the Accepted Bay unnerving, particularly when a Planner was undertaking a task (though there were some system bugs in the first few days). The participants suggested that the auto-drop functionality should be executed only on pressing the 'tidy' button. This was implemented on day nine of the simulation and was very well received by the participants, who unanimously agreed in the end of simulation questionnaire that they preferred the strips to auto-drop on 'tidy' rather than automatically during other strip movement. *'Definitely easier with new EFS, tidy, and control is better'*. Further, generally the participants reported that they had the strips that they required at an appropriate time, with the exception of occasions where the exit level of a flight (such as outbounds from Newcastle) was automatically set, the strip could drop before coordination had been agreed,

Analysis showed that (for a limited set of data) following the modification to the Dynamic EFS functionality the number of EFS in the Accepted Bay was comparable to the original build.

In the questionnaire at the end of the simulation, the participants rated the usefulness of the Dynamic EFS functionality particularly highly for the 1P-2T and SPO configurations. For the SPO, Dynamic EFS was the highest rated tool, with a median score of 5 (maximum of 5), and in the 1P-2T

environment it was the second highest rated tool, with a median score of 4.5. *'The auto-drop/auto-recover functionality concept is very good. Any system that that takes away from the Planners mundane tasks and allows more time to be monitoring the frequency and assisting the Tactical in other ways can only be for the good.'* In the 1P-1T environment, the usefulness of the Dynamic EFS scored 3.5. *'Worked well… useful especially where coordination changes required (e.g. Maastricht) after ACT has been sent. No more accessing dead bay to search for a flight saved time'.*

In the debrief at the end of a run without Dynamic EFS, a participant reported that they were conscious that they had spent the majority of their time going through the strips, even forgetting to drop some of them. Another participant similarly reported that subsequently they found it really frustrating in a baseline run that they could not drop more strips because the ACT had not been sent (as per current MOps).

Instruction Palette Coordination Function

The NERC-iFACTS Instruction Palette allowed the user to input coordination constraints (i.e. navigational or speed data) to inform both the planning and tactical trajectories, and provided the Tactical controller (or Planner) with the ability to make changes to the coordination levels (e.g. those associated with tactical releases) without the need to interact with the EFS.

Figure 22 shows the 'usefulness' ratings for the Tactical Instruction Palette Coordination function (where 1 = not at all useful, and 5 = very useful) for both the Planner and Tactical roles/tasks.

Generally the 'COORD' functionality (i.e. the use of the Tactical Instruction Palette to make co-ordination entries) was rated very highly. For the majority of participants, the functionality was equally useful for the Planner as the Tactical, in both the 1P-1T and 1P-2T configuration. *'The COORD functionality is … a very good idea, which will make the Planners plans more dynamic and therefore involve less thinking time for them'*. Another participant reported that being able to enter coordination conditions '*cuts out on unnecessary red interactions* [predicted <5Nm] *in the separation monitor which would have a Tactical returning to assess all the time when a plan had been enacted'*.

And although one participant rated the tool as 'not at all useful' in the 1P-1T configuration for either the Planner or Tactical, they did rate it as 'essential' to both the 1P-2T and SPO configurations. Two participants rated the tool as not useful (1 or 2) for the Tactical in all three staffing configurations.

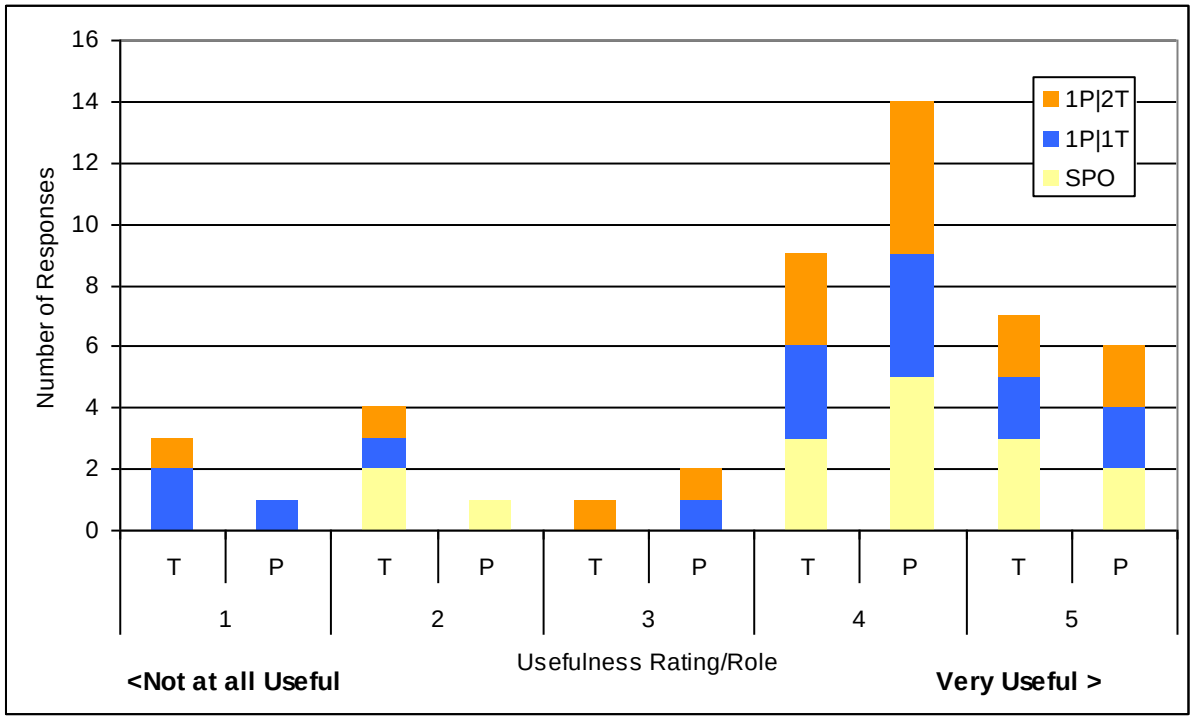


Figure 22 Instruction Pallet Coordination Functionality usefulness ratings

The overall usage of the COORD functionality for the Planner and Tactical (i.e. excludes SPO) is shown in Figure 23. In addition to applying heading, route and speed constraints, the functionality

also allowed controllers to enter multi-level coordinations, set and revise levels. Combinations of lateral constraints and releases were permitted through the COORD functionality.

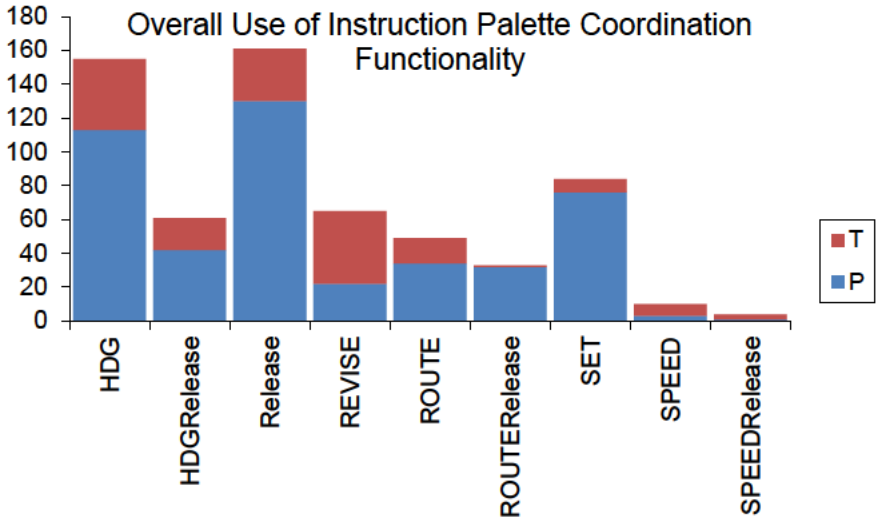


Figure 23 Use of Instruction Palette Coordination Functionality

Figure 24 shows the usage of the Instruction Palette Coordination function for SPO, and demonstrates that the SPO frequently used the functionality, in particular to set the coordination offer levels.

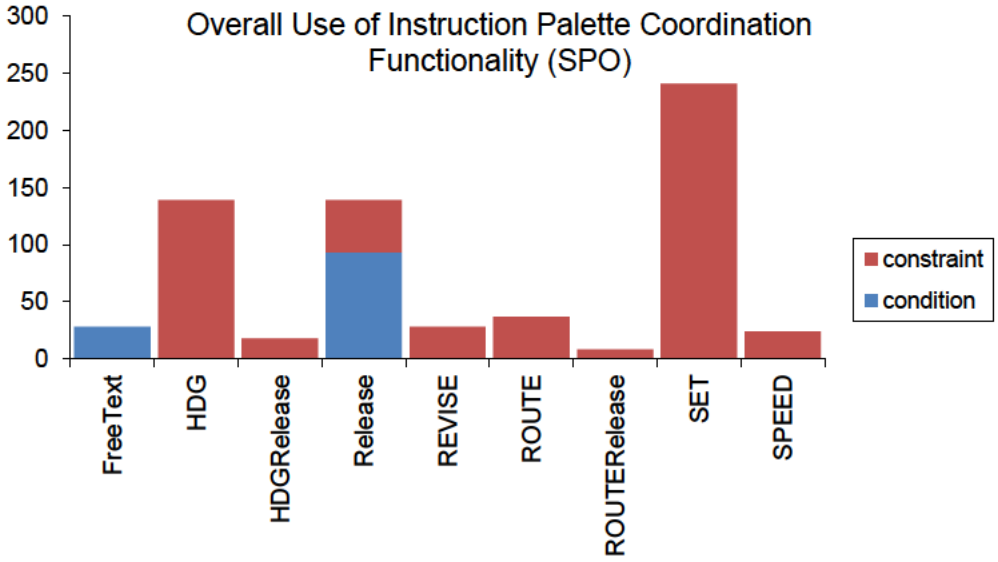


Figure 24 Use of Instruction Palette Coordination Functionality (SPO)

There were a number of suggestions on how the functionality implemented could be improved, with one participant going so far as to suggest that the ideal would be to implement all Planner tasks from the EFS in the Instruction Palette. *'Further development would be ideal to enable all the Planner tasks that are done using the EFS to be implemented into TDLs, so that the EFSs become redundant. Being able to change entry levels that would mean a change of sector within the MSP team without the need to reject and force offer an EFS. This would make the MSP's workload easier.'*

On selection of the 'ENTER' button whilst in COORD mode, the Instruction Palette returns to the normal clearance entry mode. Although the COORD state of the instruction palette was indicated to the user by a purple border, for the Planners, who do not have a need to enter Tactical Instructions, this was frustrating, and increased the risk of incomming a flight by mistake. *'[*At the Planner position] *I think the COORD button should be able to be pressed on all the time'.*

With multi-level coordinations, the primary coordinated level is different depending on whether it is a 'coordinated climb/descent' or a 'release for climb/descent'. In a coordinated climb, the primary level is the higher level (and for a coordinated descent it will be the lower level). For a 'release for climb' (RFC) coordination, the primary coordination level is the lower of the specified range selected in the Level Assessment Display (LAD), and for a 'release for descent' (RFD) coordination, the primary level is the higher level for the specified range). The controllers were able to use the LAD to input a multi-level coordination (using left-click and drag for a coordinated climb/descent or a right-click and drag for a release for climb/descent). Some participants did not find the implementation of the 'left-click' or 'right click' intuitive. Further, there were observations of the Planner trying to affect a coordinated climb, but had not selected an editable NFL/XFL field in the TDL, and therefore the 'level select' functionality in the LAD was not enabled. It was reported *'on occasions, because there were so many alternative ways of doing something (e.g., a RFC co-ordination) that it just confused things*'.

There were repeated suggestions from the participants that it should be possible to input 'tactical' data without incomming the aircraft, in order that it is not necessary to re-input coordination constraints for aircraft calling in from non-NERC sectors. (i.e. when the first NERC sector incomms a flight, then the clearances should automatically be set to any existing entry coordination constraints – much in the same way that the NFL is used as a default CFL for the first NERC sector). Further, it was considered that being able to use the COORD functionality to revise entry coordination constraints for aircraft already 'incomm' with the sector would be very useful.

Coordination Interaction Point-Out

Currently, iFACTS enables two flights involved in a tactical interaction to be highlighted on the display through the Interaction Point-Out functionality. This functionality has been extended to enable the Planner to communicate planning interactions to either one or both Tacticals. The Coordination interaction menu is invoked by a press-and-hold on the highlighted NFL, IFL or XFL of an EFS field highlighted during a Look-See/What-If.

The use of Planner Interaction Point-Outs is displayed below in Figure 25. Point-Outs were used by Planners in both a 1P-1T and 1P-2T configuration, and by SPOs. The Planners could send Point-Outs to themselves, a specific Tactical or the entire sector team. They were used to remind themselves of (and monitor) coordination problems and to show (and even delegate) problems to their Tacticals (before the iFACTS tools displayed an interaction). The Planners sometimes chose to accompany a Point-Out with verbal communication with the Tactical, but on occasions they chose not to (either they, or the Tactical, were too busy*). 'Planner would still tell you, making sure you had the situational awareness of the task.'*

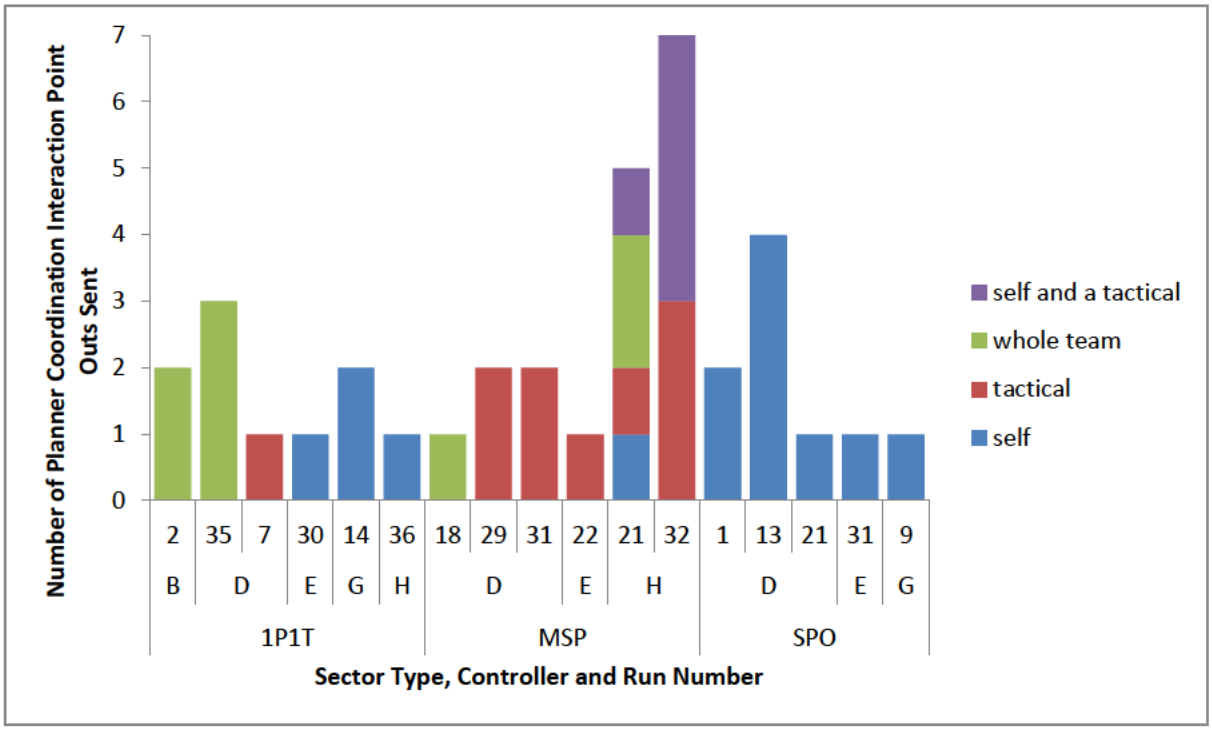


Figure 25 Use of Coordination Interaction Point-Out

In the questionnaires at the end of the simulation, six out of the eight participants rated the coordination Interaction Point-Out functionality as essential to a 1P-2T environment (whilst only five of the eight participants sent Planner Interaction Point-Outs during the simulation, the other three experienced receiving points outs as a Tactical).

One of the controllers who never sent any Point-Outs (but did receive them as a Tactical) commented that (during one run) the Point-Outs provided the most support to them as a Tactical.

Planner Context

The Planner Context tool was designed to help the Planner gain situational awareness (of the Tactical workload) which may have been impacted by the removal of paper strips. Context highlighted flights that may not be involved in an interaction with the subject flight based on the current clearance or existing coordination levels but may need to be considered by the Planner when making coordination choices for the Planning sector to mitigate Tactical workload.

In the questionnaires the participants rated the usefulness (on a scale of 1= not useful at all, and 5= extremely useful) of Planner Context with a mean score of '2' in all staffing configurations. In general, the participants reported that Planner Context was not particularly useful to the Planner, as the Planners considered the traffic highlighted to be more of a Tactical issue of how and when the aircraft gets to its XFL, and would not necessarily cause the Planner to amend XFL. '*As a Planner, I generally let the tactical decide how hard he wants to work to get an aircraft to its RFL/XFL and let me know if he wants something changed*.'

However, this possibly reflects the performance issues with the tool during the activity (see 3.3.2.2) and the challenge of attaining an assessment of the more subtle and sophisticated aspects of the Planner role and the tools designed to support these within a relatively short period of validation, as some participants held the view that Planner Context could provide more support with increased use. *'Not really sure how to use it* [Planner Context] *best but glad it's there and it's unobtrusive'*. Another participant similarly reported that '*the Planner Context is not essential but with more exposure it could become used more, especially in 1P-2T environments*.'

Further, during the end of simulation debrief, a participant reported that the Planner Context could be useful in certain sectors for the Local Area Supervisor to assist them in anticipating the appropriate staffing configuration for a sector.

Non-conformance Alerts

A 'line zero' TDB alert is designed to alert the sector team if the system predicts that an aircraft will not meet its coordination level (XFL) before the multi-sector sector internal or external boundary, or is identified as being in non-conformance with a coordination constraint (COORD). If the flight is not conforming to a coordination constraint it will initially show at the offering sector team as a line zero TDB alert. If there is further deterioration in the non-conformance the alert will be displayed at the receiving Planner position. Once the flight becomes close to the receiving sector boundary the alert will show on the receiving Tactical position. Generally the participants reported that the COORD non-conformance alerts were useful in all staffing configurations, with five participants responding that they would be essential in a 1P-2T environment.

The Planners were also shown 'QSY?' alerts on flights that were still 'incomm' with one of their Tacticals, but had left that Tactical's volume of airspace (the Planner could then prompt the Tactical to 'outcomm' that flight). The participants gave this a median usefulness rating of '2'.

4.2.1.2 Acceptability of Enhanced Planner Tools (1P-1T)

OBJ-04.07.08-VALP-0304.0004 To assess the operational acceptability of the enhanced Planner tools in a 1P-1T environment.

In Summary, the enhanced Planner tools were, on the majority of occasions, rated as 'acceptable' for both the Planner and Tactical roles, and supported many tasks better than the current NERC Planner tools for most of the participants. The participants' subjective feedback on the acceptance of the tools in the 1P-1T environment was extremely favourable with comments such as *'The tools… could be implemented into the ops room, with very little* [detrimental] *impact on the operation.'* The Coordination Interaction Vectors and Auto-Accept Conflict Detection tool were particularly highly rated, though the Planner Instruction Palette functionality and the Coordination Point-Out were also rated highly.

Figure 26 presents the difference in the CARS User Acceptance scores for the Planner (in a 1P-1T configuration) for those runs with enhanced Planner tools and those with NERC Planner tools. The user acceptance of the enhanced tools for the Planner was in most cases rated the same as that of the NERC Planner tools which have been in operational use for over ten years.

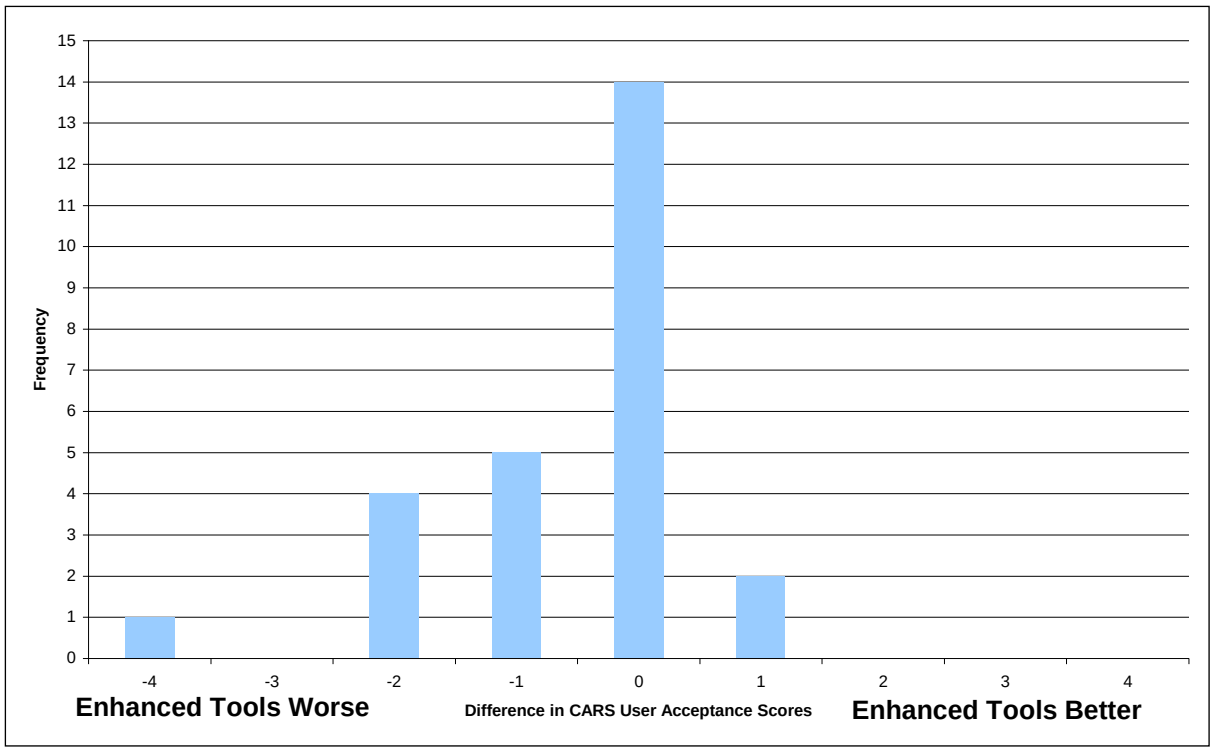


Figure 26 User Acceptance (Planner)

The CARS User Acceptance data (Planner and Tactical) for individual matched pairs of runs is presented in Appendix H (A.2.1), and shows that even in those instances when the enhanced Planner tools were not rated as highly as the NERC Planner tools, the user acceptance still rated highly for a V3 system, with the worst score of '5' (i.e. 'moderately objectionable deficiencies'). With little change for the Tactical role, the user acceptance for the Tactical when the Planner had enhanced tools was rated very similar to that where the Planner had NERC Planner tools.

Roles and Responsibilities

The chart below presents the participants rating at the end of the simulation of the enhanced tools for specific Planner tasks compared to the NERC Planner tools.

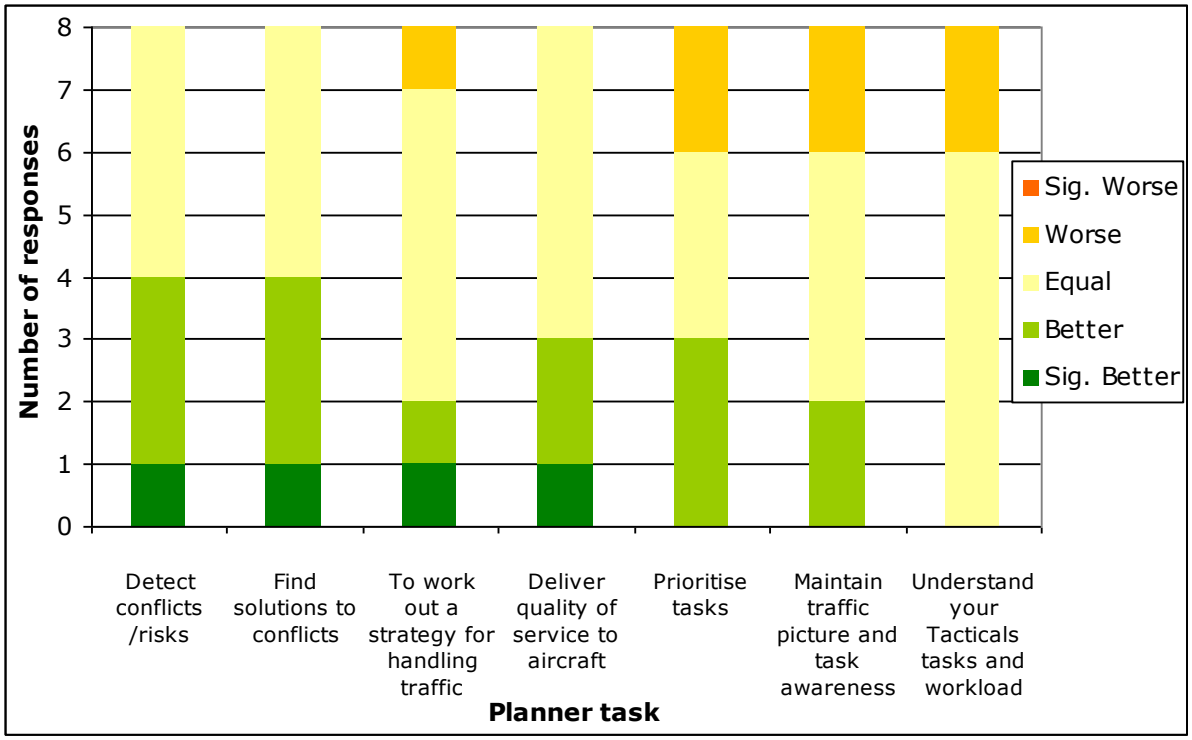


Figure 27 Planner Task Performance Rating

For many Planner tasks the enhanced tools supported some of the participants better than the NERC Planer tools. In particular, the enhanced Planner tools provided additional support for detecting and resolving conflicts. '*With some exceptions, the tools were excellent at identifying planning conflictions into the sector.'*

In a 1P-1T environment the participants did not change how they worked generally, but the tools were reported to enable them to make quicker decisions. *'The enhanced tools speed up the process of using iFACTS but … there is very little change in working practice.' 'Tools were an added aid.'*

The Dynamic EFS 'auto-drop' functionality was subjectively reported to reduce Planner workload in the 1P-1T environment (as well 1P-2T), enabling them to give increased support to the Tactical. *'The reduction in house keeping certainly helped me get into the tactical [data lines] more and also spend more time heads up looking at the radar for this requiring attention'.* This was substantiated by other participants. *'The auto-drop functionality allows for more thinking' time so therefore other tasks are being done in a more timely manner. It also means that you have more time to be situationally aware of traffic coming into the sector etc.'*

However some participants reported that a lack of order in the Accepted Bay had a detrimental affect on their ability to prioritise tasks. *'Need to make it clearer in Accepted Bay which strips have never been looked at versus recovered strips versus NFL/XFL problems'.* There was also a feeling that the new tools tended to force them into dealing with the planning tasks identified by the Accepted/Recovered Bays, but did not necessarily help them see what was happening in the sector.

Further, there was a suggestion that a Coordination Monitoring tool would be of value. *'They* [enhanced Planner tools] *generally allowed sensible levels to be planned out, however, they do not detect deteriorating exit coordinations, where a plan may have been acceptable when originally set but changes over time and becomes worse or unacceptable'.*

Figure 28 shows the medians of the participants' ratings (from the questionnaires) of the usefulness of the enhanced Planner tools in the 1P-1T environment.

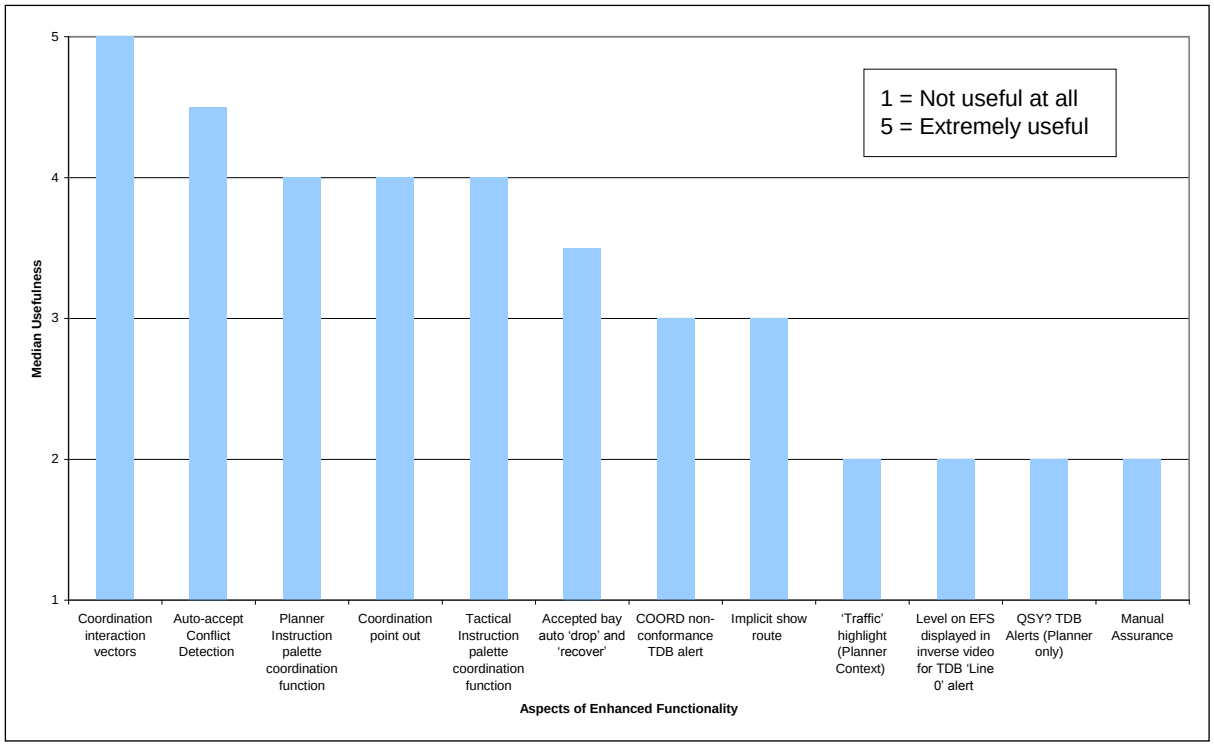


Figure 28 Tool Usefulness Scores (1P-1T)

The Coordination Interaction Vectors and Integrated Coordination Auto-Accept Conflict Detection tool were the highest rated tools for the 1P-1T configuration. The Planner Instruction Palette functionality and the Coordination Point-Out also all rated reasonably well. Although the usefulness of the Dynamic EFS functionality was not rated as highly for the 1P-1T environment as for the other staffing configurations, very positive feedback was still forthcoming; *'recover strip on hook flight is a great piece of functionality'*. Subjective feedback pertaining to the tools is reported in Section 4.2.1.1.

Operational Benefits

The participants unanimously agreed that the enhanced Planner tools would provide benefits in terms of Planner workload. However there were mixed views on the effect of the enhanced tools on the quality of service. The majority of participants reported that there would be no change in the quality of service afforded by the tools. '*We always give the aircraft the levels they want if it's available. The iFACTS tools support this enough as it is. The tools may however help the Planner pick the best level first time.'* However three participants thought there would be an increase in the quality of service One of these participants considered that the ability to enter coordination constraints through the instruction palette would provide an operational benefit *'because it shows what affect a turn will have, for example may stop Planners from going for the 'level' option which will mean aircraft can stay at the preferred levels for longer.*

4.2.1.3 Human Performance with Enhanced Planner Tools (1P-1T)

OBJ-04.07.08-VALP-0304.0005 To assess the impact of the enhanced Planner tools on Human Performance

In summary, the analysis shows that with the enhanced Planner tools there was an indication of a reduction in Planner workload over that with current NERC tools, but no difference in the situational

awareness scores of either the Planner or Tactical. Note however that the traffic samples in this activity were designed to examine the Multi-Sector Planner concept (i.e. traffic levels on the verge of bandbox/split) and as such the traffic composition may not have appropriately challenged the Planner in the 1P-1T configuration to assess human performance benefits.

Workload

Figure 29 shows the difference in the median ISA scores of the Planner with the enhanced Planner tools compared to the Planner with NERC Planner tools in the 1P-1T configuration, and shows that there were more matches where the runs with the enhanced tools scored up to one ISA score lower. However, this difference was not statistically significant at the 95% level, though was significant at the 90% level, giving an indication that there could be some reduction in workload. With many of the participants subjectively reporting some improvement in task performance (p.69), it could be that the statistical results were not as significant due to exercising the enhanced Planner tools in an environment where the Planner is not reaching capacity when the tools are likely to provide most benefit, or that the participants were still learning how to get the most from the tools. One of the participants who had previous experience to elements of the enhanced toolset commented *'only towards the end of the simulation did I realise how much extra time the Planner tools were giving me*'.

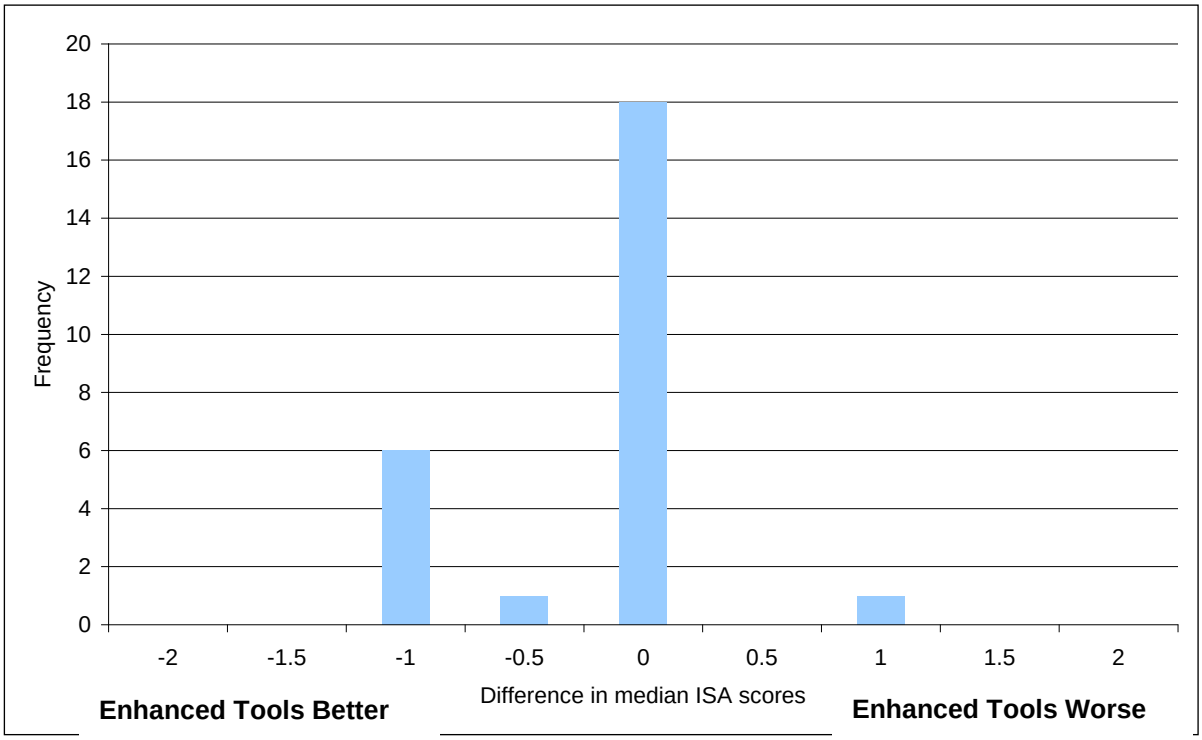


Figure 29 Difference in Median ISA (Planner)

In considering the workload 'peaks', Figure 30 presents the difference in the number of ISA scores of 4 or 5 recorded between the Planner with enhanced tools and the Planner with NERC tools for the 26 matched pairs. Analysis shows that for the most of the time there was no difference (in fact for 19 matched pairs no ISA 4 or 5s were recorded), with one matched pair where the Planner recorded six fewer ISA 4 or ISA 5s with enhanced tools than with the NERC Planner tools.

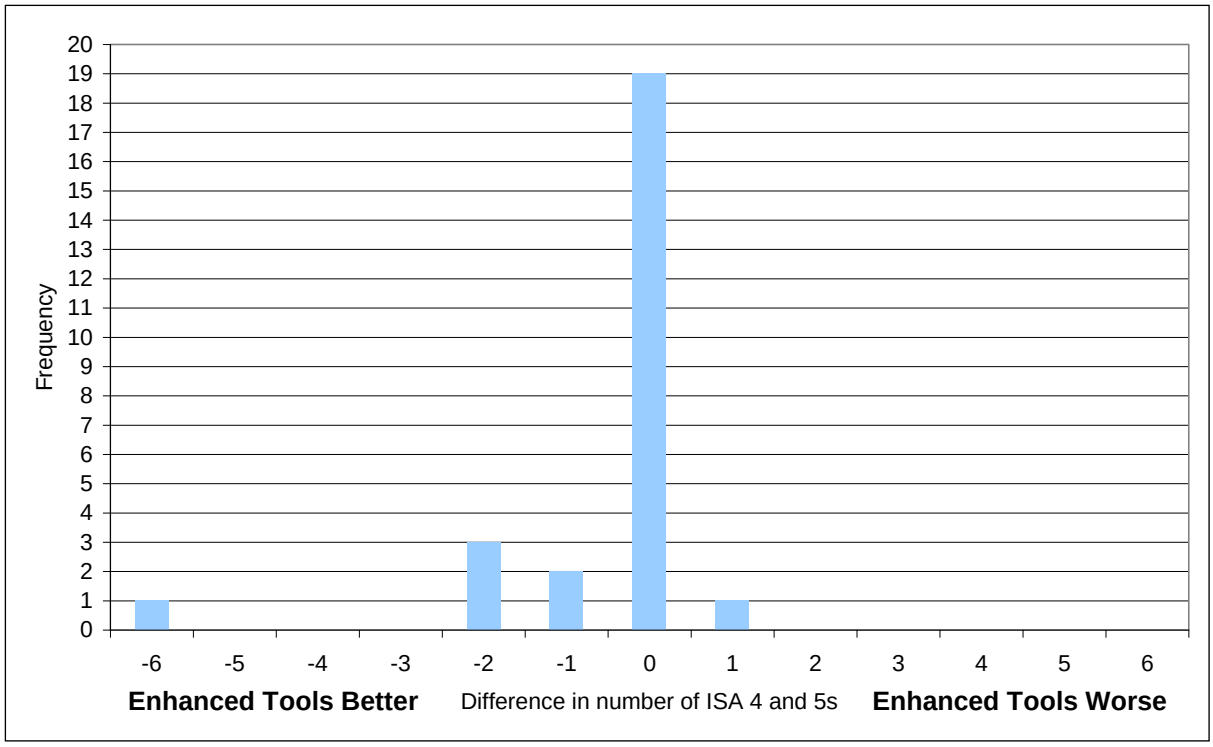


Figure 30 Difference in High/Very High ISA scores (Planner)

The 'peak' ISA scores (Planner and Tactical) for individual matched pairs of runs is presented in Appendix H (A.2.2), and shows that in most cases there was no difference in 'peak' workload of the Tactical or Planner when the Planner had enhanced tools. Analysis of the Bedford 'average' and 'peak' workload scores for the Planner and Tactical is shown in Appendix H (A.2.3) and yielded similar results.

Analysis of the number of times the vector lines were manually invoked by the Planner (Appendix H, A.1.2) shows that in the 1P-1T (bandboxed) configurations the vector lines were used less in those runs with the enhanced Planner tools. This is likely due to the Planner with enhanced tools instead attaining the required information from the Coordination Interaction Vector functionality, and would suggest that there is a workload saving. However, in a 'split' configuration there were occasions when the Planner with the enhanced tools used the vector lines more often (though this is most likely down to individual controller preference).

Situational Awareness

Figure 31 presents the difference in China Lakes Situational Awareness scores for the Planner (in a 1P-1T configuration), between those runs with enhanced Planner tools and those with NERC Planner tools. See Appendix B for a description of the China Lakes Situational Awareness metric.

The chart shows that on the many occasions there was no difference in the situational awareness scores, and broadly the same number of occasions where the situational awareness was better with the enhanced Planner tools as with the NERC Planner tools.

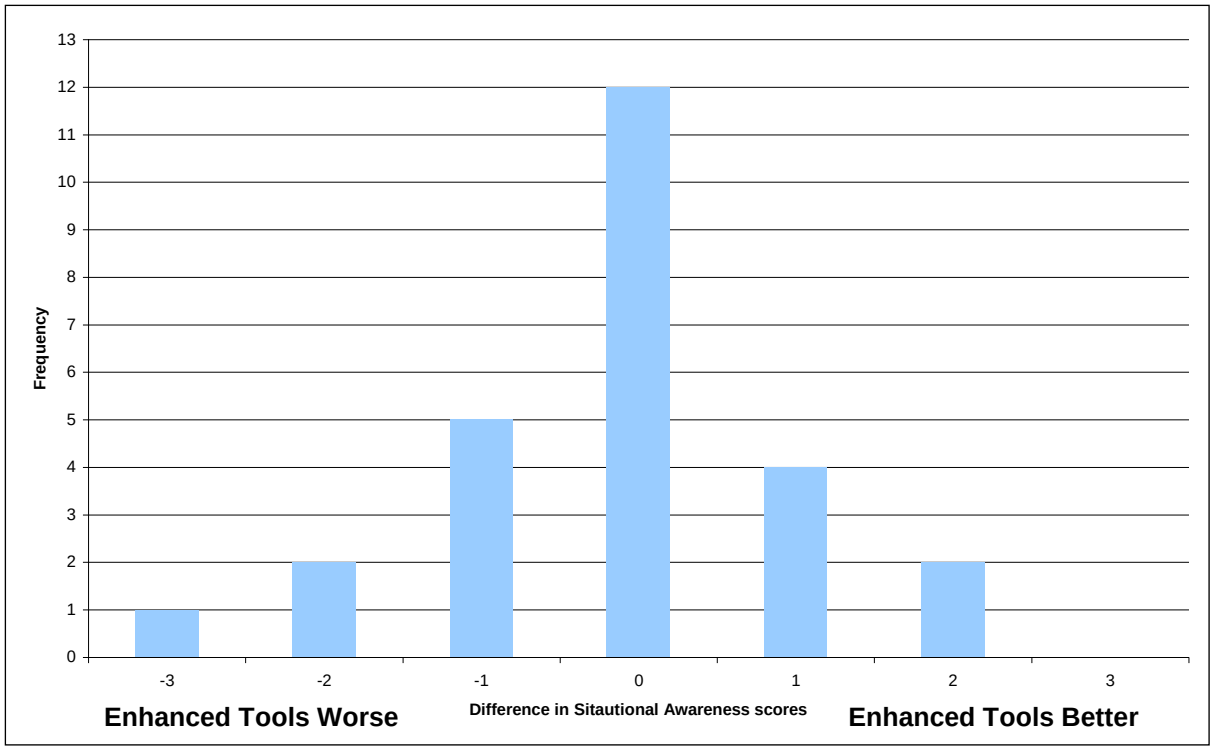


Figure 31 Situational Awareness (Planner)

The China Lakes Situational Awareness data (Planner and Tactical) for individual matched pairs of runs is presented in Appendix H (A.2.4), and shows that in on the majority of occasions, the situational awareness was rated very highly for a V3 system (i.e. below '3', 'acceptable and satisfactory'). With little change for the Tactical role, the user acceptance for the Tactical when the Planner had enhanced tools was rated very similar to that where the Planner had NERC-iFACTS tools.

Planning Times

The impact of the enhanced Planner tools on planning times can be examined to give an indication of the relative support provided by the tools. 'Reaction time' is the difference in the time at which a particular aircraft is offered from the upstream sector and the time where that aircraft is accepted, rejected or a counter offer is made by the receiving sector.

Figure 32 shows the 'reaction' time for the Planners in a 1P-1T configuration, with the enhanced Planner tools and with the NERC Planner tools. Although the median 'reaction' times are similar, in seven of the nine comparisons there is greater variation in the data (spread) for the Planner with the enhanced Planner tools.

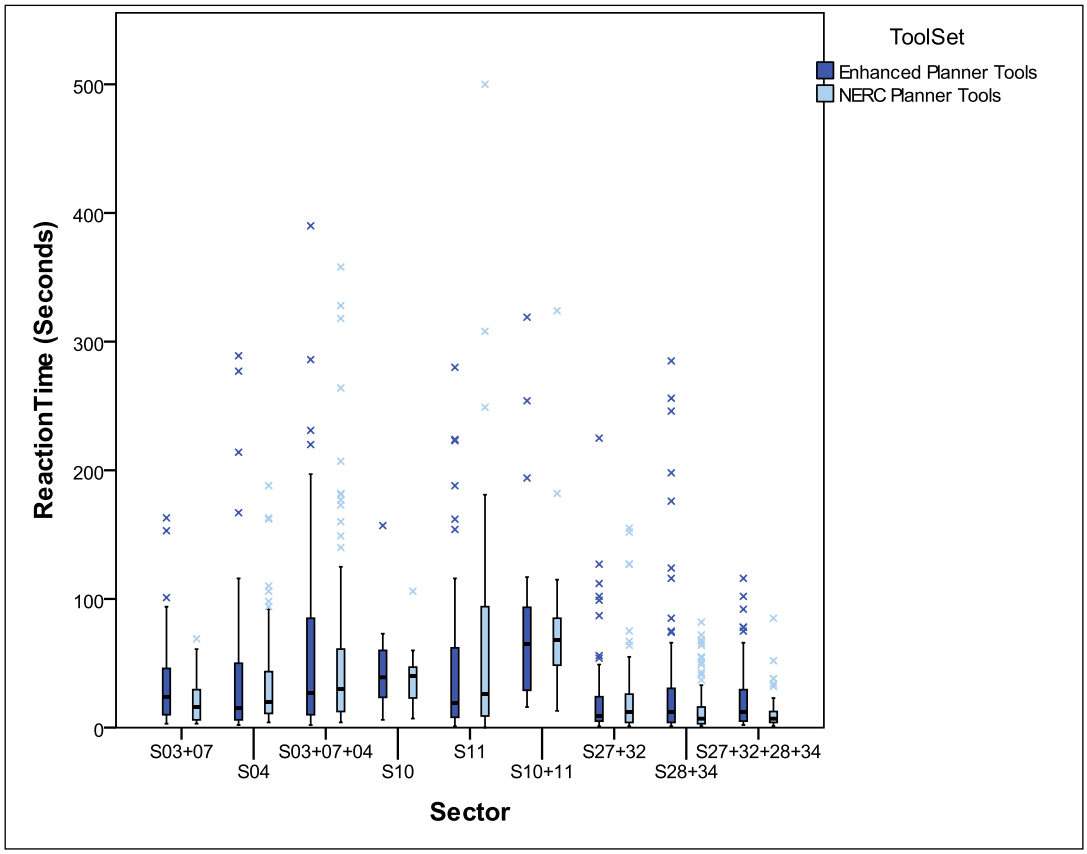


Figure 32 Planning Time

The participants' subjective view however was that *'the enhanced tools did allow me additional capacity, as they enabled me to coordinate traffic into the sector quicker'*.

4.2.1.4 Safety with Enhanced Planner Tools (1P-1T)

OBJ-04.07.08-VALP-0304.0007 To assess the impact of the enhanced Planner tools on safety.

In summary, the there were no negative issues raised regarding safety relating to the implementation of enhanced Planner tools in a 1P-1T configuration.

Situational Awareness

Analysis of the China Lakes Situational Awareness scores is presented in 4.2.1.3 and shows that there was little difference in the situational awareness of the Planner with the enhanced Planner tools.

Safety

There were mixed views as to whether the enhanced Planner tools provided any safety benefit over the NERC Planner tools. There was a suggestion by the participants that a reduction in Planner workload itself would provide a minor safety benefit. No 'risk bearing' losses of separation were recorded.

4.2.1.5 Acceptability of Multi-Sector Planner Concept

OBJ-04.07.08-VALP-0304.0001 To assess the operational acceptability of the MSP concept under assessment in appropriate traffic conditions.

In summary, for those participants with previous experience of elements of the iMSP concept, the user acceptance of the 1P-2T configuration rated well (<= 5) for traffic that today would require the sector to be split. User acceptance scores for the Tactical in the 1P-2T configuration fell within acceptable limits. However the participants' subjective view was that the acceptability of the concept was overwhelmingly affected by the ability to monitor only one of the R/T frequencies.

Although a subjective assessment by the participants of the task performance of the Planner in the 1P-2T configuration fell short of that in the 1P-1T configuration, during the end of run debriefs on most occasions the Tacticals reported that they felt supported by the Planner in the 1P-2T configuration.

Note that in the following section, analysis of objective data will be presented for both the Planner and Tactical roles, for matched pairs of runs in a 1P-2T configuration compared to both a 1P-1T (split) and a 1P-1T (bandboxed) configuration (as appropriate).

CARS User Acceptance

Figure 33 and Figure 34 presents the difference in the CARS User Acceptance scores for the Planner and Tactical roles respectively in a 1P-2T and 1P-1T (bandboxed) configuration. See Appendix B for a description of the CARS User Acceptance metric.

In three matched runs the Planner in the 1P-2T configuration (i.e. MSP) rated the user acceptance the same or better than that of the bandboxed Planner (though the workload in one of the matches was considered low enough to bandbox). For three matches the participants subjectively reported that the traffic exercised was appropriate to the 1P-2T configuration, and for these matches the user acceptance of the MSP was rated as very good (<= 3).

In three of the five matched runs where the Planner rated the user acceptance of the 1P-2T configuration as worse than that of the bandboxed Planner, the user acceptance was still rated as, at worst, a '5'. On the occasions where the user acceptance of 1P-2T was rated 4 and 6 points below that of the bandboxed Planner, the participant had not had any previous experience of iMSP.

Note that in the presentation of this data, it was considered appropriate to compare the user acceptance score for the Tactical in the 1P-2T configuration with that of the bandboxed Tactical with the 'worst' user acceptance rating; this may be a different participant. The data (Planner and Tactical) for individual matched pairs of runs is presented in Appendix H (A.3.1 (bandboxed) and A.4.1 (split)) and shows the user acceptance rating of both Tacticals in the split configuration.

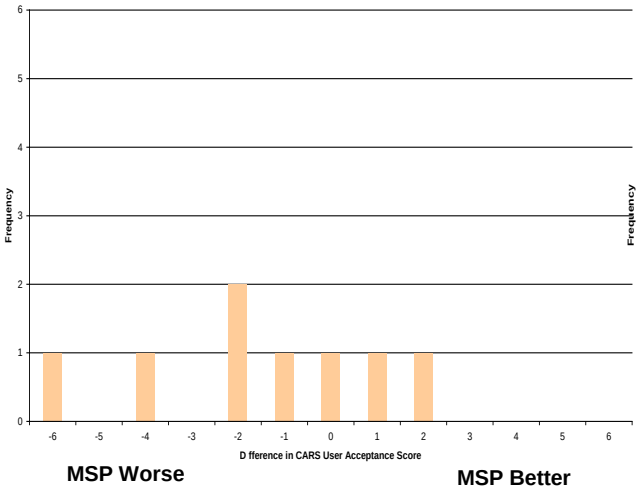


Figure 33 User Acceptance (Planner) (Bandboxed)

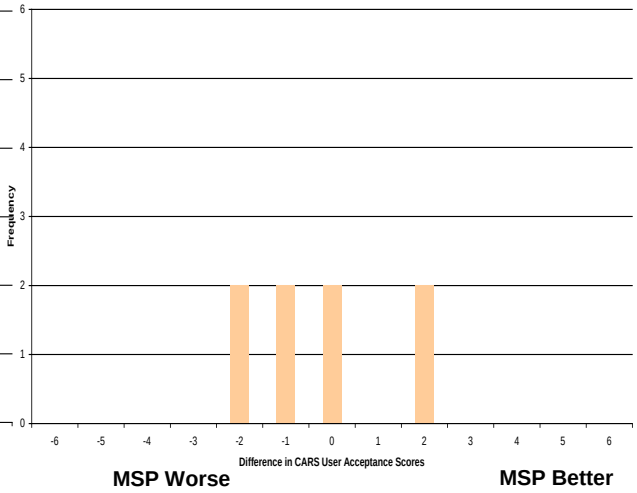


Figure 34 User Acceptance (Tactical) (Bandboxed)

Figure 35 and Figure 36 presents the difference in the CARS User Acceptance scores for the Planner and Tactical roles respectively in a 1P-2T and 1P-1T (split) configuration. Note that in the presentation of this data, it was considered appropriate to compare the user acceptance score for the Planner in the 1P-2T configuration to that of the Planner rating the 'better' usability in the split configuration; this may be a different participant.

In seven of the nine matches there was little or no difference in the user acceptance scores, and in fact in five of the nine runs the user acceptance of the Planner in the 1P-2T configuration (i.e. MSP) was rated as 'satisfactory' (i.e. 3 or lower). On only one occasion was the score rated higher than a '5', which for a V3 system is an encouraging result. On the one occasion where the user acceptance for iMSP much worse (5 points less), the participant had no prior experience of iMSP.

In all cases the user acceptance scores for the Tactical fell within acceptable limits, regardless of the Tactical having a shared or a dedicated Planner, although there were occasions where the Tactical rated the user acceptance of the 1P-2T configuration as worse than that of the 1P-1T configuration.

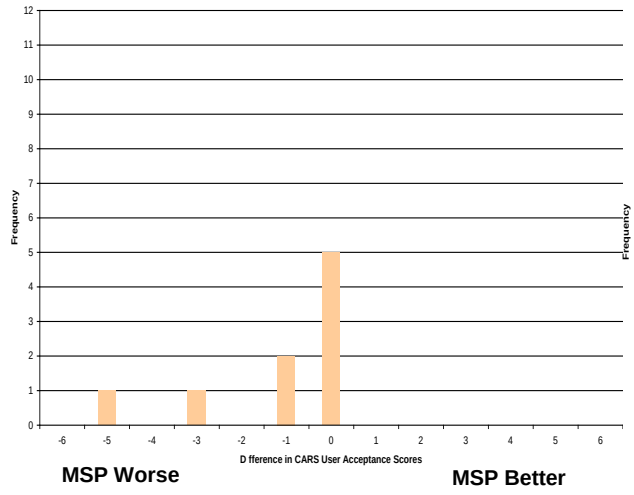


Figure 35 User Acceptance (Planner) (Split)

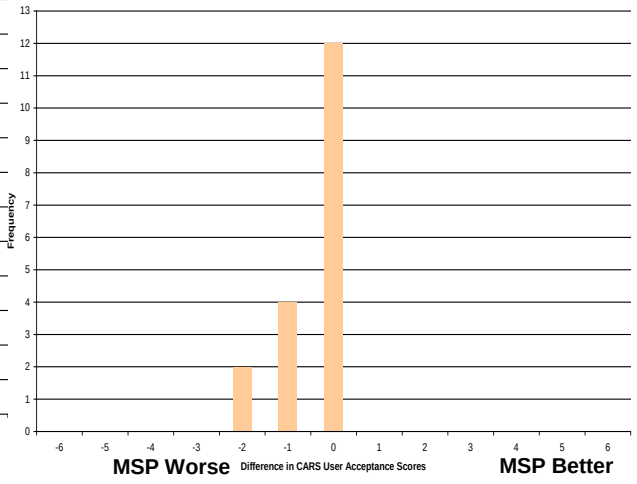


Figure 36 User Acceptance (Tactical) (Split)

Roles and Responsibilities (MSP)

In the questionnaires, the Planners reported a perceived reduction in the frequency with which they made timely and accurate coordinations in a 1P-2T environment compared to the same 1P-1T environment, with the majority (6 participants) reporting that this occurred 'very often', and two

participants reporting 'sometimes'. For the comparative 1P-1T environment (with NERC Planner tools), three participants reported 'always' making timely and accurate coordinations, the other five participants reported 'very often'. One of participant remarked: *'Although I tried to look at planning as an MSP the same way I'd plan for a bandboxed sector, it just wasn t possible. Not 100% sure why, but may be due to the lack of one frequency'.*

It was highlighted by another participant that the Planner's contribution to sector operations is complex, *'… the role of the Planner is so much more involved than planning levels in and out of the sector. The Planner can make a sector operate so much more easily when providing assistance to the traffic situation not only level planning'.*

The following chart presents the participants rating of the 1P-2T configuration (with enhanced Planner tools) compared to current operations for specific Planner tasks. The questionnaire responses were caveated by many of the participants to be dependant on appropriate traffic levels for multi-sector planning and nominal traffic situations.

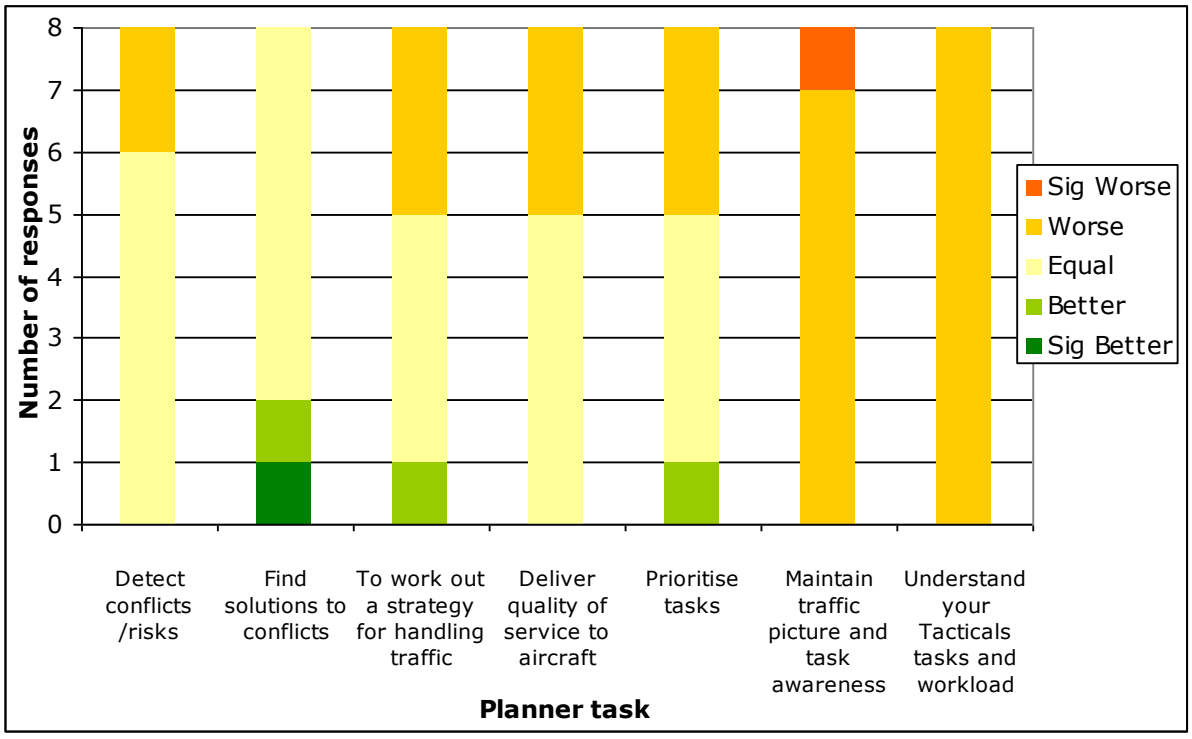


Figure 37 Planner Task Performance Rating

The majority of the participants considered that the ability to detect conflicts and risks with the iMSP concept was the same as that with the NERC Planner tools, though this is in some cases a reflection of system problems. '*If the tools can guarantee to show all relevant interactions then these tools will be brilliant for coordinating traffic in and out'.* Another participant similarly reported, *'this is what the tools are for and they are very good at allowing quick decisions for finding safe levels in and out. As the simulation progressed I realised that I had to look more carefully at the other information available, like the full flight plan window, in order to make more sensible decisions based on what was happening'.*

Three participants rated the ability of the Multi-Sector Planner to work out a strategy as worse. *'In MSP configuration, I need to be able to adjust the targeted sector i.e. a FL320 offer to S3 is in conflict whereas FL340 (S4) is not. I have no way to reflect that change'.*

The ability to maintain the traffic picture and understand Tactical workload as a Multi-Sector Planner were unanimously considered to be worse than with iFACTS. *'The fact that you are shared between two Tacticals is always going to impact on your performance; it is the degree to which this occurs that will be the key - suitable traffic levels!!'* From the Tacticals' perspective there was a comment that *'often the Planner [MSP] did not notice that coordination was necessary'*.

There was feedback during an end of run debrief that the Planner knew both Tacticals were busy, but was unsure of the complexity in the respective sectors, and did not know who to prioritise. However there was another instance where the Planner reported they were able to balance the traffic across the LKS sectors, holding down traffic in S7/3 if S4 was too busy.

In the questionnaires, all eight participants reported that in a 1P-2T configurations as Planner they were only 'sometimes' able to pro-actively assist the Tacticals in managing their workload, compared to a 1P-1T environment with NERC Planner tools where five participants reported 'always' pro-actively assisting the Tactical and three reporting *'very often'.* The participants considered that by not monitoring the R/T of one of the Tacticals, the Multi-Sector Planner was less able to pre-empt situations to support the Tactical. '*I think there's a possibility that in real life this would be more of an issue because of aircraft requesting different levels to those filed. If you don't pick that up on the R/T there will be a significant amount of talking from the Tactical to alert the Planner, because maybe as much as 20-30% of filed levels aren't the same as requested*'. However, it should be noted that with the introduction of datalink, requested levels will likely be confirmed through datalink rather than R/T.

However, although the subjective assessment by the participants of the task performance of the Planner in the 1P-2T configuration fell short of that in the 1P-1T configuration, during the end of run debriefs, on 94% of runs the Tacticals reported that they felt supported by the Planner in the 1P-2T configuration (compared to 99% in 1P-1T configurations). This suggests that on most occasions the Planner was completing all necessary tasks.

Figure 38 shows the median values of the participants' ratings (from the questionnaires) of the usefulness of the enhanced Planner tools in the 1P-2T environment.

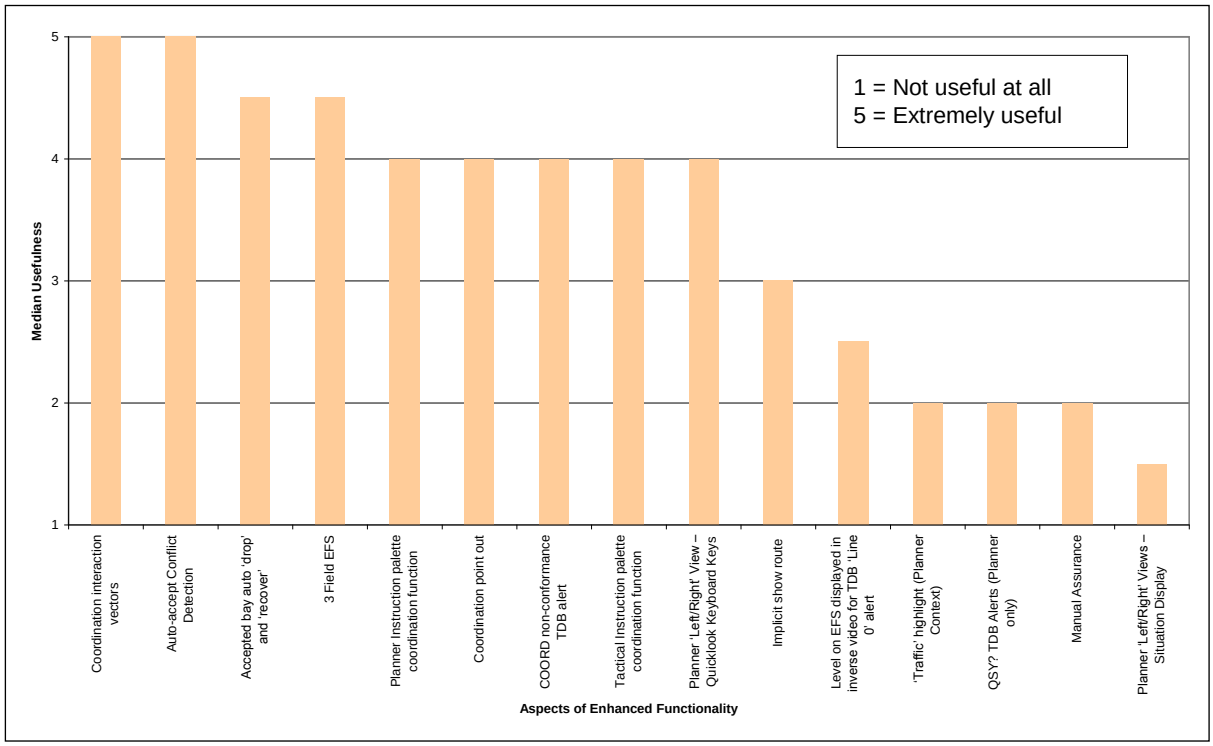


Figure 38 Tool Usefulness Scores (1P-2T)

The participants rated the Integrated Coordination Auto-Accept Conflict Detection highlight and Coordination Interaction Vectors as the most useful tools for the 1P-2T configuration. The controllers' majority view was that IC Auto-Accept Conflict Detection 'usually' or 'frequently' highlighted the right coordination issues in accordance with the concept. The Dynamic EFS 'auto-drop', Instruction Palette Coordination functions, Coordination Point-Out and 'COORD' non-conformance alert were also rated very highly for usefulness in the 1P-2T configuration. Subjective feedback pertaining to the tools is reported in Section 4.2.1.1.

Seven of the eight participants considered that Coordination Interaction Vector and Dynamic EFS 'auto-drop' would be essential to 1P-2T operations, and six out of the eight participants rated the

Coordination Interaction Point-Out, the IC Auto-Accept Conflict Detection highlight and Instruction Palette Coordination function as essential.

Six of the eight participants considered that Planner View Quicklook keys would be an essential element of the 1P-2T concept. Analysis of the number of times the 'Planner Views' were used during the simulation (Figure 39) shows that the Quicklook keys were used more than the buttons on the situation display. Note that the MSPs often pressed the 'left, right, left, right' keys alternately to get a contrasting picture, so a single 'use' may comprise multiple sequential events (events less than 5 seconds apart were counted as a single 'use').

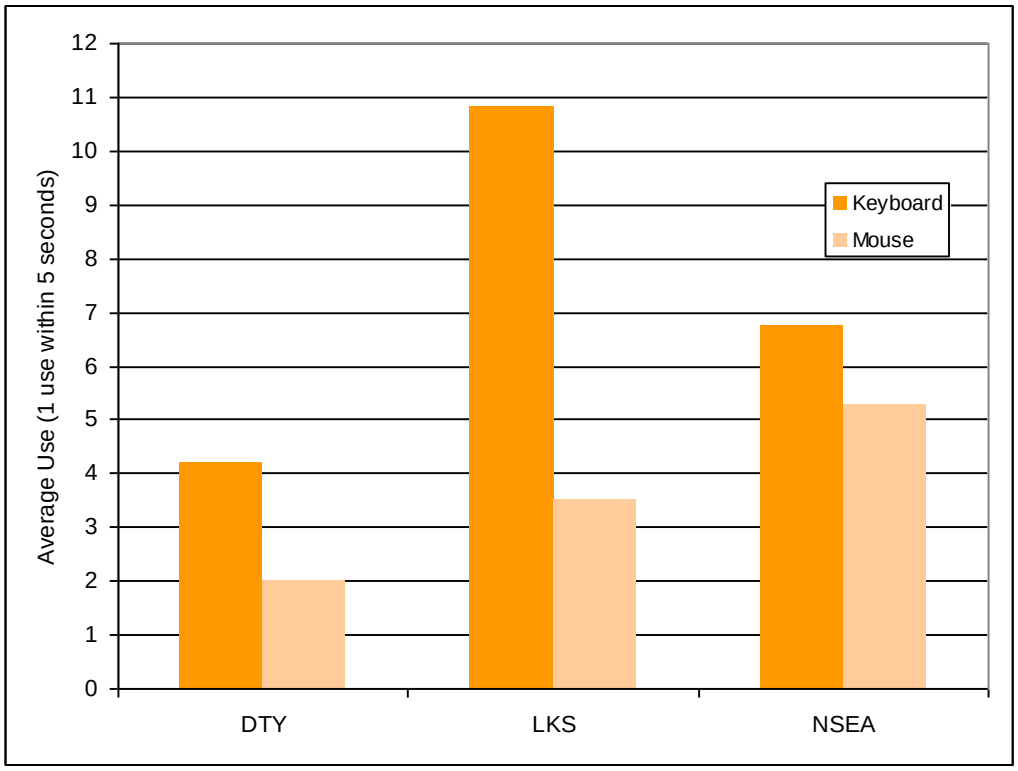


Figure 39 Planner Views

As expected, the Planner Views are used more in LKS and NSEA, as these sectors are vertically split. In Lakes, S3/7 (FL285 to FL335) sits beneath S4 (FL335 to FL660), and in NSEA, S10 (FL285 to FL315) sits beneath S11 (FL315 to FL660). This makes it difficult for the MSP to differentiate between the traffic of the two Tactical sectors. In DTY, S27/32 and S28/34 are adjacent so it is likely easier to differentiate the traffic between sectors without the need for Planner Views.

Subjectively, very positive feedback was received on Planner Views. One ATCO commented *'it was difficult to always maintain situational awareness of both sectors, particularly during busy runs. The left/right view buttons were a great assistance to achieve this though'.* Another ATCO said *'(Planner) Views allow an immediate return of situational awareness and Tactical workload'*.

Seating Arrangement

The general consensus was that the preferred seating arrangement is sector specific. On DTY it worked well with the Planner sat between the two Tacticals, who have very little, if any, interaction between them, but it was noted that this would make splitting out into two Planners difficult to execute quickly.

However it was considered that on some sectors (such as LKS) the Tacticals would need to be seated side by side as they communicate more. On LKS, the Tactical furthest away did not want to shout across the other Tactical, and it was considered too inefficient to use the phones to get the Planner's attention. This resulted in the Tactical feeling 'isolated', and they were more likely to effect their own coordinations.

As Multi-Sector Planner, some participants found it beneficial to sit next to the controller who's R/T they were not listening to, so that the nearest Tactical could verbally advise them of co-ordination needs, and by listening to the frequency of the furthest away controller they were more aware of level changes/slow climbers etc. Other participants preferred to sit next to the busiest Tactical and monitor the corresponding frequency. Although with the use of a wireless headset the Multi-Sector Planner had the opportunity to move freely between the two seats either side of the suite, the participants rarely took the opportunity to frequently change between the two Planner workstations. This may have been affected by the participants' report that the wireless headset used in the simulation felt uncomfortable after wearing for a period of time, and the Planner often returned to using the standard headset.

Concept Viability

In the end of simulation questionnaires, six of the eight participants reported that they considered the MSP concept exercised during the activity as viable, but with the caveat that the traffic levels were appropriate, and *'only on certain sectors at certain times/traffic levels - possibly never on others regardless of traffic'. 'Despite feeling uneasy and there being a lack of reality from constantly changing traffic phone calls, weather etc. there were runs where the Planner task was completed at least as well as it would have been today'.*

There was a lot of support for the enhanced tools throughout the activity. *'The tools are viable and would decrease Planner workload. Auto-drop/recover would save work. Enhanced coordination would allow flights to build a trajectory more relevant than today's that are more than 10 minutes from the boundary. This would also ease the workload/monitoring for the Tactical as well. Coordinated climbs using LAD as a Tactical is helpful. The COORD button that needs pressing is extra work though'.*

Two participants reported in the questionnaires that they did not consider the concept of 1P-2T to be viable, one of them reporting that *'it would be detrimental to safety'.* The other participant elaborated. *'If you can get round the R/T issues maybe. The tools themselves are useful, they do help the Planner. Scenarios of traffic are missed by the Planner which would normally get picked up on. Balancing workload is difficult. Any situations evolving with a particular Tactical might not be picked up….e.g. turbulence/weather. Even an emergency called on the frequency not monitored.'*

Operational Benefits

Outside of the benefit of the flexibility in staffing arrangements afforded by the Multi-Sector Planner concept, the participants reported that they could not foresee any operational benefit to the implementation of the 1P-2T configuration. In fact, three of the participants rated the quality of service to airlines as worse with MSP.

The consensus view was summarised by one of the participants: *'I can see the benefit operationally of requiring less staff, but I fail to see how that makes things safer and…will an aircraft definitely get a better service in terms of optimum climb or descent profiles or direct routings if the Planner does not have full situational awareness? If things happen quickly like aircraft asking for a different level because of turbulence or they have an emergency, how does it make things more efficient if the Tactical has to explain to the Planner what is going on when today, they would have heard from the R/T and would probably have started making accommodations before the pilot had finished speaking'.*

4.2.1.6 Human Performance with Multi-Sector Planner Concept

OBJ-04.07.08-VALP-0304.0002 This section presents the results for the objective: 'To assess the impact of the MSP concept under assessment on Human Performance, in appropriate traffic conditions'.

In summary, the results of the analysis were greatly affected by the participants' exposure to the concept. For participants that had previous experience of the iMSP concept, three runs were exercised where the Multi-Sector Planner subjectively reported workload was acceptable at a level where the Tactical controller in the corresponding matched runs of a bandboxed sector reported that the workload was too high. Additionally, four runs were exercised where the Multi-Sector Planner subjectively reported that workload was acceptable at a level where, in the matched runs with the 'split', the Tacticals reported that it was not appropriate to bandbox the sector, although as a result of

not having a dedicated Planner, the Tacticals did make more telephone calls in the MSP configuration.

The situational awareness of the Multi-Sector Planner was repeatedly reported to be adversely affected by not being able to monitor both R/T frequencies, yet was scored as 'acceptable' in those runs deemed to have appropriate traffic levels for the 1P-2T configuration. All situational awareness scores for the Tactical fell within acceptable limits, regardless of the Tactical having a shared Planner or a dedicated Planner.

Workload

Comparison of Multi-Sector Planner with Bandboxed Planner

If the workload of a Tactical in a bandboxed sector is reported as 'unacceptable' this indicates that, for the traffic volume exercised, operationally the sector would have had to split. If the data for the matched run shows that the Multi-Sector Planner workload was 'acceptable', then this suggests that the traffic could be comfortably exercised as a 1P-2T configuration rather than splitting. Therefore relatively busy traffic samples were exercised for the bandboxed configuration, and as such high workload would be expected, particularly for the Tactical role.

The following section presents the analysis of the workload metrics for the Tactical and Planner roles for matched pairs of runs in a 1P-2T and 1P-1T (bandboxed) configuration. (See Appendix B for a description of the ISA and Bedford measures of workload.)

In order to provide context to the appropriateness of the traffic volumes exercised (i.e. that the bandboxed sectors would have had to split at some point in the run), the median and peak ISA scores for the Tactical role in both the 1P-2T and 1P-1T (bandboxed) configurations were examined (see Appendix H, A.2.2).

The participants subjectively reported that, with the exception of two of the matched pairs, the bandboxed sector would have had to split at some point in the run as the Tactical was too busy. This is borne out in the analysis of the ISA scores, with the Tactical in the bandboxed sector recording a peak ISA of at least '4' for five of the eight matched pairs. Note that where the participants subjectively reported that workload was manageable for the bandboxed Planner, it is of limited value to make a comparison of the MSP. Analysis of the Bedford Workload scores for the Tactical role yielded similar results (see Appendix H, A.2.3).

In each case the Planner has to manage the same flight set, and as such have comparative tasks. However, the Planner in the 1P-2T configuration has to consider and set the internal boundary level between the two tactical sectors, has two Tacticals with which to communicate (and hence two R/T frequencies to contend with), but has the enhanced Planner tools. Although the Planner of the bandboxed sector need only communicate with a single Tactical, they only have the NERC Planner tools. If the workload of the Planner in the 1P-2T configuration is considered manageable at the same level considered by the bandboxed Tactical to necessitate the sectors to be split, this would be an appropriate period to exercise the Multi-Sector Planner concept.

Figure 40 shows the difference in the median ISA scores of the MSP compared to the Planner in the 1P-1T bandboxed configuration.

Despite these additional tasks and the inability to monitor both frequencies, Figure 40 shows that there was very little difference in the average ISA scores between the MSP and bandboxed Planner, with the MSP recording the same or lower (up to one ISA score lower) average workload than that of the comparative bandboxed Planner for all but one matched pair of runs, where the MSP recorded a median of one ISA score higher.

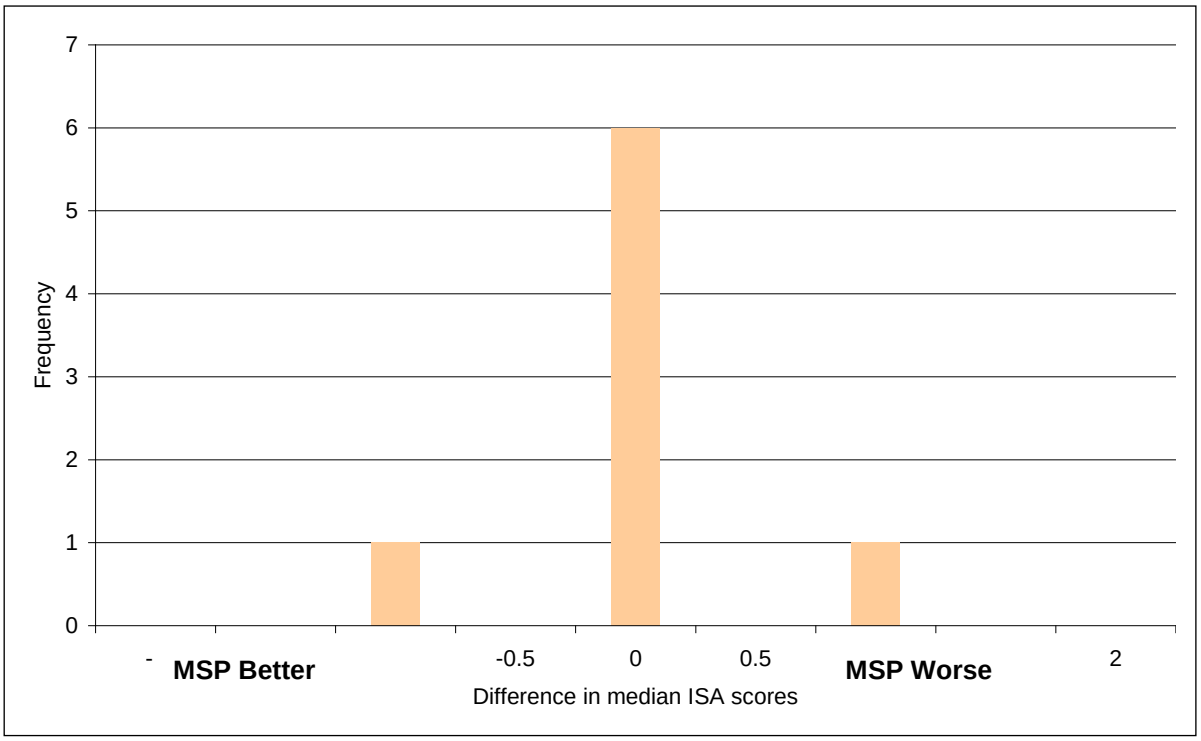


Figure 40 Difference in Median ISA Scores (to Bandboxed Planner)

In considering the workload 'peaks', Figure 41 presents the difference in the number of ISA scores of 4 or 5 recorded for the eight matched pairs for the MSP compared to the bandboxed Planner. Analysis shows that there was little difference in 'high/very high' ISA scores, with no more than three more ISA 4 or 5s recorded during a run for the MSP than for the Bandboxed Planner, and in fact there were one matched pair where the MSP recorded eight fewer ISA 4s or 5s than the equivalent bandboxed Planner. Note that for those matches where a higher workload was recorded for the MSP, the data was either gathered during the first day of measured runs when the MSPs reported that they were still getting used to the system, or the MSP reported that there were significant system problems affecting their performance.

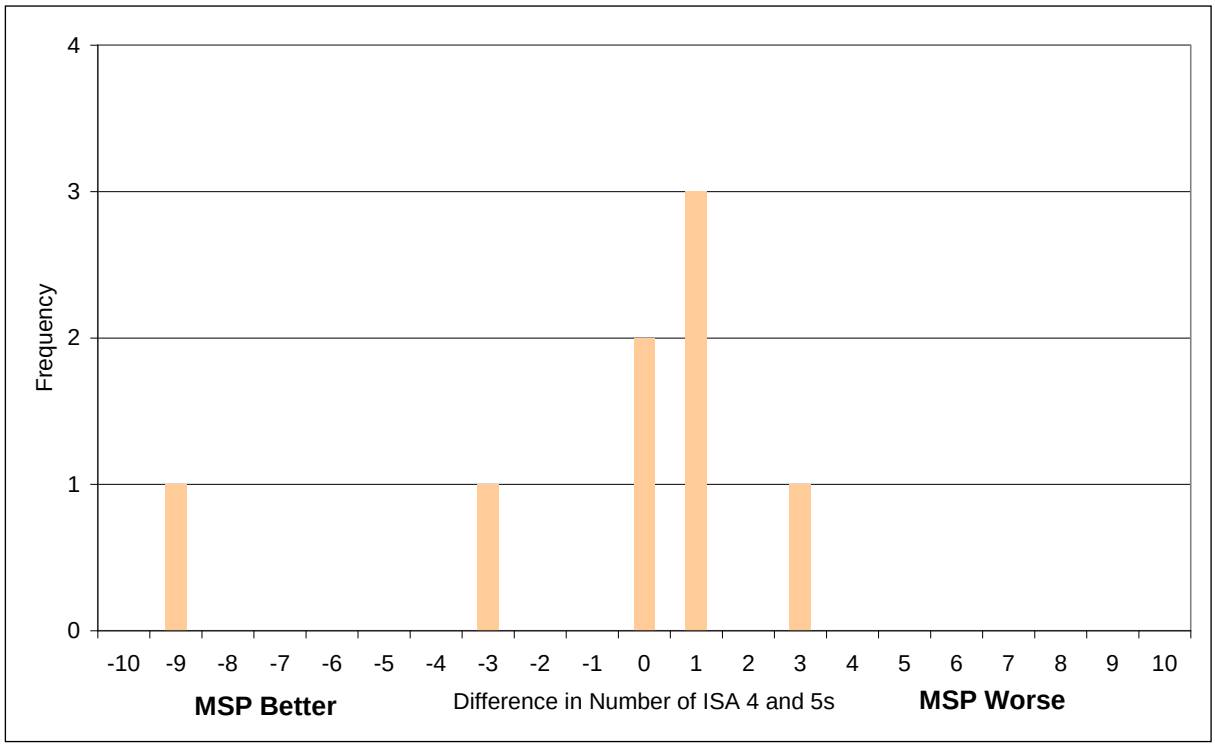


Figure 41 Difference in High/Very High ISA (to Bandboxed Planner)

The data for individual matched pairs of runs is presented in Appendix H (A.3.2). Analysis of the Bedford 'average' and 'peak' workload scores for the Planner is also shown in Appendix H (A.3.4) and yielded similar results.

For three of the matched pairs where the bandboxed Planner and/or Tactical subjectively reported that the sectors would have had to have been split in operations, in the corresponding run, the MSPs subjectively reported that their workload was acceptable. The 'interval ISA' scores of these three matched pairs are presented in Appendix H (A.3.5.)

Comparison of Multi-Sector Planner with 'Split' Planners

When examining the workload of two Tacticals in a split configuration, ideally the workload in the run should be high enough to justify that the sector is split (tactically) rather than being bandboxed. If in the corresponding runs the MSP can cope with these levels of traffic at acceptable workload levels (with the MSP tacticals still reporting acceptable/same workload), then this would suggest that the MSP configuration is viable here.

In order to ensure that the two Tacticals in the split configuration remained sufficiently occupied for the duration of the run, the traffic samples were fairly busy, but not so busy as to necessarily require a second Planner. A consistently low level of Tactical workload would indicate that the Tacticals were not being fully utilised and could have been bandboxed.

Analysis of the ISA scores of the Tactical (Appendix H, A.4.2) showed that the workload of the Tacticals with a dedicated Planner is similar (and in most cases the same) as that of the Tacticals with a MSP. Further, although the median ISA of the Tactical did not exceed 'comfortable' workload, the participants subjectively reported that, with the exception of two matched pairs, all runs required two Tacticals. For the other two matched pairs, the participants suggested that the sectors could have been bandboxed for much of the run, but would have required a split towards the end as a result of Tactical workload. However the 'peak' ISA of the matched Tacticals is higher in some cases where the Tactical has a shared Planner. This might indicate that the Multi-Sector Planner is starting to get behind on tasks.

Analysis of the Bedford 'average' and 'peak' workload scores respectively for the Tactical role are shown in Appendix H (A.4.3), and show similar results to the ISA metric.

Figure 42 shows the difference in the median ISA scores of the MSP compared to the Planner with the higher workload in the 1P-1T split configuration (as with the analysis of difference in user acceptance scores for the split configuration, this may be a different participant, though the data for individual matched pairs of runs is presented in Appendix H (A.4.4)).

Bearing in mind that the workload of the MSP is being compared to the workload of two Planners, the analysis shows that during four of the matched runs, the MSP did not score (median) workload any higher than that of the busier of the two Planners. Additionally, on five of the matched runs the MSP rated the median workload as only one ISA score higher than that of the busier of the two Planners.

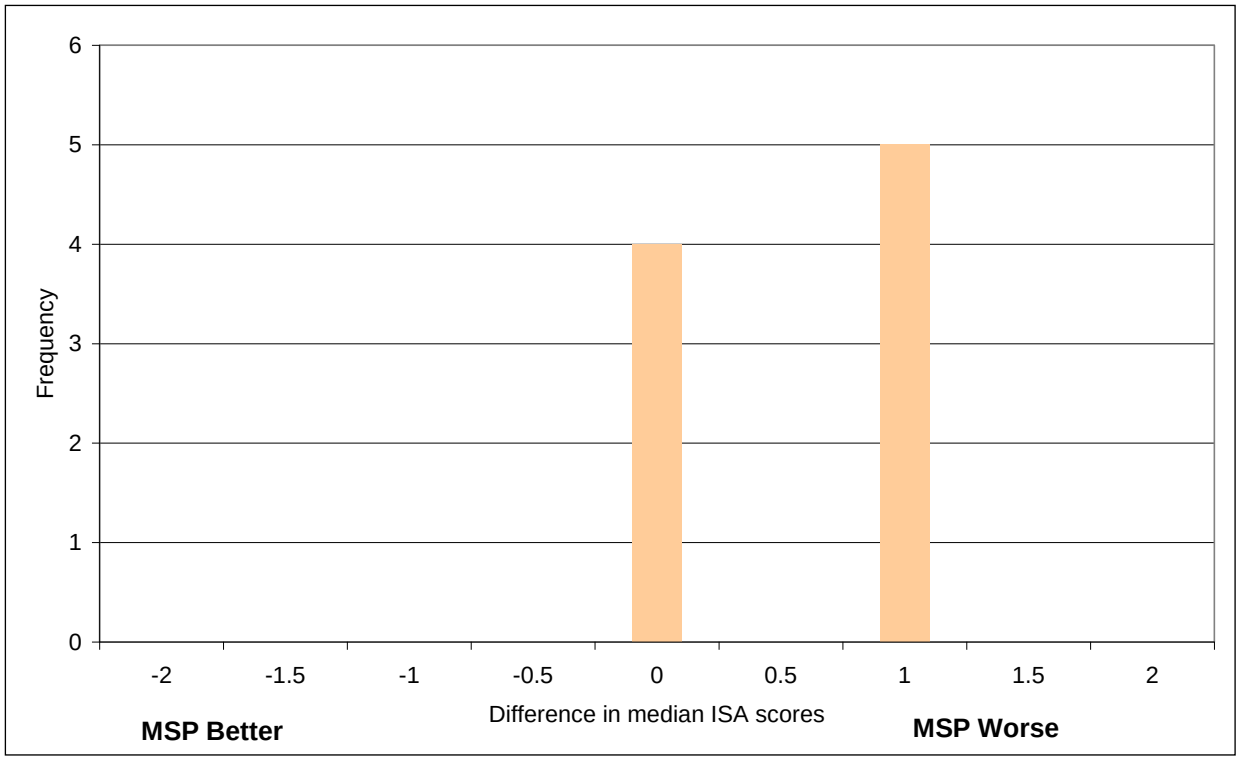


Figure 42 Difference in Median ISA Scores (to Split Planner)

In considering the workload 'peaks', Figure 43 presents the difference in the number of ISA scores of 4 or 5 recorded for the nine matched pairs for the MSP compared to the (busier of the) split Planners.

Analysis shows that there were more occasions where the MSP recorded an ISA score of 4 or 5s during a run than for the (busier of the two) split Planners; in one run, nine more ISA 4 or 5s were recorded for the MSP. For all the exercises where the workload of the Planner was greater in the 1P-2T configuration, the participants had no previous experience of the iMSP concept (and in some cases this run was their first exposure of the MSP role in this activity) and as such reported that the traffic levels were too high for an MSP. However, the Tacticals on all but the busiest of these runs did not report that their workload was unmanageable.

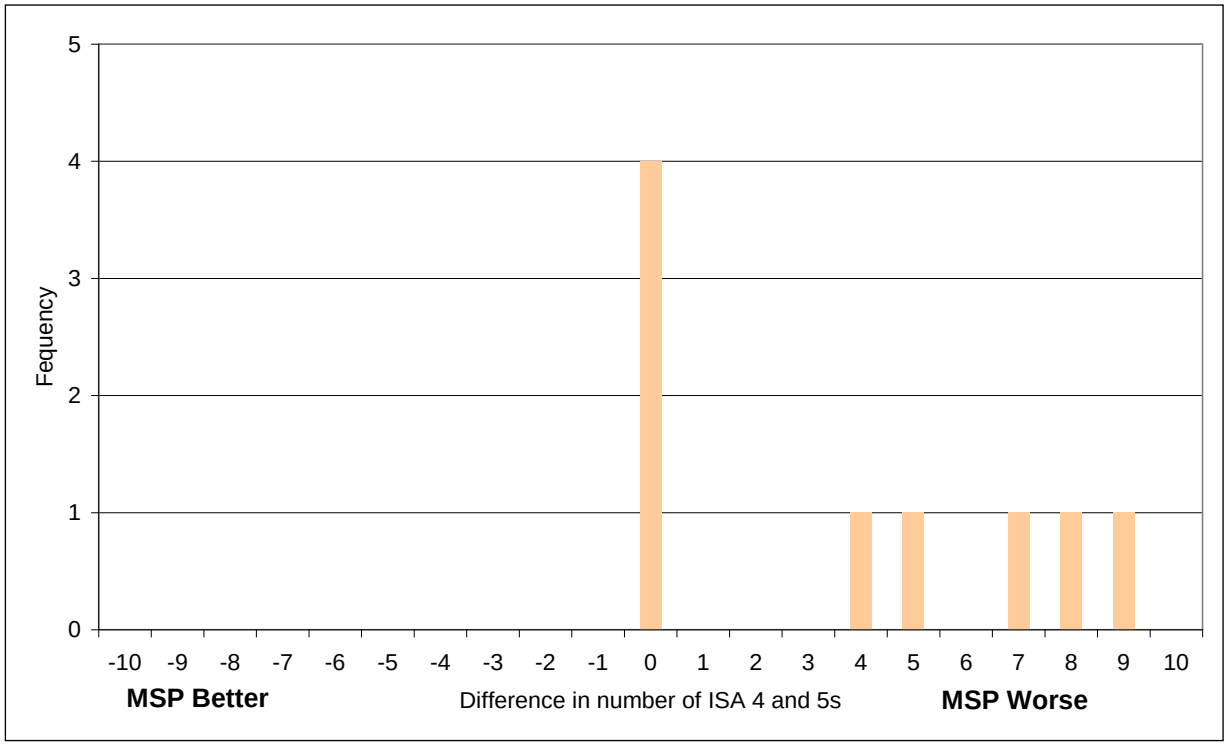


Figure 43 Difference in High/Very High ISA (to Split Planner)

Analysis of the Bedford workload metric is shown in Appendix H (A.4.5) and yielded similar results to the ISA metric.

The interval ISA scores for the four runs (and associated matched runs) where the participants subjectively reported that the 1P-2T configuration was appropriate are shown in Appendix H, A.4.6. The analysis shows that the Planners of the 'split' sector for the most part recorded 'low' or 'comfortable' workload over the duration of the run (even though the Tacticals reported that they were too busy to bandbox). However, in the comparative runs, the MSPs still recorded a steady and 'comfortable' level of workload.

In the end of run questionnaires, the Multi-Sector Planners reported that, in general, core ATC tasks were the major contributor to their workload, although in many cases lack of familiarity with the tools and system bugs/simulation errors were also reported to be contributing factors.

Situational Awareness

Figure 44 show the difference in the China Lakes Situational Awareness scores for the Planner in both a 1P-2T and 1P-1T (bandboxed) configuration. The charts show that there is much variation in the difference in scores, however, the analysis showed that for two of the three runs where the participants subjectively reported appropriate application of the 1P-2T configuration the situational awareness of the MSP was rated better than that of the bandboxed Planner (and on all three occasions the user acceptance was also rated as 'acceptable and satisfactory').

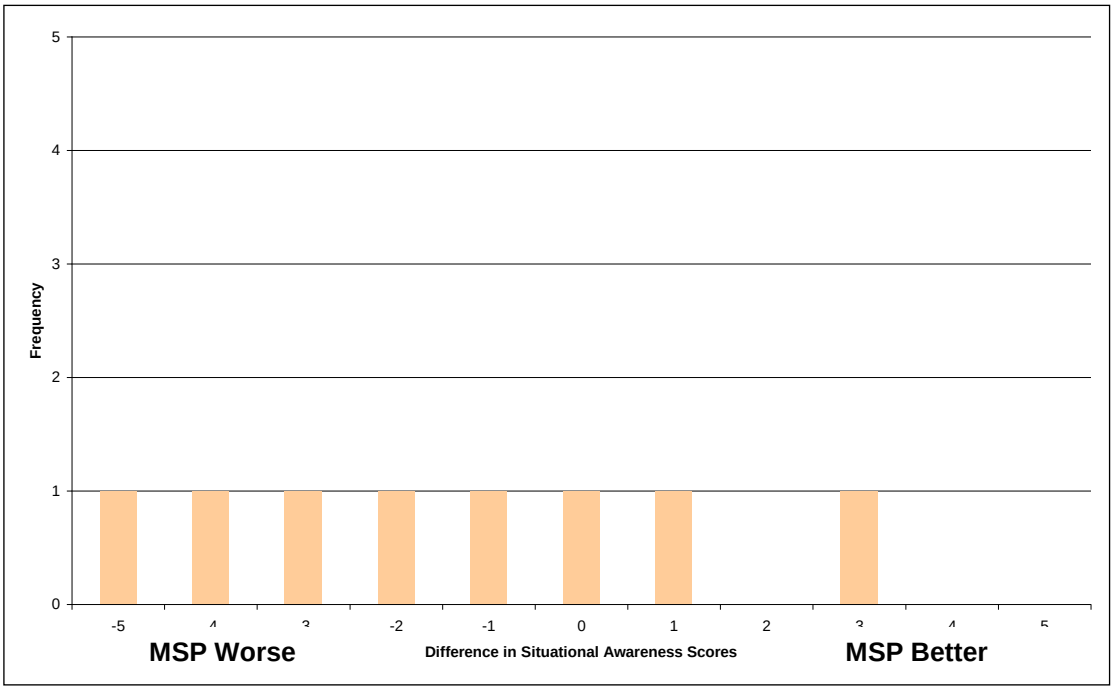


Figure 44 Difference in Situational Awareness (MSP compared to Bandboxed Planner)

The data for Planner and Tactical roles for individual matched pairs of runs is presented in Appendix H, A.4.7). The situational awareness for the MSP only scored above '4' on the scale for those participants without prior experience of the concept. This suggests that the situational awareness of the Multi-Sector Planner could increase to acceptable limits with further exposure. There was however a view that this would be more difficult in an operational environment. *'In reality there are more variables the Planner needs to be aware of than in the simulation.'*

Figure 45 show the difference in the China Lakes Situational Awareness scores for the MSP compared to the Planner with the better situational awareness in the 1P-1T (split) configuration (as with comparisons of other metrics for the split configuration, this may be a different participant).

Bearing in mind that the situational awareness of the MSP is being compared the situational awareness of two Planners covering the same sector, on four of the nine matched run there was a little or no difference in the situational awareness scores of the Planner in the 1P-2T configuration compared to that of the two Planners in the 1P-1T (split) configuration, with the SA of the MSP rated as 'acceptable and satisfactory' on three of these occasions.

On those occasions where the situational awareness of the MSP fell well short of the Planners in the split configuration, the participants had no prior experience of the iMSP concept and as such subjectively reported that the MSP role would have had to be 'split'.

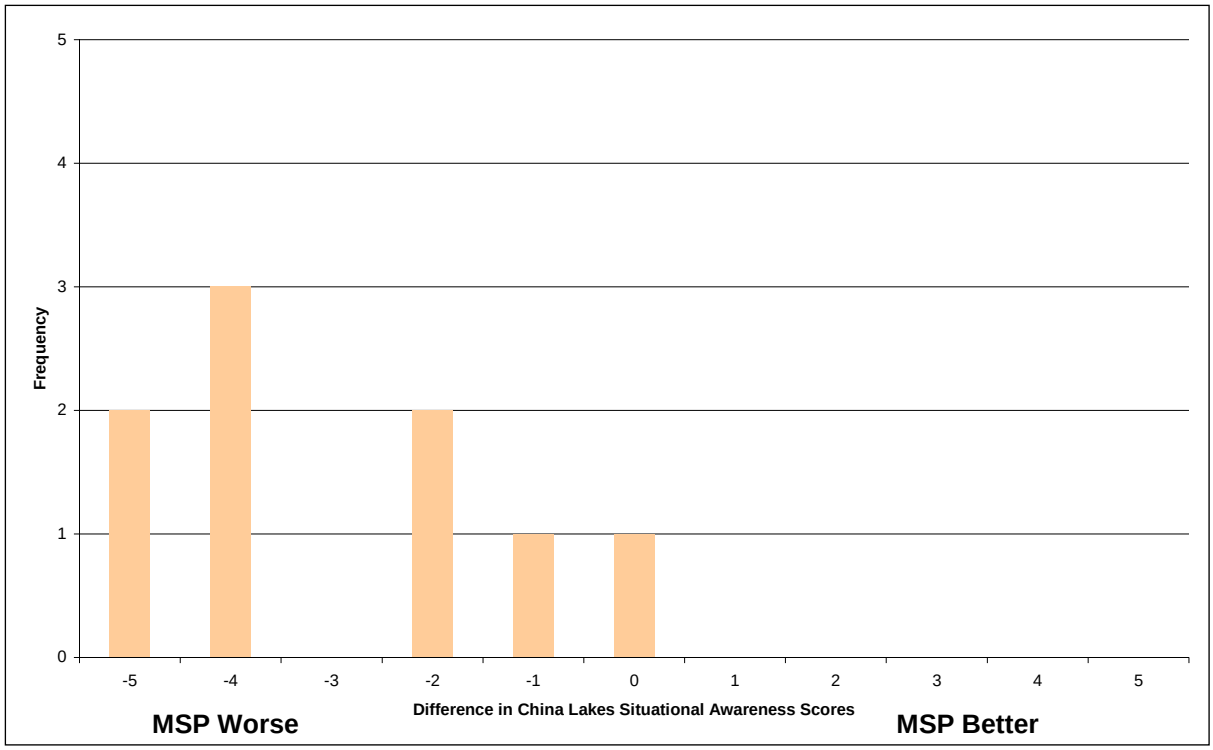


Figure 45 Situational Awareness (MSP compared to Split Planner)

Subjectively, the participants repeatedly reported that only being able to monitor the R/T for one of their Tacticals was considered to be a significant factor in reducing Planner situational awareness. *'Only monitoring one frequency had an impact on situational awareness, sometimes situations were developing within the sectors and unaware of their immediate needs. Coordination was generally timely, although trying to tie in the picture of both sectors was not always there; this needed the Tacticals to prompt'.* One participant commented that to overcome this, Planners will have to change their scan.

Planning Times

The impact of the 1P-2T concept and enhanced Planner tools on planning times can be examined to give an indication of the relative support provided by the tools. As previously, 'reaction time' is the difference in the time at which a particular aircraft is offered from the upstream sector and the time where that aircraft is accepted, rejected or a counter offer is made by the receiving sector.

The median 'reaction' time was similar for the comparison of MSP with the bandboxed Planner. Comparing the MSP with the Planner in a split configuration, there was little difference the median 'reaction time' for DTY and LKS, but a much greater difference in the median for the NSEA sectors.

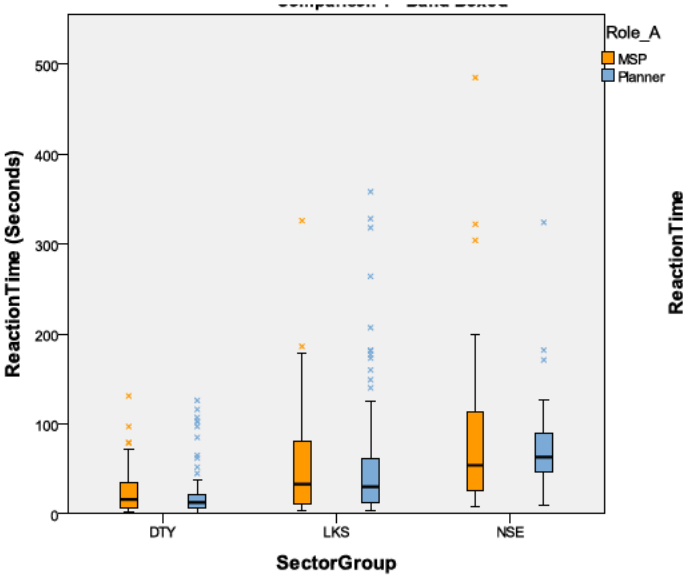


Figure 46 Reaction Time (Bandboxed)

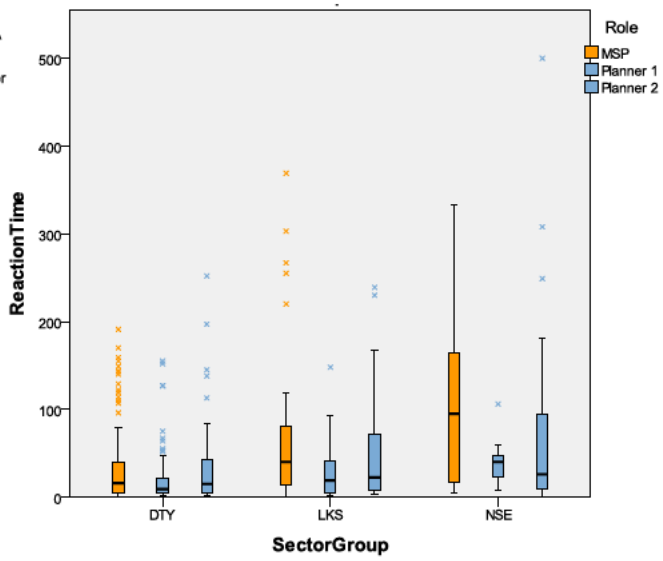


Figure 47 Reaction Time (Split)

The participants' subjective view however was that *'the enhanced tools did allow me additional capacity, as they enabled me to coordinate traffic into the sector quicker'*.

Telephone Use

As a Planner, making telephone calls is an important way of mitigating sector workload for a Tactical. Often Planners are able to anticipate the needs of their Tactical and will make telephone calls requesting releases before the Tactical needs to ask the Planner to do so, or before the Tactical makes the call.

Observations of telephone use showed a difference between individual controllers. Some controllers were very proactive and made many calls on behalf of their Tactical, negotiating releases and revising levels to provide the best service for each flight. Other controllers focussed solely on ensuring that coordinated levels in and out of the sector were safe, only making calls when prompted by their Tactical.

The workload of the Planner and the number of telephone calls (both sent and received) are closely linked. When the Planner's workload is low they are able to proactively assist their Tacticals (making calls is an indicator of this). However when the Planner is forced to make (or answer) calls, perhaps interrupting other tasks, then their workload increases.

Analysis of telephone calls is shown in Appendix H, A.4.8. On most occasions, the number of telephone calls made by the Planner in a 1P-2T configuration was similar to (or higher than) that of the bandboxed Planner, suggesting that the MSP was making all the necessary phone calls.

The subjective feedback suggests that frequently the Multi-Sector Planner found it difficult to proactively mitigate workload for both Tacticals. As one participant commented, '*when it was very busy I didn't give the Tacticals the attention they required, so on occasions I didn't reduce their workload by making phone calls on their behalf*'.

This was a common view. Other participants stated: *'The* [Planner] *awareness of the workload of both Tacticals is reduced in this configuration* [1P-2T]. *You can realistically monitor only one frequency. During quiet times you can monitor workload and be proactive but during busier times the proactive part takes a back seat and this can increase the Tacticals' workload'. 'Most decisions were made based on planning in and out….any tactical late coordination was not picked up all the time'*. The Tacticals did on more occasions record higher 'peak' workload in the 1P-2T configuration than in a 1P-1T (split) configuration (see Appendix H, Figure 106).

The Tacticals reported that when in a 1P-2T configuration, at times the Planner was too busy to make phone calls and therefore it became a necessity for Tacticals to implement their own telephone calls. '*As a Tactical some calls were made that a Planner would normally have done. This was because I*

felt at times the Planner did not have the capacity to do it. Tacticals communicated a lot more between themselves as the Planner had enough to do'.

There was also sometimes a feeling of 'obligation' for the Tacticals to make their own telephone calls, which was exacerbated by the seating arrangement. *'If you were the Tactical in the quieter seat then you felt you should affect some of the coordination yourself.' 'Tacticals sitting away from the Planner are more likely to take on co-ordination tasks themselves. This is because of a reluctance to use the phone due to the time it takes and also not wanting to shout past the other Tactical.'*

4.2.1.7 Safety of Multi-Sector Planner Concept

OBJ-04.07.08-VALP-0304.0003 To assess the impact of the MSP concept under assessment on level of safety in appropriate traffic conditions

In Summary, at appropriate traffic levels the situational awareness of the Multi-Sector Planner was acceptable; however, the participants' perception was that having only a single controller monitoring the R/T would have a detrimental impact on safety.

Situational Awareness

Analysis of the China Lakes Situational Awareness scores is presented in 4.2.1.6, and shows that SA was scored 'acceptable' in those runs deemed to have appropriate traffic levels for the 1P-2T configuration, even though the participants repeatedly reported that SA was greatly affected by the not being able to monitor both R/T frequencies. All SA scores for the Tactical fell within acceptable limits, regardless of the Tactical having a shared Planner or a dedicated Planner.

Safety

The most significant concern of the participants regarding the 1P-2T configuration was that only a single controller was monitoring the R/T. It was recognised that in parts of NATS' operations this is standard practice (LACC TMA and Approach, and Scottish operations) however the participants considered that in LACC En Route the airspace is less procedural and less predictable, and as such it is easier to miss an incorrect readback. They consider that the support from the Planner in this respect is essential to the safety of the system (as well as supporting the Tactical by pre-empting situations by monitoring the R/T), although it was highlighted to them that monitoring tools can provide additional support to controllers. However, there were no 'risk bearing' losses of separation recorded.

One participant summarised the collective view particularly well, *'multi-sector planning is a nice idea, but after trying over the last two weeks to listen to two frequencies at the same time I can see no way this can be implemented without safety being seriously compromised. Any aircraft calling 'mayday' could be completely missed by an MSP and therefore Tactical is left to sink by themselves. Also incorrect readbacks will NOT be picked up by the Planner'.*

Another participant's comment elaborates on this. *'The issue of an MSP trying to listen to two sectors R/T is an issue that I am not sure can be resolved without an impact on the Swanwick safety case. Over the development of Swanwick the Planner role has changed to become more active and assist the Tactical. This is part of the reason that Swanwick Area Control has such a good safety record. Changing this current process can only have a negative impact on this.'*

4.2.1.8 Acceptability of Single Person Operations

OBJ-04.07.08-VALP-0304.0007 To assess the operational acceptability of the SPO concept

In Summary, the results indicate that the SPO concept with the enhanced Planner tools would be acceptable given an appropriate level of traffic. Even though traffic levels for the activity were necessarily designed to undertake an evaluation of the 1P-2T concept (and were therefore far in excess of that which would be anticipated for Single Person Operations) the user acceptance rated well, and workload rated at worst 'tolerable' for 'non-matched' exercises. However, the concept of Integrated Coordination, Dynamic EFS, and the ability to effect coordination from the Tactical Instruction Palette were considered by the majority of participants to be essential to SPO operations.

CARS User Acceptance

Although this concept is still in the early stages of development, quantitative data was gathered as part of the activity to provide an initial insight to the concept, and this data could be matched with data from the same runs completed in a 1P-1T configuration.

SPO is proposed as a staffing configuration to be used when traffic levels are low, however feedback from the participants during the SPO runs of the 'matched' runs suggested that the traffic levels were far in excess of that which would be acceptable; in fact the traffic levels had been designed to stretch the 1P-1T staffing.

Figure 48 shows the difference in the CARS User Acceptance scores between the SPO (with enhanced Planner tools and Integrated Coordination and the scores for the Planner and Tactical in the matched run (matched runs included LKS and DTY only). Interestingly, the participants mostly (on all but one occasion) rated the user acceptance of the concept as no worse than that of the current 1P-1T arrangement; aside from the fact that the traffic levels being exercised were too high; the reason why on three occasions the SPO role was recorded as not acceptable.

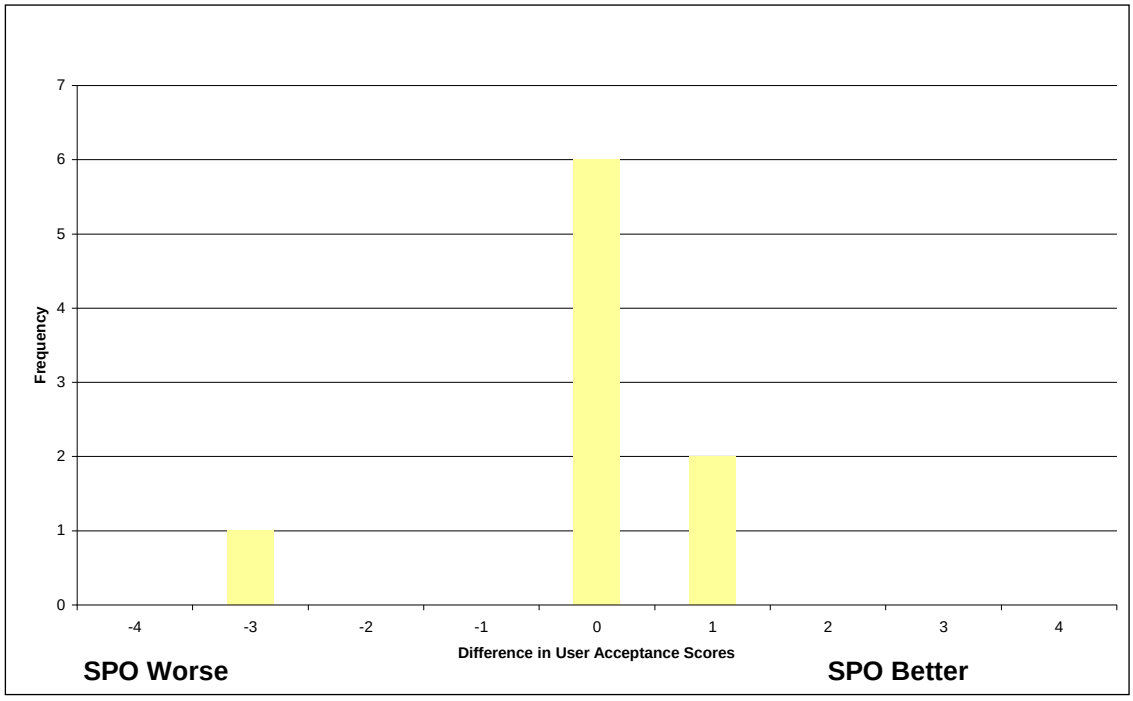


Figure 48 Difference in User Acceptance (matched runs)

The data for individual matched pairs of runs is presented in Appendix H (A.5.2).

The participants' user acceptance of the SPO concept was also measured during other 'non-matched' runs (and included NSEA sector), during which the traffic levels were lower though still above those anticipated for the SPO concept (see Appendix H, A.5.1). When data from these runs is considered (Figure 49), the user acceptance of the SPO concept was mostly rated as 'acceptable' (i.e. below '3').

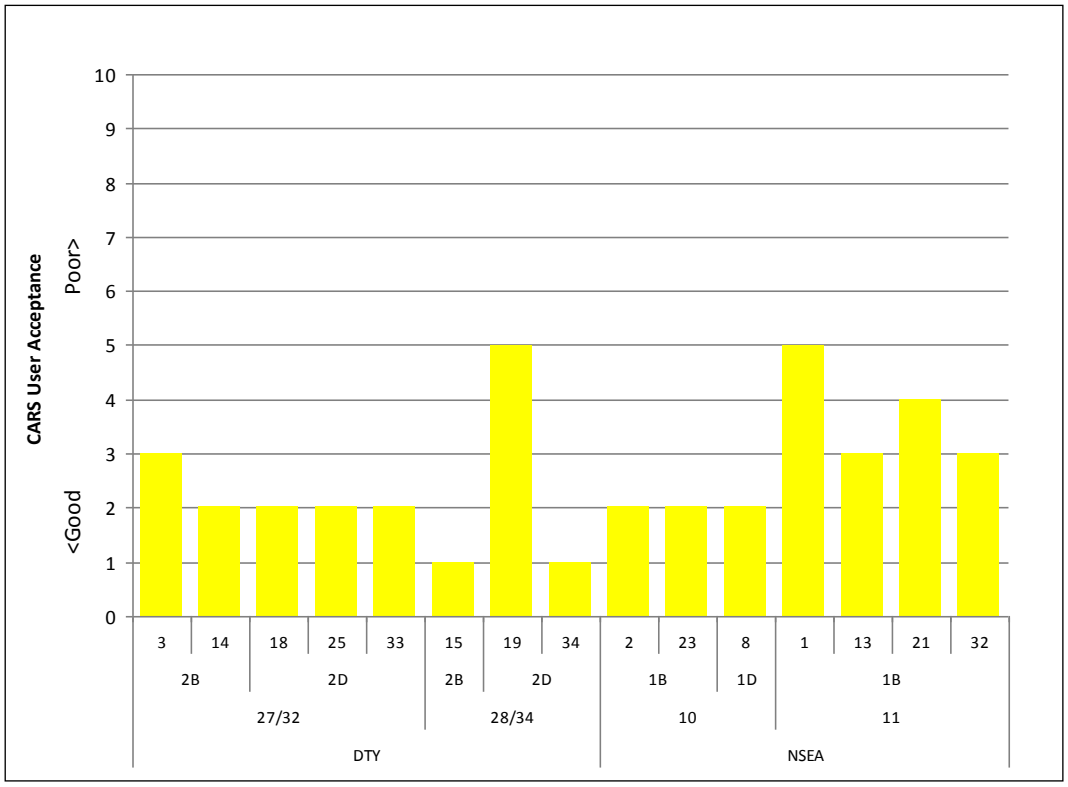


Figure 49 User Acceptance (non-matched runs)

Roles and Responsibilities

The chart below presents the participants rating of 'Planner' task performance for SPO with enhance tools compared to the 1P-1T configuration with NERC Planner tools.

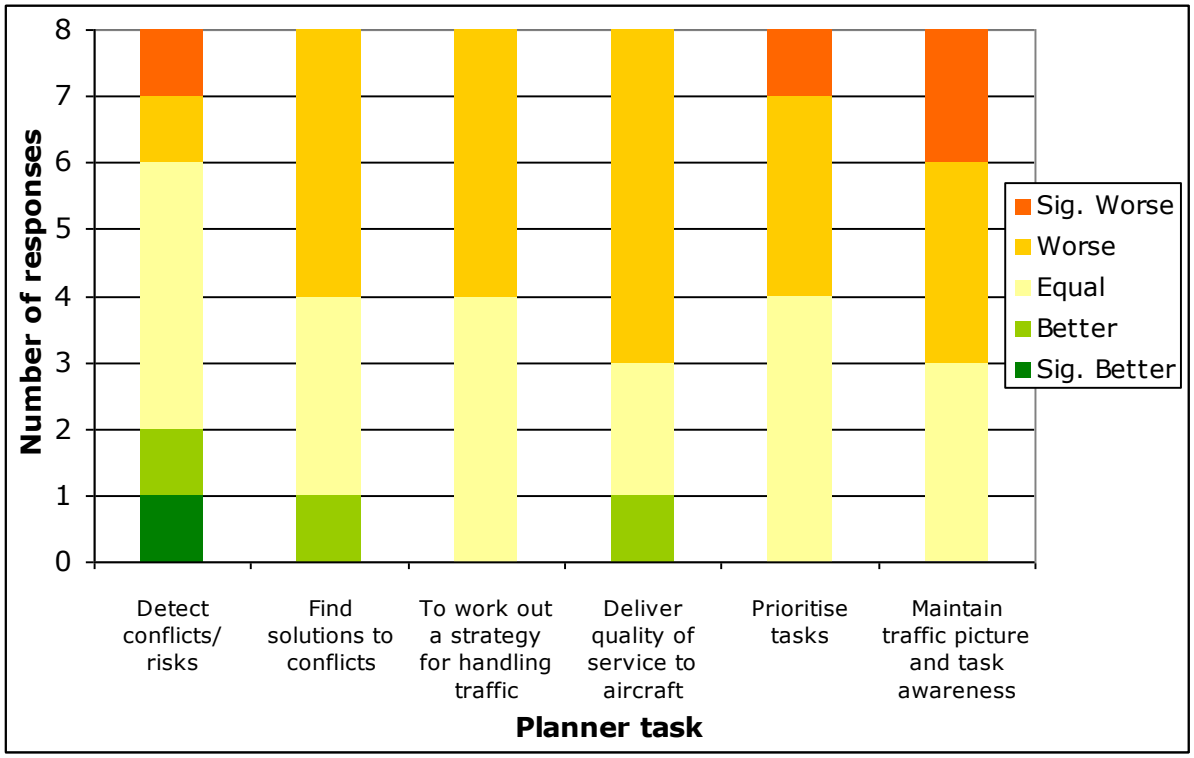


Figure 50 'Planner' Task Performance Rating

In many cases, task performance as SPO fell below that of 1P-1T. Although the traffic volumes in many of the runs exceeded the level deemed appropriate to SPO, some of the issues raise are still relevant to lower traffic levels, in particular juggling the Planner and Tactical tasks. *'Last minute revisions were difficult if there were R/T calls at the same time'*, and conversely planning tasks, should there be a conflict to resolve in an offer, distracted from the R/T.

Tactical clearances were prioritised over planning tasks, which were on occasion postponed for a not insignificant period of time, and phone calls had to be ignored due to R/T.

One participant reported rating task awareness as worse because co-ordinations were made when the R/T was quiet, not at a time that was appropriate. *'As an SPO you are spending the majority of your time concentrating on the tactical tasks as a result of this the pre-planning in the sector does not take place as efficiently, thus making the tactical tasks slightly harder (snowball effect)'.* Further, Planner tasks that took the SPO away from the radar, such as typing with their head down to enter coordination conditions, were considered to have a detrimental impact on situation awareness.

One of the participants summarised the consensus view well: *'The tools allow quick planning decisions to be made, assuming you trust the tools completely which lets you concentrate on the tactical task. I think the problem will be when a planning task takes a prolonged amount of time which will then cause the you to fall behind with the tactical task'.*

Subjectively many of the participants regarded the ability to affect coordination from the Instruction Palette as essential, as using the EFS would draw their attention away from the Tactical task. *'Couldn't have done it without TDL COORD mode and NFL/XFL editing'.* However, as previously reported, there were occasions were observed where aircraft were incommed by mistake. *'If we are to use the TDLs more for coordinations then the interface with them needs to be improved'.* Other participants reported a preference for keeping the Planner and Tactical task separate, and used the EFS for all the Planner tasks.

Figure 51 provide a summary of the participants' ratings (from the questionnaires) of the usefulness of the Planner tools in the SPO environment. The Dynamic EFS auto-drop function and Coordination Interaction Vectors were considered the most useful tools to the SPO operations. The Instruction Palette coordination functions and Integrated Coordination were also all highly rated.

Indeed, seven of the eight participants considered that the coordination interaction vector would be essential to SPO operations. The participants also rated other elements of the enhanced toolset as essential to the SPO operations, particularly the Dynamic EFS auto-drop/auto-recover functionality and Integrated Coordination.

A summary of the subjective feedback regarding each of the tools specific to the SPO environment is given below; see also 4.2.1.1 for SPO feedback on generic tools.

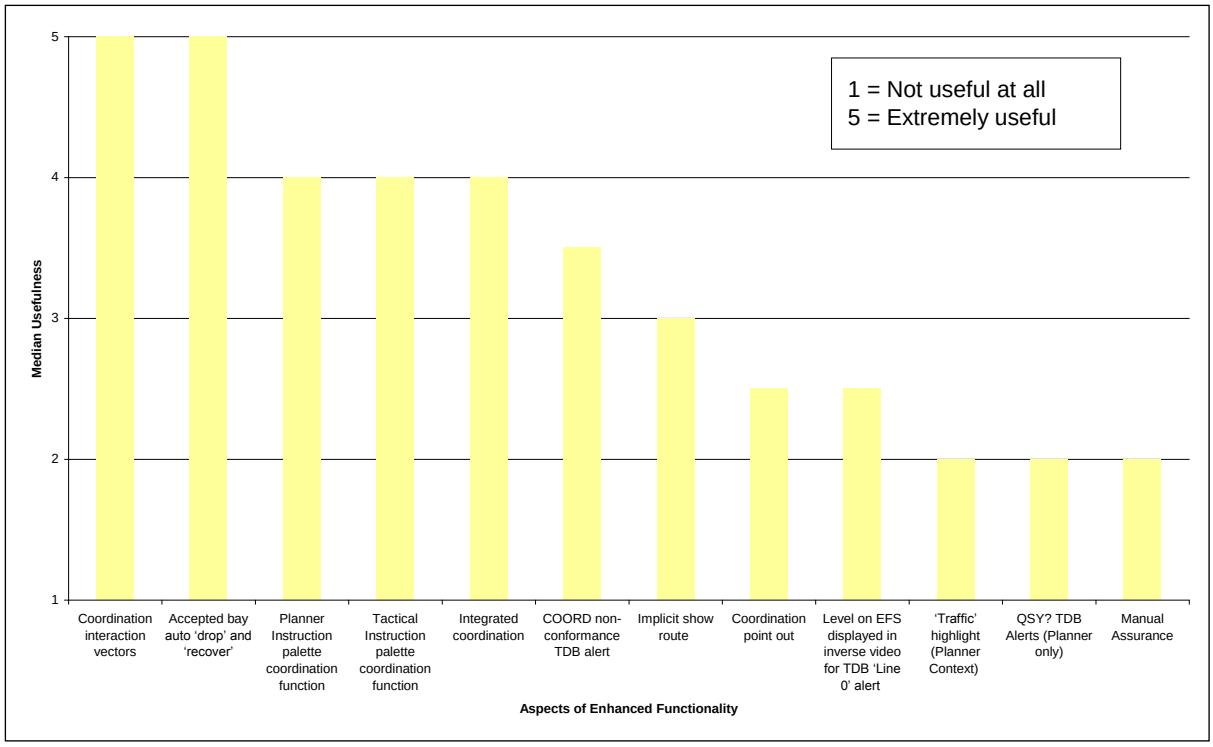


Figure 51 Tool Usefulness Scores (SPO)

On average, Integrated Coordination referred 13% of all offers in LKS, and 3% in NSEA (all other offers were automatically accepted by IC). Only 1% of offers were referred in DTY South (S27/32) compared to 6% in DTY North (S28/34).

The concept of Integrated Coordination was considered to be useful in the SPO environment by all the participants, with five of the participants rating it as essential to SPO operations. *'*[IC] *critical in my opinion, as would the* [EFS] *auto-drop feature, must minimise unnecessary workload'.* However, it was considered to have a negative impact on situational awareness. '[IC] *accepted in traffic meant not aware how this will impact workload later on'.*

The participants unanimously agreed that the implementation of IC in the simulation was acceptable for the SPO, with three participants reporting that IC 'always' referred relevant coordinations to the SPO, and four participants reported that IC 'very often' did.

Usage of the Instruction Palette coordination function by the SPO is presented in 4.2.1.1. Towards the end of the simulation activity, there were runs where the SPO did not open the Planner Accepted Bay, and executed both the Planner and Tactical functions from the Instruction Palette. This did raise some issues. As with the Planner, the SPO reported frustration at having to select the COORD checkbox to change from Tactical to Planner mode, though unlike the Planner, it is necessary for the SPO to execute both planning and tactical tasks. *'Having to click on the COORD button just slowed you down'. 'I should be able to access incomm flight's XFL without having to press COORD'.*

Concept Viability

There was a majority view that the SPO concept (with tools) could be viable, but only in very light traffic, *'specifically night shifts where traffic is low for prolonged periods, or in a [1P-2T] configuration where one sector is getting significantly busier, a quick change from MSP to 1P-1T and SPO'*. One participant considered that it would be viable only if the need for phone calls was eliminated (and only with enhanced tools).

The SPO concept was exercised without the enhanced Planner tools support on two occasions. Although this meant that only two participants had exposure to this, the participants reported a majority view that Single Person Operations without the support tools would not be viable.

Operational Benefits

The only benefit that the participants could foresee was with regards to flexible use of staff. However, the participants highlighted that a second controller would need to be in close proximity to assist during an unusual event, and as such there would be no real staff saving.

Generally the participants reported that the SPO concept would have a detrimental affect on quality of service, perceiving that at times some aircraft were not getting their requested level, which they would have got in a 1P-1T environment, though again the high levels of traffic exercised may have skewed this view.

There was also a perception that there were more occasions of the SPO having to ask pilots to repeat their transmissions.

4.2.1.9 Human Performance of SPO

OBJ-04.07.08-VALP-0304.0006 To assess the Human Performance of the SPO concept

In Summary, for the lower of the traffic levels exercised (i.e. the non-matched runs for NSEA and DTY (27/32)), generally the workload was acceptable, and the situational awareness was satisfactory.

Workload

Figure 52 shows the difference in the median ISA scores of the SPO compared to the busier of the two roles of Planner and Tactical in the 1P-1T configuration. The analysis shows that during seven of the matched runs the SPO did not rate (median) workload any higher than the Planner or Tactical in the 1P-1T configuration. On the other two matched runs, the SPO rated the median workload as only one ISA score higher than that of the Planner or Tactical.

The data for individual matched pairs of runs is presented in Appendix H (A.5.3).

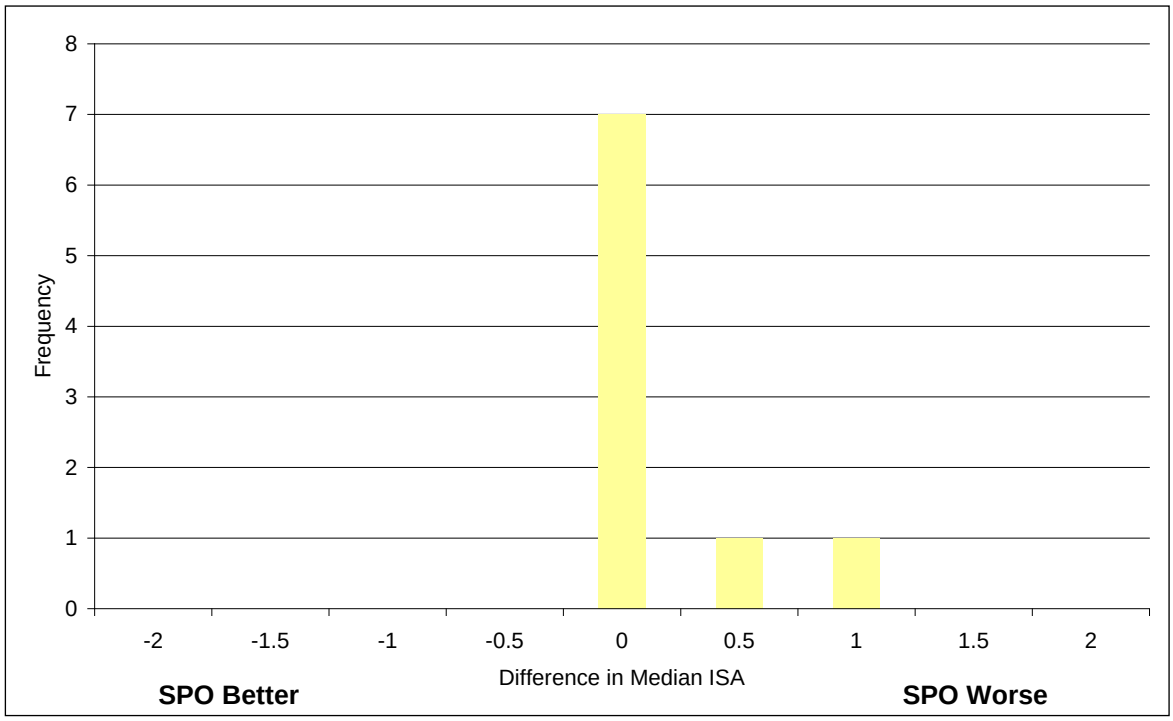


Figure 52 Difference in Median ISA Workload (matched runs)

In considering the workload 'peaks', Figure 53 presents the difference in the number of ISA scores of 4 or 5 recorded for the nine matched pairs for the SPO compared to the busier of the Planner or Tactical in the 1P-1T configuration. Analysis shows that there were more occasions where the SPO recorded an ISA score of 4 or 5 (in one run, ten more ISA 4 or 5s were recorded). This is further indication that during peak periods the workload for the matched runs was not sustainable during SPO operations.

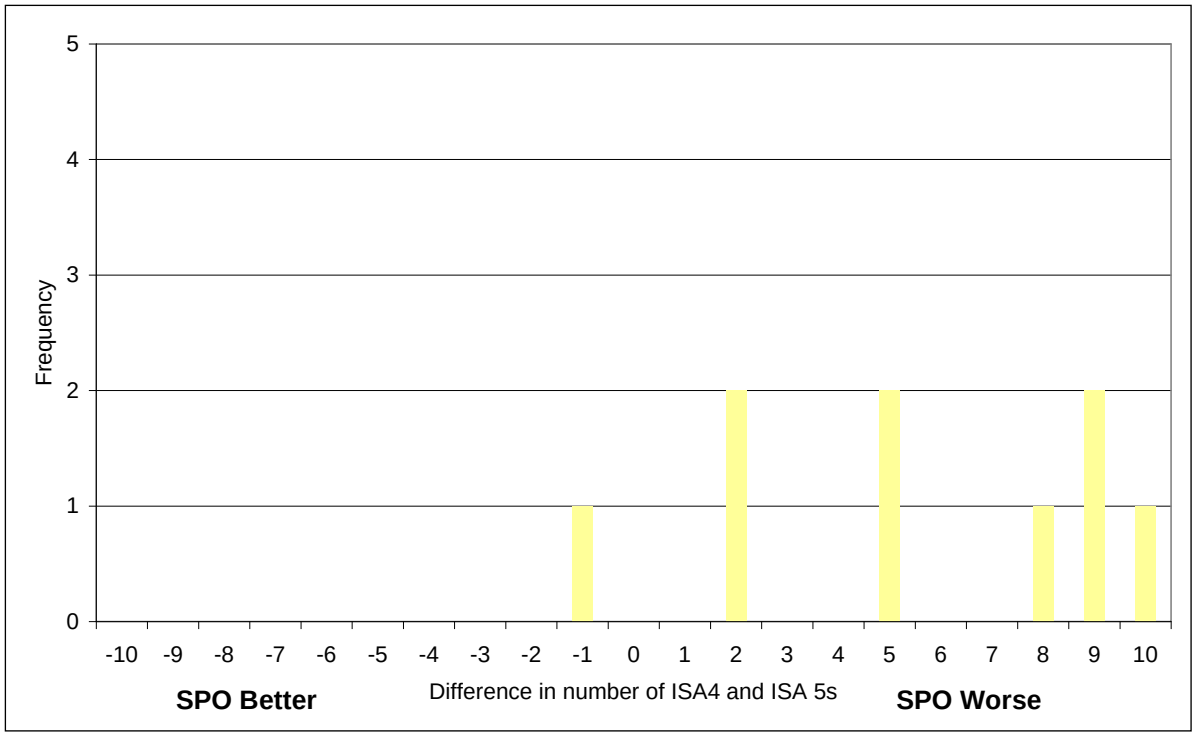


Figure 53 Difference in number of High/Very High ISA scores (matched runs)

The data for median and peak ISA scores for individual matched pairs of runs is presented in Appendix H (A.5.3).

Figure 54 and Figure 55 show the median and peak **ISA** workload scores for the **SPO** 'non-matched' runs. The charts show that the workload relating to the traffic levels exercised for the NSEA and DTY (27/32) sectors was generally acceptable to the SPO (a median ISA score of '3' and peak of '4'), with a throughput of up to 34 aircraft (over 40 minutes) being exercised.

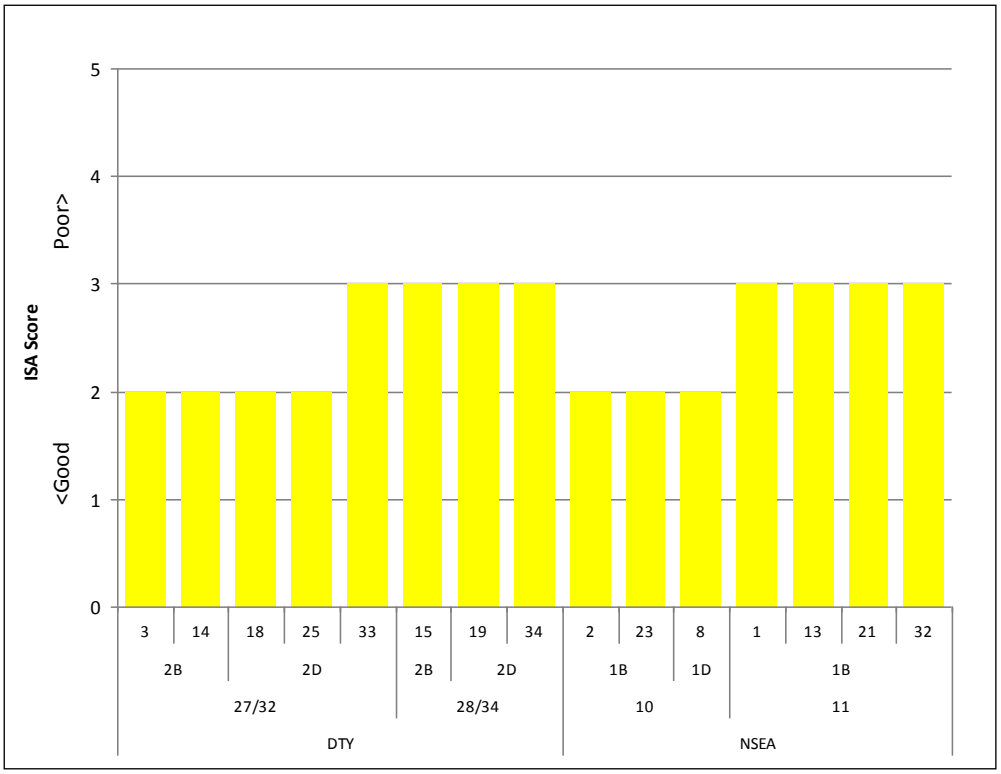


Figure 54 Median ISA (non-matched runs)

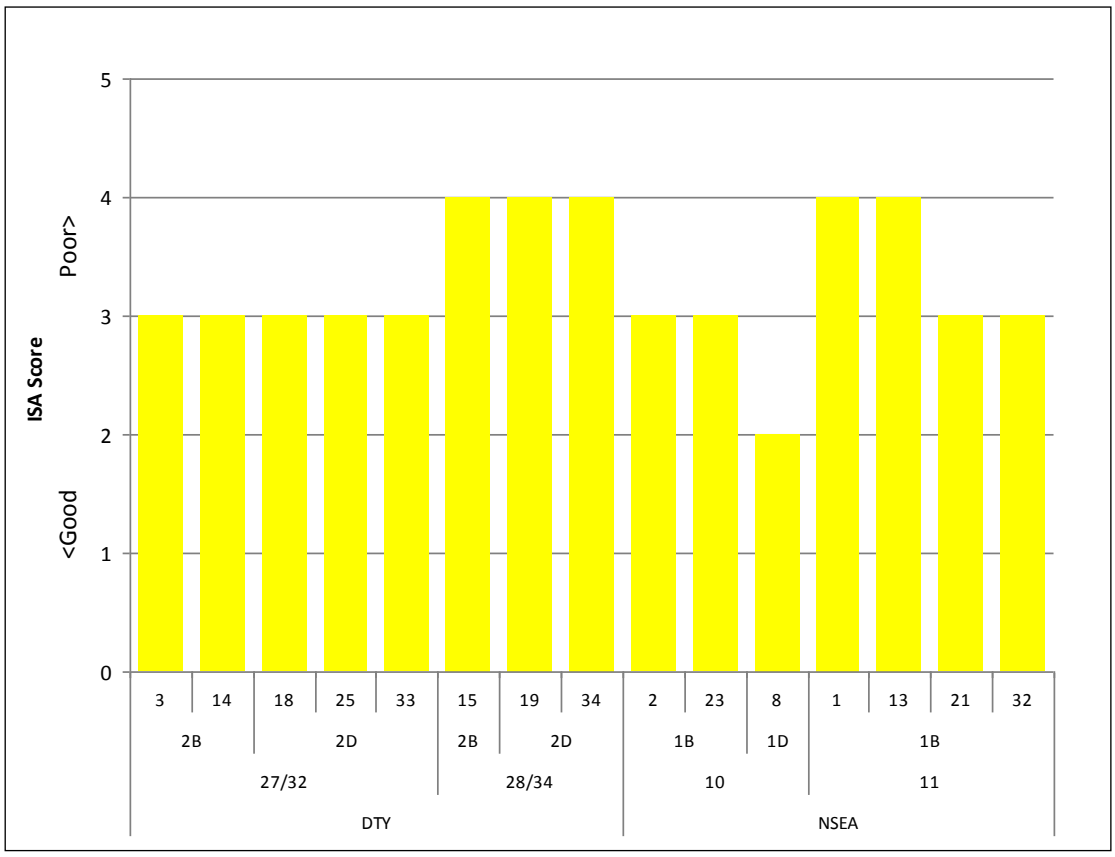


Figure 55 Peak ISA (non-matched runs)

Analysis of the Bedford workload metric is presented in Appendix H (A.5.4) and yielded similar (though more pronounced) results to the ISA metric.

Situational Awareness

Figure 56 shows the difference in the China Lakes Situational Awareness scores between the SPO and the Planner/Tactical in the 1P-1T configuration for matched pairs of exercises. Not surprisingly the situational awareness in such high traffic volumes was generally worse for the SPO, with a single controller performing the role of two controllers. (The individual situational awareness scores for each matched pair of runs is shown in Appendix H, A.5.5)

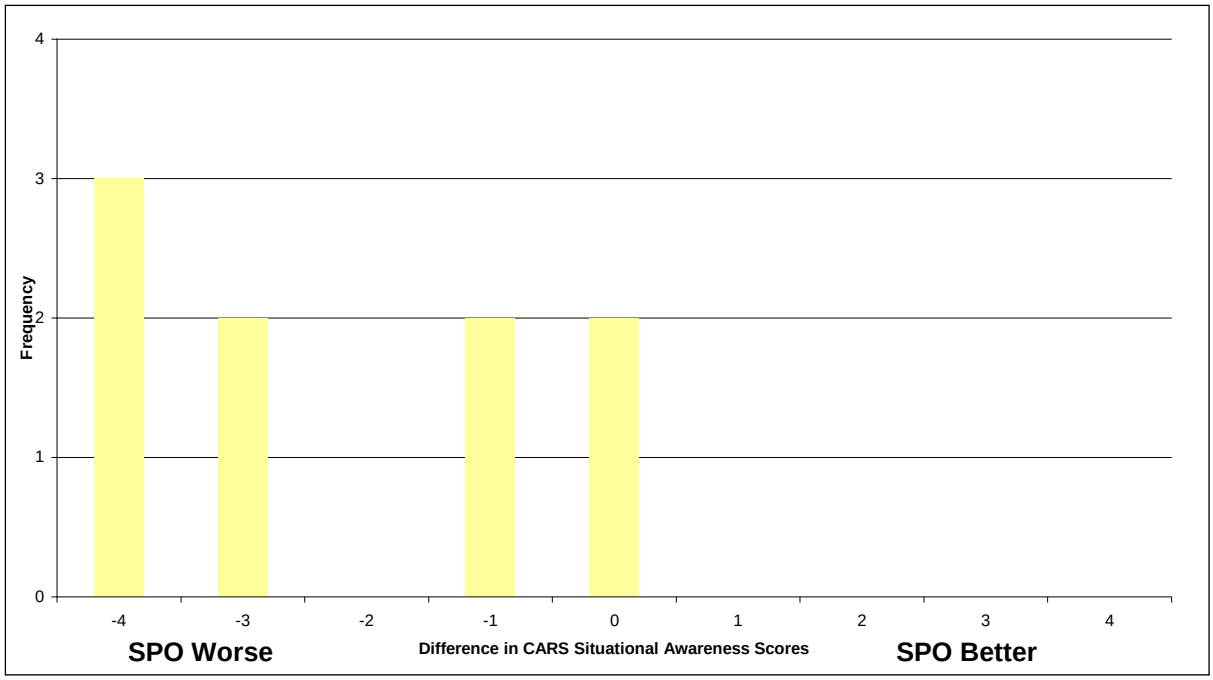


Figure 56 Difference in China Lakes Situational Awareness Scores (matched runs)

However, when considering the situational awareness scores across the 'non-matched' runs (Figure 57), the situational awareness for the SPO was rated 'acceptable and satisfactory' for DTY (S27/32), and for six of the seven runs in NSEA, even though traffic levels were still high. However one controller stated that *'auto-accept decreased my situational awareness'.*

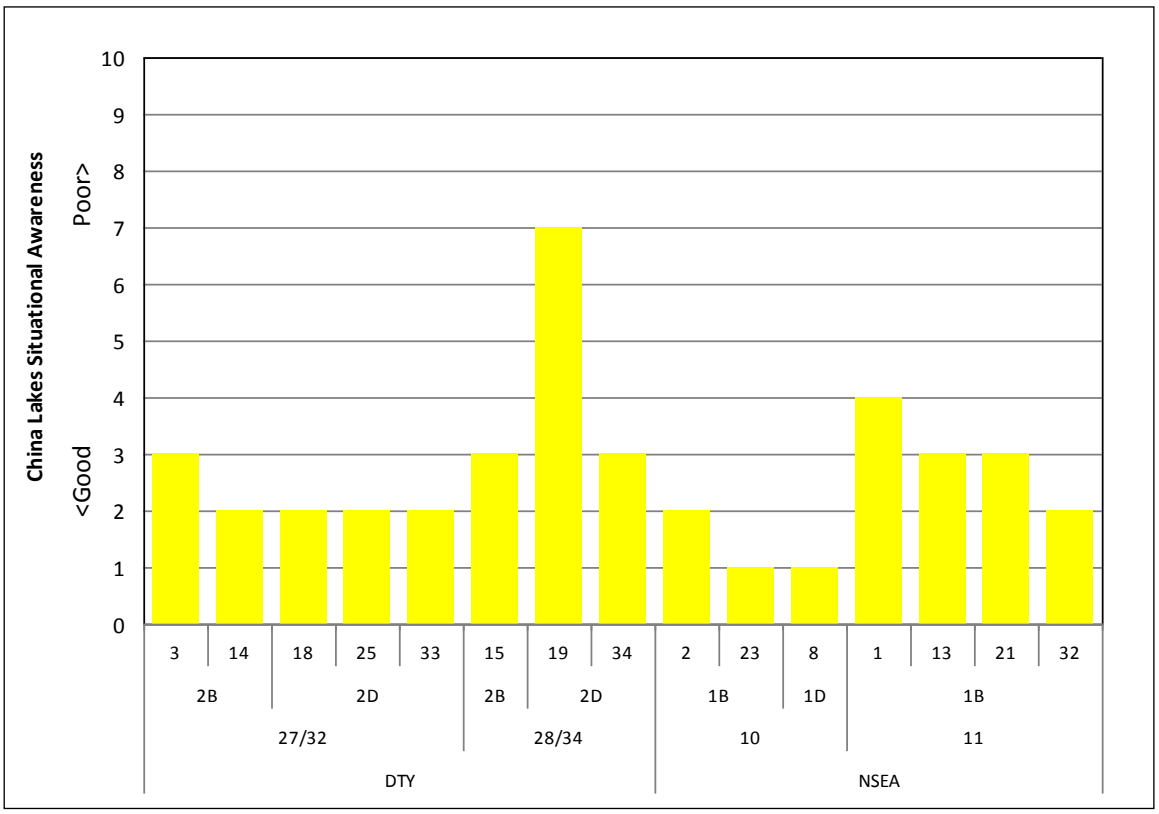


Figure 57 Situational Awareness (non-matched)

4.2.1.10 Safety of SPO

OBJ-04.07.08-VALP-0304.0009 To assess the Safety of the SPO concept

In Summary, although the situational awareness was generally acceptable during the non-matched runs, the participants' perception was that having only a single controller monitoring the R/T and managing complex traffic, particularly should an emergency situation arise, would have a detrimental impact on safety.

Situational Awareness

Analysis of situational awareness is presented in 4.2.1.9., and shows that when the traffic levels were lower (as experienced for NSEA and DTY (27/32)), the situational awareness was generally rated as 'acceptable and satisfactory'.

Perceived Safety

As with the1P-2T configuration, the participants considered that only a single controller monitoring the R/T would be the biggest issue. It was also considered that the SPO was exposed to more risk by potentially having to listen to the R/T whilst making a phone call.

Further, in a debrief at the end of a run, a participant highlighted that as an SPO it can be hard to judge when it gets too busy as the controller can get drawn in, and could even get too busy to ask for help. There were also concerns raised regarding dealing with emergency situations. '*I believe that there would be an increase in overloads, and safety errors as a result due to anything non standard that does occur regularly'.*

4.2.2 Unexpected Behaviours/Results

Contrary to the assumption stated in 2.2.5.1, there was some evidence to suggest that the scenarios exercised in adjacent sectors could have had an impact on the measurements taken. At the end of each run, the participants were asked whether the scenarios exercised in adjacent sectors had any impact on their ability to undertake tasks and there were some occasions, particularly where an adjacent sector was operating as SPO, that this was considered to have some negative impact. However, in general, this is not considered to have a significant impact on the overall results.

Other unexpected behaviours and results, such as learning effect, are discussed elsewhere in the report.

4.3 Confidence in Results of Validation Exercises

4.3.1 Quality of Validation Exercises Results

A total of eight London Area Control controllers were involved in the simulations, and were valid on the sectors on which they were measured (with one exception where a non-sector valid controller staffed a Tactical position). The participants were also all valid on the operational use of iFACTS (baseline scenario), which they had been using for a number of months prior to the activity. Overall, the simulation had a good representation of the target users.

Three of the eight participants had previous experience of elements of the iMSP concept, with the remaining participants being new to the concept. As a result of the possible level of exposure of the eight participants to the iMSP concept over the duration of the exercise (the toolset was also susceptible to technical issues that affected its functionality) the participants were still learning and experimenting with the tools and concept towards the end of the exercise. When runs were exercised with matching traffic samples, participants with previous experience almost exclusively scored the concept more favourably on the subjective measures. They recorded lower workload, better situational awareness, and greater user acceptance. There are strong indications that learning and familiarity with the concept had a major influence on results presented. This should be taken into account when interpreting the results. The influence of previous experience is highlighted throughout the results.

Due to a change in the schedule to increase exposure, the volume of data collected for analysis was somewhat reduced, though was still of a reasonable amount and of good quality, which has enabled detailed analysis to be performed.

For the comparison of MSP to a bandboxed Planner, analysis was undertaken using eight matched pairs of data, and to a split sector configuration analysis used nine matched pairs of data. For the comparison of a Planner with enhanced Planner tools to that with NERC Planner tools, analysis was undertaken using 26 matched pairs of data. For a comparison of an SPO to a Planner and Tactical configuration nine matched pairs of data was used in the comparison.

4.3.2 Significance of Validation Exercises Results

A limitation of the comparative analysis was the relatively small sample sizes from the matched runs for controller metrics, e.g. end of run questionnaires. However, sufficient data was available to test for statistical significance for tools performance data (i.e. Look-See/What-If), and human performance metrics in the 1P-1T configuration. For these larger sample sizes, the Wilcoxon Signed-Rank Test was used to determine whether the differences were statistically significant at the 95% confidence level.

5 Conclusions and Recommendations

5.1 Conclusions

The simulation provided the opportunity to exercise the Multi-Sector Planner (1P-2T) concept and simulated an operational baseline (1P-1T) against which a quantitative assessment could be made as well as enabling the participants to baseline their subjective assessment. The same enhanced Planner tools were also exercised in a 1P-1T environment to assess the feasibility of an early operational implementation for the enhanced Planner tools in order to provide an early benefit to operations. Also, with the addition of full Integrated Coordination, the tools were exercised in a combined Planner and Tactical role.

The simulation aimed to achieve a considerable number of objectives in a very short period, and as such the experimental design was necessarily complex to achieve these objectives with limited operational resources, across three operational sectors, in a relatively short timescale. The limited exposure of the many of the participants during the simulation had a significant impact on the quantitative assessment. Participants who had not had previous exposure to the iMSP concept had a particularly steep learning curve prior to commencing measured runs (and thereafter). Analysis showed that the participants' responses changed, for the better, over the duration of the simulation, particularly with regards to user acceptance of the iMSP concept, and showed that those participants with previous experience of the concept performed much better, almost exclusively recording lower workload and better situational awareness. Software fixes in the first few days of the activity also improved user acceptance.

5.1.1 Enhanced Planner Tools

The controllers reported that MTCD-enhanced Look-See/What-If was a significant improvement over current NERC Look-See/What-If, enabling them to assess offers more quickly in both a 1P-2T and 1P-1T environment. As such, the participants reported that they would like to see the MTCD-enhanced Look-See/What-If implemented in current operations at the earliest opportunity. The participants concurred that taking into account coordination actions that the Planner had taken to resolve interactions (such as requesting that the offering sector lock an aircraft onto a heading) was also of significant benefit.

Enhanced Planner MTCD filtering logic was created for each of the measured sectors/groups used in the validation exercise. The reduction of irrelevant MTCD highlighted aircraft during a Look-See/What-If was considerable (in comparison to iMSP2) and Planner controllers demonstrated they were able to disseminate the focused information more efficiently. These rules (alongside improved -See/What-If HMI and a better fidelity of planner trajectory modelling) are considered to be a great success. Further work will be needed to extend the planner MTCD rule base to the other sector LAGS and to (operationally) validate the current rule base. This study produced some discussion points to initialise these future workshops.

5.1.2 Enhanced Planner Tools in 1P-1T configuration

Subjectively the participants all reported that the enhanced Planner tools were useful in a 1P-1T environment, with the quantitative analysis showing an indication of a reduction in Planner workload, and no change in situational awareness. However the nature of the activity, whereby in order to exercise appropriate traffic levels for the MSP concept, the traffic samples were selected such they did not load the Planner to the point where the Planner had to 'split', may have impacted the significance of the results. Some participants (3) subjectively reported an improved quality of service with enhanced Planner tools.

5.1.3 Multi-Sector Planning

There were some very good examples of the Multi-Sector Planner planning effectively for two Tactical controllers who were working traffic for which, in their opinion, the sectors would have been split in current operations. These observations were mainly from participants with previous experience of the iMSP concept. The objective data gathered from the other participants during the majority of the

activity was less positive mainly due to lack of familiarity with the system. However towards the end of the activity the subjective feedback from these participants was also fairly positive, with a total of six of the eight participants reporting that they considered the iMSP concept viable under appropriate traffic levels.

Seven of the eight participants considered that Coordination Interaction Vector and Dynamic EFS 'auto-drop' would be essential to 1P-2T operations, and six out of the eight participants rated the Coordination Interaction Point-Out, the IC Auto-Accept Conflict Detection highlight and Instruction Palette Coordination function as essential.

For the three matched runs where the Tactical reported that the bandboxed sector should have been split and where the participants had previous experience of the iMSP concept, the Multi-Sector Planner recorded an average perceived workload (ISA and Bedford) the same or lower than that of the bandboxed (i.e. single sector Planner). For the same subset of runs, the situational awareness of the Multi-Sector Planner was generally rated as good, even though the participants repeatedly reported that only being able to monitor the R/T for one of their Tacticals would be a significant factor in reducing the Multi-Sector Planner's situational awareness.

For the four matched runs where the Tactical confirmed that their workload was sufficient to justify the sector being split and the respective Planners were under-utilised, those participants that had previous experience of the iMSP concept recorded acceptable workload and situational awareness levels for the Multi-Sector Planner role.

In the questionnaires the controllers recorded a perceived reduction in the frequency with which they made timely and accurate coordinations in the iMSP environment compared to the current baseline, though this was generalised over all runs, not just those runs where the 1P-2T configuration was deemed appropriate. Although a subjective assessment by the participants of the task performance of the Planner in the 1P-2T configuration fell short of that in the 1P-1T configuration, during the end of run debriefs, on most occasions the Tacticals reported that they felt supported by the Planner in the 1P-2T configuration.

Generally, the iMSP concept had little impact on the Tactical role. The Tacticals' situational awareness was generally recorded as good or acceptable, and user acceptance rated the same as that for the split sector configuration. Although the majority of the participants reported that as Multi-Sector Planner they were often unable to proactively assist the two Tacticals in managing their workload, when the Tactical had to carry out Planner tasks they did have the capacity to do this (although as the number of phone calls exercised during the simulation was deemed to be greatly reduced when compared to current operations) and they felt that there was generally no notable reduction in the level of support that the Multi-Sector Planner provided. The Tacticals did however raise concerns that they would not have the support of a 'dedicated' Planner should a non-nominal situation occur. There was also some concern raised that as only the Tactical would be monitoring the R/T there would be an increased reliance on monitoring aids to help detect R/T errors.

Of the three sector groups exercised, the participants reported that the iMSP concept was better suited to DTY and NSEA.

5.1.4 Single Person Operations

The results indicate that the workload, situational awareness and user acceptance of the SPO concept would all be satisfactory given the appropriate level of traffic. The concept of Integrated Coordination was considered to be useful in the SPO environment by all the participants, with five of the eight participants rating it as essential to SPO operations. The Dynamic EFS auto-drop functionality was also considered by the majority of participants to be essential to SPO operations.

However, there were safety concerns raised over the increased risk of errors when there are incoming R/T transmissions whilst making phone calls, and the absence of immediate support during abnormal events.

5.1.5 Summary

This was a very productive (though complex) activity, with many aspects of the enhanced Planner toolset being extremely well received. Given the appropriate traffic conditions, the 1P-2T

configuration was seen to work where the Tactical in a bandboxed arrangement was overloaded; and where Planners in a split configuration were under-utilised, the 1P-2T configuration provided a scenario where all controllers reported a comfortable level of workload. However, there was still concern regarding the Multi-Sector Planner role, particularly the impact on the Planner of not being able to monitor all R/T.

It is likely that increased exposure to the role would have made a difference to the quantitative assessment of the Multi-Sector Planner concept, and provided a more accurate picture of the range of traffic levels where the 1P-2T configuration is appropriate.

5.2 Recommendations

As a result of this validation activity, the following recommendations should be considered:

(R1) Subjectively the participants reported improved support to the core Planner tasks, a view born out by the objective data, and as such felt that there would be a significant benefit across the unit through an early implementation of the enhanced Planner tools particularly the MTCD-enhanced Look-See/What-If, IC Auto-Accept Conflict Detection highlight, and Dynamic EFS, on the NERC-iFACTS platform (subject to suitable refinement of the tools in line with the recommendations outlined below). As such it is recommended that NATS enters into an implementation programme at the London Area Control Centre.

(R2) As part of an implementation programme, a wider evaluation of the enhanced Planner tools more fully simulating the Planner's role (e.g. military) than was considered here, and other LAGs, should be undertaken to verify the workload benefit.

(R3) The participants rated the Dynamic EFS as being essential to the application of an MSP concept. As such, and as part of an implementation programme, this concept element should be refined, particularly to improve further the support for prioritisation of tasks by the Planner.

(R4) Further refine the changes to the Instruction Palette to ensure that there is a clearer distinction between the coordination (planning) and clearance (tactical) modes of operation.

(R5) Engage the controller community in the development of the Multi-Sector Planning and Single Person Operations environments. Procedures, methods of operation, and system mitigations should be identified that address areas of concern such as roles and responsibilities, R/T monitoring, seating position, and support during emergencies and failures in order that the 1P-2T and SPO staffing configurations are accepted into the Operation.

(R6) The procedures for transitioning into and out of the 1P-2T team structure were not explored in this validation activity, and thus will need to be developed and validated by an implementation programme along with other outstanding issues such as military interface, fallback modes of operation etc.

(R7) MTCD-enhanced Look-See/What-If improved significantly between iMSP2 and iMSP3 due to sector-specific filtering logic. This logic was only developed for the sector combinations simulated in this activity (DTY, LKS and NSE). Any implementation of MTCD-enhanced Look-See/What-If should include Planner MTCD filtering rules for all LACC sector combinations.

6 References

Reference to Main Documentation, delete If not required.

This section identifies the documents (name, reference, source project) the Validation Report has to comply to or to be used as additional inputs.

6.1 Applicable Documents

[1] Template Toolbox 03.00.00
https://extranet.sesarju.eu/Programme%20Library/SESAR%20Template%20Toolbox.dot

[2] Requirements and V&V Guidelines 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Requirements%20and%20VV%20Guidelines.doc

[3] Templates and Toolbox User Manual 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Templates%20and%20Toolbox%20User%20Manual.doc

[4] European Operational Concept Validation Methodology (E-OCVM) - 3.0 [February 2010]

[5] EUROCONTROL ATM Lexicon
https://extranet.eurocontrol.int/http://atmlexicon.eurocontrol.int/en/index.php/SESAR

6.2 Reference Documents

The documents mentioned in the template are examples that can be removed.

The following documents provide input/guidance/further information/other:

[6] 4.7.8 Validation Plan, EXE-04.07.08-VP-304, 00.00.00, August 2012.

[7] 4.7.8 Validation Report (QW1), EXE-04.07.08-VP-157, March 2011.

[8] 4.2 En Route Concept Validation Strategy Document Step 1, 00.02.03, December 2011.

[9] 4.7.8 OSED for Controller Team Organisation – Roles and Responsibilities in Trajectory Based Operation within En-Route Airspace (including MSP), 00.01.00, January 2013

[10]WP C.03, C.03-D03-Regulatory Roadmap Development and Maintenance Process
https://extranet.sesarju.eu/Programme%20Library/Forms/General.aspx

[11]WP C.03, C.03-D02-Standardisation Roadmap Development and Maintenance Process
https://extranet.sesarju.eu/Programme%20Library/Forms/General.aspx

[12]SESAR Business Case Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[13]SESAR Safety Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[14]SESAR Security Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[15]SESAR Environment Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[16]SESAR Human Performance Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[17]D07 Guidance on list of KPIs for Step 1 Performance Assessment Ed1
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

Remark: *if help is needed, the* **WP16 Front-Office** *can be contacted by e-mail. Do not hesitate to send an e-mail to* extranet@sesarju.eu*. Please start the subject line with Front-Office and use relevant keywords e.g. Safety, ATM Security, etc., or 16.06.01, 16.06.02 ..."*

[18]ATM Master Plan
https://www.atmmasterplan.eu

Appendix A KPA Templates

Results per KPA can be found in section 4.1.2.

Appendix B Metric Descriptions

1	Very Low	Little or nothing to do. Talking more than controlling. Time drags.
2	Low	More time than necessary to do tasks. Time moves slowly.
3	Routine	Enough work to keep stimulated. All tasks under control.
4	High	Working at the limit. Non-essential tasks postponed. Time goes quickly.
5	Very High	Overloaded. Some tasks not completed. Don't feel in control.

Figure 58 ISA Workload Scale

10	Impossible to complete the task.	Task abandoned. I was unable to supply sufficient effort
9	Possible to complete the task, but workload intolerable.	Extremely high workload, no spare capacity. Serious doubts as to the ability to maintain level of service
8		Very high workload with almost no spare capacity. Difficulty in maintaining level of work
7		Very high workload with almost no spare capacity but no impact to the primary ATM task
6	Workload tolerable, but not satisfactory without reduction	Little spare capacity. Level of effort allows little attention to additional or other tasks
5		Reduced spare capacity. Additional or other tasks cannot be given the desired amount of attention
4		Insufficient spare capacity for early attention to additional tasks
3	Workload satisfactory without reduction	Enough spare capacity for all desirable additional tasks
2		Workload low
1		Workload insignificant

Figure 59 Bedford Workload Rating Scale

10	Impossible to complete the task.	My SA with respect to the task was far too low. I could not perform the task because I did not possess the necessary information.
9	Possible to perform the task, but situational awareness not acceptable.	My SA with respect to the task was very low. I was unaware of almost all of the information required to perform the task effectively.
8		My SA with respect to the task was low. I was unaware of most of the information required to perform the task effectively.
7		My SA with respect to the task was low. I was unaware of about half of the information required to perform the task effectively.
6	Able to perform the task, situational awareness acceptable, but not satisfactory.	My SA with respect to the task was reduced. I was unaware of some of the important information required to perform the task effectively.
5		My SA with respect to the task was insufficient. I was not aware of all the information required to perform the task effectively.
4		My SA with respect to the task was not complete. I was able to perform the task, but not satisfactorily.
3	Able to perform the task, situational awareness acceptable and satisfactory.	My SA with respect to the task was good. I was able to perform the task well most of the time.
2		My SA with respect to the task was very good. I was able to perform the task well all of the time.
1		My SA with respect to the task was excellent. I was able to perform the task extremely well all of the time.

Figure 60 China Lakes Situational Awareness Rating Scale

10	The system is not safe and comfortable	Improvement mandatory. Safe operation could not be maintained
9	The system is safe and comfortable but adequate system performance is not attainable with tolerable workload	Major Deficiencies. Safety not compromised but system is barely controllable and only with extreme controller compensation
8		Major Deficiencies. Safety not compromised but system is marginally controllable. Considerable compensation is needed by the controller
7		Major Deficiencies. System is controllable. Some compensation is needed to maintain safe operations
6	Adequate system performance is attainable with tolerable workload but the system is unsatisfactory without improvement	Very Objectionable Deficiencies. Maintaining adequate performance requires extensive controller compensation
5		Moderately Objectionable Deficiencies. Considerable controller compensation to achieve adequate performance
4		Minor but Annoying Deficiencies. Desired performance requires moderate controller compensation
3	The system is satisfactory without improvement	Mildly unpleasant deficiencies. System is acceptable and minimal compensation is needed to meet desired performance
2		Negligible Deficiencies. System is acceptable and compensation is not a factor to achieve desired performance
1		Deficiencies are rare. System is acceptable and controller doesn't have to compensate to achieve desired performance

Figure 61 CARS User Acceptance Rating Scale

Appendix C Measured Airspace

Maps of these sectors are shown below.

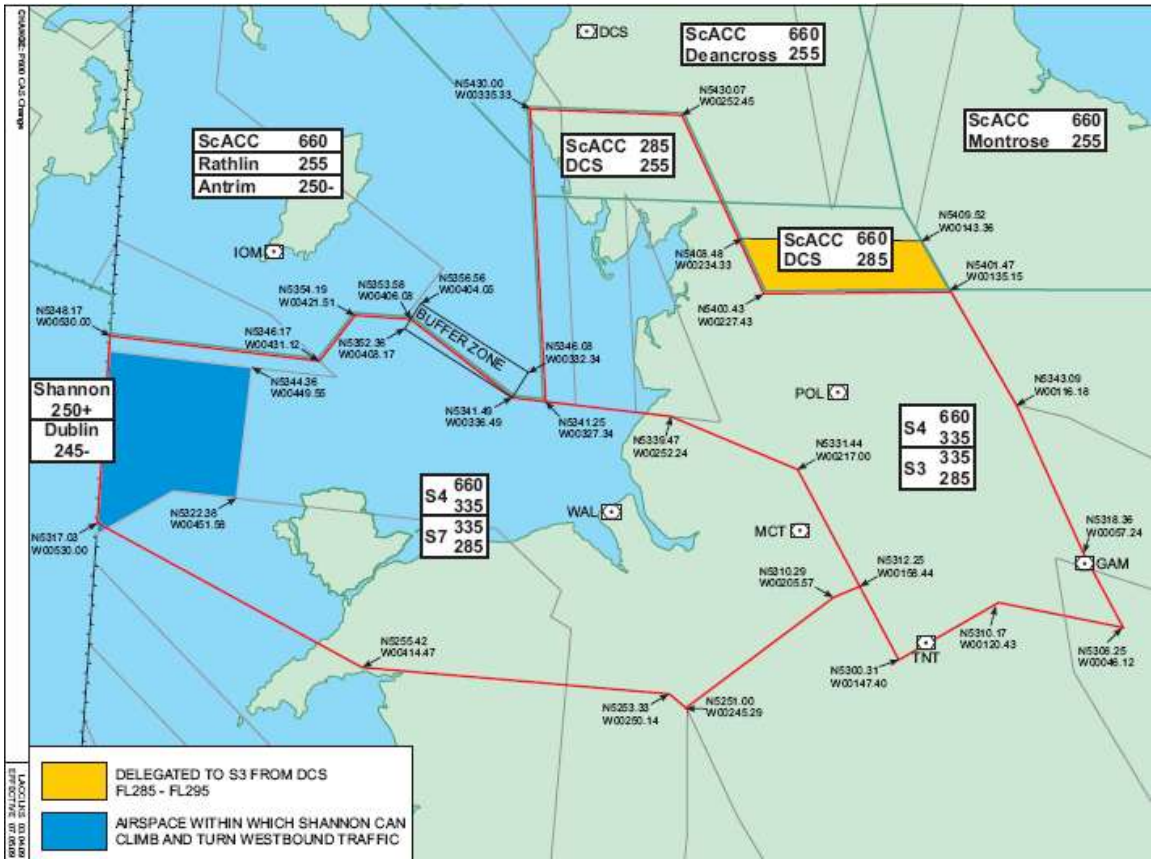


Figure 62 LAKES (S3, S4, and S7)

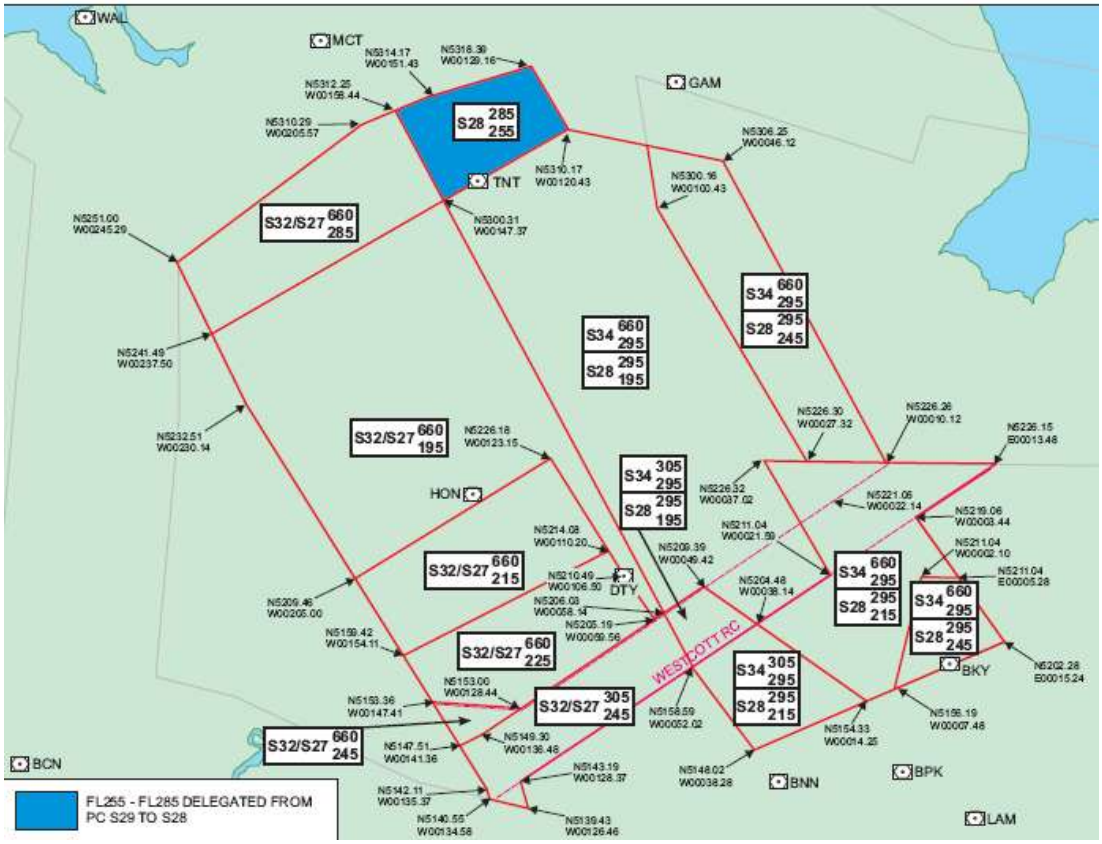


Figure 63 DAVENTRY (S27/32 and S28/34)

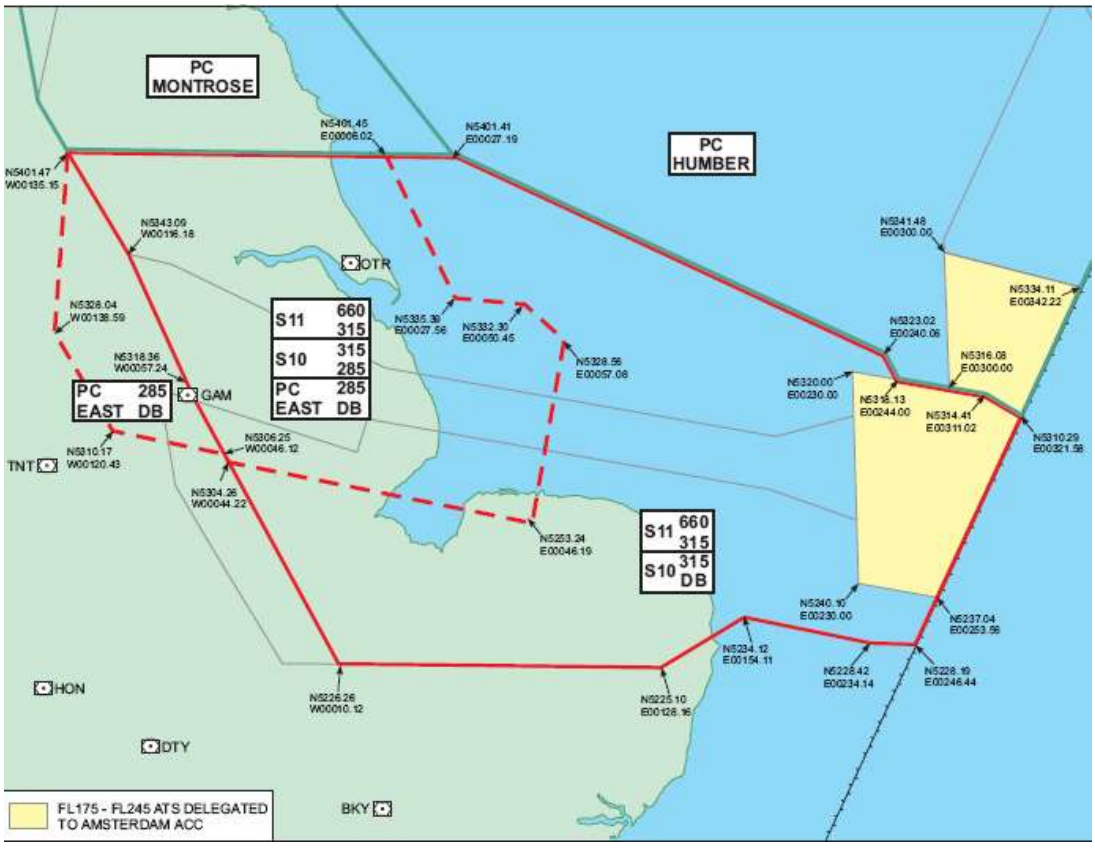


Figure 64 NORTH SEA (S10 and S11)

Appendix D Sector Staffing Configurations

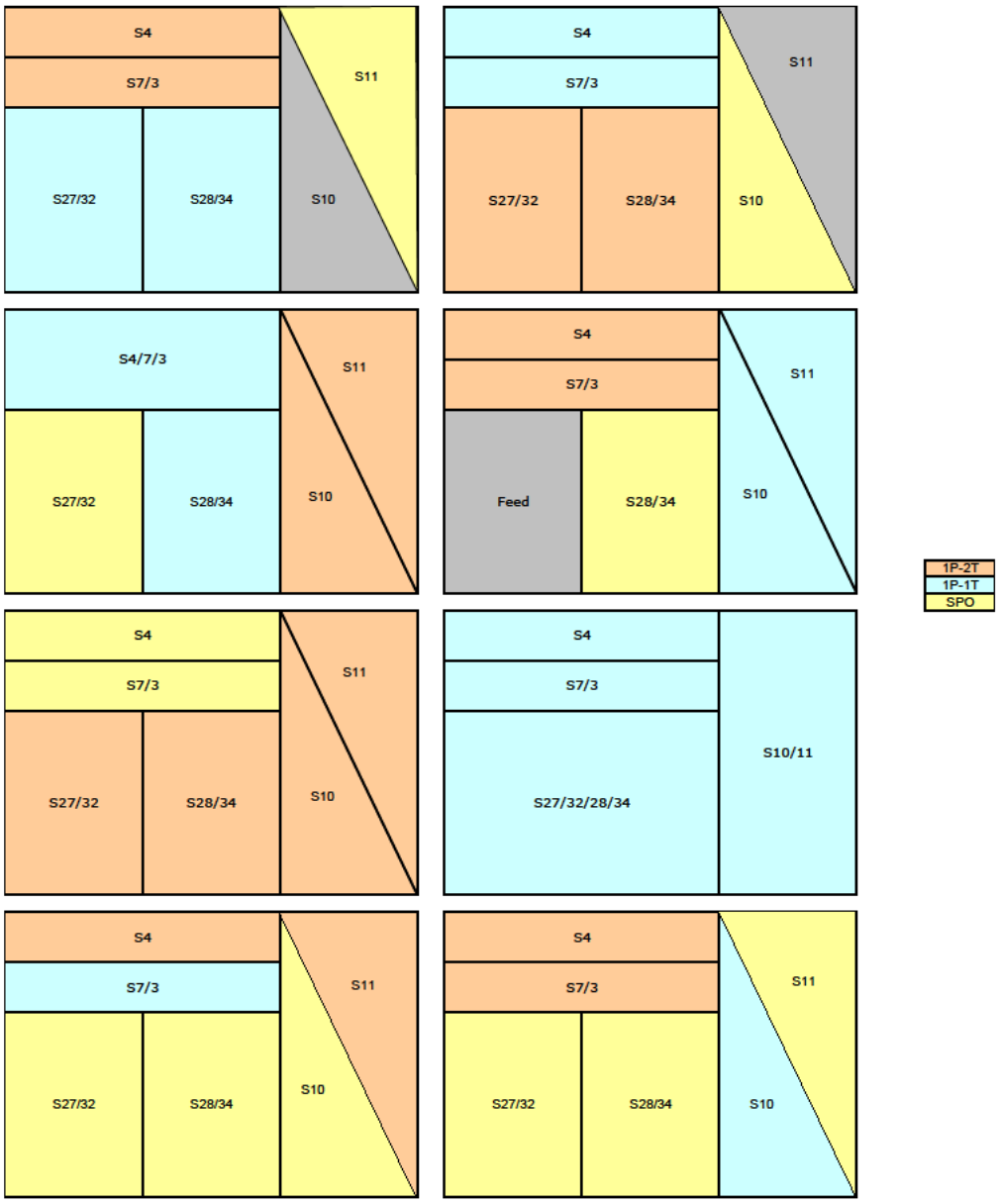


Figure 65 Sector Staffing Configurations

Appendix E Sector Staffing/Tools Configurations

Figure 66 Sector Staffing/Tools Configurations

Appendix F Room Layout

Figure 67 Simulator Room Layout

Appendix G Analysis of Learning Effect

For those traffic samples/sector groups where matched pairs of data exist, the following chart shows a comparison of Bedford 'average' workload scores in the Multi-Sector Planner role for those participants with previous experience of elements of the iMSP concept and those without any previous experience. (Note that on one of these 'matched' runs significant technical/simulator issues impacted the participants' response, and therefore this match has been excluded from the following analysis).

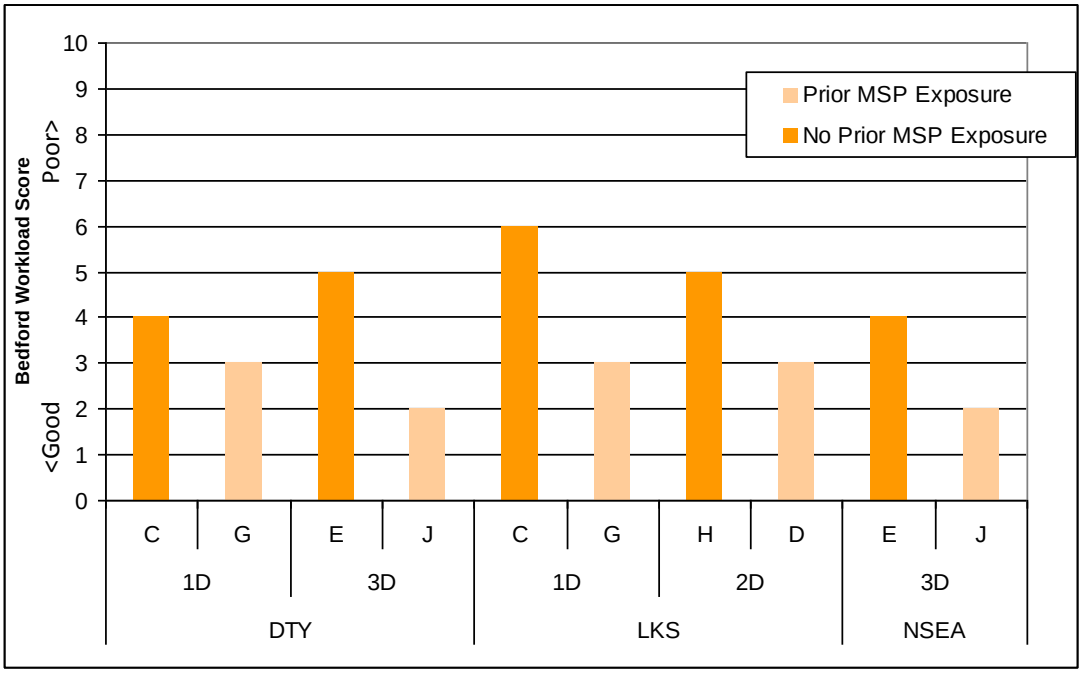


Figure 68 Bedford Average Workload

Figure 68 shows that previous experience did have an impact on the results:

- All five direct comparisons showed lower workload recorded by the participant with previous experience of iMSP.
- All five participants with previous experience recorded satisfactory workload (i.e. <3).

Examination of the Bedford 'peak' workload (Figure 69) shows that previous experience had a much more pronounced effect. All of the participants with previous experience of iMSP rated the 'peak' workload for MSP as 'satisfactory without improvement'; this was not the case for any of the participants who had not had previous experience. Considering the extreme, for the Multi-Sector Planner for DTY with sample 3D, the inexperienced participant rated the peak workload as '10: Impossible to complete task: Task abandoned. I was unable to supply sufficient effort'. For the equivalent run, the experienced participant rated workload '2: Workload satisfactory without reduction, Workload low'.

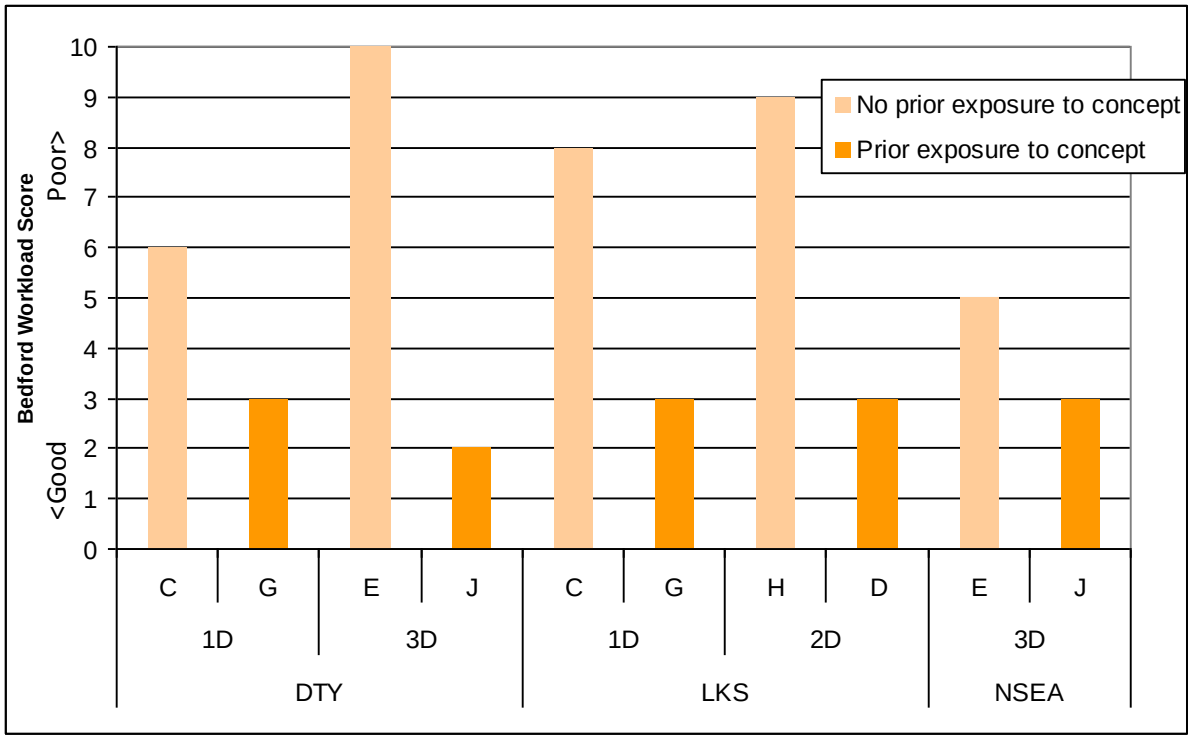


Figure 69 Bedford Peak Workload (Planner)

Previous experience also had an impact on the situational awareness scoring. Figure 70 shows that previous experience has shifted SA into the 'acceptable and satisfactory' region (i.e. 3 or below) in four of the five matches. SA scored better for those participants with previous experienced of iMSP in all cases.

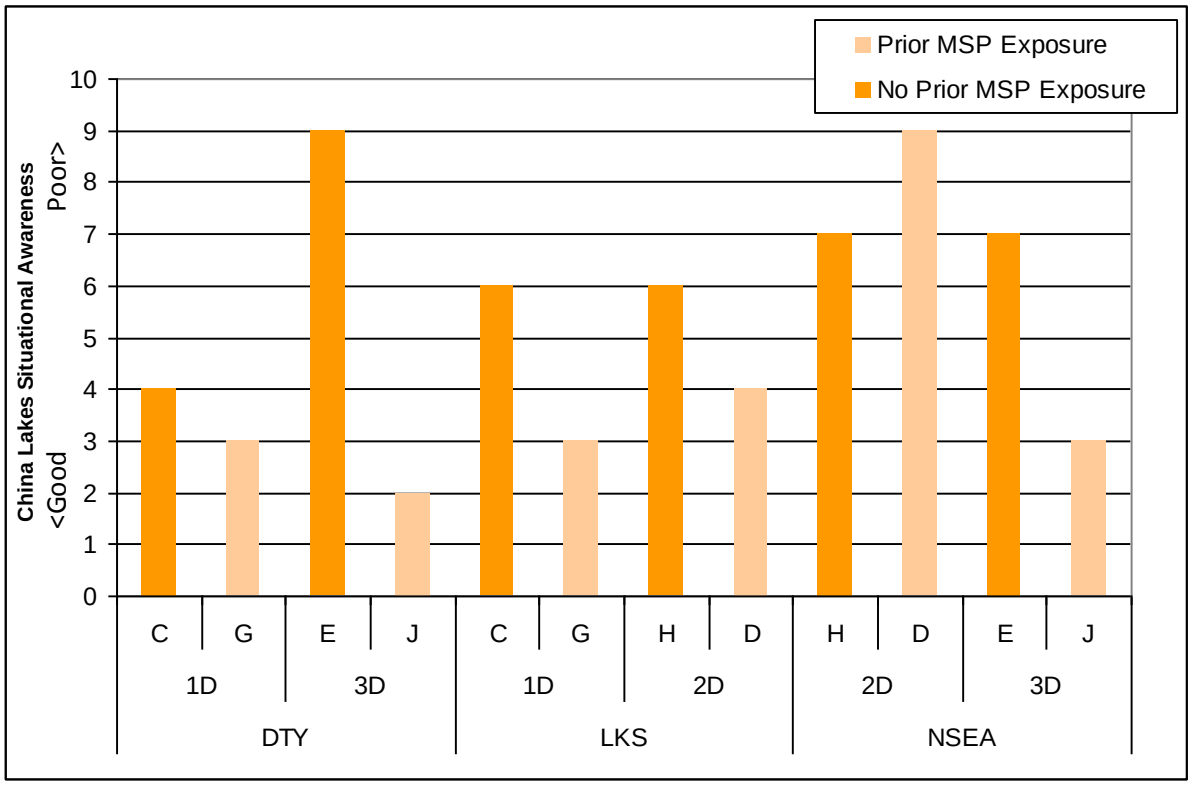


Figure 70 Situational Awareness (Planner)

Appendix H Results Appendix

A.1 Generic Tools Use

A.1.1 MTCD-Enhanced Look-See/What-If

A What-If on the NFL can be invoked using the What-If button in the 'Coord In' window or the keyboard What-If key, whilst the What-If on the XFL can be invoked by using the What-If button in the 'Coord Out' window or the keyboard What-If key. For the MTCD-enhanced What-If, Planner interaction vectors are shown for all flights highlighted by the What-If probe (for NERC What-If, vector lines are displayed).

Figure 71 and Figure 72 show the difference between the number of aircraft highlighted by the MTCD-enhanced What-If and the NERC What-If (per sector group) for NFL and XFL respectively (only 22 instances were recorded for the IFL). A Wilcoxon signed-rank test showed that there were significantly more NERC Look-See highlights than MTCD-enhanced Look-See highlights: z=62.827, p=.000, with a strong effect size (*r* = .789).

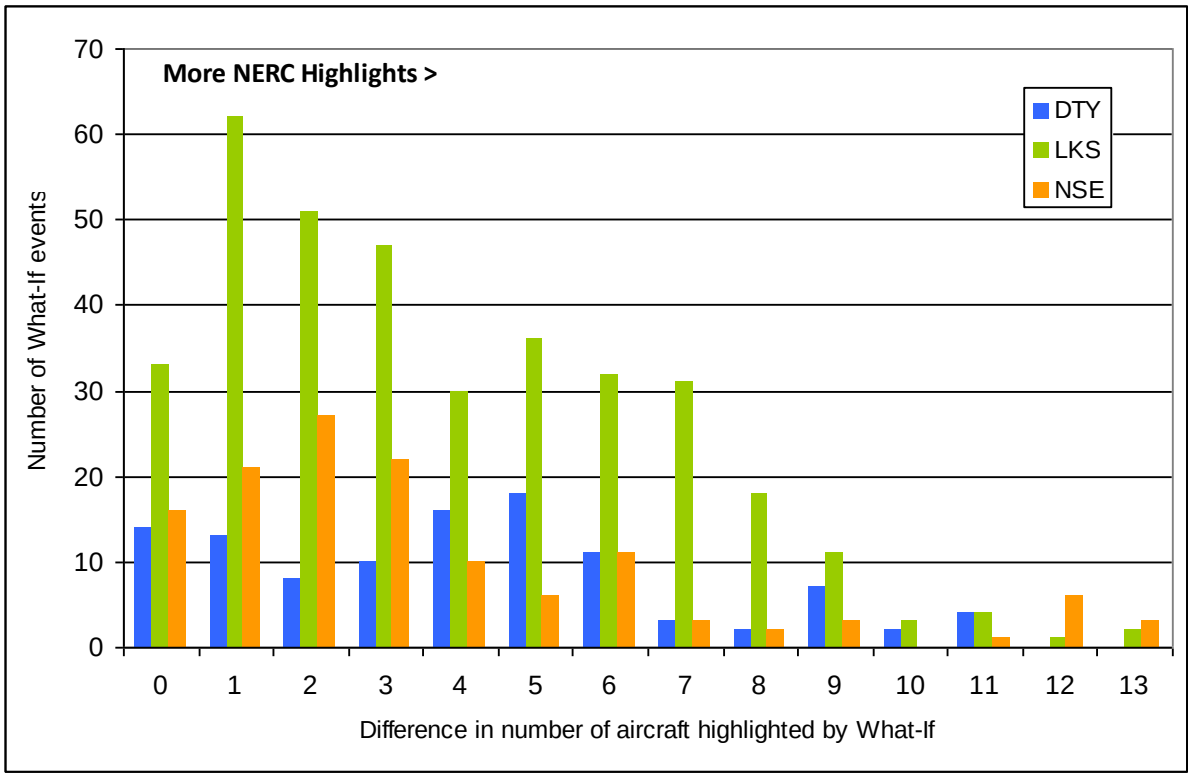


Figure 71 What-If (NFL)

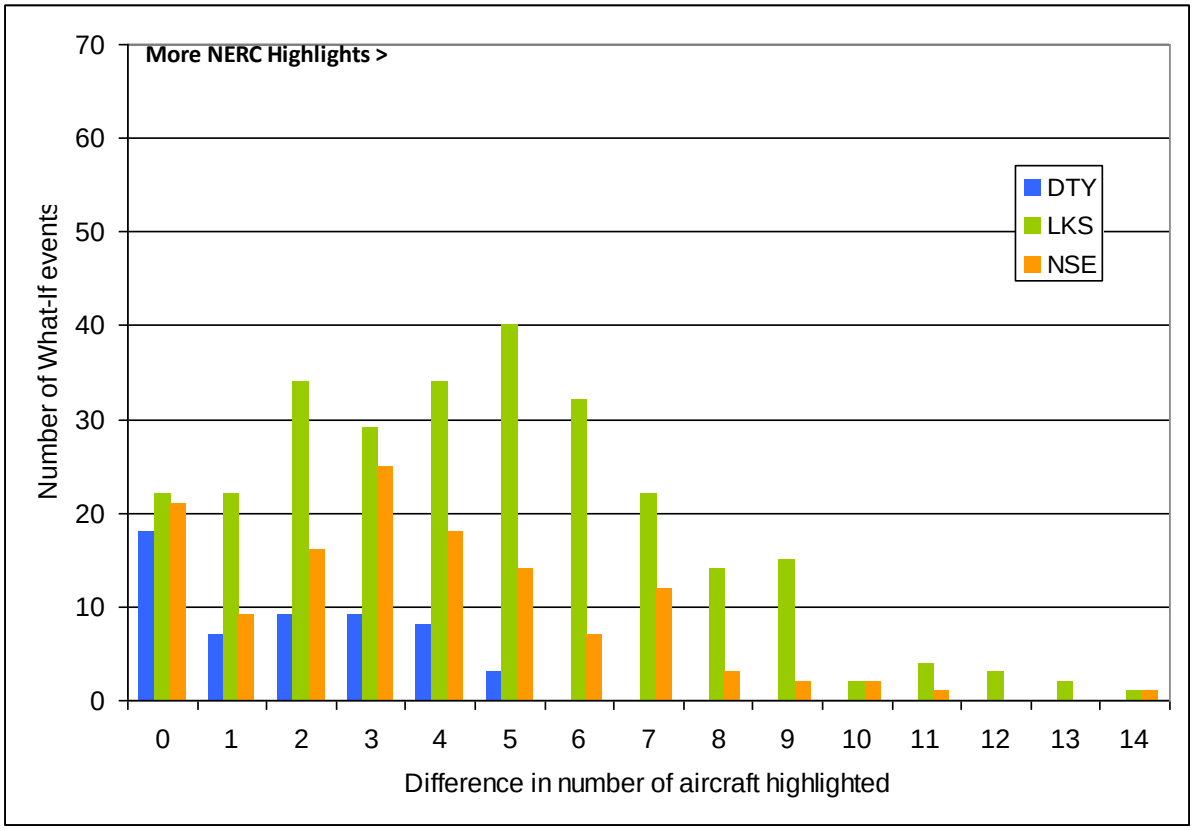


Figure 72 What-If (XFL)

Similar to the analysis of Look-See, the graph shows that the MTCD-enhanced What-If highlighted fewer aircraft, demonstrating that the MTCD-enhanced What-If provides a large improvement over the NERC What-If. Again, for both the NFL and XFL, the analysis shows a slightly different distribution between the three sector groups, with the greatest impact on the LKS sectors. A Wilcoxon signed-rank test showed that there were significantly less aircraft highlighted by MTCD-enhanced What-If than NERC What-If for the NFL and XFL.

A.1.2 Vector Lines

Figure 73 shows an illustration of the time spent adjusting vector line settings to assess situations regardless of whether they were automatically or manually invoked. For NERC, as over 80% of the vector lines were automatically invoked as part of a Look-See, this is a good indication of the workload involved in assessing offers.

The Planner with the enhanced tools (in the example shown this is the MSP) spent less time overall making adjustments to vector lines than the comparative bandboxed Planner, which contributes to a reduction in workload as the Coordination Interaction Vector provides an instantaneous assessment of a traffic situation. Interestingly the difference between the MSP and bandboxed Planner is greater for DTY and LKS, than for NSEA, perhaps suggesting that Coordination Interaction Vectors provided more benefit to the DTY and LKS sectors.

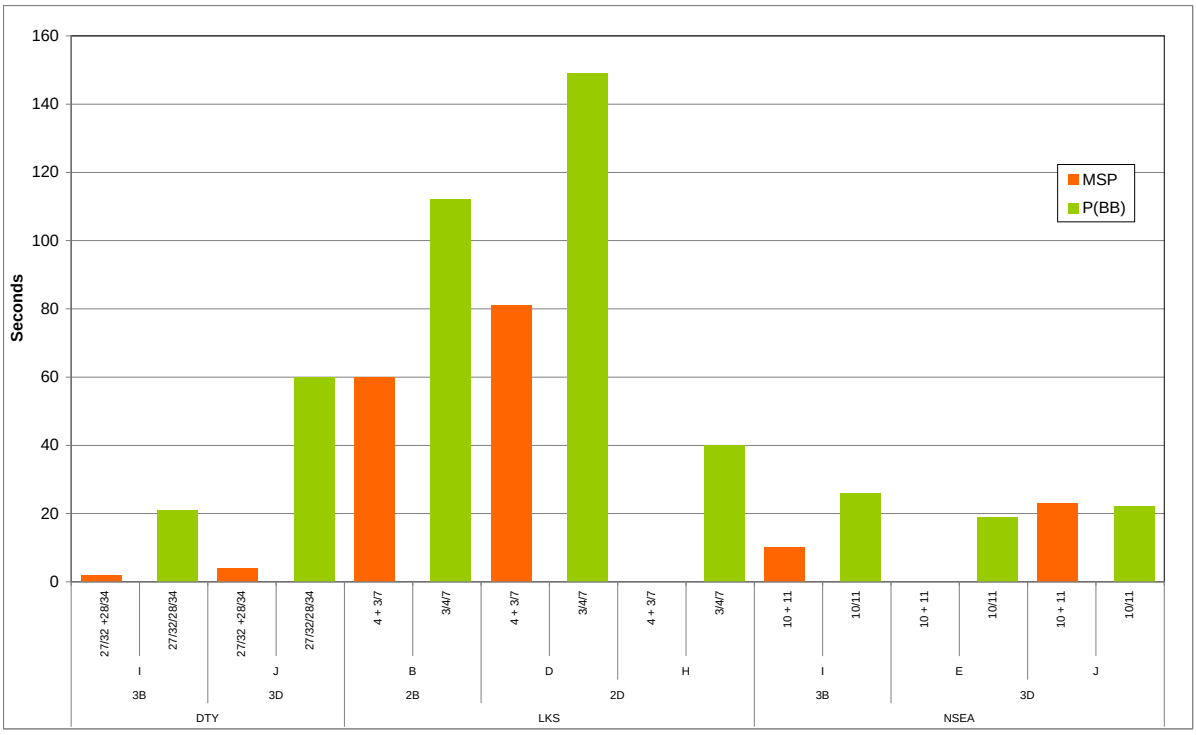


Figure 73 Vector Line Settings

Figure 76 shows that in the 1P-1T bandboxed configuration, the Planners with the enhanced Planner tools made less use of the vector lines than those with NERC Planner tools, but Figure 77 shows that in a 'split' configuration there were occasions when the Planner with the enhanced tools used the vector lines more often.

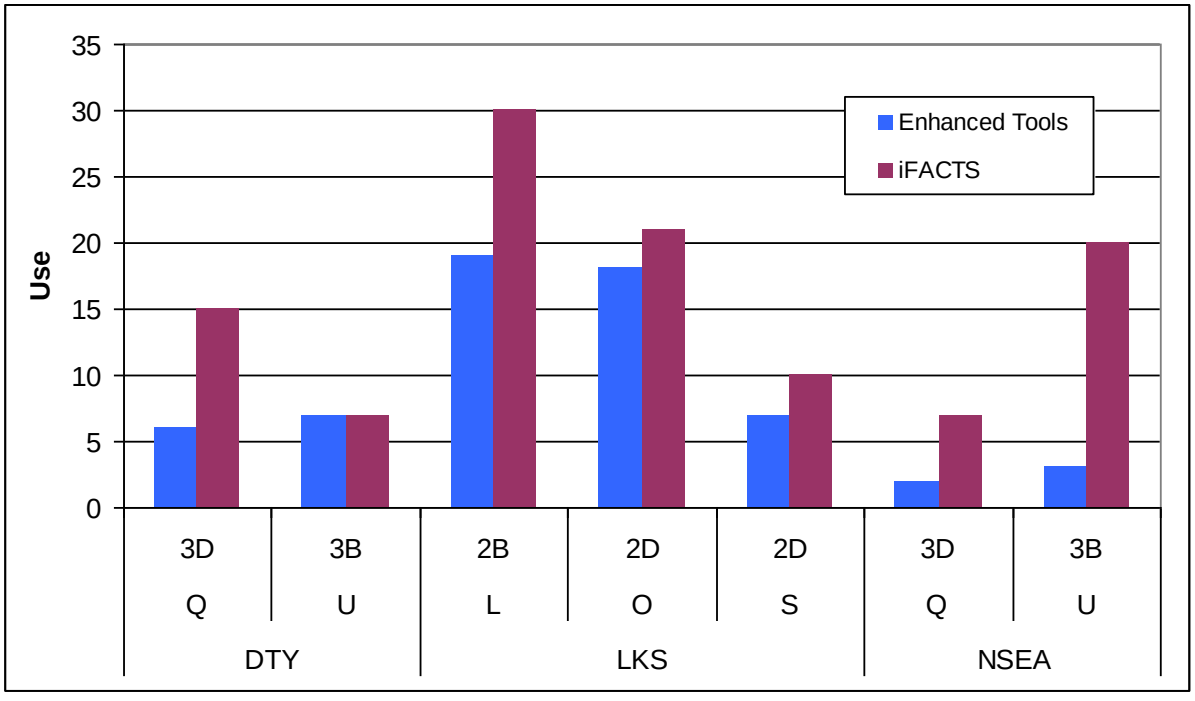


Figure 74 Vector Line Use (1P-1T Bandboxed Planner)

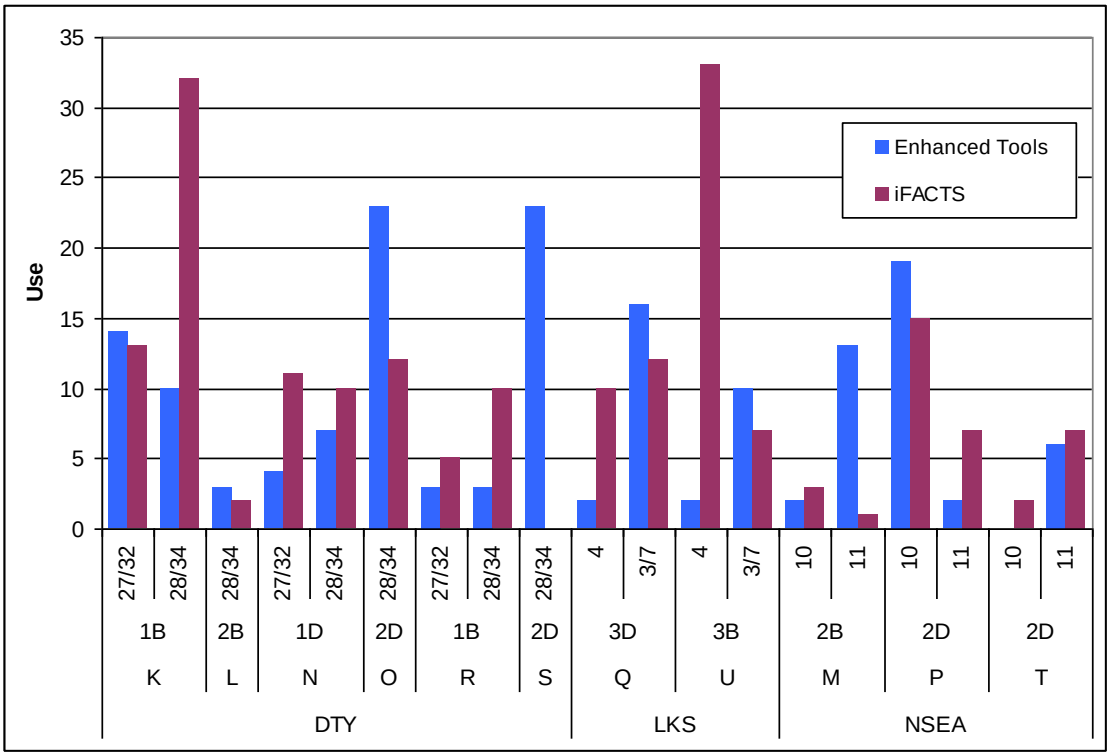


Figure 75 Vector Line Use (1P-1T Split Planners)

Figure 76 and Figure 77 show the number of times the vector lines were manually invoked by the Planner with the enhanced tools in the 1P-2T configuration and the Planner with NERC Planner tools in a 1P-1T bandboxed and split configurations respectively.

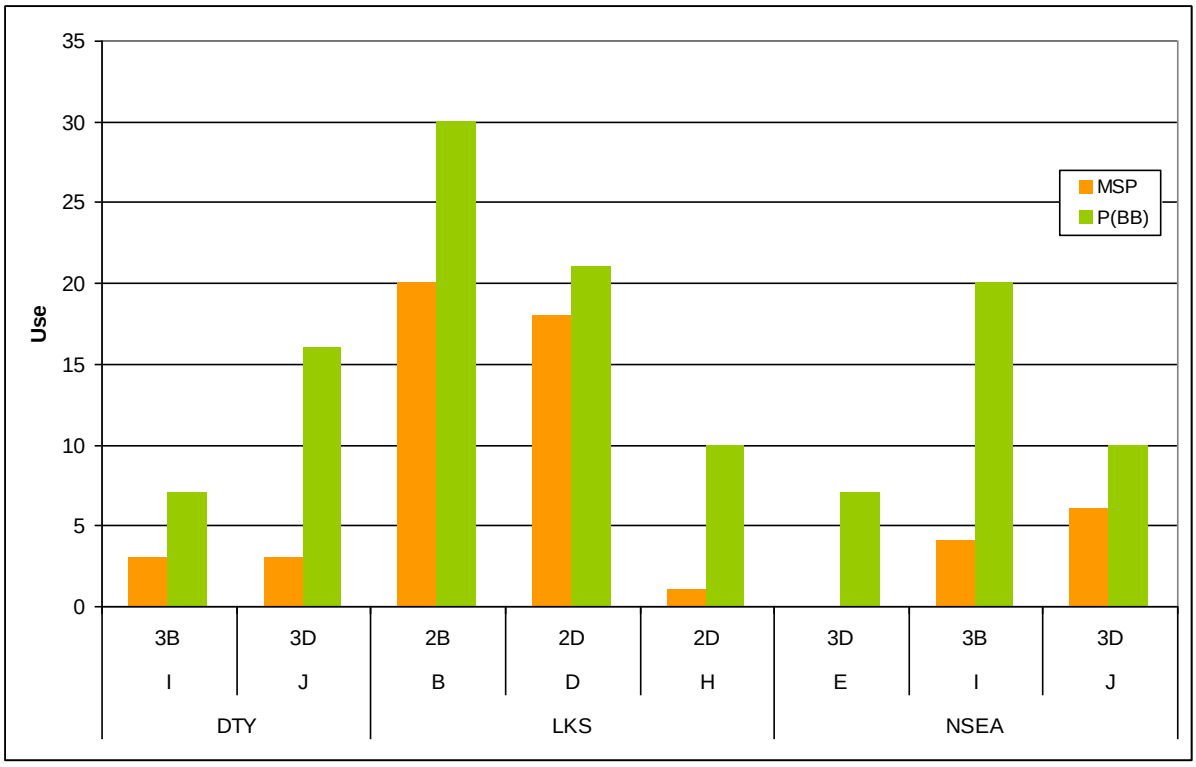


Figure 76 Vector Line Use (MSP compared to Bandboxed Sector)

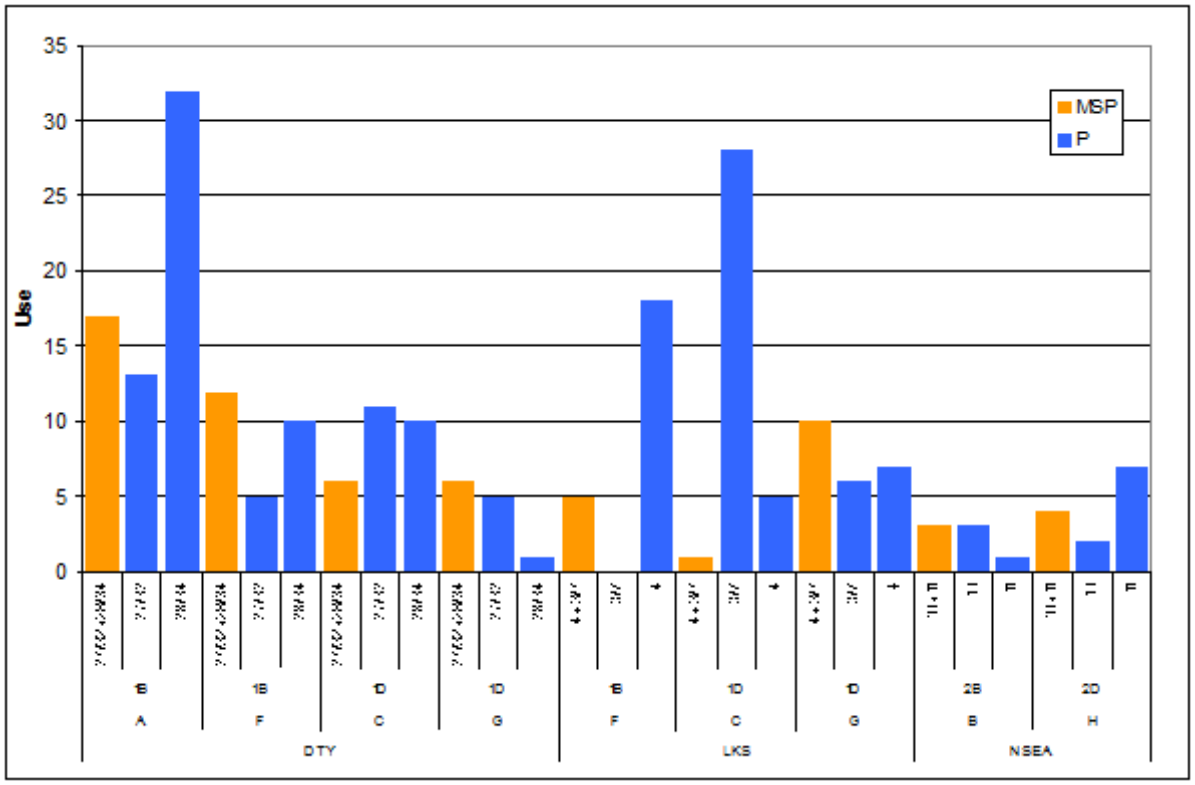


Figure 77 Vector Line Use (MSP compared to Split Sector)

The graphs show that the Planner with the enhanced tools (MSP) manually invoked the vector lines considerable less than the Planner with NERC tools in the 1P-1T configuration. This is likely due to the MSP instead using the Coordination Interaction Vector functionality.

A.1.3 Dynamic EFS

Figure 78 shows the number of EFS in the Accepted Bay during a snapshot in time for runs for those runs with enhanced Planner tools (and hence Dynamic EFS), and those without. Note that the simulator logged the number of strips in the Accepted Bay each time the number of strips in the bay changed. The Dynamic EFS functionality will naturally cause more frequent strip events, however this chart shows the breadth of the distribution of the number of strips in the Accepted Bay.

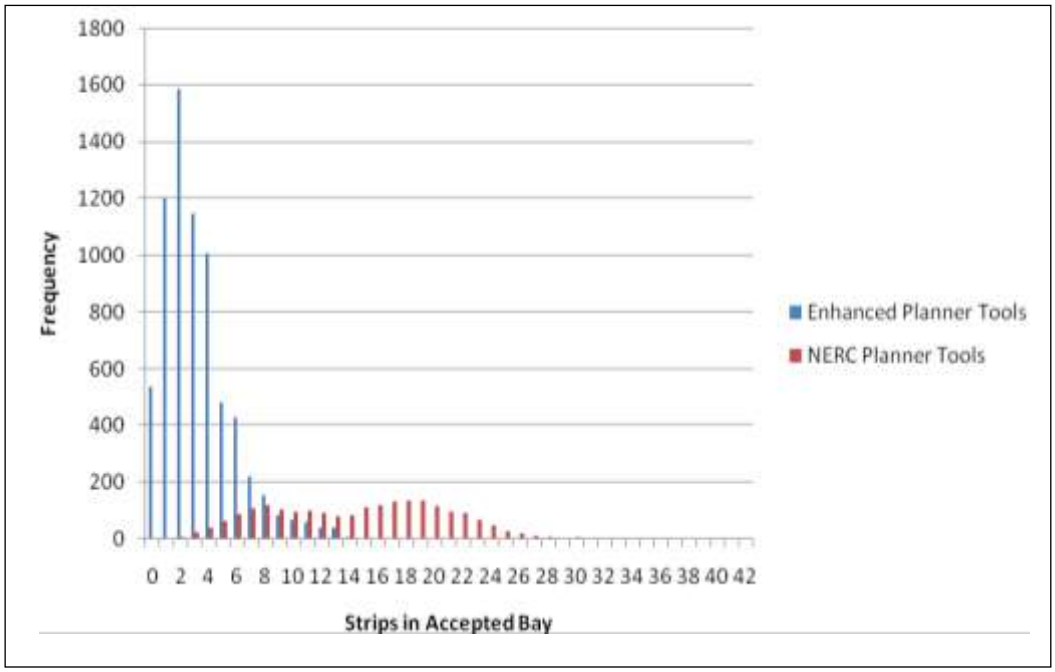


Figure 78 Number of EFS in Accepted Bay

A.2 Enhanced Tools (1P-1T)

A.2.1 CARS User Acceptance

Figure 79 and Figure 80 show the CARS User Acceptance scores with enhanced Planner tools and with NERC Planner tools for the Planner and Tactical (in a 1P-1T configuration) respectively. Note that a low score represents good user acceptance.

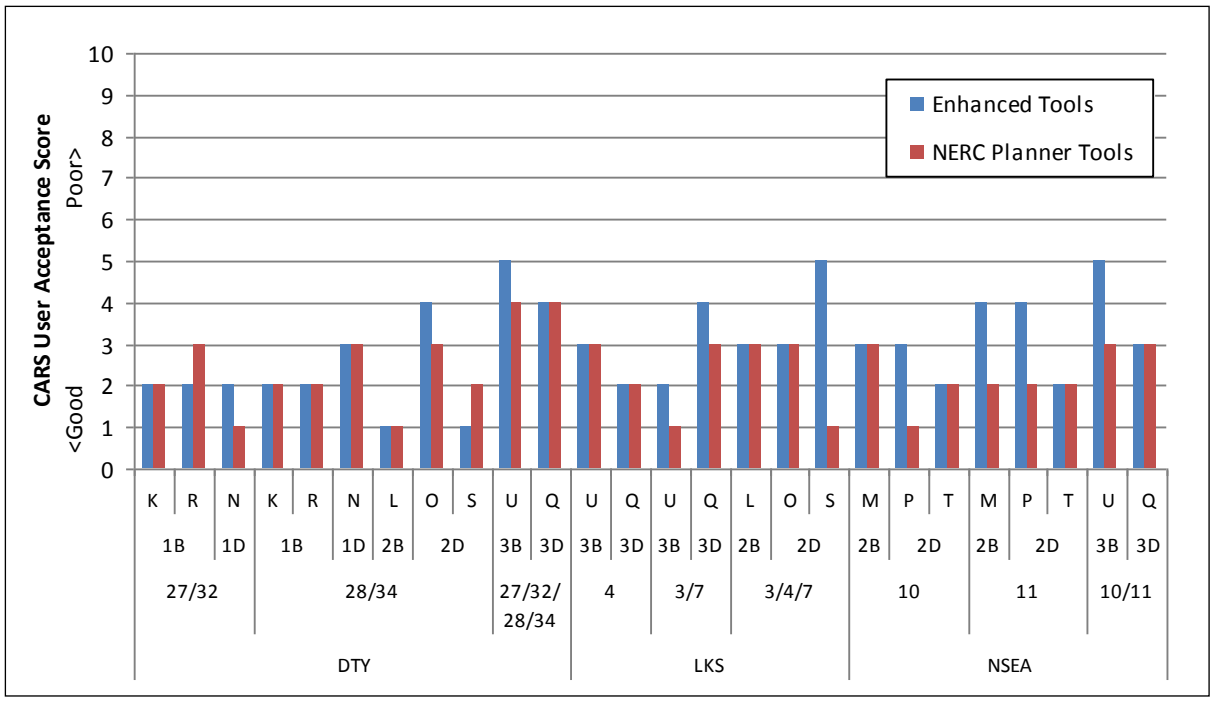


Figure 79 User Acceptance (Planner)

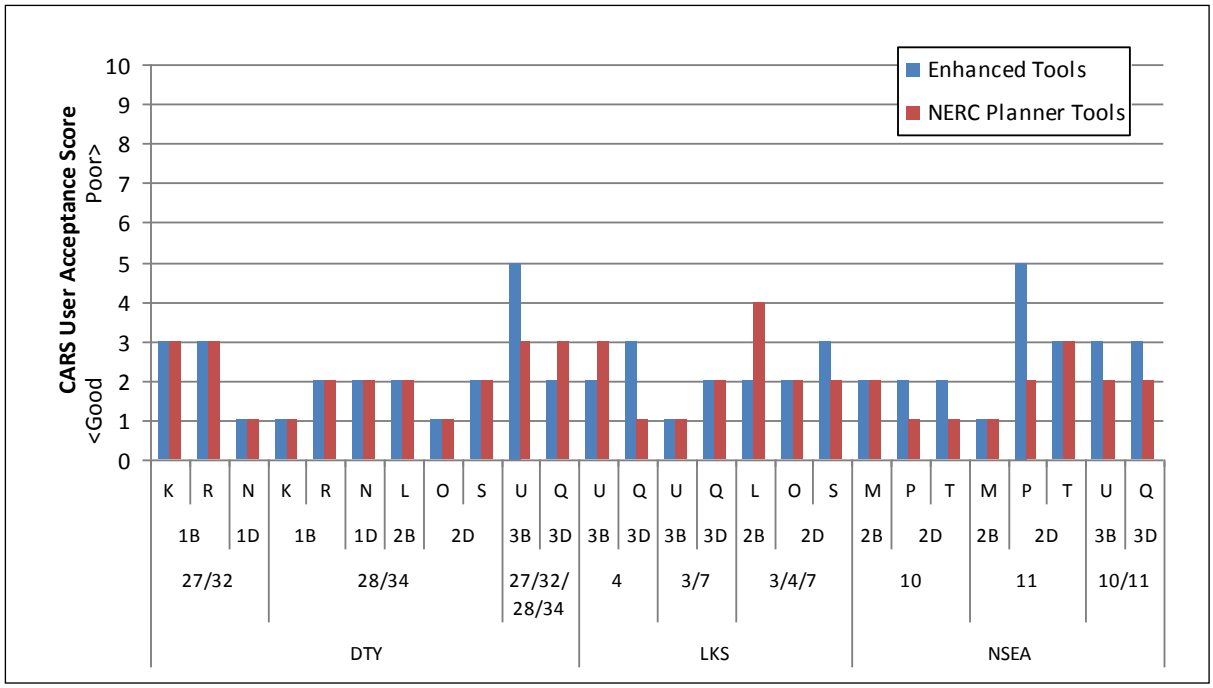


Figure 80 User Acceptance (Tactical)

A.2.2 ISA Workload

Figure 81 and Figure 83 show the median ISA workload scores respectively for the Planner and Tactical (in a 1P-1T configuration) with enhanced Planner tools and with NERC Planner tools.

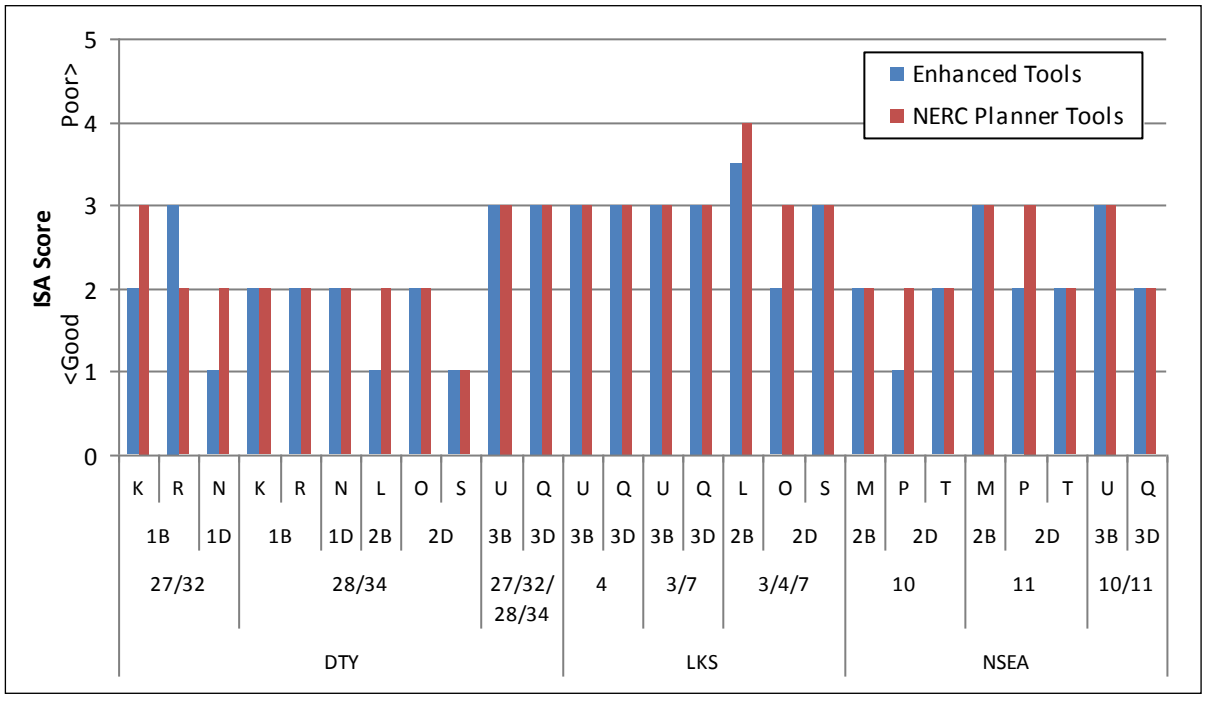


Figure 81 Median ISA Workload (Planner)

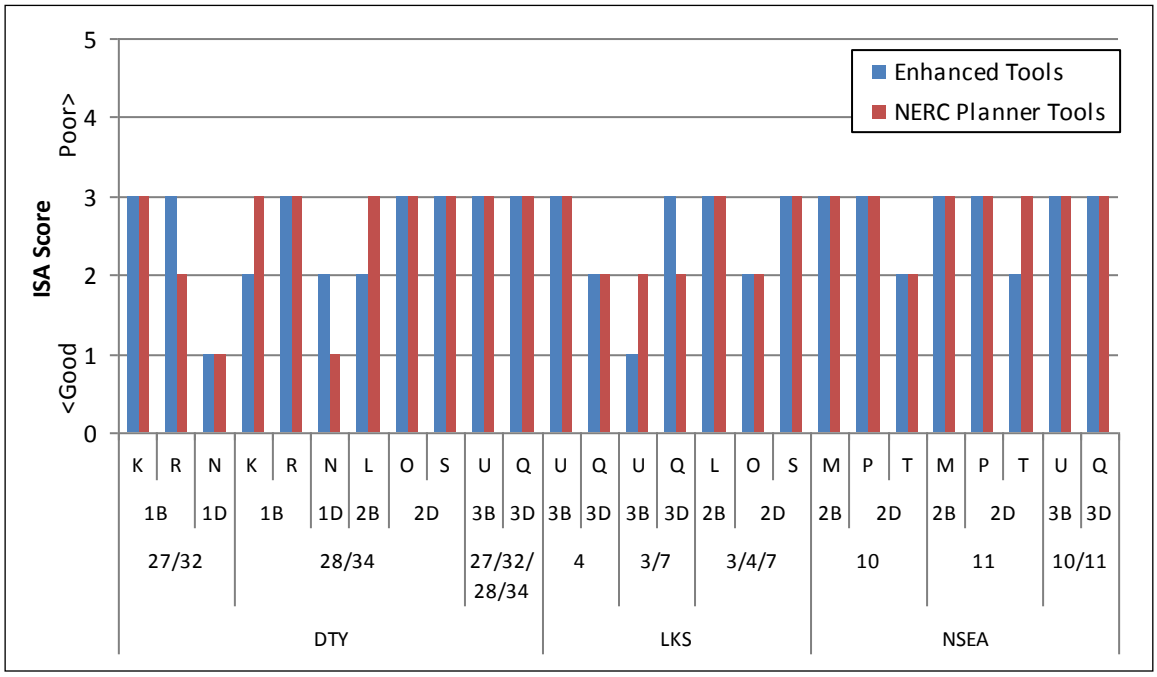


Figure 82 Median ISA Workload (Tactical)

Figure 83 and Figure 84 show the ISA 'peak' workload scores respectively for the Planner and Tactical (in a 1P-1T configuration) with enhanced Planner tools and with NERC Planner tools.

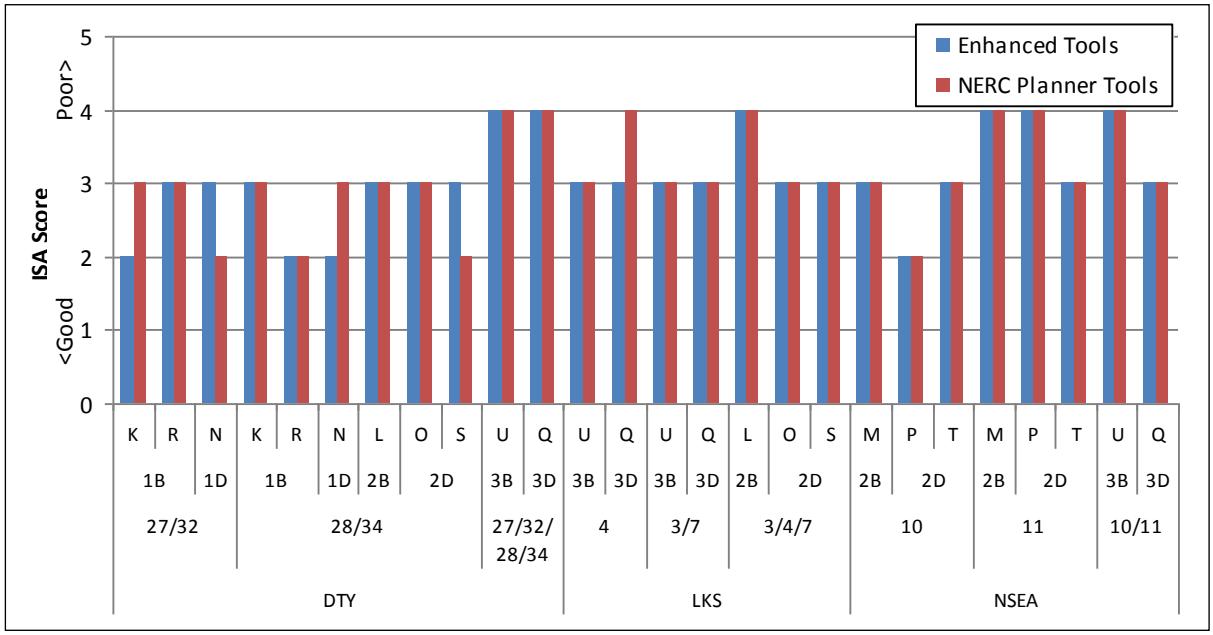


Figure 83 Peak ISA Workload (Planner)

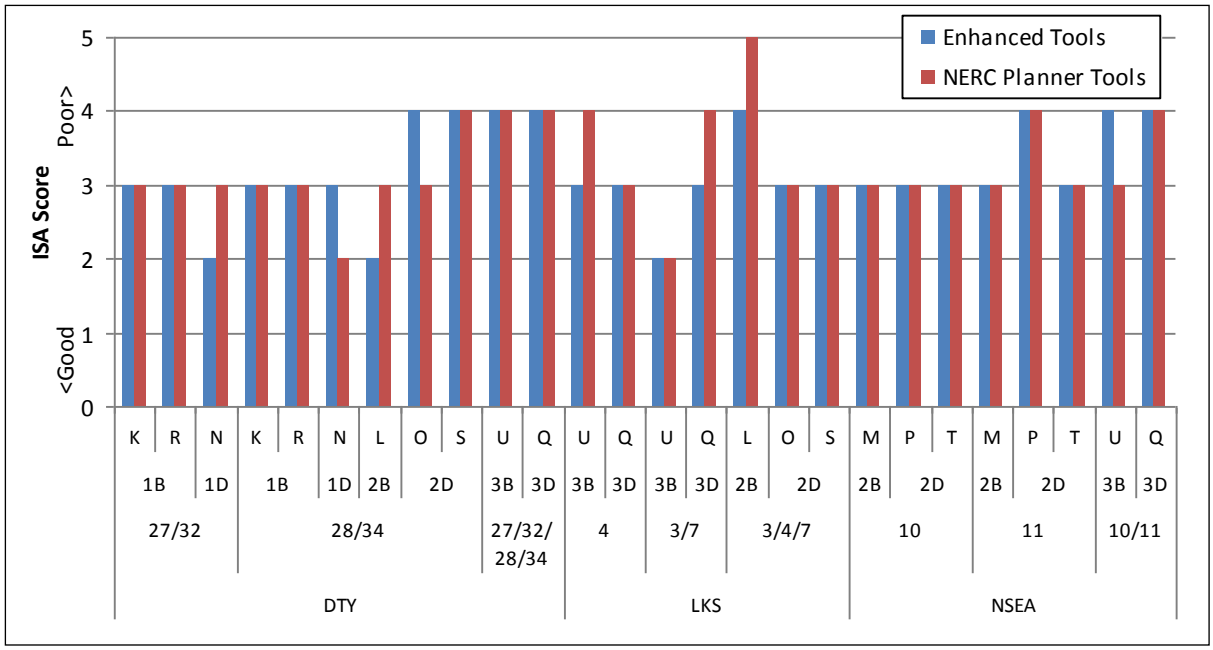


Figure 84 Peak ISA Workload (Tactical)

Analysis of the ISA scores showed very little difference (if any) between 'peak' workload of the Planner or Tactical with the enhanced Planner tools or the NERC Planner tools.

A.2.3 Bedford Workload Scores

Figure 85 and Figure 86 show the Bedford 'peak' workload scores respectively for the Planner (in a 1P-1T configuration) with enhanced Planner tools and with NERC Planner tools, and the Tactical, which yielded similar results to ISA. Note that a low score represents low workload.

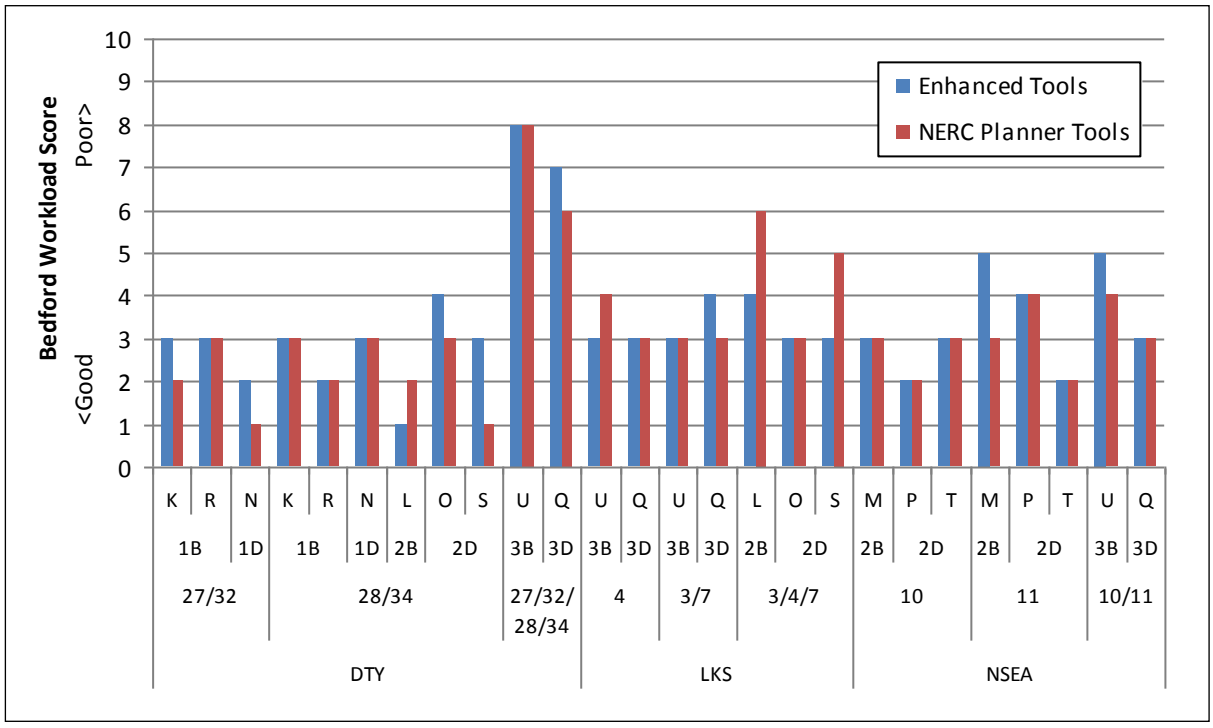


Figure 85 Bedford Peak Workload (Planner)

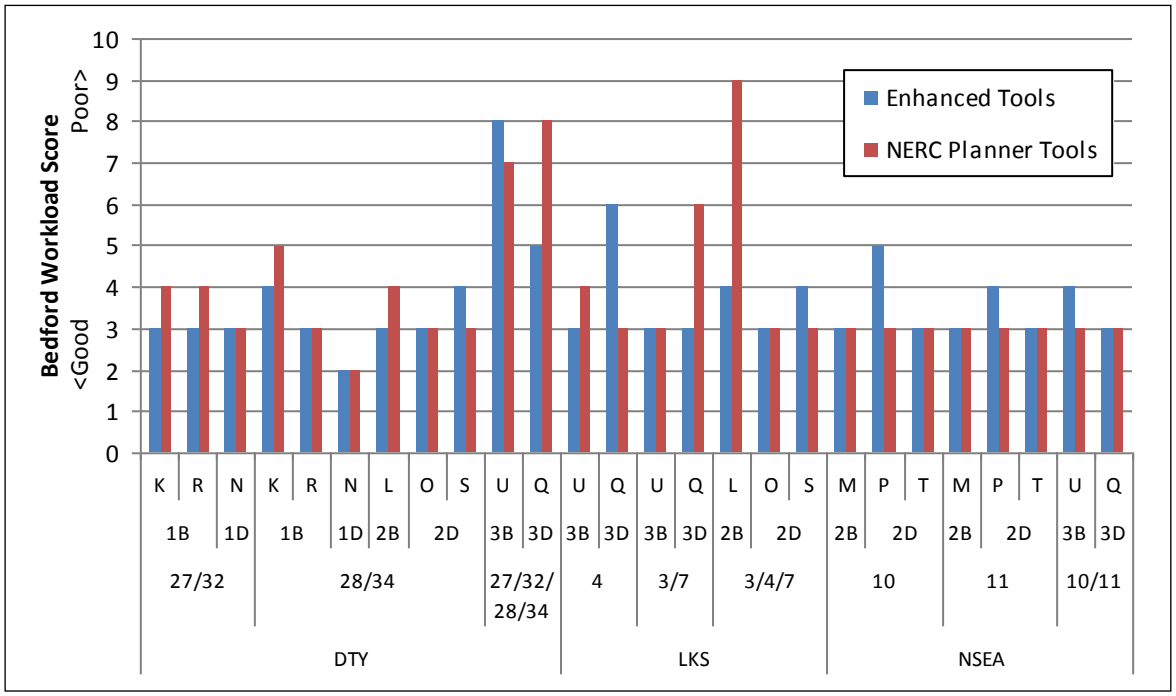


Figure 86 Bedford Peak Workload (Tactical)

A.2.4 China Lakes Situational Awareness

Figure 87 and Figure 88 show the China Lakes Situational Awareness scores with enhanced Planner tools and with NERC Planner tools for the Planner and Tactical (in a 1P-1T configuration) respectively. Note that a low score represents good situational awareness.

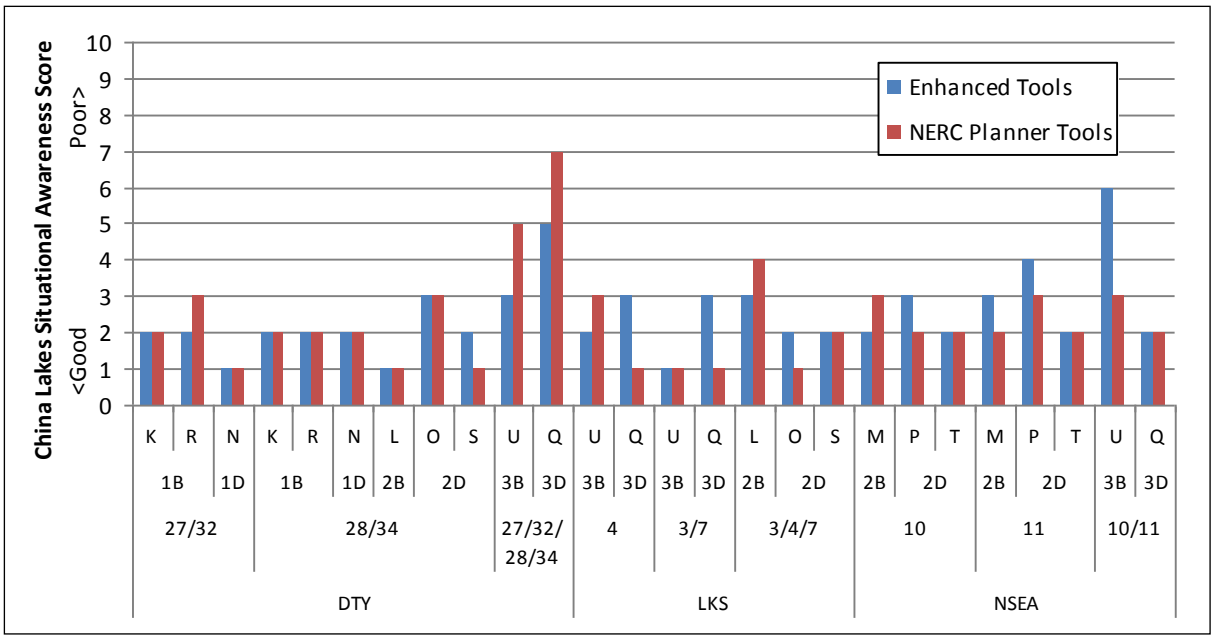


Figure 87 Situational Awareness (Planner)

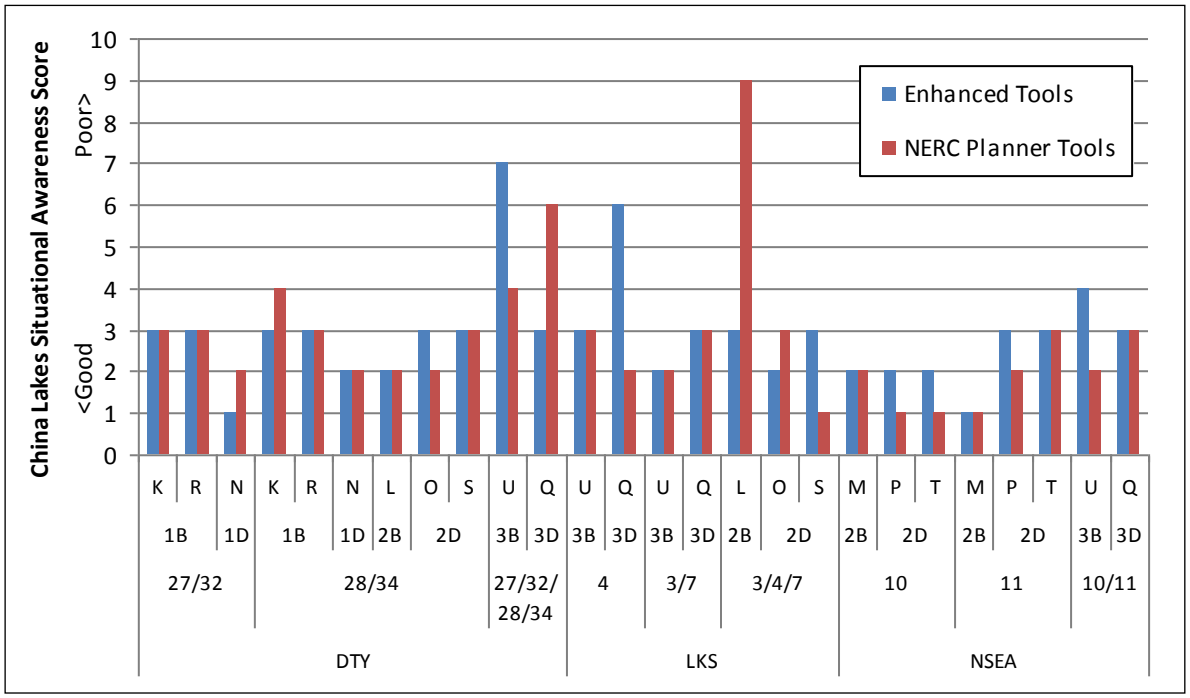


Figure 88 Situational Awareness (Tactical)

The analysis shows that, generally, the situational awareness of the Planner and the Tactical with the enhanced Planner tools was similar to that with the NERC Planner tools, and in the majority of runs was rated ‘acceptable and satisfactory’ (i.e. ‘3’ or below).

A.3 Multi-Sector Planning (compared to bandboxed Planner)

A.3.1 CARS User Acceptance

Figure 89 and Figure 90 shows CARS User Acceptance scores for the Planner and Tactical roles respectively in a 1P-2T and 1P-1T (bandboxed) configuration.

In five of the eight matches the participants rated the user acceptance of the MSP as, at worst, a ‘4’ (‘minor but annoying deficiencies’), and in three matches the MSP rated the user acceptance the same or better than the current operational system (though in each case the workload in one of the matches was workload was considered low enough to bandbox).

For three matches the participants subjectively reported that the traffic exercised was appropriate to the 1P-2T configuration, and for these matches the user acceptance of the MSP was rated as very good (<= 3). On the two occasions where the user acceptance of MSP exceeded ‘6’, the participant had not had any previous experience of the iMSP concept.

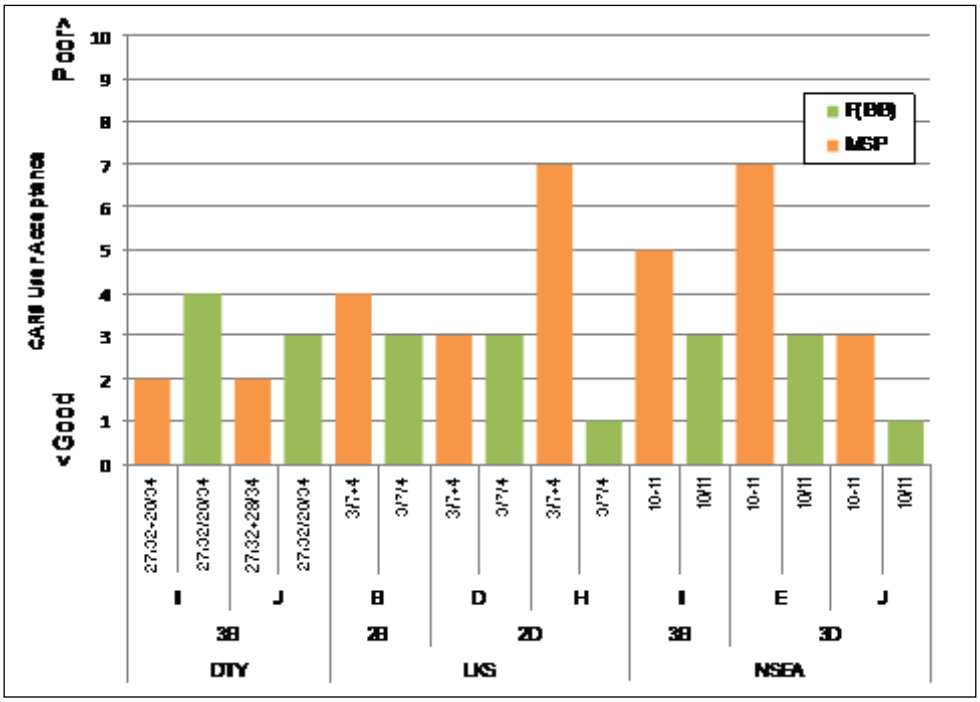


Figure 89 User Acceptance (Planner)

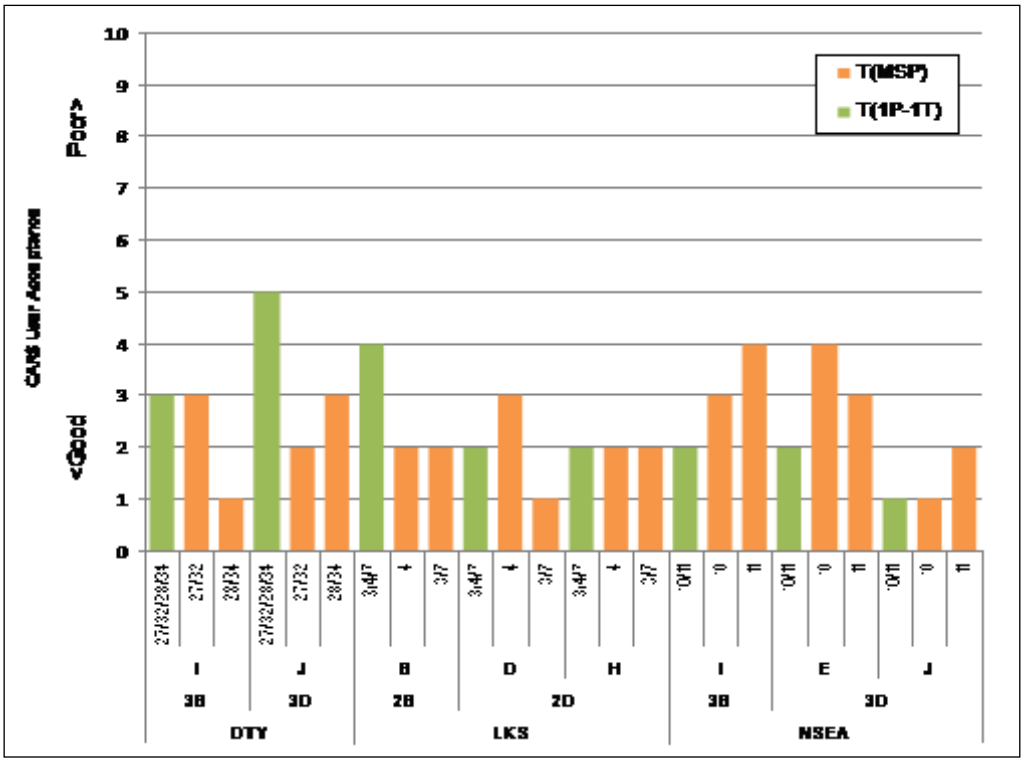


Figure 90 User Acceptance (Tactical)

Note that as the traffic levels in the bandboxed sectors were purposely designed to exceed tolerable Tactical workload limits, it is not unexpected that there are some responses where the bandboxed Tactical rates user acceptance exceeding '3', though all ratings are still within acceptable limits.

A.3.2 ISA Workload (Tactical)

Figure 91 and Figure 92 show the median and peak ISA scores for the Tactical role in both the 1P-2T and 1P-1T (bandboxed) configurations.

The participants subjectively reported that, with the exception of two of the matched pairs (LKS (D) and LKS (H)), the bandboxed sector would have had to split at some point in the run as the Tactical was too busy, and this is borne out in the graphs, with the Tactical in the 1P-1T (bandboxed) sector recording a peak ISA of at least '4' for five of the eight matched pairs. For LKS (D) and LKS (H), although the Tactical(s) in the bandboxed sector recorded a peak of ISA 3, they reported that the bandboxed configuration was appropriate (although for LKS (H) the corresponding Planner subjectively reported that the Tactical would probably have split). As such, making a comparison of the Planner (MSP) role in these two matches is of limited value as the workload was considered too low.

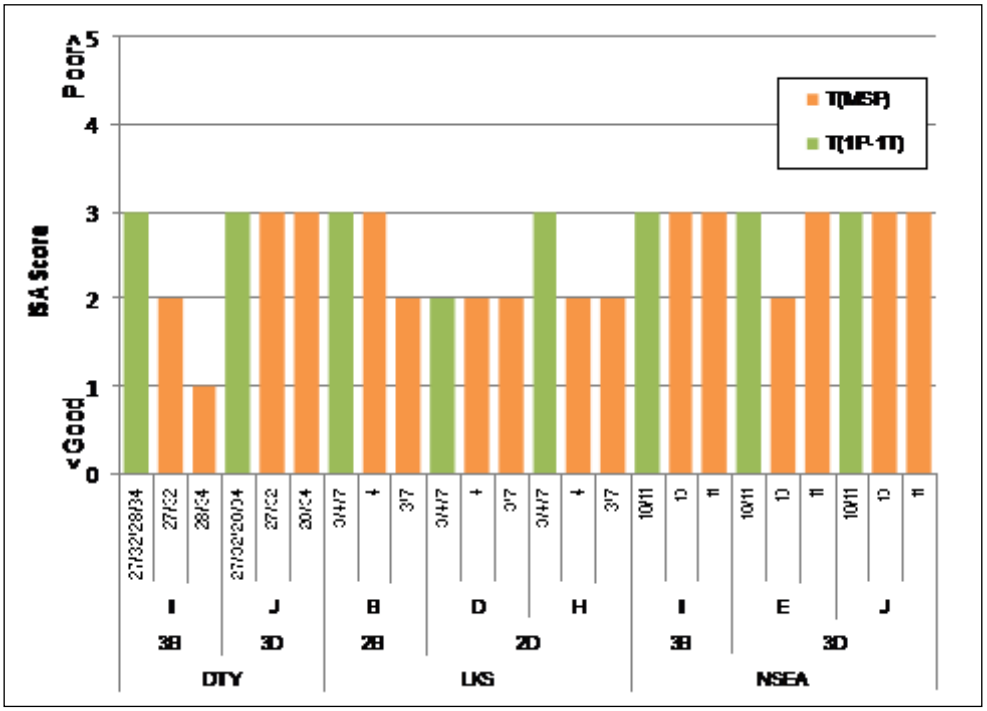


Figure 91 Average ISA Workload (Tactical)

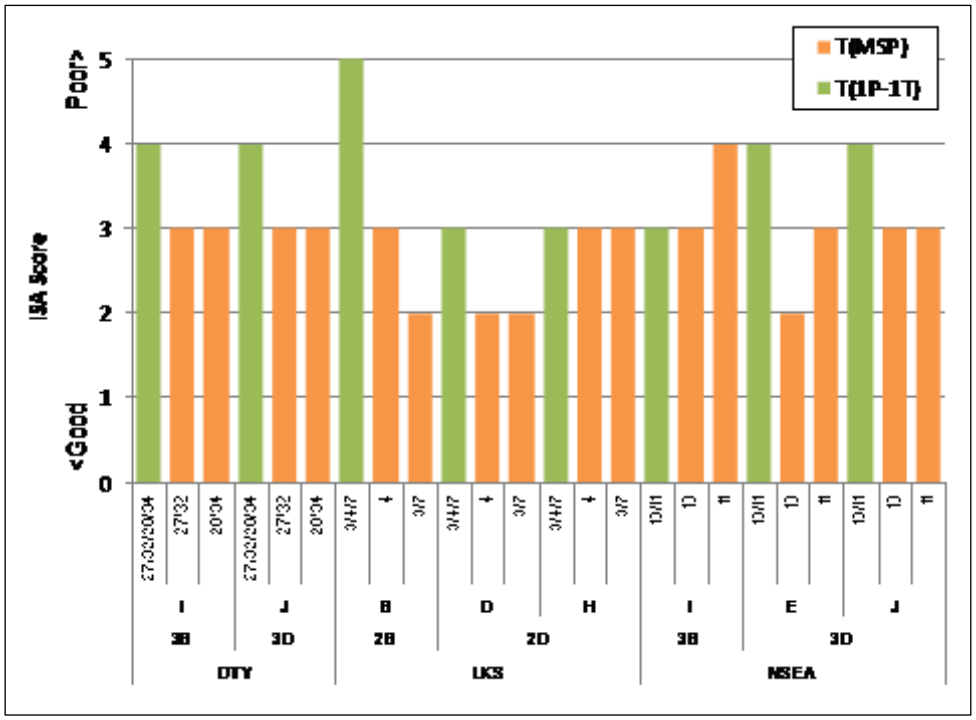


Figure 92 Peak ISA Workload (Tactical)

Analysis of the Bedford Workload scores for the Tactical role yielded similar results (see below).

A.3.3 Bedford Workload (Tactical)

Figure 93 and Figure 94 show the Bedford 'average' and 'peak' workload scores respectively for the Tactical role. The results for the DTY and LKS sectors are broadly consistent with the results from the analysis of ISA scores.

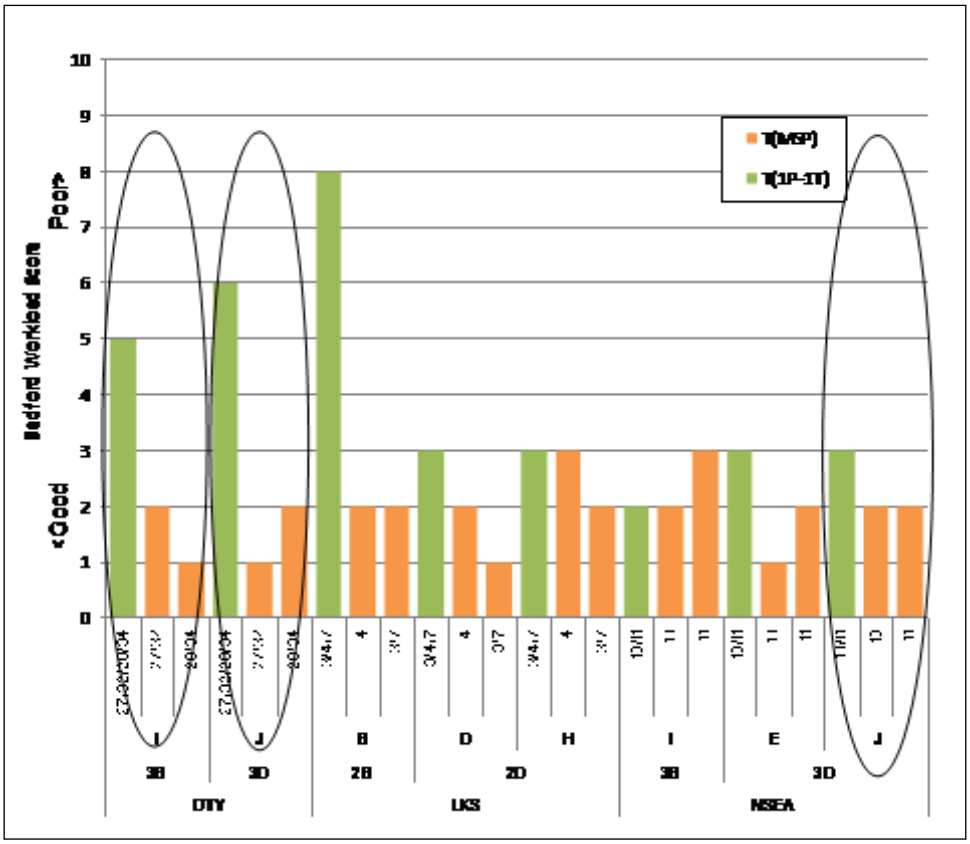


Figure 93 Bedford Average Workload (Tactical)

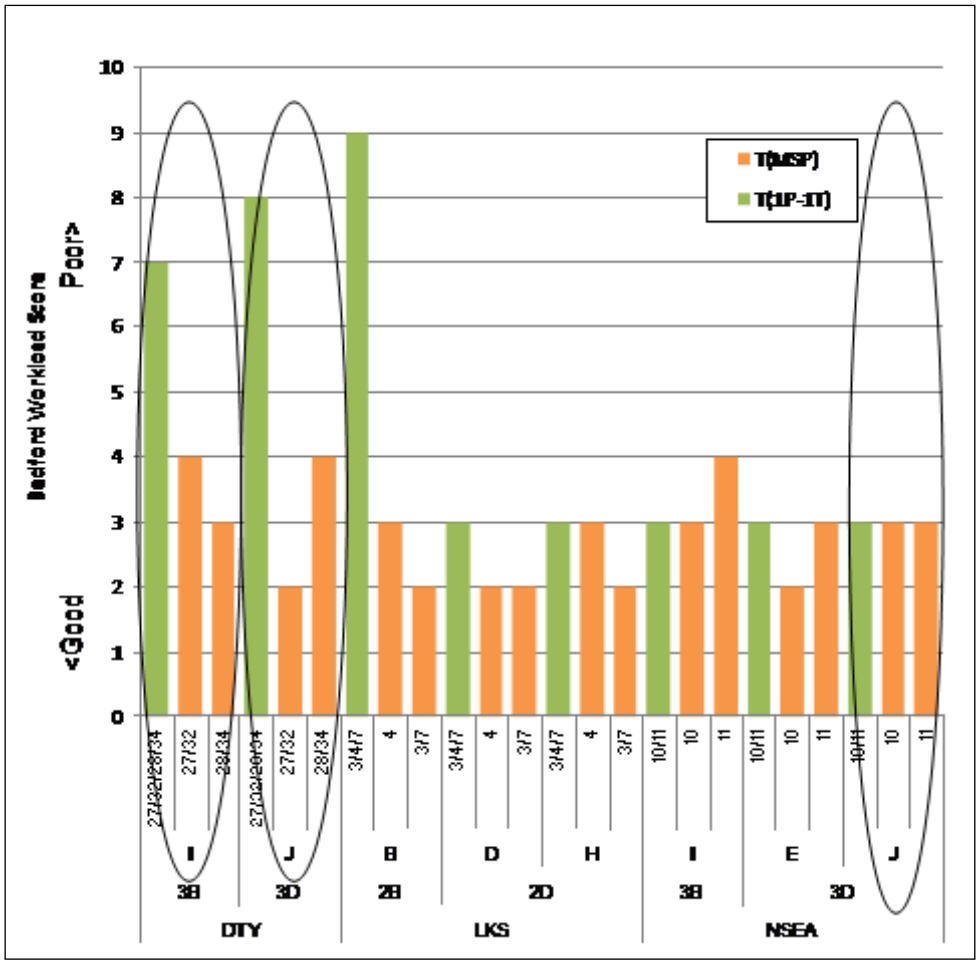


Figure 94 Bedford Peak Workload (Tactical)

For DTY sector, in all cases the average workload of the bandboxed Tactical was recorded as 'unacceptable' indicating that (from a Tactical perspective) it would have been necessary to split the sector. Similarly, the Bedford score for the bandboxed Tactical during LKS (B) indicate that the sector would have had to split. (Note: The corresponding MSP was recording 'tolerable' (Bedford '5') so was appropriate to exercise an MSP here rather than have a need to split.) For NSEA, although the participants subjectively reported that the sectors should have been split, this is not reflected in the Bedford 'peak' data.

Figure 95 and Figure 96 show the average and peak ISA workload scores for the Planner in the 1P-2T and 1P-1T (bandboxed) configurations. Figure 95 shows that the 'average' workload of the Planner in the 1P-2T configuration is similar to that of the Planner in the 1P-1T (bandboxed) sector, with seven of the eight median ISA scores the same or lower than that of the bandboxed Planner (it is only higher for NSEA (E)).

Figure 96 shows that in five of the eight matched runs, the 'peak' workload ratings of the MSP were the same or lower than that of the bandboxed Planner. However, for those matches where a higher workload was recorded for the MSP (LKS (D), LKS (H) and NSEA (E)) the MSP data was either gathered during the first day of measured runs when the MSPs reported that they were still getting used to the system, or the MSP reported that there were significant system problems affecting their performance.

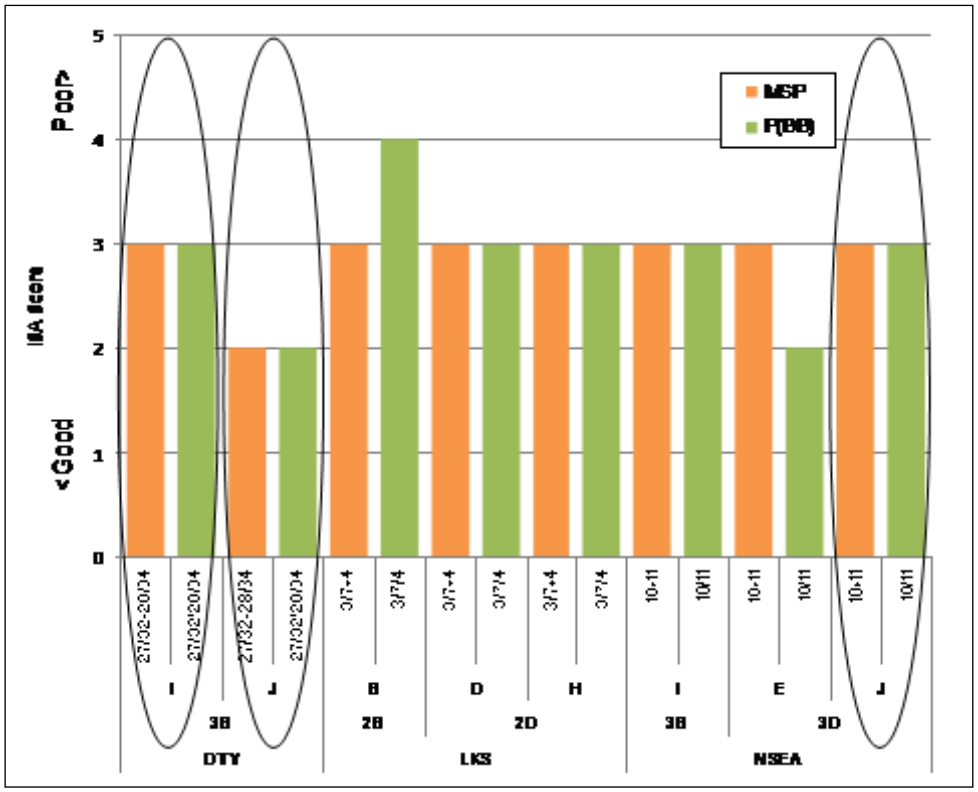


Figure 95 Average ISA Workload (Planner)

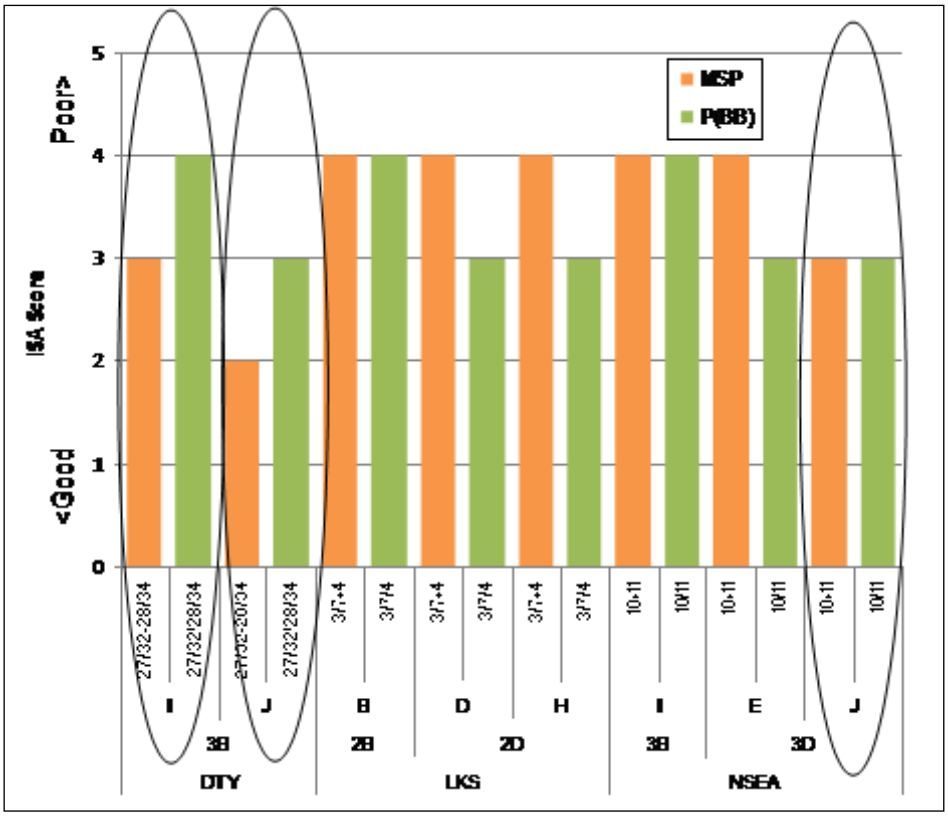


Figure 96 Peak ISA Workload (Planner)

For matched pairs DTY (I), DTY (J) and NSEA (J) (indicated in the charts above) the bandboxed Planner and/or Tactical subjectively reported that the sectors would have had to have been split in operations, but in the corresponding run, the MSPs subjectively reported that their workload was

acceptable. As such, these three matched pairs become the main focus of this analysis, the 'interval ISA' scores of which are shown below.

A.3.4 Bedford Workload (Planner)

Figure 97 and Figure 98 show the Bedford 'average' and 'peak' workload scores for the Planner in the 1P-2T and 1P-1T (bandboxed) configurations. Again, those runs that the participants subjectively reported as being appropriate to the 1P-2T configuration are 'highlighted' in the chart.

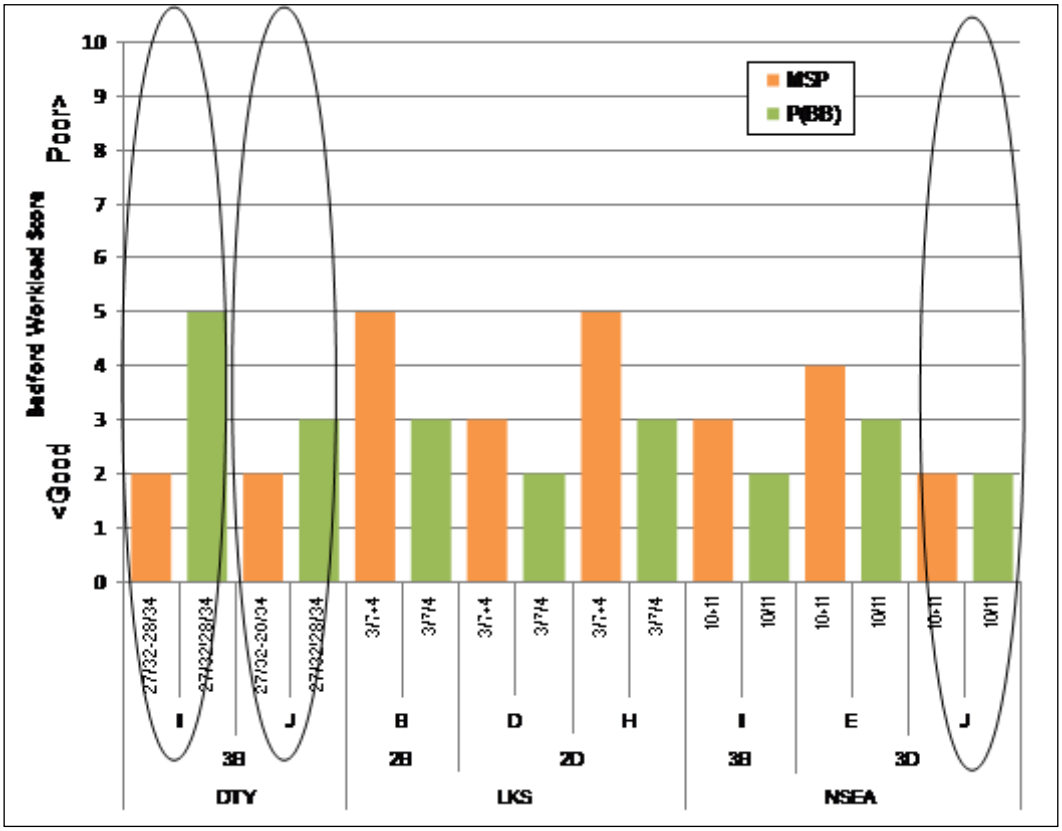


Figure 97 Bedford Average Workload (Planner)

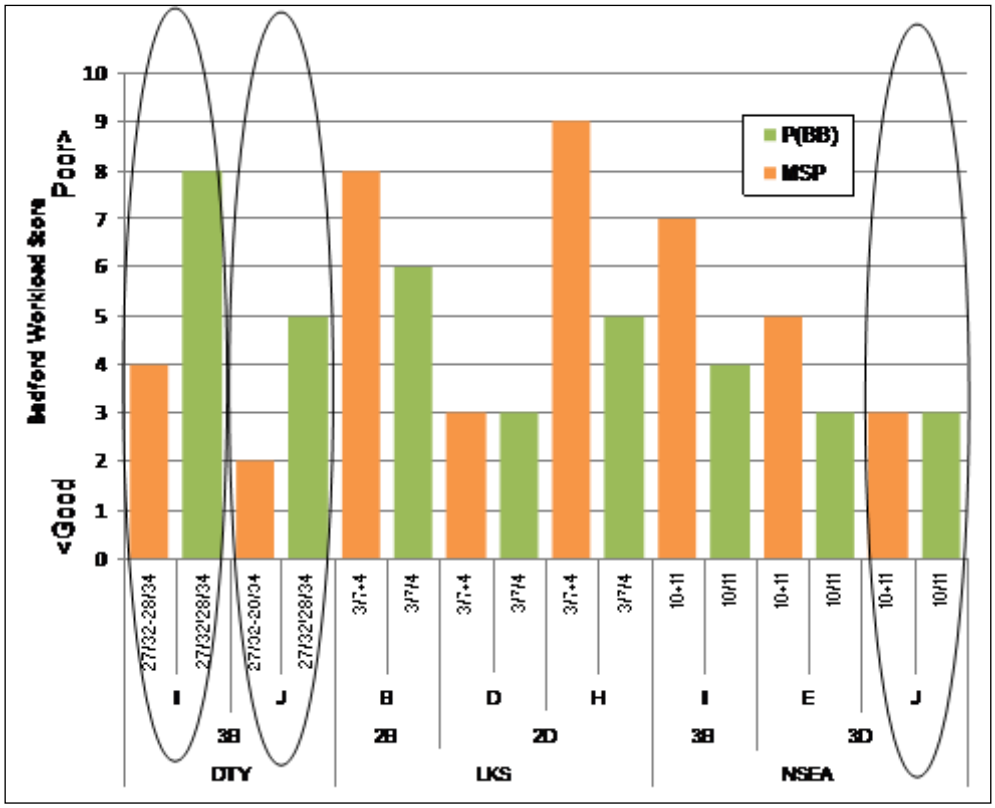


Figure 98 Bedford Peak Workload (Planner)

The results from the Bedford workload metric are consistent with the participants subjective assessment in that, for those runs that were reported as being appropriate to the MSP configuration (highlighted), the Bedford 'peak' workload for the MSP never scored above '4'.

For DTY, the Bedford 'average' workload for the MSP was rated the same or lower than that for the bandboxed Planner in both matches. For LKS and NSEA, the MSP reported the same or higher 'average' and 'peak' workload for the MSP. On further examination, for the four runs with the greatest difference in 'peak' workload, three of the participants had no previous experience of the iMSP concept (Note also that for LKS (H) feed sector issues were reported as causing significant problems to the MSP).

A.3.5 Interval ISA Scores

Figure 99 shows the interval ISA scores for these runs, and demonstrates that the workload of the MSP is similar or lower than that of the bandboxed Planner, indicating that the MSP could cope with at least the same traffic levels as the bandboxed Planner with NERC Planner tools.

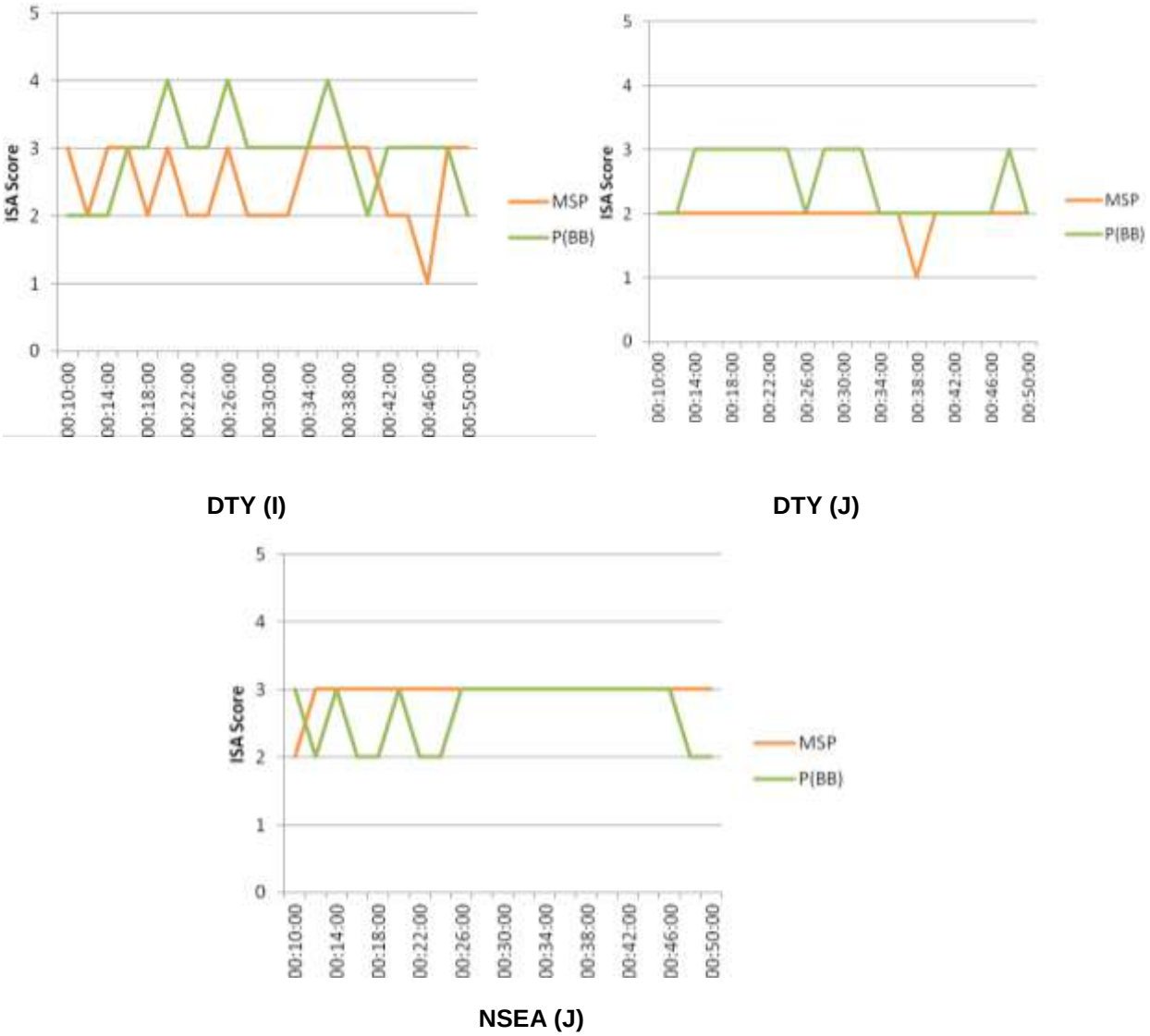
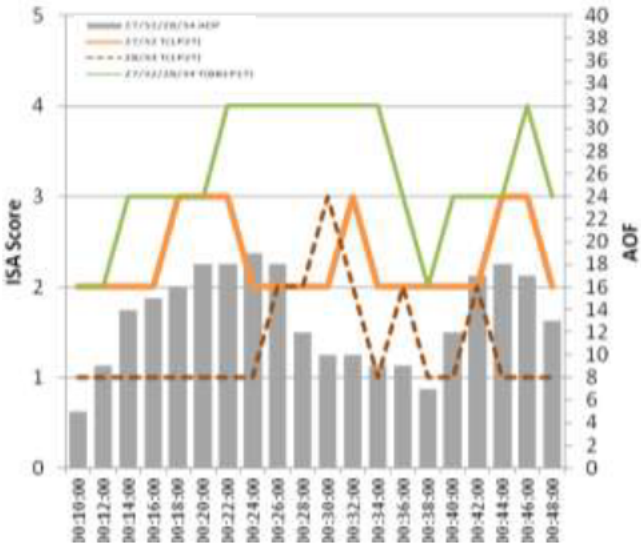


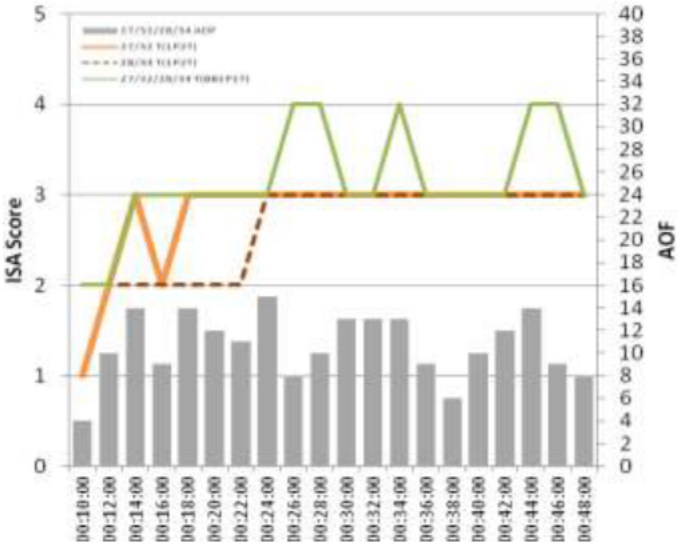
Figure 99 Interval ISA (MSP compared to Bandboxed Planner)

Figure 100 shows the interval ISA scores for the corresponding Tacticals for these runs, along with the number of aircraft on frequency (AoF). The charts show that for DTY (I), the Tactical of the bandboxed sector was recording ISA 4 (high) for a significant period of time (on reaching 18 aircraft on frequency) supporting the subjective view that they would have requested the sector to be split. The MSP of the matched run however was rating workload as 'comfortable' (Figure 99).

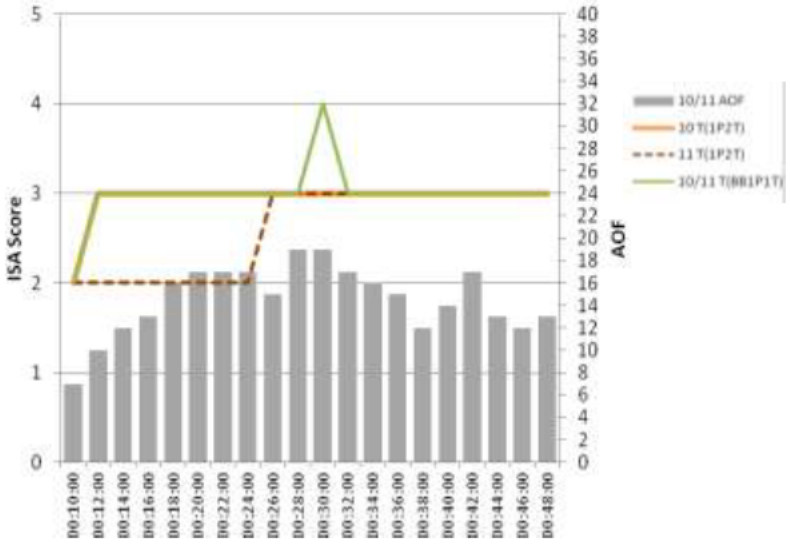
For NSEA (J), the Tactical of the bandboxed sector recorded ISA 4 (high) on only the one occasion, but in the matched MSP (1P-2T) run, both Tacticals were recording ISA 3 for over half the run which suggests that it was appropriate to have two Tacticals.



DTY (I)



DTY (J)



NSEA (J)

Figure 100 AOF/Interval ISA (Tactical)

A.3.6 China Lakes Situational Awareness

Figure 101 and Figure 102 show the China Lakes Situational Awareness scores for the Tactical and Planner roles respectively, in both a 1P-2T and 1P-1T (bandboxed) configuration; note that a low score represents good situational awareness.

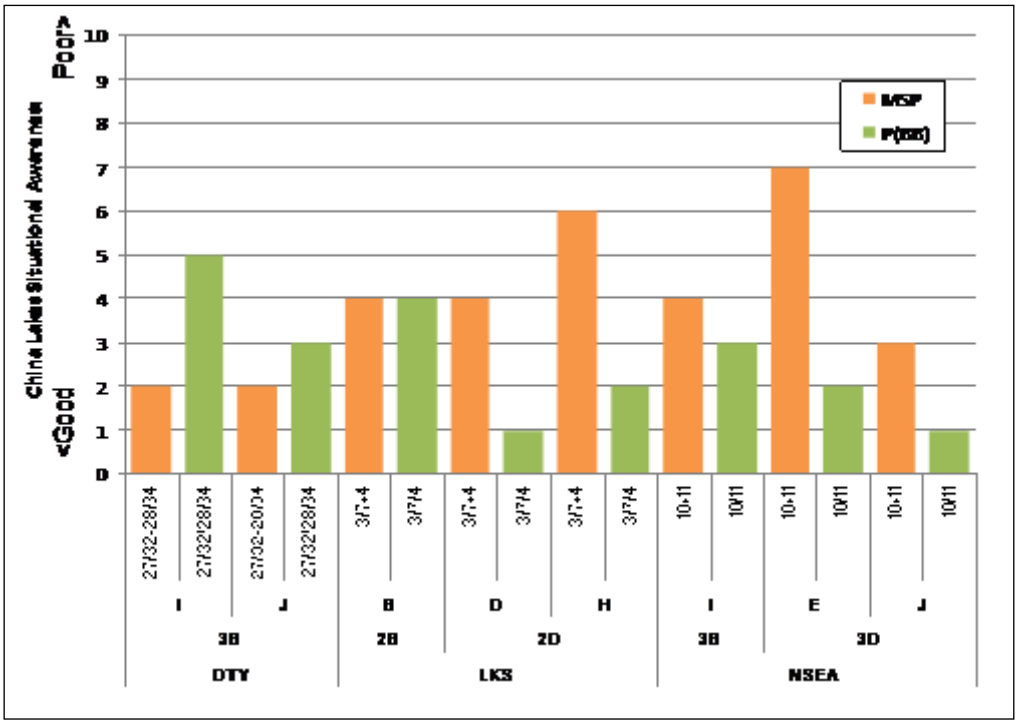


Figure 101 Situational Awareness (Planner)

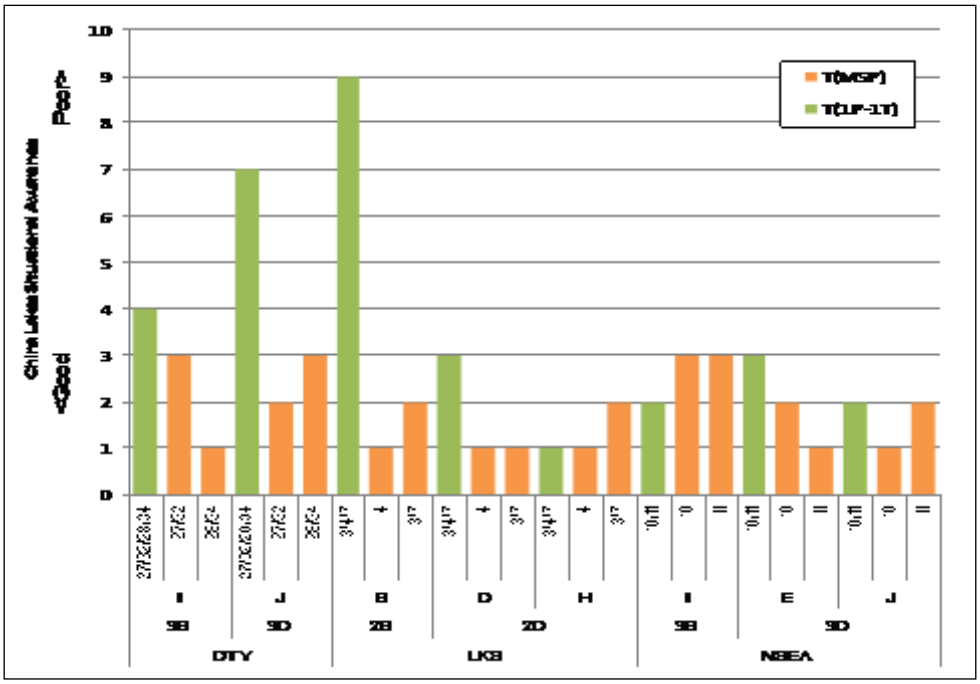


Figure 102 Situational Awareness (Tactical)

Even though the traffic samples were busy for the Tactical, the situational awareness of the Planner in the 1P-1T (bandboxed) configuration is generally rated as acceptable (below '6'). The analysis also shows that for the runs where the participants subjectively reported appropriate application of the 1P-2T configuration [DTY(I), DTY(J), NSEA(J)] the situational awareness of the MSP was rated as

'acceptable and satisfactory'. Further, the situational awareness for the MSP only scored above '4' on the scale for those participants without prior experience of the concept.

Again, as the traffic samples were designed to be relatively busy for the bandboxed configuration it is not unexpected that on occasion the Tacticals rated a very poor level of situational awareness. On these runs, the participants subjectively reported that the Tactical should have been 'split'. Not surprisingly, the two Tacticals associated to the MSP on all occasions rated their situational awareness as good.

A.4 Multi Sector Planning (compare to split Planners)

A.4.1 CARS User Acceptance

Figure 103 and Figure 104 show **CARS User Acceptance** scores for the Planner and Tactical roles respectively in a 1P-2T and 1P-1T (split) configuration.

In eight of the nine runs the participants rated the user acceptance of the Planner in the 1P-2T configuration (i.e. MSP) fairly well (<=5), though the user acceptance of iMSP was rated below that of the current operational system (which was, on all but one occasion, rated highly (<='3') for both the Planner and Tactical role).

On the one occasion where the user acceptance for iMSP exceeded 5, the participant had no previous experience of iMSP. The worst score from a participant with previous experience of the iMSP concept was '5', which equates to *'Moderately objectionable deficiencies'*, which for a V3 system is a promising result.

All user acceptance scores for the Tactical fall within acceptable limits, regardless of the Tactical having a shared or a dedicated Planner.

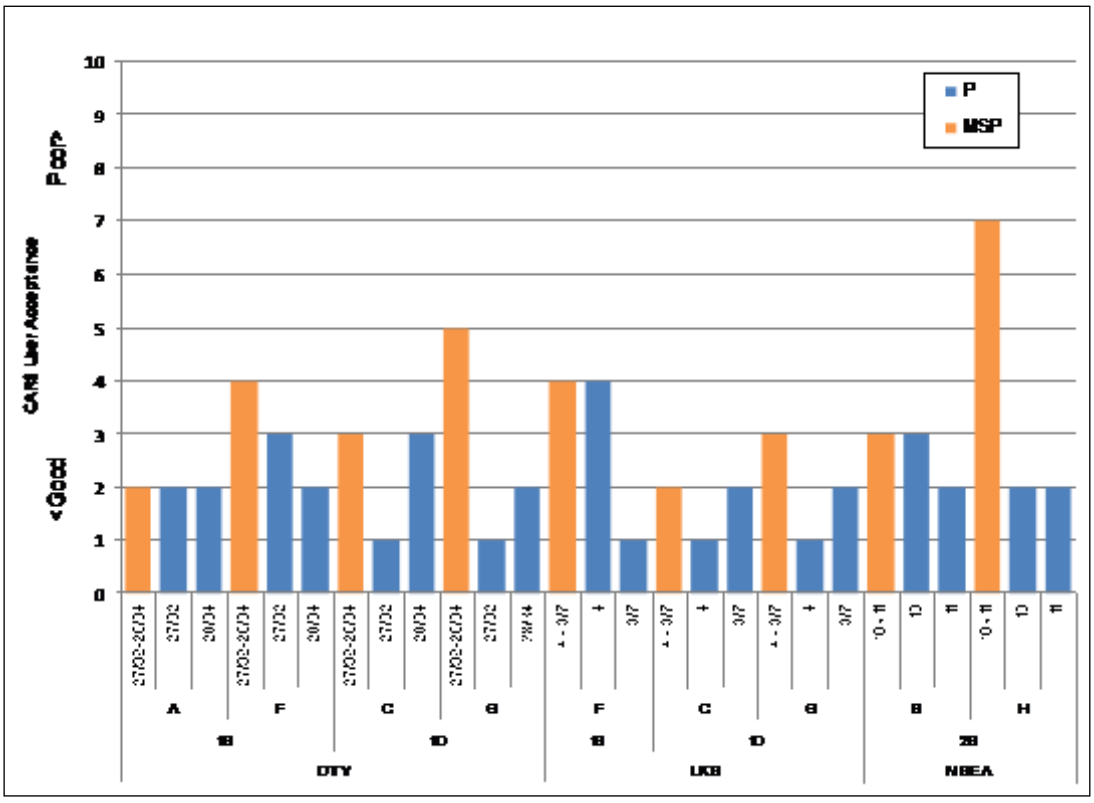


Figure 103 User Acceptance (Planner)

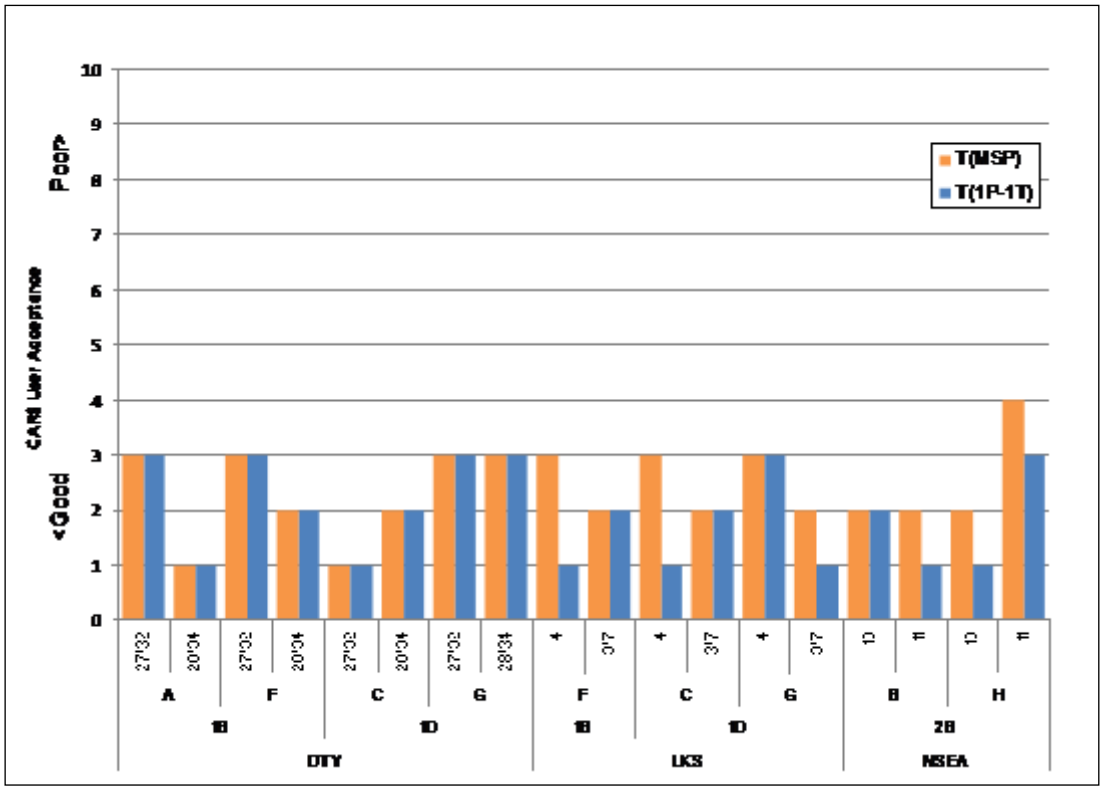


Figure 104 User Acceptance (Tactical)

A.4.2 ISA Workload (Tactical)

Figure 105 and Figure 106 show the median and peak ISA workload scores respectively for the Tactical role. In order to ensure that the two Tacticals in the split configuration remained sufficiently occupied for the duration of the run, the traffic samples were fairly busy, but not so busy as to necessarily require a second Planner. A consistently low level of Tactical workload would indicate that the Tacticals were not being fully utilised and could have been bandboxed. It is anticipated that the workload of those Tacticals with a shared Planner would be very similar to those with a dedicated Planner.

Figure 105 and Figure 106 show that, as expected, the ISA scores of the Tacticals with a dedicated Planner is similar (and in most cases the same) as that of the Tacticals with an MSP. Further, although the median ISA of the Tactical does not exceed 'comfortable' workload, the participants subjectively reported that, with the exception of matches DTY (C) and DTY (G), all runs required two Tacticals. For DTY (C) and DTY (G), the participants suggested that the sectors could have been bandboxed for much of the run, but would have required a split towards the end as a result of Tactical workload.

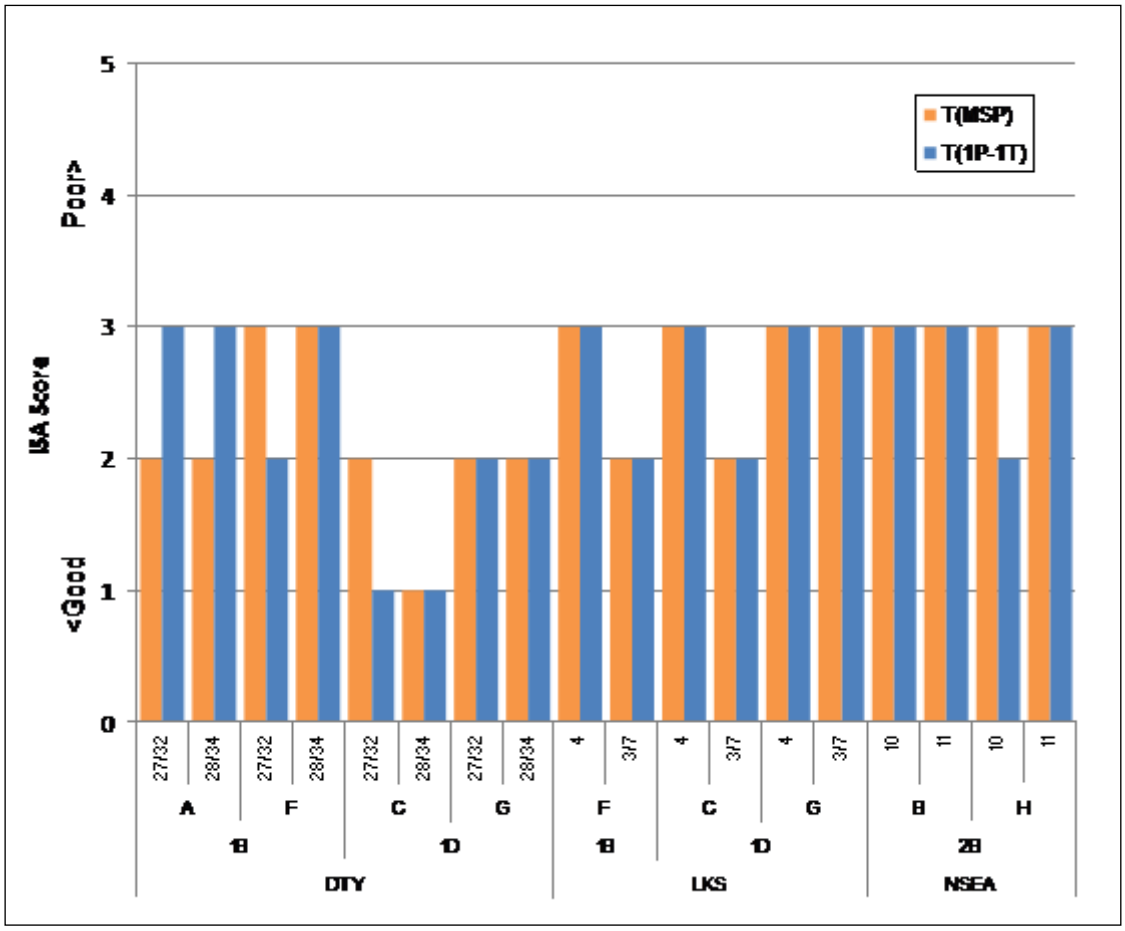


Figure 105 Average ISA Workload (Tactical)

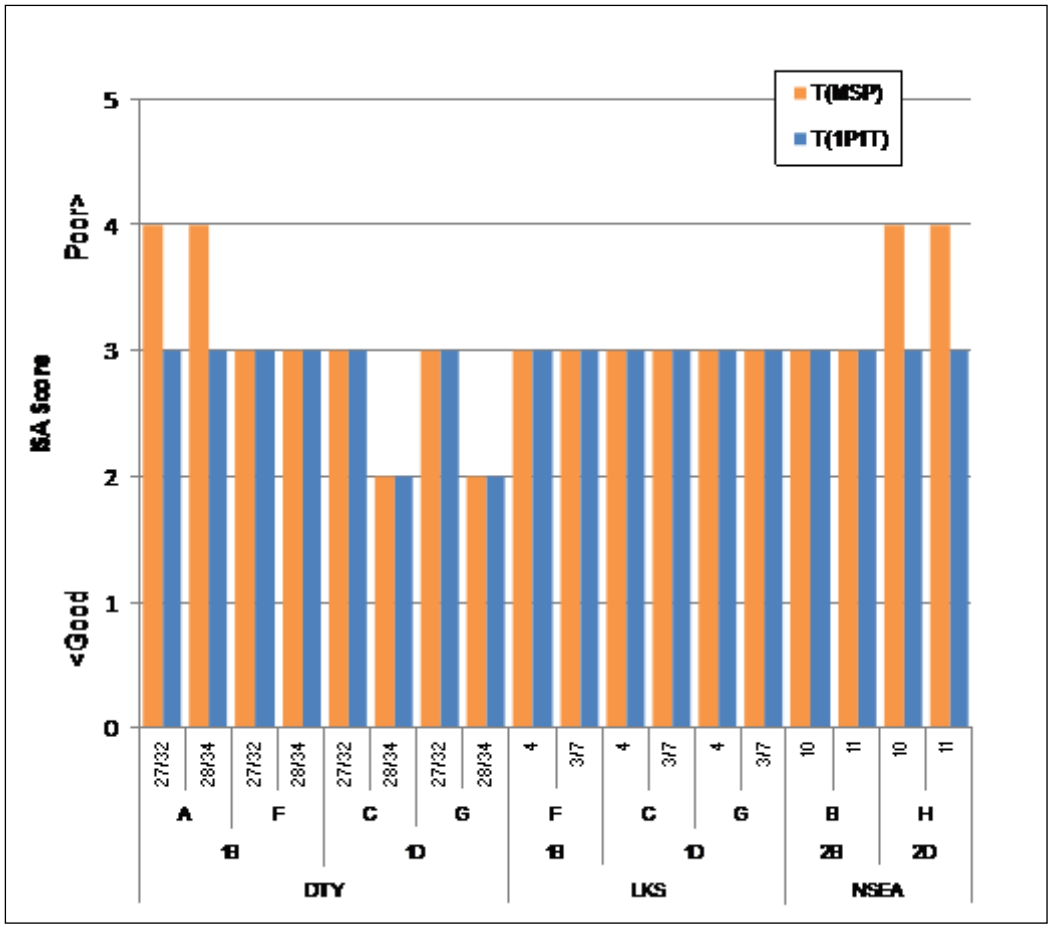


Figure 106 Peak ISA Workload (Tactical)

A.4.3 Bedford Workload (Tactical)

Figure 107 and Figure 108 show the Bedford ‘average’ and ‘peak’ workload scores respectively for the Tactical role.

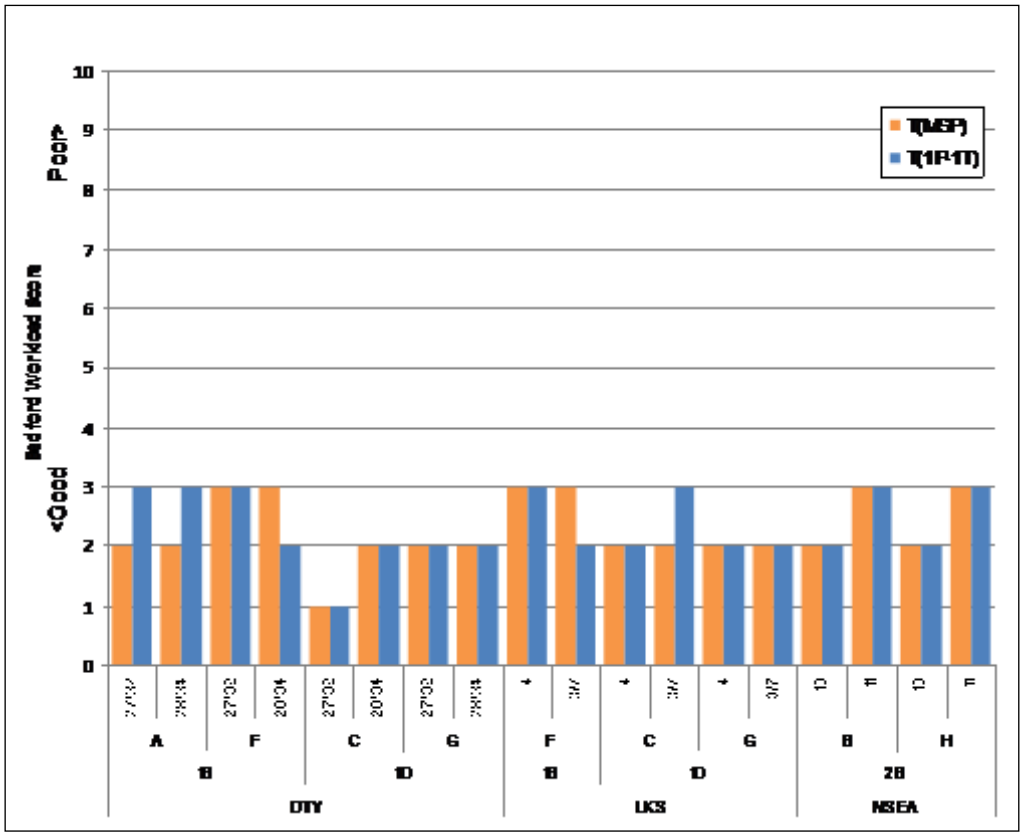


Figure 107 Bedford Average Workload (Tactical)

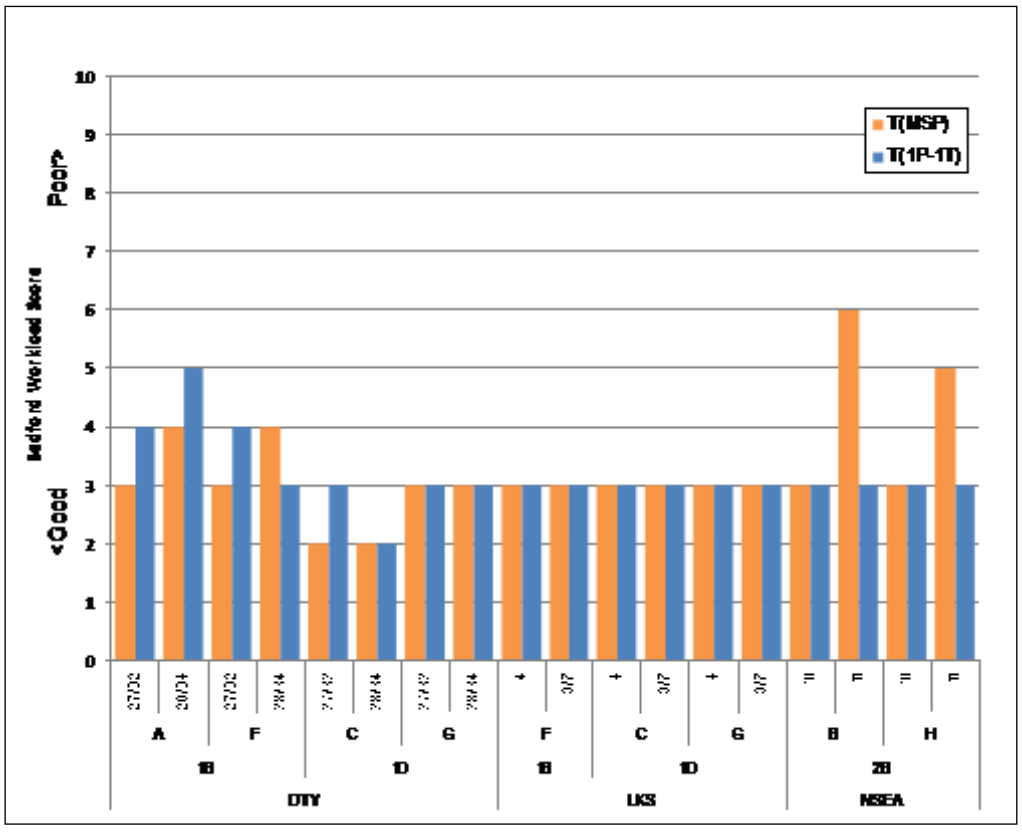


Figure 108 Bedford Peak Workload (Tactical)

The Bedford measure of workload shows similar results to that of the ISA metric. Figure 107 shows that there the Tactical 'average' workload is similar in a 1P-1T and 1P-2T configuration. Figure 108 shows that in the majority of runs the Tactical peak workload is tolerable, and in most cases satisfactory. For NSEA (B) however, the S11 Tactical workload is much higher for the Tactical in the 1P-2T configuration. On this occasion the S11 Tactical reported '*It would have definitely been split. It was a little complex which ups the workload. I wasn't aware of the MSP workload as I was super busy. I would have felt more comfortable with two Planners as one aircraft didn't check in. There were short periods where my workload really peaked'.*

A.4.4 ISA Workload (Planner)

Figure 109 and Figure 110 show the median and peak ISA workload scores respectively for the Planner in a 1P-2T and 1P-1T (split) configuration. Figure 109 shows that the Planners in each of the 'split' sectors recorded that average workload was relatively low, with at least one of the Planners in the split sector recording 'under-utilised' (recall that the relative Tacticals had reported that the sectors were too busy to be run bandboxed). In the corresponding runs with a Multi-Sector Planner, the MSP recorded that the average workload, although higher than that of the separate Planners, it was still recorded as being 'comfortable'.

However, when considering 'peak' workload (Figure 110), the Multi-Sector Planner recorded workload above 'comfortable' on six occasions. In these runs, the Multi-Sector Planners subjectively reported that the workload was too high for the Multi-Sector Planner configuration.

Thus, for matches DTY (A), DTY (C), DTY (G), and LKS (G), the analysis of workload and subjective feedback from the participants suggests that the Multi-Sector Planner configuration was appropriate.

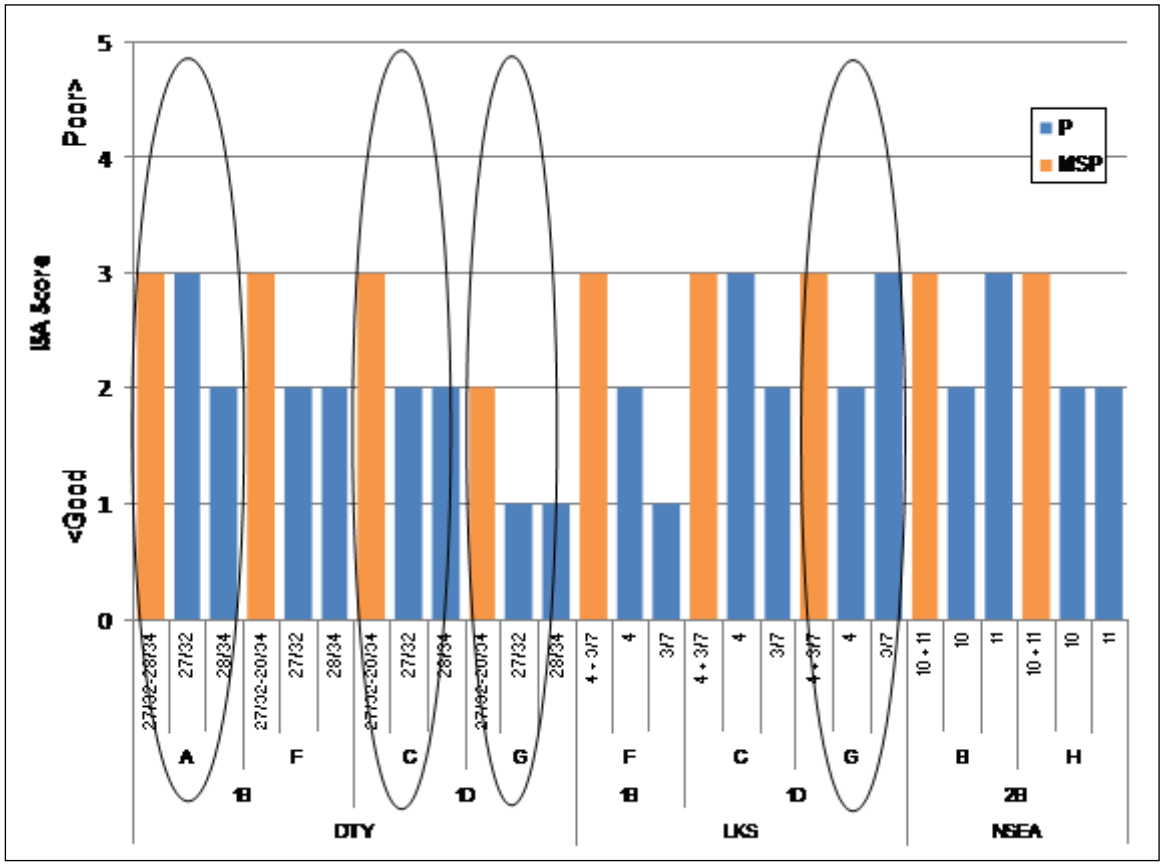


Figure 109 Average ISA Workload (Planner)

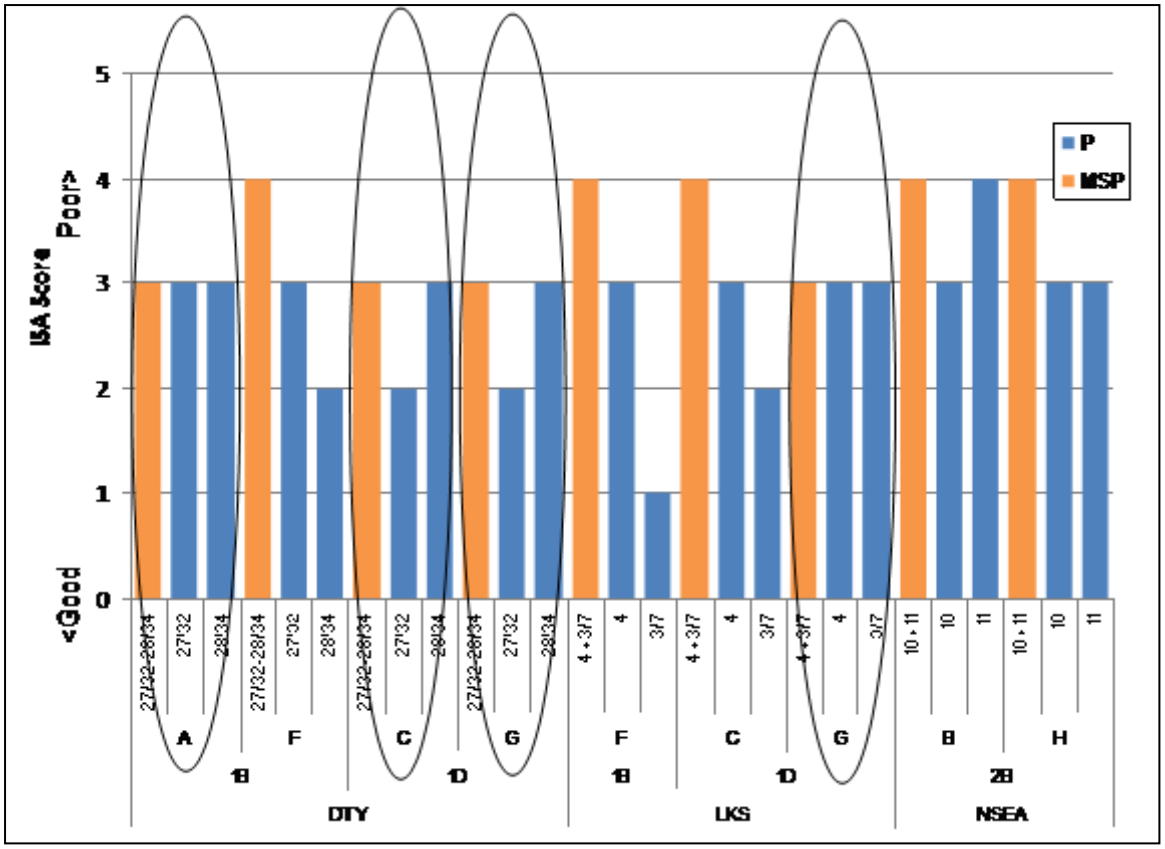


Figure 110 Peak ISA Workload (Planner)

A.4.5 Bedford Workload (Planner)

Figure 111 and Figure 112 show the Bedford 'average' and 'peak' workload scores respectively for the Planner role in a 1P-2T and 1P-1T (split) configuration.

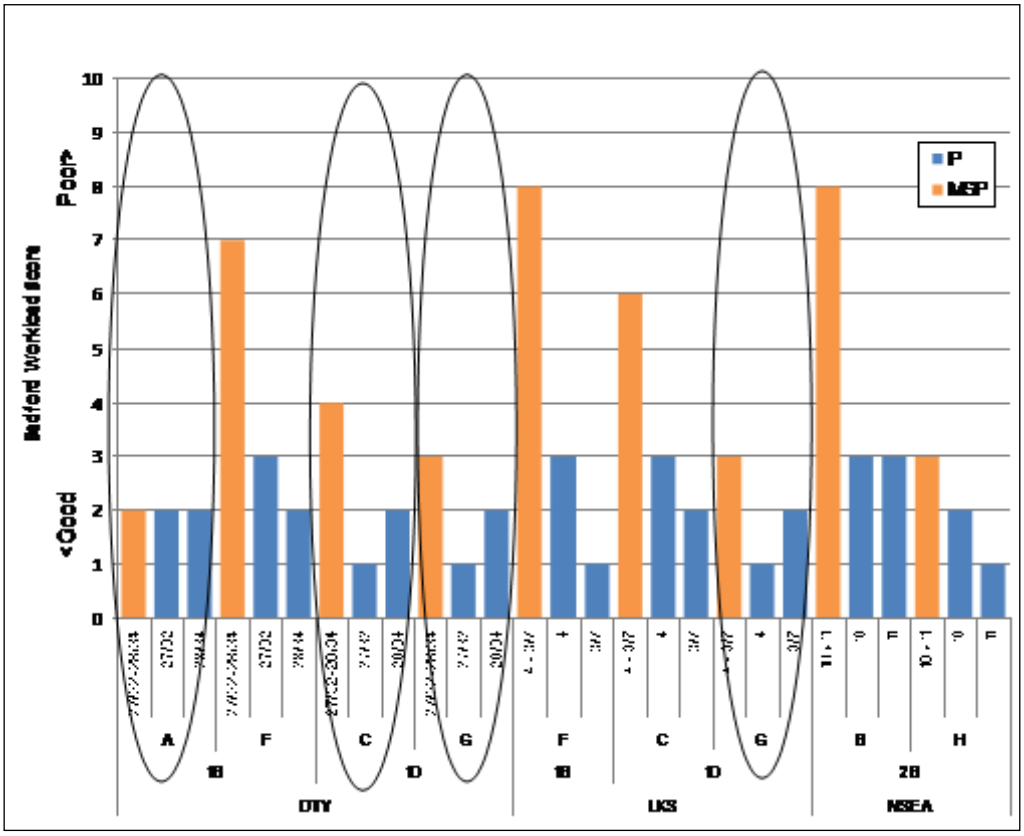


Figure 111 Bedford Average Workload

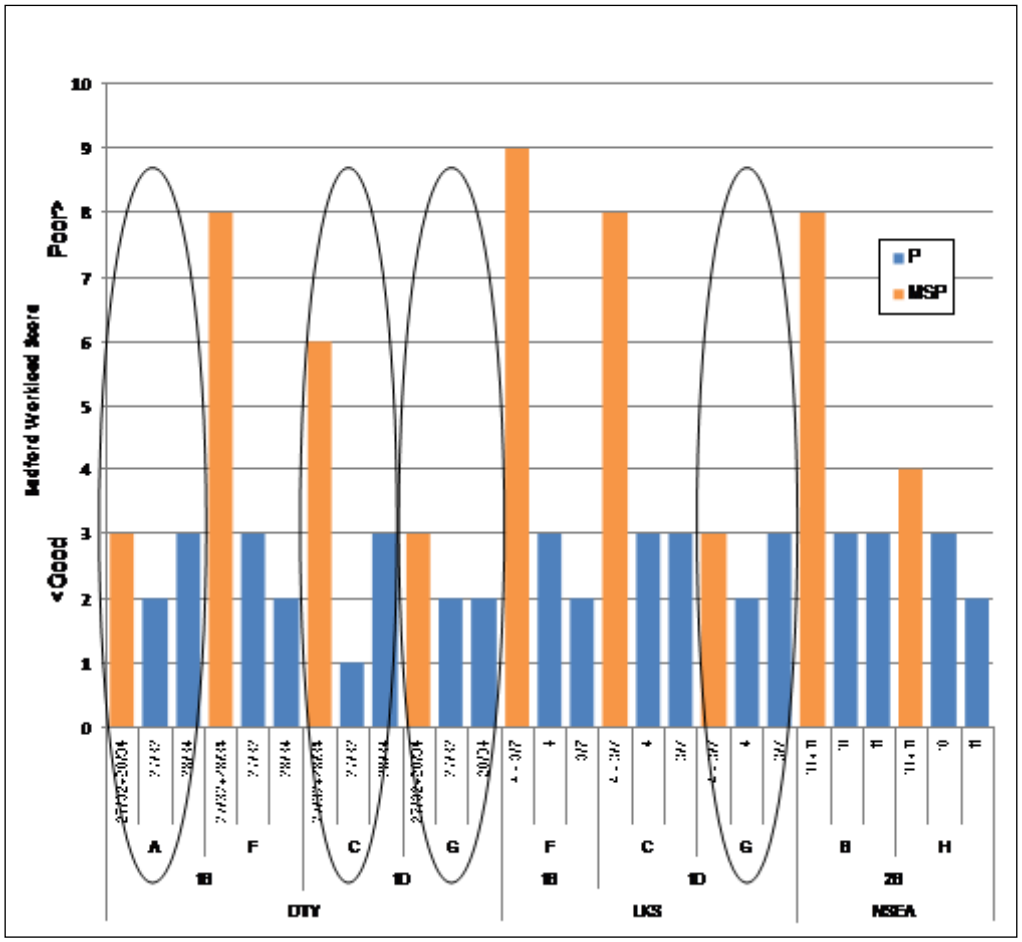


Figure 112 Bedford Peak Workload

Again, the Bedford measure of workload shows broadly similar results to that of the ISA metric in that where the Tacticals reported that a split sector was required; the Planners of the split sectors are recording relatively low average workload). For those runs where the participants subjectively reported that the workload of the MSP was acceptable (DTY (A), DTY (C) and DTY (G), and LKS (G)) the Bedford metric also shows that the average workload was also broadly acceptable. Note the Bedford 'peak' workload reached the tolerable limit ('6') on DTY (C) though the debriefs and observations do not give any reason for this response.

Matches that use the same traffic sample within a sector, although possibly having different participants in the role of MSP, should produce broadly similar workload scores. However, this is shown not to be the case here, and on further investigation it again becomes evident that the participants' previous experience of iMSP was a factor.

In match LKS (C), this was the participants first measured run as MSP, whereas the MSP in the similar run LKS (G) had previous experience of the iMSP concept. Interestingly, this is a factor in all four matched pairs where the MSP reported that the Bedford 'average' or 'peak' workload was 'intolerable' (greater than a score of '6'), with this being either their first or second measured run as MSP. The effect of sector validity exacerbated this. DTY (F) was the run where one of the Tacticals was not sector valid, and the Planner (MSP) reported that this had an effect on their workload.

A.4.6 Interval ISA Scores

The interval ISA scores for those matched pairs of runs where the participants subjectively reported that the MSP configuration was appropriate (DTY (A), DTY (C), DTY (G), and LKS (G)) are shown in Figure 113 below.

Each chart shows the ISA scores recorded for the Planners in matched runs of the 1P-2T and 1P-1T (split) configurations. The ISA score is plotted against time, displayed as minutes into the run. Note

that ISA scores recorded in the first 10 minutes and last 5 minutes of the run were excluded from the analysis.

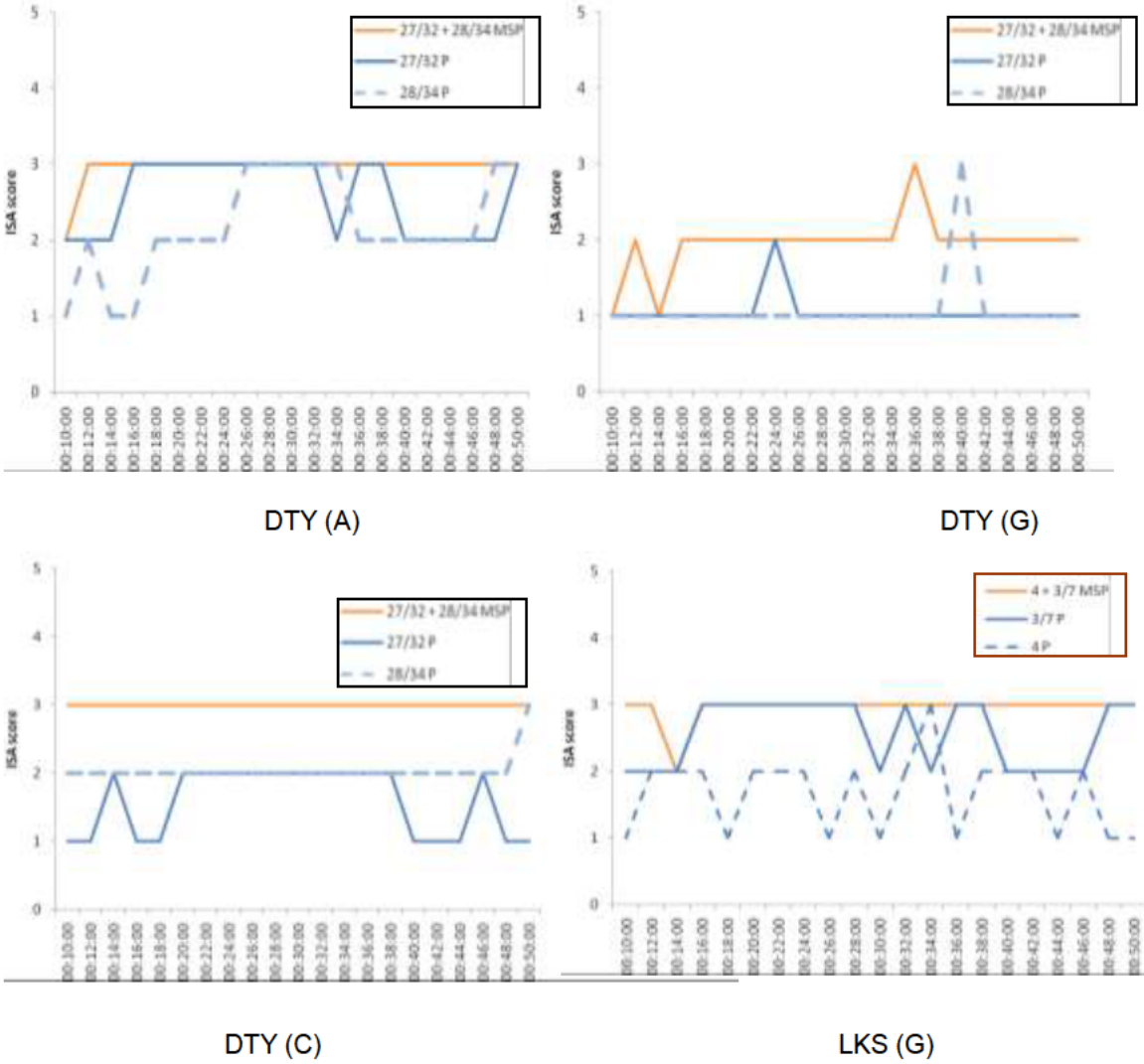


Figure 113 Interval ISA (MSP compared to Split Planners)

The chart shows that the Planners of the 'split' sector for the most part recorded 'low' or 'comfortable' workload over the duration of the run (even though the Tacticals reported that they were too busy to bandbox). However, in the comparative runs, the MSPs still recorded a steady and 'comfortable' level of workload. (Interestingly the MSP in match DTY (A) did not have previous experience of the concept).

The associated aircraft on frequency charts are shown in Figure 114. The charts demonstrate that, although the MSP was 'comfortable', the Tacticals were sufficiently busy to justify the sector being split.

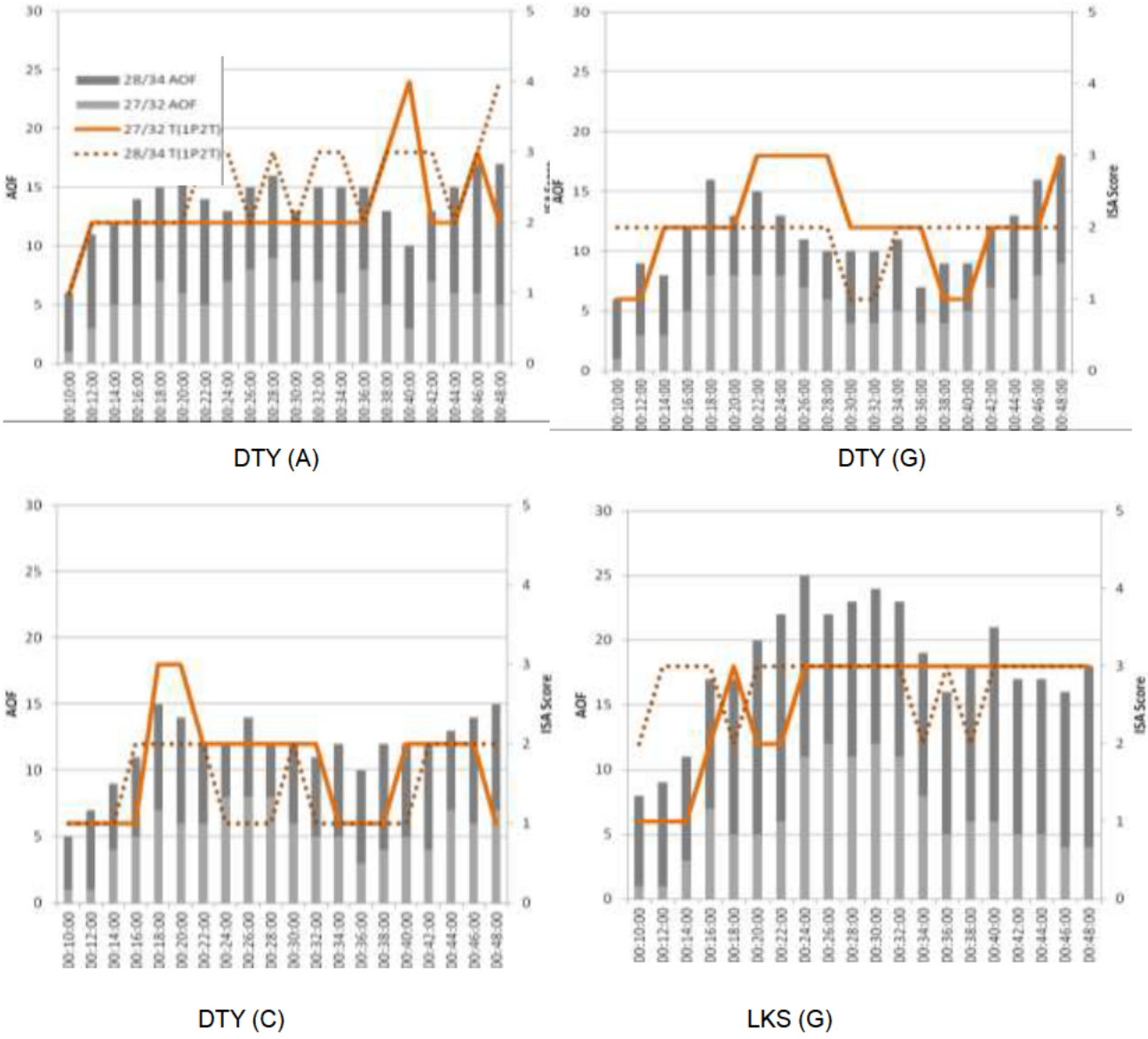


Figure 114 AOF/Interval ISA (Tactical)

A.4.7 China Lakes Situational Awareness

Figure 115 and Figure 116 show the China Lakes Situational Awareness scores for the Tactical and Planner roles respectively, in 1P-2T and 1P-1T (split) configuration.

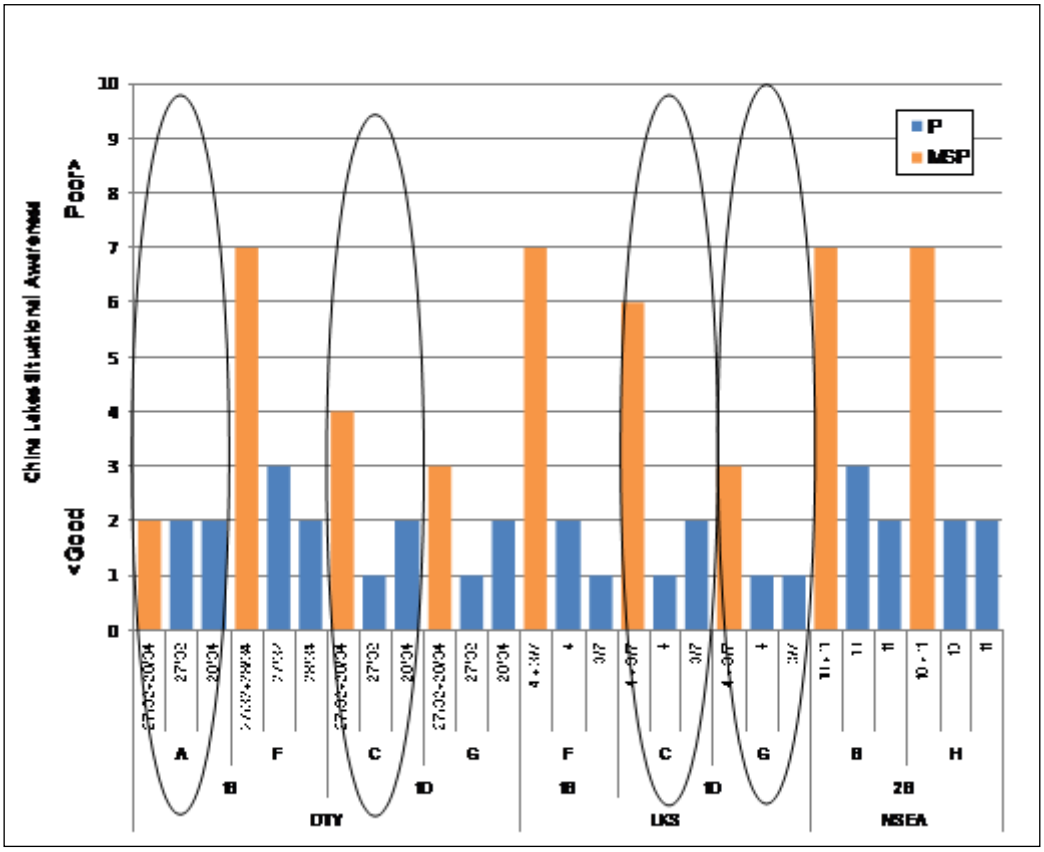


Figure 115 Situational Awareness (Planner)

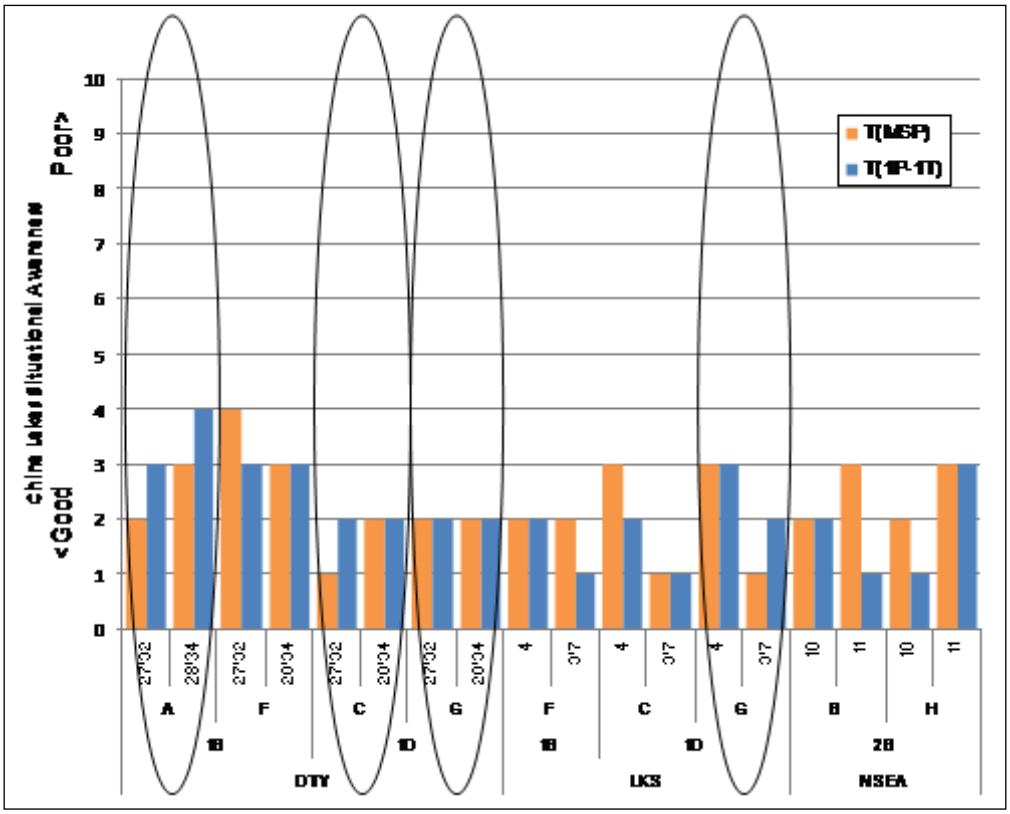


Figure 116 Situational Awareness (Tactical)

As would be expected, the situational awareness of the Planner role with the current NERC system was, on all occasions, rated as very good (below '3'). The situational awareness for the Planner in the 1P-2T configuration was rated as good (below '4') on four occasions; on three of these occasions the participants subjectively reported that the 1P-2T configuration was appropriate. On the four occasions where the situational awareness exceeded '6', the participants had no prior experience of the concept (and as such reported that the MSP role would have had to be 'split').

All situational awareness scores for the Tactical fell within acceptable limits, regardless of the Tactical having a shared Planner or a dedicated Planner.

A.4.8 Telephone Calls

Figure 117 shows the number of telephone calls made by the Planner in a 1P-2T configuration and the Planners from the corresponding sectors in a 1P-1T (bandboxed) configuration. In each case the Planners have comparative tasks, however, the Planner in the 1P-2T configuration has two Tacticals (and hence two R/T frequencies) to manage, but has the support of enhanced Planner tools.

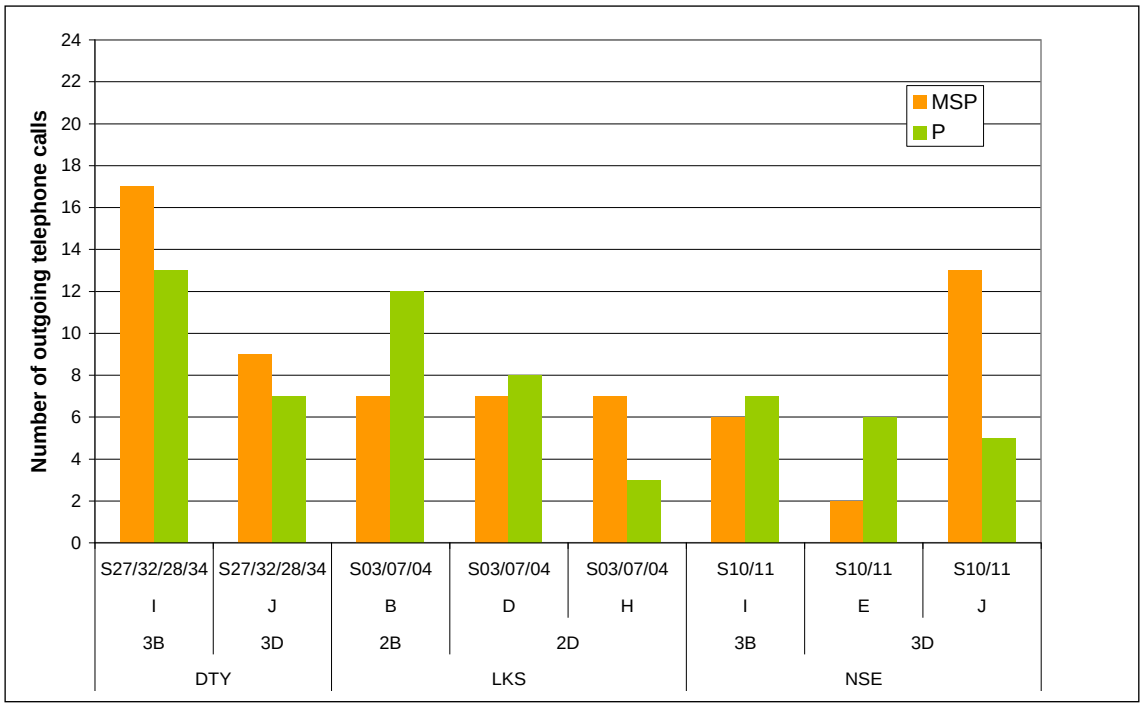


Figure 117 Telephone Use (Planner)

Figure 118 shows the number of telephone calls made by the Tacticals in both a 1P-2T and 1P-1T (bandboxed) configurations. Over all runs, the Tacticals in a 1P-2T configuration made more telephone calls than the Tactical in 1P-1T (bandboxed); the Tacticals in the 1P-2T configuration made a total of 13 calls, compared to a total of 3 for the single Tactical in the 1P-1T (bandboxed) configuration. However, the two Tacticals in the 1P-2T configuration may simply have had the capacity over that of the single Tactical to pro-actively make additional phone calls to improve quality of service.

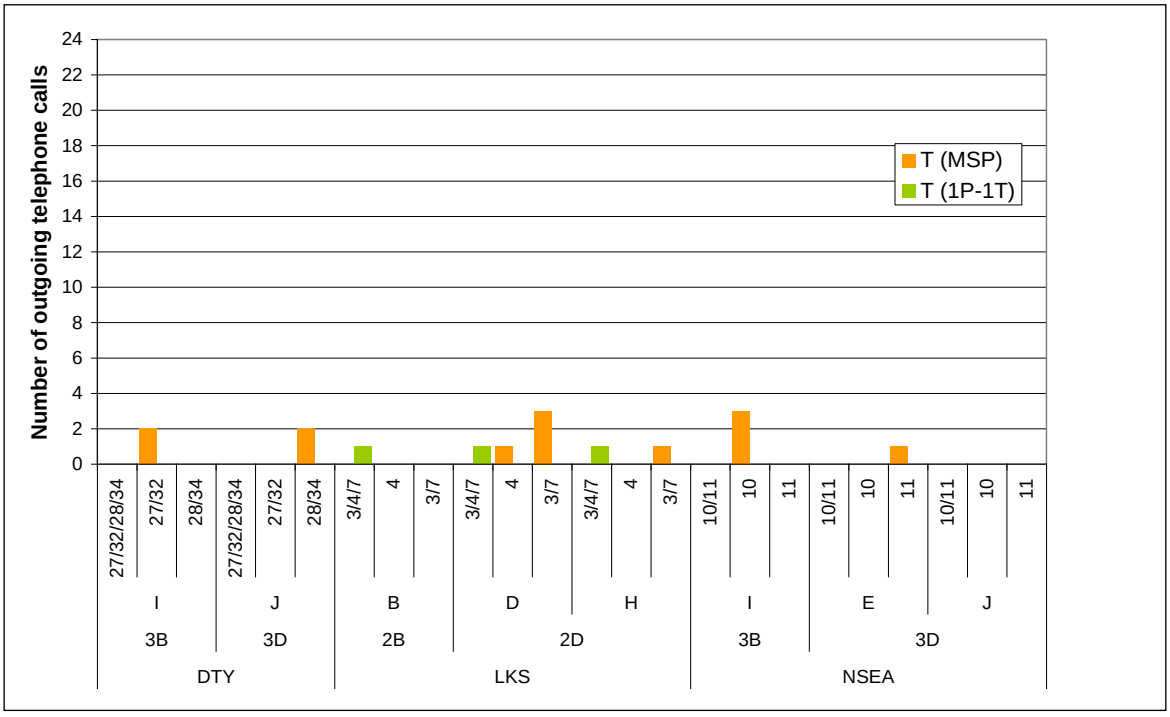


Figure 118 Telephone Use (Tactical)

It would be a reasonable assumption to make that a Planner would make more telephone calls in an MSP environment compared to either of the Planners in the corresponding 1P-1T (split) environment because the MSP is responsible for planning all aircraft entering the same planning volume as that of the two respective Planners.

To demonstrate relative magnitude of telephone use, Figure 119 shows the total number of telephone calls made for the Planner in the 1P-2T configuration and the Planners from the corresponding sectors in a 1P-1T (split) configuration.

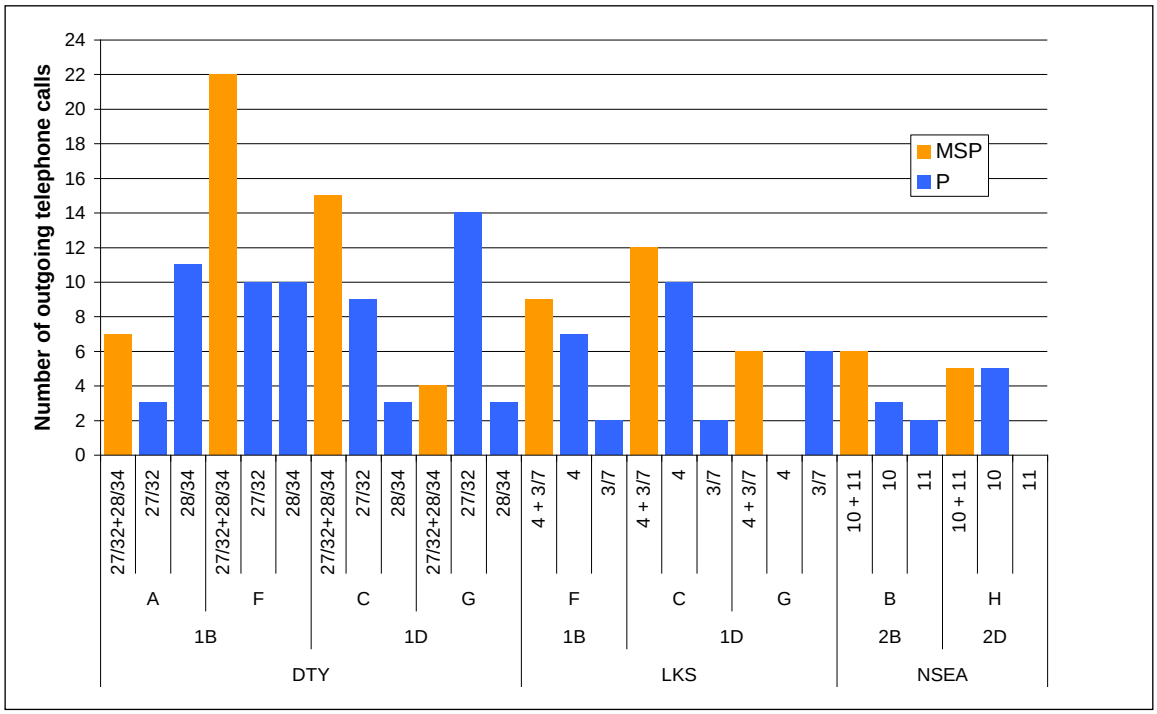


Figure 119 Telephone Use (Planner)

In the majority of the matches shown above in Figure 119 the number of calls made by the MSP is less than the sum of two separate Planners; this is (at least in part) because the relative split Planners will have a need to telephone each other; these calls are not required in the 1P-2T environment.

The exception to this is LKS (F). Further investigation shows a Bedford average workload score of '7' for the Multi-Sector Planner, whereas the individual Planners recorded a Bedford average workload of '2' and '3'. The MSP in the run reported that it was far too busy for a 1P-2T staffing configuration; therefore a possible explanation for the high number of phone calls may be due to the MSP falling behind in their tasks, resulting in more phone calls for events such as late offers/late accepts etc.

Figure 120 shows the number of telephone calls made by the Tactical in both a 1P-2T and 1P-1T (split) configuration. The chart shows that over all runs the Tacticals in a 1P-2T staffing configuration made more telephone calls than the Tacticals with a dedicated Planner (overall runs a total of 30 compared to 19). This suggests that the Tacticals are likely to make more telephone calls when they do not have a dedicated Planner.

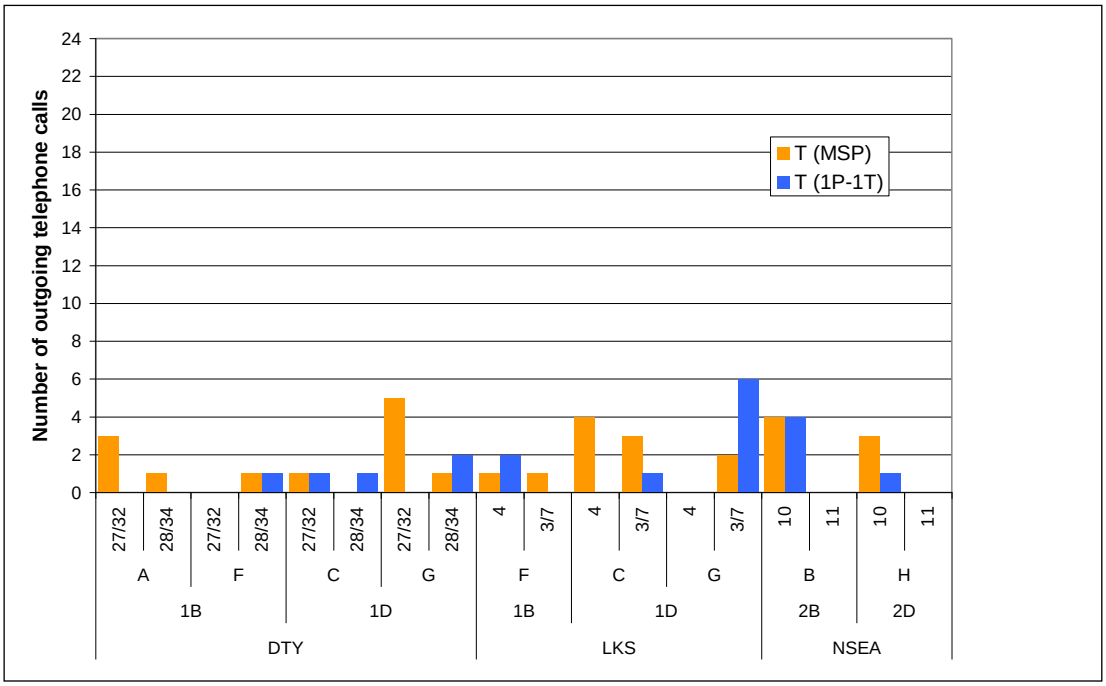


Figure 120 Telephone Use (Tactical)

A.5 Single Person Operations

A.5.1 Traffic Levels

The traffic levels in this activity were necessarily designed to examine the period between bandboxing and splitting of sectors and as such were intended to stretch the 1P-1T staffing configuration. Examination of the number of aircraft on frequency for matched runs for SPO (Figure 121) shows that the throughput (number of aircraft initially on frequency plus the number of aircraft joining the frequency) was between 40 and 50 aircraft over the duration of the 40 minutes measured time, which is in excess of the traffic levels intended for the simulated SPO concept.

Sector group	Sector	Traffic Sample	Aircraft Throughput (40 mins.)
DTY	28/34	2B	50
		2D	43
			40
LKS	4	3B	46
		3D	46
			45
	3/7	3B	48
		3D	49
			50

Figure 121 SPO Traffic levels (matched runs)

In addition to the ‘matched’ runs for SPO, the SPO role was exercised during measured runs (which included SPO for NSEA) aiming to address other objectives, and feedback from the participants was that the traffic levels for the SPO positions during some of these runs was more manageable. Figure 122 shows that in contrast to the matched runs, the throughput for the SPO during these additional runs was as low as 16 aircraft.

Sector group	Sector	Traffic Sample	Aircraft Throughput (40 mins.)
DTY	27/32	2B	34
			33
		2D	35
			36
			35
	28/34	2B	49
		2D	42
NSEA	10	1B	17
			18
		1D	16
	11	1B	28
			28

Figure 122 SPO Traffic levels (non-matched runs)

As such, where appropriate, the data from these runs (with no equivalent matched 1P-1T data) is shown.

A.5.2 CARS User Acceptance

Figure 123 shows the User Acceptance scores for all matched runs of the SPO and 1P-1T configurations.

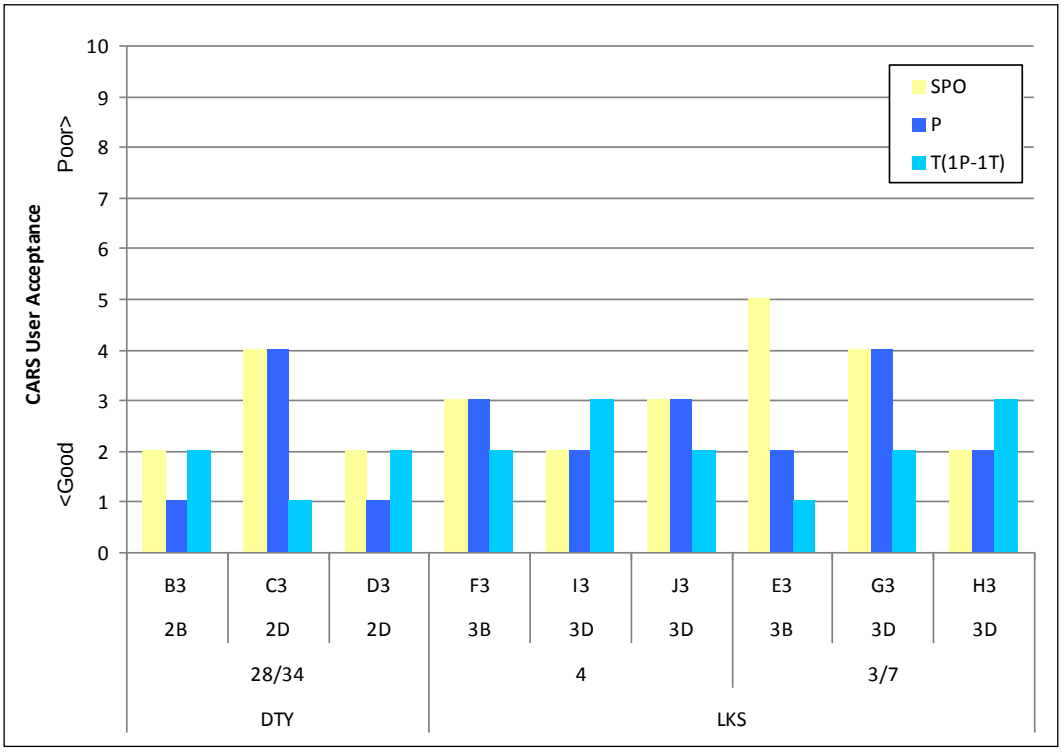


Figure 123 User Acceptance
(matched runs)

A.5.3 ISA Workload

Figure 124 and Figure 125 shows the median and Peak ISA workload scores for the SPO (with enhanced Planner tools and Integrated Coordination) and the scores for the Planner and Tactical in the matched run (with NERC Planner tools).

The charts for the matched runs show that generally, the median workload for at least one of the two roles in the 1P-1T configuration has reached a comfortable level and in some runs both the Planner and Tactical in the 1P-1T configuration are recording a comfortable level of workload. It is therefore interesting that the SPO reports comfortable workload for eight of the nine matched runs. However, when the 'peak' workload levels are examined, it is not surprising that with both the Planner and Tactical recording comfortable levels of workload, the SPO is recording a minimum 'peak' workload of 'high' or 'very high'.

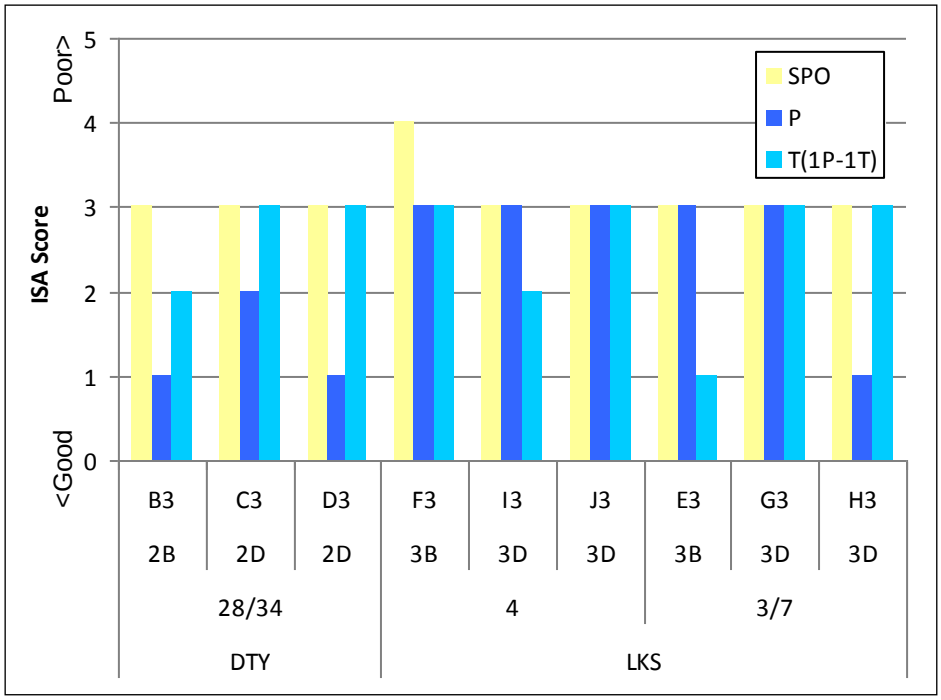


Figure 124 Median ISA Workload (matched runs)

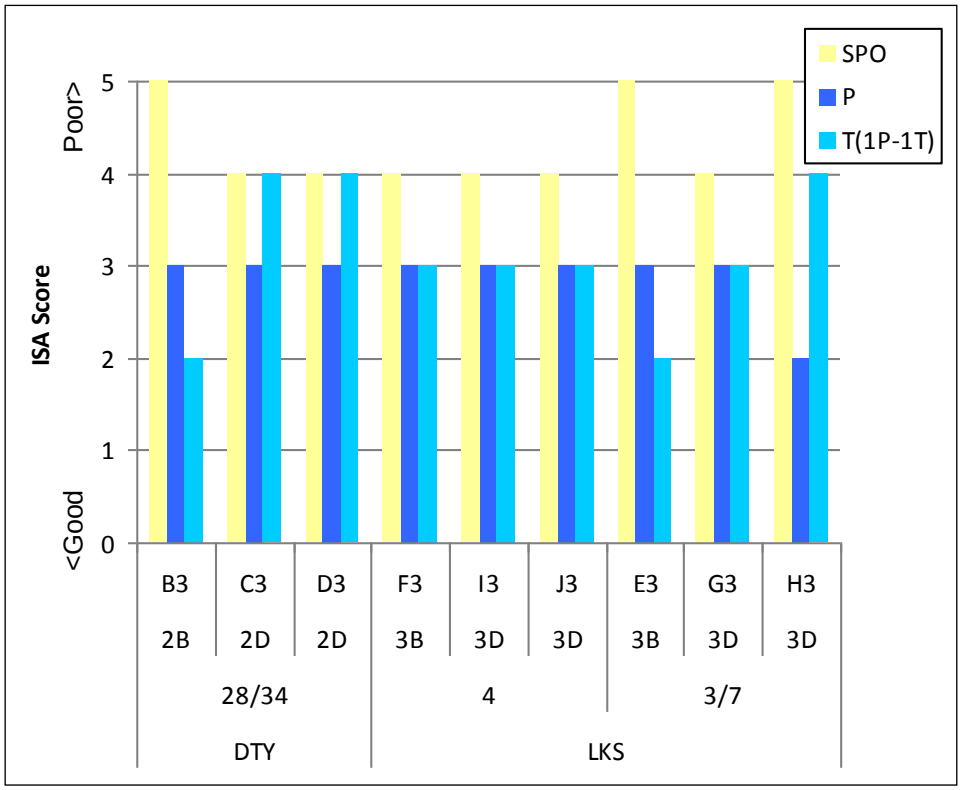


Figure 125 Peak ISA Workload (matched runs)

A.5.4 Bedford Workload

Figure 126 and Figure 127 show the Bedford 'average' and 'peak' workload scores respectively for the SPO (with enhanced Planner tools and Integrated Coordination) and the scores for the Planner and Tactical in the matched run (with NERC Planner tools). The Bedford 'average' score shows that for a comfortable to low level of workload for the Planner and Tactical in the 1T-1P configuration, the workload of the SPO is very high. The 'peak' workload scores are pushing the bounds of 'acceptable' level of workload for the 1P-1T configuration, and therefore unsurprisingly the participants recorded an unacceptable 'peak' workload for the SPO.

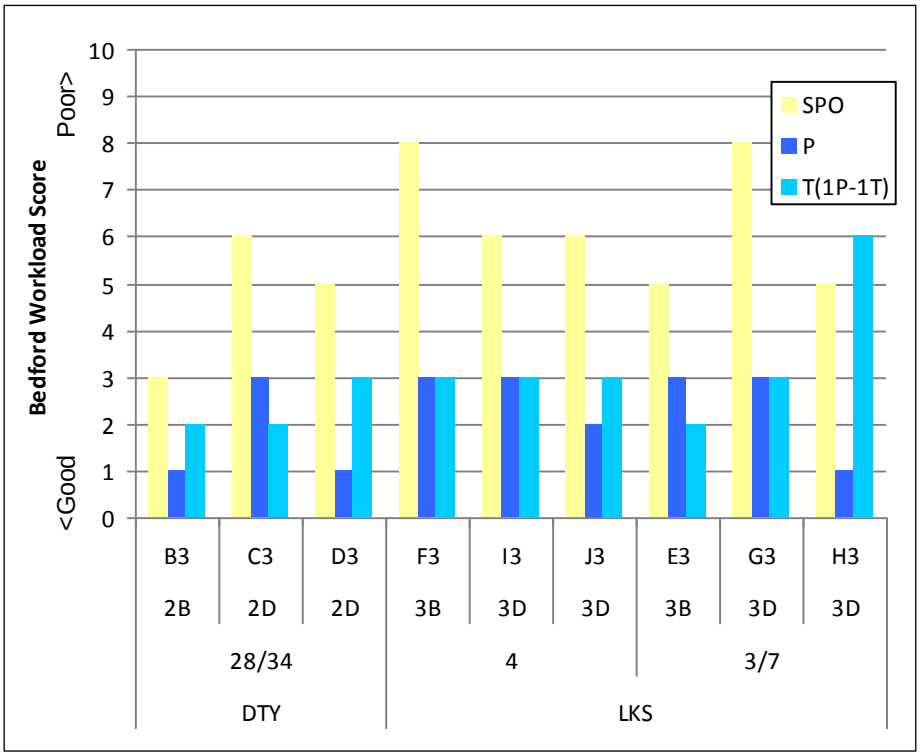


Figure 126 Bedford Average Workload (matched runs)

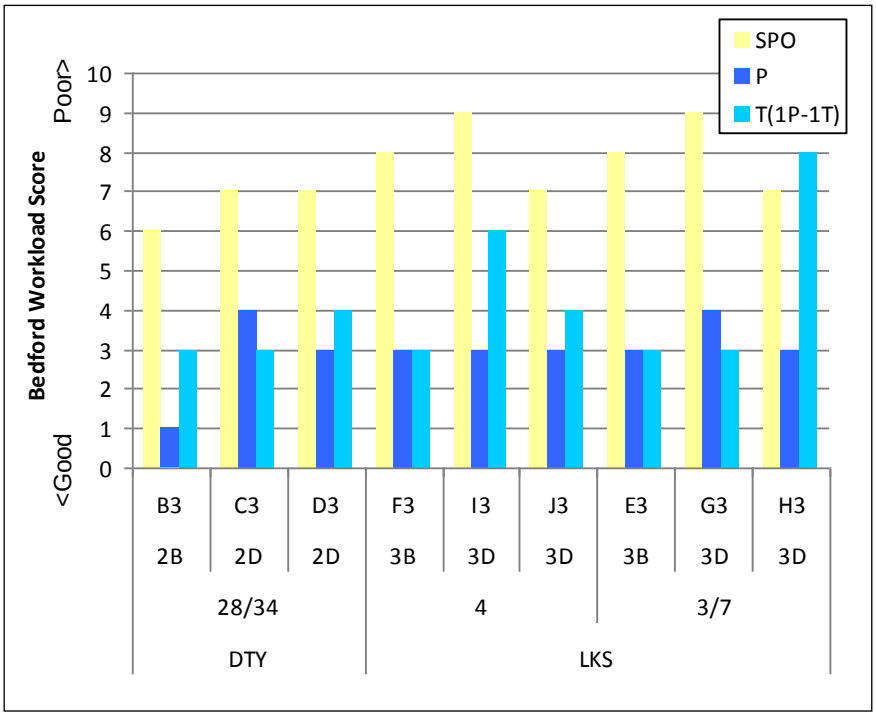


Figure 127 Bedford Peak Workload (matched runs)

Figure 128 and Figure 129 show the Bedford 'average' and 'peak' workload scores respectively for the SPO (with enhanced Planner tools and Integrated Coordination) for the non-matched runs. Bedford 'average' score shows that generally the workload of the SPO was 'comfortable'. The majority of the 'peak' workload scores in the non-matched exercises were also rated as acceptable.

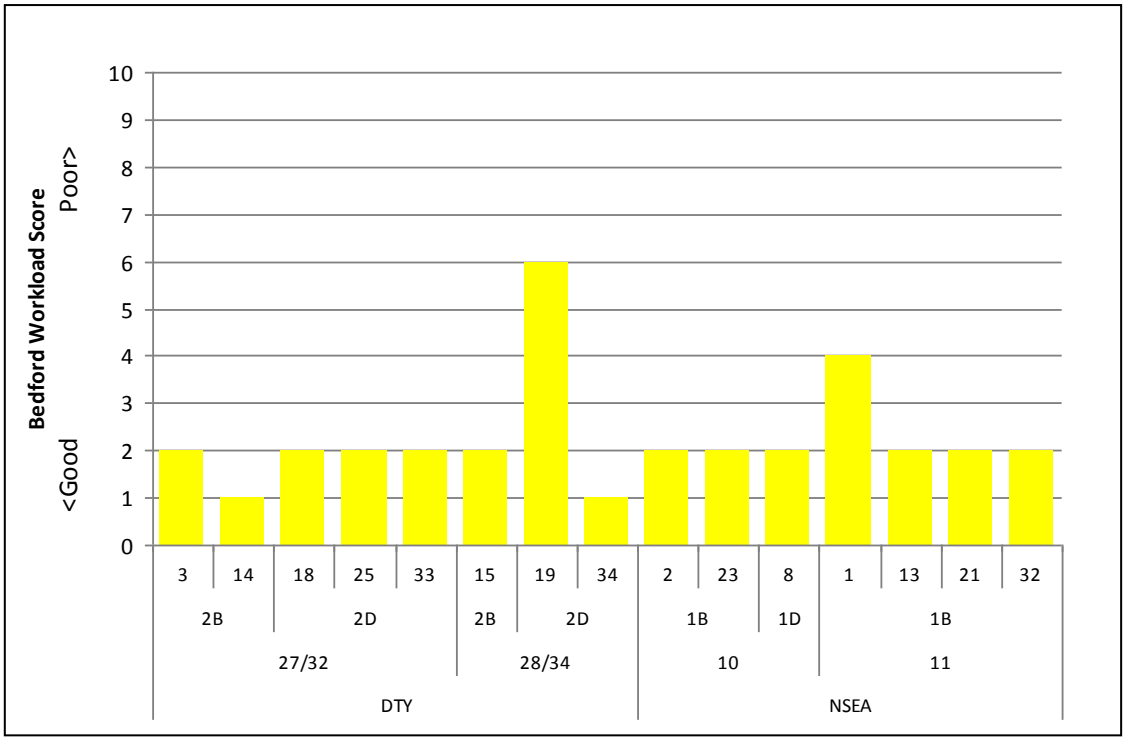


Figure 128 Bedford Average Workload (non-matched runs)

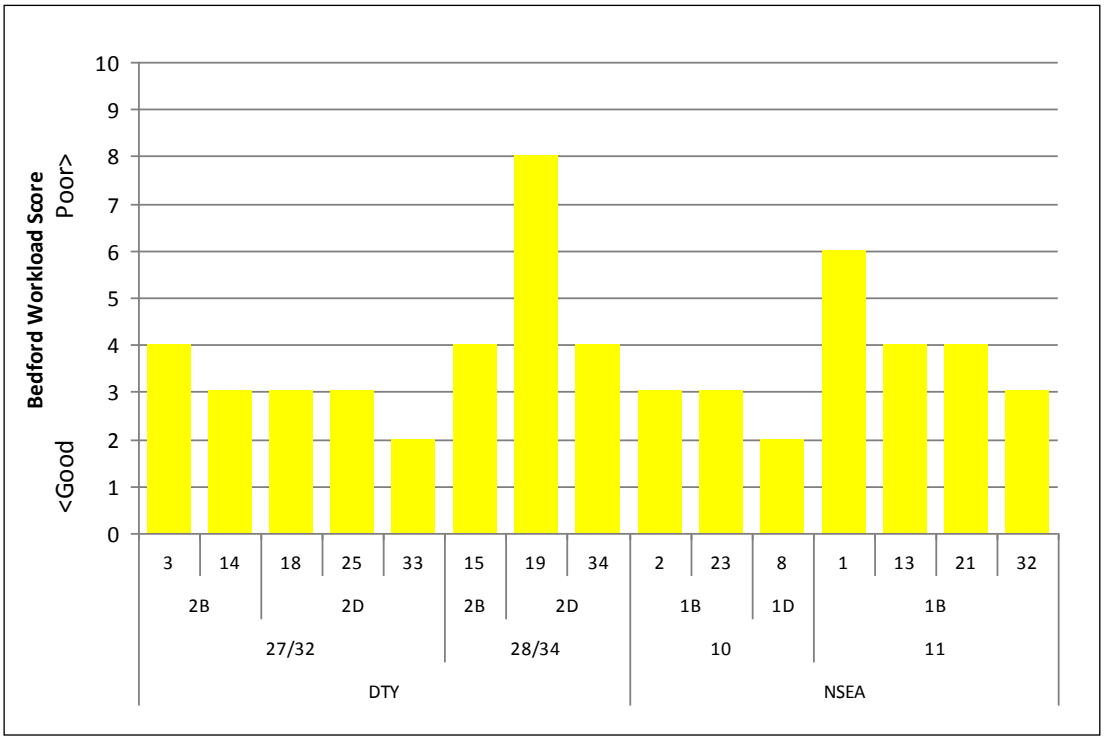


Figure 129 Bedford Peak Workload (non-matched runs)

A.5.5 China Lakes Situational Awareness

Figure 130 show the China Lakes Situational Awareness scores for the SPO (with enhanced Planner tools and Integrated Coordination and the scores for the Planner and Tactical in the matched run (with NERC Planner tools). Not surprisingly the situational awareness in such high traffic volumes was generally 'acceptable, but not satisfactory'.

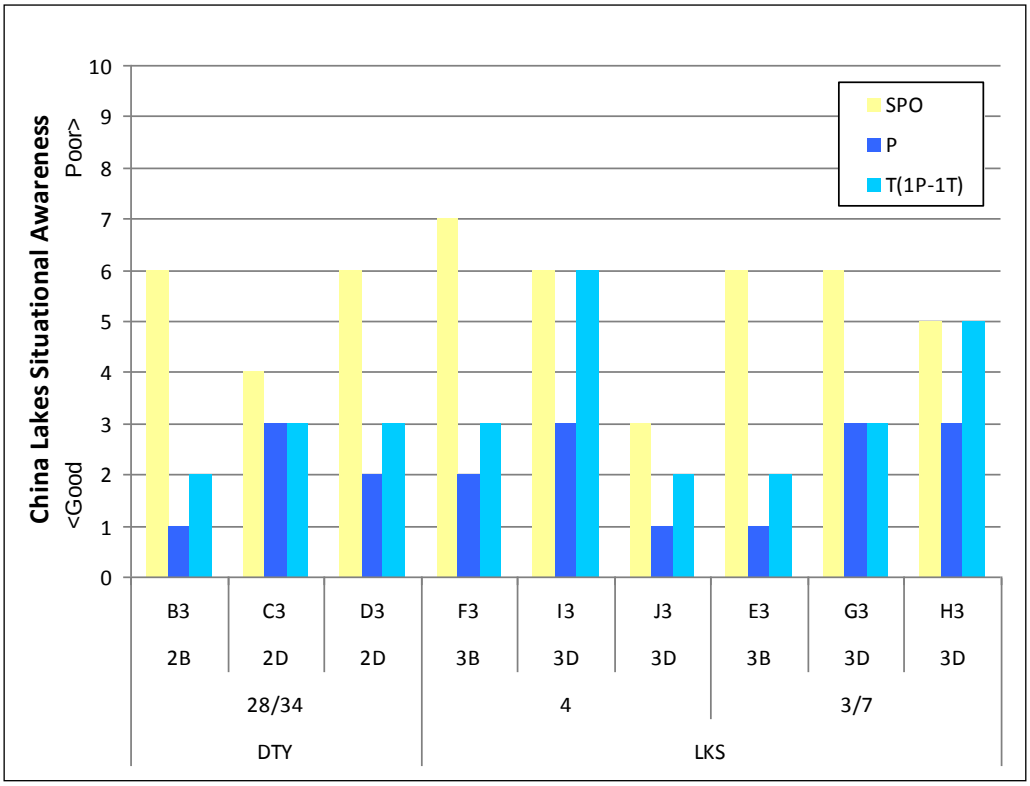


Figure 130 Situational Awareness (matched runs)

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