Project Report
ATC-393

Dallas/Fort Worth Field Demonstration #2 (DFW-2) Final Report for Tower Flight Data Manager (TFDM)

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16. Abstract

The Tower Flight Data Manager (TFDM) is the next generation air traffic control tower (ATCT) information system that integrates surveillance, flight data, and other sources, which enables advanced decision support tools (DSTs) to improve departure and arrival efficiency and reduce fuel burn at the airport. TFDM was exercised as a prototype installed at the Dallas / Fort Worth International Airport (DFW) during a two-week demonstration in the spring of 2011 termed DFW-2. MIT Lincoln Laboratory conducted this demonstration for the FAA in coordination with DFW air traffic control (ATC) and the DFW airport authority.

The objective of this TFDM field demonstration was to validate the operational suitability and refine production system requirements of the Tower Information Display System (TIDS) surface surveillance display and Flight Data Manager (FDM) electronic flight data display and to evaluate the first iteration of the Supervisor Display and DSTs. These objectives were met during the two-week field demonstration.

Results indicated that the TIDS and FDM exhibited capabilities considered operationally suitable for the tower as an advisory system and as a primary means for control given surface surveillance that is approved for operational use. Human factors data indicated that TIDS and FDM could be beneficial. The prototype Supervisor Display and DSTs met a majority of the technical performance criteria, but fewer than half of the human factors success criteria were met. As this was the first iteration of the Supervisor Display and DST capabilities, subsequent prototype iterations to achieve the target concept of operations, functionality and information presentation with accompanying field demonstrations to evaluate these honed capabilities were recommended and expected. FLM/TMC feedback will help refine subsequent system design.

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EXECUTIVE SUMMARY

The Tower Flight Data Manager (TFDM) is the next generation air traffic control tower (ATCT) information system that integrates surveillance, flight data, and other sources, which enables advanced decision support tools (DSTs) to improve departure and arrival efficiency and reduce fuel burn at the airport. TFDM was exercised as a prototype installed at the Dallas/Fort Worth International Airport (DFW) during a two-week demonstration in the spring of 2011 termed DFW-2. MIT Lincoln Laboratory conducted this demonstration for the FAA in coordination with DFW air traffic control (ATC) and the DFW airport authority.

DFW air traffic provided twelve controllers, three front line managers (FLMs), and three traffic management coordinators (TMCs) as test subjects. The twelve National Air Traffic Controllers Association (NATCA) DFW controllers shadow controlled East Tower traffic according to their own techniques, using new hardware and software that included high resolution displays of surveillance data and touchscreen electronic flight data displays. The six FLM & TMCs exercised functionality of a traffic management display, which aggregated information on flight status, weather, and other diagnostic information.

This proof-of-concept demonstration of an intermediate prototype version of TFDM was conducted with live traffic and was performed by shadowing East tower operations from the DFW center tower, which is a back-up facility currently not typically used for air traffic control. The objective of this TFDM field demonstration was to validate the operational suitability and refine production system requirements of the Tower Information Display System (TIDS) surface surveillance display and Flight Data Manager (FDM) electronic flight data display and to evaluate the first iteration of the Supervisor Display and DSTs. These objectives were met during the two-week field demonstration.

Results indicated that the TIDS and FDM exhibited capabilities considered operationally suitable for the tower as an advisory system and as a primary means for control given surface surveillance that is approved for operational use. Human factors data indicated that TIDS and FDM could be beneficial. The prototype Supervisor Display and DSTs met a majority of the technical performance criteria, but fewer than half of the human factors success criteria were met. As this was the first iteration of the Supervisor Display and DST capabilities, subsequent prototype iterations to achieve the target concept of operations, functionality and information presentation with accompanying field demonstrations to evaluate these honed capabilities were recommended and expected. FLM/TMC feedback will help refine subsequent system design. Table 1 shows the percentages of human factors and technical success criteria that passed at DFW-2.

Table 1: TFDM DFW-2 human factors and technical results summary

	Human Factors	Technical
TIDS	72% (39/54 questions met criteria)	69% (42/61 criteria met)
FDM	100% (5/5 questions met criteria)	83% (20/24 criteria met)
DSTs & Sup Display	47% (9/19 questions met criteria)	70% (40/57 criteria met)

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1. INTRODUCTION

1.1 PURPOSE

This document provides an evaluation of the second field demonstration for the Tower Flight Data Manager (TFDM) and Staffed NextGen Tower (SNT) programs. The purpose of this field demonstration, known as DFW-2, was to collect human factors and system performance data for intermediate TFDM and SNT engineering prototypes and to build upon findings from the first field demonstration, DFW-1. The TFDM prototype display suite included the Tower Information Display System (TIDS), the Flight Data Manager (FDM), and a set of Decision Support Tools (DSTs), which were displayed on a Supervisor display. Simultaneously with TFDM, the Staffed NextGen Tower (SNT) program performed concept exploration using cameras intended to augment the controllers' out the window view. The SNT prototype augmented TFDM with two long-range scanning cameras, a fixed-range camera array, and an external camera display. Camera-related results are reported separately in the *Field Demonstration #2 Final Report for Staffed NextGen Tower (SNT).*

DFW-2 was conducted from 26–28 April and 2–5 May 2011, at the Center Tower at Dallas/Fort Worth International Airport (DFW), which is a fully operational contingency facility (currently not used daily for air traffic control). This demonstration consisted of controller evaluations, flight tests, and performance and human factors data collection.

1.2 BACKGROUND

TFDM will serve as the future automation platform to support surface and local airspace operations at airports with an operating air traffic control tower. TFDM will consolidate the functions of tower systems, displays, and input devices presently used in the airport tower environment. It will electronically process and distribute flight data to different control positions in the tower and exchange pertinent flight data with other stakeholders in airport operations. The electronic processing and distribution of flight data will significantly enhance data exchange between the Air Route Traffic Control Center, Air Traffic Control Systems Command Center, Terminal Radar Approach Control (TRACON), airline, and airport authority domains. A suite of DSTs will also be available to aid in managing airport configuration, runway assignment, sequencing and scheduling, taxi routing, and departure routing. TFDM will integrate into and efficiently interact with the automation platforms and personnel associated with arrival/departure services for the airport.

A total of 18 participants were involved with DFW-2. Each day, two DFW Certificated Professional Controllers (CPCs) alternated at the ground (GC) and local control (LC) positions, which were outfitted with the TIDS, FDM, and external camera displays. The Supervisor position was staffed by a Front Line Manager (FLM) or Traffic Management Coordinator (TMC), and included a TIDS, a Supervisor/DST display, and an external camera display. The Flight Data/Clearance Delivery position was staffed by a test team member who was not an air traffic controller but was cognizant of procedures at DFW, and consisted of a non-touchscreen FDM.

1.3 OBJECTIVES

The goal of this evaluation was to provide proof of concept and validate a subset of production system requirements for TFDM components by means of shadow operations evaluations with live traffic. The version of TFDM that was tested was an intermediate prototype, with additional refinement and maturation of components planned to occur subsequent to the DFW-2 tests. During shadow operations, controllers verbalized but did not transmit clearances and commands to real-time targets of opportunity (TOO) and followed pre-scripted flight test scenarios. This goal was supported by the following objectives that are detailed in the DFW-2 Test Plan (*Field Demonstration #2 Test Plan for Tower Flight Data Manager (TFDM) and Staffed NextGen Tower (SNT)*).

TFDM Objectives

1. Demonstrate the ability to provide accurate real-time situation awareness information, including integrated surveillance, traffic flow, weather, and electronic flight data information.
2. Demonstrate the ability of TFDM to provide timely and appropriate DSTs.
3. Demonstrate weather-cognizant decision support functions that integrate information from various weather tools.
4. Assess improvements to TFDM based on input from DFW-1.
5. Evaluate presentation and user interface of DSTs as provided on TIDS, FDM, and Supervisor display.
6. Evaluate Supervisor display.
7. Provide recommendations for design modifications for the next field demonstration.

SNT Objectives

1. Demonstrate initial camera capabilities, including display, tracking, control, and data processing, for scanning and fixed cameras.
2. In visual meteorological conditions, assess performance, including line-of-sight issues, and usefulness of camera capabilities used as part of an SNT installation in an operational air traffic control (ATC) tower.
3. Collect user feedback on feasibility, usability, and usefulness of the supplemental SNT concept.
4. Reaffirm the operational suitability of the controller situation display known as the TIDS.

1.4 METHOD AND MATERIALS

DFW-2 evaluation sessions used normal traffic operations on the East side of the DFW airport. Participant controllers performed “shadow operations” using the TFDM and supplemental SNT displays. The test procedures for these operations are detailed in *Field Demonstration #2 Test Procedures for Tower Flight Data Manager (TFDM) and Staffed NextGen Tower (SNT).*

The success criteria as defined in the *Field Demonstration #2 Test Plan* are shown with corresponding results in Appendix A. For the DSTs, success criteria were written based upon expectations of capabilities that should be achieved by the mature TFDM system. Because the prototype TFDM system that was evaluated in DFW-2 did not include all of the capabilities at their eventual maturity levels, it was expected that there would be some unmet test criteria. Failure to meet a criterion does not imply such a criterion cannot or will not be met by future prototype versions or the final production version of TFDM. Additionally, some criteria were not tested due to limitations in the testing protocol or equipment available for data collection.

Participants listened to East side radio communications and were asked to respond as if they were controlling traffic, using TIDS and FDM to assist them in performing air traffic control (ATC) tasks. Participants' responses were not broadcast to the traffic, which remained under control of the East side controllers. Observers sat with the participants to answer any questions and to record participant comments, difficulties, and other observations relating to participants' activities and reactions throughout the test sessions. The typical daily schedule for the test participants is provided in Table 1-1.

Table 1-1: Typical controller schedule

Time	Activity
7:00	training
7:15	
7:30	familiarization
7:45	
8:00	shadow ops
8:15	
8:30	
8:45	
9:00	shadow ops
9:15	
9:30	
9:45	
10:00	break
10:15	scenarios
10:30	
10:45	
11:00	questionnaires
11:15	
11:30	lunch
11:45	
12:00	shadow ops
12:15	
12:30	
12:45	shadow ops
13:00	
13:15	
13:30	questionnaires
13:45	
14:00	
14:15	discussion
14:30	
14:45	

During shadow operations, controllers were issued awareness probes in which an observer requested that the participant find an aircraft meeting certain characteristics. These probes were conducted to gather information about how controllers used the displays to complete certain tasks.

Controllers also were exposed to flight test scenarios. These scenarios mimicked common off-nominal situations that controllers encounter during ATC operations and included an aircraft go-around and flyby, a flight plan change, a taxi route deviation, and an incorrect beacon code. Controllers were not notified in advance of the scenarios and were monitored to determine how quickly they noticed the scenarios.

During the evaluations, controllers worked with the TFDM and the external camera display. The TIDS and external camera displays were 30" monitors set up at workstations that could be switched between a local control and a ground control configuration. These workstations also included a touchscreen FDM, a keyboard, and a mouse (Figure 1-1). One workstation was located in the northeast corner of the Center Tower, while the other was in the southeast corner. Screen capture recordings of each display were made, along with recordings of participant controllers and observers and of the East side traffic and controllers. These recordings were merged together after the evaluations to allow analysts to review actions and comments made during DFW-2.

The TIDS provided a display of the terminal area and of the traffic and features within it; the FDM is an electronic flight data display. The TIDS and FDM each included a limited number of DSTs, but the bulk of the DSTs were provided on the Supervisor display.

An external camera display and a PiP camera window inset into the TIDS were provided as part of the prototype SNT display. For further details on the SNT camera displays, see the SNT DFW-2 Final Report.

Figure 1-1: DFW-2 controller workstation

Participant FLMs and TMCs evaluating the Supervisor/TMC position were also led through a series of directed interactions, exercising the extent of the functionality on the Supervisor Display. After each interaction, the function was evaluated by the participant for both usefulness and usability. Examples of the functionality evaluated included airport configuration change, identifying route weather blockage for departures, and changing the departure fix to runway mapping.

At the close of each evaluation day, participant controllers and FLMs participated in a discussion session where they were given the opportunity to comment on the display capabilities and to provide suggestions regarding current and future functions. These discussions were recorded and controller comments are provided throughout the report.

After participating in the shadow operations, the controllers were asked to rate their level of agreement to a number of statements pertaining to the TIDS, FDM, and the DSTs/Supervisor Display. They provided feedback by using iPads to input their responses to online surveys that included questions about the TIDS, FDM, integrated TFDM system, DSTs/Supervisor Display, flight scenarios, and perceived workload. All CPCs completed all questionnaires. The FLMs and TMCs all completed the

Supervisor/DST questionnaire, and some of them also completed the TIDS and/or the camera questionnaires. These differences in questionnaire completion resulted in variations between the sample sizes specified in each questionnaire. All questionnaires can be found in Appendix B.

Responses to each question were voluntary and were left to the controllers' discretion, including the options to not respond or to respond that the question was not applicable (N/A). Any N/A responses were not included in the statistical results discussed here, resulting in variations in sample size between the questions.

Participants provided ratings using a five-point Likert scale. Ratings ranged from negative (1) to positive (5). They were also encouraged to add comments in their own words to augment their ratings.

A success criterion was predetermined for each Likert scale (see the DFW-2 Test Plan for further details). The success criteria for the agreement scale was determined to be a rating of somewhat agree or above, that is, an average rating of four or greater. Post-hoc analyses using Goodness of Fit Chi Square analyses were used to analyze TIDS data for SNT purposes. The Chi Square analyses determined which items passed the success criteria with, at least, 95% accuracy (i.e., $p < .05$) and were therefore considered statistically significant. Chi Square tests the goodness of fit between hypothetical expected data and actual observed data[1].

1.5 RESULTS OVERVIEW

Participants responded positively to the TIDS and its potential uses in a supplemental context in an operational ATC tower. Controllers agreed that the depiction of the overall traffic situation was accurate enough for them to use as advice to complete their duties. They expressed appreciation for the tools and features provided on the TIDS. However, some controllers found that some of these features were difficult to set up to their liking or needed improvement to improve their usefulness to controllers. Some were distracted by display anomalies resulting in the appearance of multiple copies of a given target's icon and data block. Others were unable to see a few targets on TIDS since the display was not configured to depict them in areas that were off the screen, such as for targets on bridges seen OTW. Overall, however, 72% of the TIDS human factors success criteria passed according to the criteria determined a priori and documented in the DFW-2 Test Plan.

The TIDS performed adequately against its technical success criteria. Sixty-nine percent of these criteria passed as written. Due to a lack of sufficient logging abilities and decisions to not include certain features for DFW-2, 16% of the criteria were not tested. The remaining 15% of the criteria did not pass. The main deficiencies found for TIDS during DFW-2 were related to the display of traffic targets and the storage of recorded data. The display of targets failed when the north side TIDS lost all data blocks twice for brief periods of time because of incorrectly configured settings to log data in real time during shadow

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[1] Despite the fact that expected frequencies were less than five, a Goodness of Fit Chi Square with equal expected frequencies is robust to violations of sample size. (Sheskin, 2004)

operations. The success criteria specified zero tolerance for missing targets and one missing target per 2400 hours, so any instance of either resulted in the criteria not passing. In addition, there were multiple instances of flashing targets, some unknown or split targets, and occasionally targets that were shown repeatedly (an effect termed as "caterpillaring").

The FDM also passed a majority of its technical and human factors success criteria. Due to logging issues, 8% of the success criteria were unable to be tested, and the remaining 8% were not met. The primary technical issue with the FDM included a failure to correctly transfer 100% of the FDEs. The majority of the acceptability issues with the FDM centered around the ground metering recommendation, which was intended to recommend a rate of departures cleared to taxi out to the runway in order to prevent long queues at the runway. This capability was not considered acceptable, either in concept or in display by the participants evaluating it in its current prototyped form.

The prototype Supervisor Display and DSTs passed a majority of their technical criteria, but less than half of the criteria for acceptability were met. Due to issues logging the appropriate data, 16% of the technical criteria were unable to be tested. The technical criteria that were not met were due to the inability of the departure estimates to achieve the accuracy requirements, a misallocation of a seldom-used departure procedure to a fix in the runway assignment logic, and D-ATIS data feed latency. None of the acceptability criteria were met for the departure routing DST and few of the acceptability requirements for sequencing & scheduling were met. A majority of the success criteria were met for airport configuration, taxi routing, and runway assignment. A significant number of suggestions were provided by participants to improve the usefulness of the DSTs and the Supervisor Display functionality.

1.6 REPORT ORGANIZATION

This report discusses the results of the DFW-2 field demonstration for TFDM. Controller demographics are summarized in Section 2. Sections 3, 4, and 5 discuss the technical and human factors performance of the TIDS, FDM, and DSTs/Supervisor Display, respectively. A summary of controllers' comments and suggestions for future improvements regarding TFDM is also provided in these sections. Section 6 is a discussion of the scenarios and awareness probes as they pertain to TFDM. A summary of DFW-2 results is provided in Section 7, and the collected data, questionnaires, and detailed results (including the post-hoc video/audio playback analyses) are provided in the appendices.

2. CONTROLLER DEMOGRAPHICS

Twelve CPCs, three FLMs or supervisors, and three TMCs participated in the shadow operations evaluation for DFW-2 TFDM. All participants were active controllers, supervisors, or TMCs at DFW, and spanned a range of age and experience.

Table 2-1 provides some basic information about the makeup of the participant pool. Not all participants responded to the biographical survey, so the participant statistics are not fully representative of the participant pool. A total of nine out of twelve CPCs and five out of six FLMs/TMCS responded with their demographics information.

Table 2-1: Demographics of 9 CPCs and 5 FLMs/TMCs

	Average	Standard Deviation	Max	Min
Age (years)	44.7	6.9	53	28
Years as active tower controller	21.1	8.0	30	4
Years as active tower controller at DFW	11.6	5.9	18	3

Table 2-2 summarizes the participants' previous experience with demonstration or simulation activities related to TFDM/SNT. Controllers who had not had previous experience with TFDM/SNT were given additional time to familiarize themselves with the displays and were also given reminders and pointers during the evaluation as needed.

Table 2-2: Other participation in SNT-related demonstrations or human-in-the-loop (HITL) simulations

SNT/TFDM Demonstration	ASDE-X/TIDS Demonstration (April 2009)	ASDE-X Performance Evaluation (April 2010)	DFW-1 (August 2010)	HITL-1 (May 2010)	None
Number of participants	2	1	3	2	5

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3. TOWER INFORMATION DISPLAY SYSTEM (TIDS)

The TIDS provides controllers with surveillance information obtained from the Airport Surveillance Detection Equipment, Model X (ASDE-X), overlaid on a map display that reflects the airport layout for DFW. Aircraft icons indicate target type, position, heading, speed, and aircraft weight category using color, size, and shape variations. Leader lines associate icons with data blocks that provide alphanumeric indications of runway assignment, destination or departure fix, speed, altitude, and aircraft type and flight number or call sign. Relative position, heading, speed can be inferred from the icons.

Users are able to configure the TIDS according to their own preferences, by changing map orientation and zoom levels, moving data blocks, and creating and moving PiP windows to provide more detailed views of the airport surface. Users can also create restricted areas and open or close runways to update the map display to match the OTW situation. User preferences, including font sizes, display features, and PiP window positions, can be saved and selected for later use.

The TIDS provides advisory information to the user in the form of runway hold bars, wake turbulence timers, and textual wind displays. Color- and shape-coded icons indicate aircraft weight class and colored data block text reflects the aircraft state (cyan while airborne and white while on the ground). Additionally, camera information that supports the SNT concept can be displayed in a PiP window on the TIDS. These features are described in more detail in the TIDS User Guide.

3.1 TIDS TECHNICAL RESULTS

Table 3-1 summarizes the technical success criteria that passed or did not pass during DFW-2. For a criterion to have passed, no contrary indications against the predetermined success criteria were observed during DFW-2 and/or during post-hoc analysis. If any contrary indications were seen or uncovered during either the demonstration or analysis, the criterion did not pass.

Table 3-1: TIDS technical success criteria results

Category	Passed	Did Not Pass
Surveillance object	• Icon types shown on TIDS match aircraft type, weight class provided by ASDE-X data. • Icon types shown on TIDS match aircraft type, weight class seen OTW. • All targets seen OTW have icons on TIDS. • All targets provided by ASDE-X have icons on TIDS.	
Data blocks	• Content of each data block matches the OTW information	• All icons on TIDS have a data block that can be selected for display.

Category	Passed	Did Not Pass
	observed for each target. • Content of each data block matches the information received from ASDE-X, FDIO, and TFDM for each target.	
Airport Adaptation	• Depiction of airport adaptation is consistent with what's seen OTW.	
User Interaction	• Users can select a customized preference set. • Users can create a customized preference set based on their preferred display settings. • Users can save a customized preference set. • Users can select a user profile based on runway configuration and control position.	
Winds	• A wind PiP is displayed on the TIDS. • The wind PiP contains data for wind speed and direction for each runway threshold. • The wind data is received from the external weather data interfaces.	
Runway Closures	• Closed runways are outlined in red. • Closed runways have a white X displayed on each threshold.	
Hold Bars	• Threshold hold bars are shown on TIDS	
Wake Turbulence Timers and Surface Monitor	• All B757s and heavy aircraft trigger the display of the wake turbulence timer.	• Wake turbulence timers are displayed within 1 s of when aircraft begins takeoff roll. • Duration of wake turbulence timer is within 5 seconds of the required time (2 min, 3 min, etc.).
Filtering	• Aircraft overflying the airport at or above 500' AGL are absent from the TIDS. • Aircraft that meet user-defined filtering criteria are absent from the TIDS.	
Surveillance Processor	• ASDE-X position reports include MLAT, ADS-B, SMR, and ASR data. • The number of false targets	• ASDE-X detects 1 or fewer false tracks per 2400h of collected data.

Category	Passed	Did Not Pass
	detected by ASDE-X is 2% or less for the entire data collection period. • Mode C altitudes stored by TFDM for each aircraft match Mode C altitudes provided by ASDE-X.	
Target Broker		• Flight data stored by TFDM/TIB matches flight data received from ASDE-X, FDIO, and other data sources.
Data Archiving	• All recorded test data can be opened and viewed with the appropriate viewers/readers/etc. after each test session is complete and all data is saved.	
ASDE-X	• ASDE-X data is available and recorded on the TIB. • Surveillance data is shown on TIDS. • The time elapsed between receiving data from ASDE-X and showing it on the display is 1 second or less. • The time elapsed between receiving data from ASDE-X and its being available on the TIB is 1 second or less.	• No discrepancies are found between recorded ASDE-X data and the ASDE-X data stored on the TIB. • ASTERIX Cat 10 and 11 data are available and recorded on the TIB. • ASTERIX Cat 10 and 11 data are displayed in TFDM format when it's retrieved from the TIB.
ITWS/External Data	• Centerfield wind data is displayed on TIDS ribbon display	
Airport Configuration	• Configuration shown on displays represents configuration currently in use. • Runway status shown on displays reflects current status of runways. • Unavailable runways shown on displays reflect current status of runways.	

Certain test criteria were unable to be evaluated during DFW-2 due to a number of circumstances. The ability to open and close taxiway segments from the TIDS was not implemented for DFW-2, and the ability to change runway status was only available on the Supervisor display. ASDE-X hold bar, microburst, and wind shear data were not available during DFW-2 and therefore were unable to be tested. Finally, the latency and accuracy of ITWS and winds data was unable to be evaluated due to the lack of the required logging capabilities. (Success criteria 2.1.9, 2.1.20, 2.1.30, 4.4.2, 4.4.3, 4.4.4, 4.4.5)

3.1.1 Aircraft Icons

All aircraft icons shown on the TIDS were consistent with the icon types shown on the ASDE-X and the aircraft types seen OTW. These requirements were verified by visual inspection during DFW-2. There were no discrepancies found by controllers or observers during the evaluation periods. (Success criteria 2.1.1, 2.1.2)

All targets seen OTW were represented by icons on the TIDS. Three instances of a target seen OTW but not on the TIDS were reported; however, post-hoc analysis revealed that the targets were available in the recorded ASDE-X data and in the recorded display data. The aircraft in question left East side spots to cross the bridges to the West side. The combination of the display setup, which may have lacked a PiP of the bridge, and the destination of the planes, may have resulted in the controllers' inability to notice the icons on the TIDS. (Success criteria 2.1.3, 2.1.4)

3.1.2 Data Blocks

Data Block Visibility

Four brief instances of data block loss (on the order of a few seconds) were reported during a ten minute period on 26 April 2011. During this time, the north side TIDS processor spent more time requesting data than processing it, which slowed down the system performance and caused a loss of all datablocks on this display. Also, one icon was displayed with multiple data blocks for a brief time. The display anomalies were caused by an incorrect configuration of the logging settings.

On 27 and 28 April 2011, clicking on a flight's flight data entry (FDE) on the FDM resulted in the data block being removed from the TIDS; a left click on the FDM then returned the data block. This problem is also suspected to be due to incorrect logging settings. The logging settings were reconfigured after these problems were discovered and this issue did not arise during the second week of DFW-2. If logging levels for this message had been initially set correctly, this issue would not have arisen. (Success criterion 2.1.5)

Data Block Content

Data block content shown on the TIDS matched the information available to controllers by means of the OTW view. This requirement was verified by visual inspection during DFW-2, and no controllers or observers reported any discrepancies during the evaluation periods. (Success criteria 2.1.6, 2.1.7)

3.1.3 Airport Adaptation

The airport adaptation shown on the TIDS was consistent with the airport layout seen OTW and known to the test subjects. This requirement was verified by visual inspection during DFW-2, and no controllers or observers reported any discrepancies during the evaluation periods. (Success criterion 2.1.8)

3.1.4 User Interaction

Runway and Taxiway Status

Supervisors were able to open and close runways using the Supervisor display in DFW-2. Success criterion 2.1.30 states that users should be able to change runway status using the TIDS; however, this capability was delegated to the Supervisor position only and the success criterion was not updated to reflect this.

Closed runways were outlined in red with white Xs were displayed at the runway ends. These requirements were visually verified during DFW-2. Controllers and observers did not note any incorrect or missing closed runway indications. (Success criteria 2.1.18, 2.1.19, 2.1.30, 2.3.2)

The ability to open and close individual taxiways was not enabled in DFW-2, so the criteria addressing this capability were not evaluated. (Success criteria 2.1.9, 2.1.10)

Profiles and Preference Sets

Users were able to select profiles based on runway configuration and control position. In DFW-2, test staff primarily selected the user profile, but test subjects were able to see how the selections were made. (Success criterion 2.1.14)

Test subjects were also shown how to create and save preference sets based on their individual preferences. Not all subjects elected to do this, but those who did were able to create and retrieve their preference sets when returning to their positions. (Success criteria 2.1.11, 2.1.12, 2.1.13)

Wind Display

A wind PiP window could be displayed on the TIDS by pressing the correct hot key combination. The test staff tried to make sure that the PiP was visible during the setup process following any startup or restart situations, but there were some instances where the wind PiP was not brought up. However, the wind PiP was available when the hot keys were pressed. Further information on the available hot key combinations can be found in the TIDS User Guide. (Success criterion 2.1.15)

The wind PiP contained wind speed and direction for each runway threshold and for the average winds. (Success criterion 2.1.16)

Wind data shown on the TIDS is received from the MIT Lincoln Laboratory Integrated Terminal Weather System (ITWS) data feed. On 3 and 4 May 2011, the DFW TDWR experienced issues that resulted in no data available to TFDM, so the data feed was unavailable or considered unreliable for the entire day. The ribbon displays available in the Center Tower receive information from the Low Level Windshear Alert System (LLWAS) and were available at this time, so providing LLWAS data to TFDM could mitigate this problem. (Success criterion 2.1.17)

3.1.5 Advisory Tools

Hold Bars

Runway hold bars were displayed across all entrances to a runway whenever a landing or departing aircraft occupied it. The success criterion required that runway hold bars be shown on TIDS within a second of their display on the ASDE-X. However, observers noted an instance where a TIDS runway hold bar was shown incorrectly across the runway intersection when the runway was unoccupied. (Success criteria 2.1.20, 3.2.1)

At the time of testing, the TFDM Direct ASDE-X Connect (TDAC), which will provide ASDE-X data to TFDM in place of the ASDE-X Data Distribution Unit, had recently begun development. Its development has since been completed and has been tested at the ASDE-X Program Support Facility in Oklahoma City, and TIDS is now able to display alerts and hold bars according to data received from the ASDE-X.

Hold bars were displayed across runway thresholds in front of departing aircraft whenever an aircraft was crossing the runway. This requirement was verified visually during DFW-2; observers and controllers did not report any instances of hold bars being displayed incorrectly. (Success criterion 2.1.21)

Wake Turbulence Timers

Wake turbulence timers are shown for all heavy and Boeing 757 aircraft departures. Video review of the DFW-2 display recordings showed 35 heavy or B757 aircraft; of these, 22 correctly displayed the wake turbulence timer. On 26 and 27 April, no wake turbulence timers were visible on the display. This occurred because of a mistake made in configuring the component manager. It had not been set up to start the wake turbulence timer service. Including the service in the component manager fixed this issue, which has not been seen since. (Success criterion 2.1.23)

During the DFW-2 evaluation, a test staff observer recorded the takeoff roll initiation time for each of these aircraft, and a post-hoc video review was conducted to determine the time at which the wake turbulence timer was displayed. The difference between the times was determined to assess the requirement that the wake turbulence timer appear on the TIDS within one second of takeoff roll initiation. By this analysis, the criterion of a one-second latency was not met: the average latency was 14 seconds, with the maximum latency of 26 seconds. (Success criteria 2.1.22, 3.2.2)

This variability is due to a combination of human and system error. The system’s criteria for takeoff roll initiation is a source of error, as the takeoff determination is made using a speed threshold, which would result in a later display of the timer than a visual observation of takeoff roll initiation. This problem was observed during DFW-1. Another possible source of error is human error in determining takeoff roll initiation time and/or timer display time. Improvements to reduce the latency in the appearance of the wake turbulence timer are being considered for future software development.

Finally, the requirement that the timer be within five seconds of the required delay time was also not met. Aircraft departing from a runway intersection require a three-minute timer, while full-length runway departures only need two minutes. However, the timer duration was three minutes, regardless of whether the departure was full-length or from an intersection. A configurable wake turbulence timer has since been implemented in the software. (Success criterion 3.2.3)

3.1.6 Filtering

Users were able to filter traffic they did not want to see from the TIDS. The displays were configured so that aircraft overflying DFW were not displayed, and users were able to configure filters so that additional traffic was hidden from view. The overflight filter was configured so that targets closer than two nm to the airport center and targets above 2500 feet were hidden from view. No targets within this range were seen.

However, controllers remarked on the overflights that did not fall into these categories and indicated that they were distractions, so the parameters of the default overflight filter may need to be extended, at least for DFW. Since the overflight filter is configurable, users are also able to modify the parameters to suit their own needs. (Success criteria 2.1.24, 2.1.25)

3.1.7 Surveillance Processor

Surveillance Success Criteria Tested at DFW-2

Mode C altitudes stored by TFDM matched the Mode C altitudes provided by ASDE-X. No conflicts in altitude were seen when plotting Mode C altitude and the surveillance track altitude data. Occasionally the ASDE-X system track altitude will drop to zero when the aircraft is obviously not at a zero altitude. Investigation has revealed that if the ASDE-X data drops to zero, the Surveillance Processor will persist the zero altitude until a nonzero altitude is received from the ASDE-X. To eliminate this problem, the Surveillance Processor will provide its own altitude predictions. This functionality has not yet been implemented, but will be addressed in future development efforts. (Success criterion 3.1.3)

Fused position reports from the ASDE-X provided surveillance data. These reports consisted of information from multilateration (MLAT), automatic dependent surveillance—broadcast (ADS-B), surface movement radar (SMR), and airport surveillance radar (ASR) data; this was verified by accessing position reports received from ASDE-X during post-hoc analysis. (Success criterion 3.1.4)

Surveillance Success Criteria Tested at DFW-1

A number of success criteria for position and aircraft state accuracy were previously tested and passed in the DFW-1 demonstration. Because of this, they were not further evaluated during DFW-2, with the assumption that no differences would arise during this demonstration. These criteria are indicated as being tested in DFW-1 in the success criteria detailed in Appendix A. For detailed results, see the *DFW-1 Field Demonstration Final Report for Tower Flight Data Manager (TFDM) and Staffed NextGen Tower (SNT)*.

3.1.8 Data Archiving and Logging

Data was recorded during DFW-2 (ASDE-X, Flight Data Input/Output (FDIO), audio, video, and display recordings) and were able to be played back during post-hoc analysis. (Success criterion 3.4.1)

Various data were logged in system logs during DFW-2. These data included taxi times, time in runway queue, airport configuration changes, and runway closures and openings, and were used to help verify some of the success criteria. Additional logs will be required in the future to more thoroughly evaluate the success criteria, as a number of requirements were unable to be tested due to lack of sufficient logging data.

3.1.9 ASDE-X

ASDE-X Success Criteria Tested at DFW-2

Surveillance data is received from the ASDE-X, which is then shown on the displays as necessary. The entirety of the DFW-2 demonstration showed that surveillance data was available on the TIDS. Additionally, ASDE-X data was recorded on local disks throughout DFW-2 in Berkeley Packet Filter (.bpf) format and was able to be retrieved after the completion of the demonstration. The availability of this data on the TIDS satisfies the requirement that ASDE-X data is available and recorded. However, the data was not recorded directly onto the TFDM Information Bus (TIB), as there was a concern that doing so would result in degraded server performance. (Success criteria 4.1.1, 4.1.2)

Because ASDE-X data was not stored on the TIB, it was unable to be retrieved from the TIB for post-hoc analysis, so the success criterion that no discrepancies are found between recorded ASDE-X data and ASDE-X data stored on the TIB was not evaluated directly. For this reason, the success criteria did not pass. Additionally, due to the point at which the data was recorded, it is possible that data may have been lost further along in the data processor. There were no outward indications of ASDE-X data loss during DFW-2, but since this is a possibility, further investigation of the ASDE-X data recording process should be considered. (Success criteria 3.3.4, 4.1.3)

Similarly, the requirements that ASDE-X ASTERIX Category 10 and 11 data are available and recorded on the TIB, and are also available in TFDM format when they were retrieved from the TIB did not pass. (Success criteria 4.1.5, 4.1.6)

No observable delays were seen when comparing the data shown on the TIDS to the real-time OTW information. This requirement, which states that the time elapsed between receipt of ASDE-X data and the time the data appeared on the TIDS must be one second or less, was verified by observation during DFW-2. A test was performed each morning where an observer would refresh the system, then verify a target's position both OTW and on the TIDS and note the latency observed based on the system clock. Additionally, neither participants nor observers made reports of position discrepancies during the evaluation sessions. (Success criterion 4.1.4)

The occurrence of false targets and tracks was assessed for DFW-2. Based on observations during the evaluation, the success criterion of one or fewer false tracks per 2400 hours of data did not pass. A number of split and other unidentified targets were seen and are listed in Appendix C. However, the success criterion for false targets did pass: the false target rate was less than 0.01% for the DFW-2 data collection period, which is well below the 2% specified in the criterion. (Success criteria 3.1.9, 3.1.10)

Finally, an analysis of time stamps in message headers and time stamps logged by the ASDE-X adapter shows that the time between receiving data from the ASDE-X and it being available on the TIB is less than 1 second. (Success criterion 4.1.7)

ASDE-X Success Criteria Tested at DFW-1

ASDE-X surveillance coverage and latency were assessed successfully during DFW-1 and were not reassessed in DFW-2. The performance during DFW-2 was assumed to be similar to that from DFW-1, and controllers and evaluators did not observe any latency or coverage gaps during DFW-2. These success criteria are provided in Appendix A.

3.1.10 ITWS

Centerfield wind data were available on the TIDS ribbon display and could be toggled for display by means of a hot key combination, described in more detail in the TIDS User Guide. Microburst and wind shear data from ITWS were available for DFW-2 and had the ability to be shown textually on the TIDS PiP window that replicates data from the ribbon display. (Success criteria 4.4.1, 4.4.2, 4.4.3) However, the only microburst/windshear alert occurred on April 27 between 02:17Z and 02:34Z at night, which was not during the demonstration time.

Aside from the ITWS outage on 27 April (described in Section 3.1.4), no discrepancies between ITWS data and the data shown on TFDM were noted during DFW-2. As this outage is not due to any fault of TFDM, success criterion 4.4.1 passed. Due to time constraints, ITWS data was unable to be analyzed and so success criteria 4.4.4 and the ITWS portion of 3.3.4 were not tested. Similarly, log files were not analyzed in time and success criterion 4.4.5 was not tested.

3.1.11 TIDS Performance Issues

Surface Monitor Crashes

The Surface Monitor crashed once during DFW-2 (26 April 2011). When the Surface Monitor crashes, hold bars are not displayed on the TIDS and the ground- and air-based state changes do not occur. Despite investigation, it is unclear what caused this. At DFW-1, various alarms and alerts caused problems to the point where it was decided to not listen to the Notification topic to eliminate these issues. Significant work was done to improve the code after DFW-1, but issues with the logic that could result in a crash likely still exist.

Following the crash, the Surface Monitor, which checks every two seconds to make sure the surface monitor is still running and restarts it if necessary, was turned on to reduce the potential for a crash, though this is only a workaround. Additional work has been done to improve the alarm and alert logic following DFW-2 to prepare for additional human-in-the-loop simulations at the FAA's William J. Hughes Technical Center, including the addition of a flag that can be used to disable the arrival alarms and alerts that could be used if necessary. However, when the TDAC becomes available, the alarms and alerts will be passed through from the ASDE-X to TFDM so the alarms and alerts can be totally disabled in the Surface Monitor in future builds.

Kernel Panic

Two display freezes were seen on 3 May 2011, and both were determined to be the result of a kernel panic. System administrators looked through the system logs to see if there were any indications of the cause of the kernel panics, but could not find any reason for the failures. It is suspected that they may be related to the touchscreen drivers; however, for the crashes that occurred during the second week, the controllers were not heavily using the touchscreens at the time when they occurred. Engineers have been in contact with the Aydin display sales representative and engineers, who recommended that the driver be updated and that analysts attempt to reproduce the issue. A new display driver has been installed and testing and investigation is ongoing.

Data Tags

Lost Data Tags

On 26 April 2011, the north side TIDS lost all its data tags due to an incorrect logging level in the TIDS. The TIDS was repeatedly writing a debug message to the log file, which caused the display machine to spend more time waiting for data than processing it. By adjusting the verbosity of the logging level, this problem was prevented from reoccurring. However, since data tags were unavailable, success criterion 2.1.5 did not pass.

Multiple Data Tags

On 3 May 2011, a single target was seen with two data tags. This problem occurred between an arrival flight (AAL567) and a departing flight (AAL1113). As AAL567 was coming into the ramp area, AAL1113 was exiting. When the ASDE-X system dropped the track for AAL567, the track was then linked to AAL1113 by an existing sensor track shared by both system tracks and moved along with it as the target taxied to the runway. Code has since been added to the surveillance processor to validate ASDE-X association data based on position heading so that this erroneous linkage does not happen, but this new code was not available for DFW-2.

Lost Data Feeds

On 27 April 2011, access to the Airport Situation Display to Industry (ASDI) data feed provided by the FAA Telecommunications Infrastructure (FTI) National Test Bed at the William J. Hughes Technical

Center was lost. It is unclear why the ASDI data feed was turned off. It could have been caused by events including preventive maintenance, software upgrade, or hardware issues. The data outage lasted for 24 minutes. This outage was not due to any TFDM defects; the recommended mitigation to this is that notification of outages be provided well in advance of the scheduled date so that alternate resources can be deployed.

Inconsistent TIDS Views

On 4 May 2011, the north side TIDS experienced a case where the flights in the PiP window were flashing but the flights in the main window were not. This has been verified through inspection of the recorded video data. The log files were examined for errors around this time but did not yield any obvious answers. This problem continues to be investigated.

Surveillance Issues

During DFW-2, surveillance issues manifested themselves on the TIDS. These issues included flashing and frozen targets, targets that were unable to be selected, "caterpillaring" targets, unknown targets, and split targets.

Flashing and Frozen Targets

Fourteen instances of flashing targets were recorded during DFW-2. It is thought that the Surveillance Processor will sometimes send multiple track drop messages for a single track, which seems to trigger target flashing and/or caterpillaring, depending on the version of the Target Broker. To mitigate this, the software was updated to process only the first dropped message. This fix was not included in the DFW-2 software but has since been implemented.

A single frozen target was reported during DFW-2. This target begins as track number 2321 and continued as track 2378. This frozen target was due to a problem with the logic used to merge and split tracks. This problem has since been fixed, but this fix was not implemented in the DFW-2 software.

Non-Selectable Targets

To assign all unique identifiers to all individual flights in the TFDM system, the Target Broker builds up a database of flight information received from FDIO, Traffic Flow Management System (TFMS), ASDE-X, and airport information data. These sources may send incomplete, incorrect, contradictory, or incompatible data. When a new message arrives, the Target Broker attempts to match the message against the flights contained in the database. Because the data used may be incomplete as received from the sources, the Target Broker may discover that two entries that were tagged as separate flights actually correspond to the same flight. In this case, the Target Broker makes the two entity identifications (IDs) equivalent (i.e., "merges" them) and sends a message to other TFDM components to notify them of the equivalence.

In DFW-2, the non-selectable targets were caused because the FDM used the merged version of the entity ID, while the TIDS used the initial entity ID. Since the two entity IDs did not agree, the FDEs not highlighted on the FDM when the aircraft target was selected on the TIDS.

After DFW-2, the Target Broker's matching logic was completely redesigned to improve performance and to handle missing and minimal data more efficiently and predictably. The newly designed Target Broker also has a notion of the reliability of a data source, and refuses to update a more reliable value with a less reliable. An analysis of logs for the redesigned Target Broker shows that, in all the testing to date, the improved algorithm has not failed to identify the correct flight. These changes have eliminated flights that are non-selectable between the TIDS and the FDM.

Caterpillaring Targets

During DFW-2, some flights left a moving trail of icons on the TIDS display, resembling a caterpillar's gradual movement. Almost always, this was initiated by a "dropped track" situation in the Surveillance Processor.

When the Surveillance Processor starts tracking a flight, it assigns a unique identifier to the flight, separate from the track identifier. Even when the Surveillance Processor has to stitch tracks or pick up a lost track, this unique identifier is preserved. The DFW-2 Target Broker uses this unique identifier for matching Surveillance Processor messages to existing flights, and this match is almost always successful. However, in some cases the Surveillance Processor outputs a second track that has the dropped flag always set to true. Because of the change in unique identifiers, the Target Broker also treats it as a new flight and assigns a new entity ID. In this case, the TIDS shows two icons: one for the position of the first target and one for the position of the new target when using the Target Broker. When the Target Broker is not used, the TIDS shows one track with no "caterpillaring" since the second track contained all drop messages that signaled the TIDS not to display the target.

The "caterpillaring" occurs as the Target Broker attempts to recover from this situation. Its self-audit logic detects that the newly created flight matches another flight in its database and merges the two flight entries. However, the DFW-2 Target Broker merges the new non-reliable data into the flight database entry, making it less likely that the match will succeed for the next message. This can lead to a "merge-a-thon" as the Target Broker creates and immediately merges and deletes dozens of flights, until its database stabilizes and starts matching again. The "caterpillaring" is the visible manifestation of the merge-a-thon, as the TIDS attempts to display all the generated flights.

The post-DFW-2 Surveillance Processor is much more robust about managing track splits and preserving unique identifiers in the presence of multiple tracks. For the unique identifier splits that do get through, the Target Broker handles them differently: it treats them as a "half-match" data item. That is, if the unique identifier matches an entry in the database, the match is resolved as before. But if the unique identifier does not match an entry in the database, the Target Broker repeats the search using the Mode 3/A transponder code and the Mode S transponder code. In all testing to date, this matching has been completely successful in coping with changes in unique identifiers, and has completely eliminated caterpillaring.

To validate the design changes in the post-DFW-2 Target Broker, analysts used the improved Target Broker to process eight hours of recorded TFMS and FDIO data from 4 May 2011 at DFW. The output of the Target Broker was captured in a database. Arrival and departure times of all flights during the same period were then extracted from the Passur flights database. Departure and arrival times predicted by the Target Broker for each flight were then compared against the actual Passur data. This experiment, plus hundreds of hours of unit testing and integration testing, demonstrates that the post-DFW-2 Target Broker is now a more reliable matching engine for all its data sources.

Split and Dual Targets

Flight FIV431 split while on the departure runway on 28 April 2011. This flight's ASDE-X system track (track 1751) split into a new system track (track 3179), which appeared as an unknown target and remained on the runway while track 1751 took off. The current Surveillance Processor may have problems handling this type of case since unknown tracks have no identifying information except position or system track sensor association to use in merging the two tracks.

On 3 May 2011, AAL2050 and AAL1629 appeared to be merged on taxiway K. One of these targets was an arrival, while the other was a departure. When the arrival target's system track is dropped, the system attempts to fill in surveillance reports using the best available data from the ASDE-X components of the fused track. However, it is thought that the ASDE-X associates the departure's track components with both the departure and the arrival; thus, when the system tries to fill in the gaps on the dropped arrival track, the legitimate departure track data is used, resulting in the dual target seen in this case. The code has been updated so that the system validates the data and filter associations based on position and headings; however, this issue was resolved after the software lockdown for DFW-2, so this fix was not included in the evaluation. This issue has not been seen since implementing the current version of the software with this fix in place.

Unknown Targets

On 28 April 2011, EJA964P, departing on 35L, changed to an unknown target once it became airborne. This target lost its ASDE-X system track on departure, and TFDM then created a new system track. This new track was displayed as an unknown target before it was matched with its correct tag. The current Surveillance Processor may have problems handling this type of case since unknown tracks have no identifying information except position or system track sensor association to use in merging the two tracks.

A second unknown target, identified by a controller as AAL708, was seen head-to-head with the arrival AAL1878 on taxiway K near the intersection with K8. This target is an unknown in both the old and new versions of the Surveillance Processor and never properly tagged up with its correct call sign in the ASDE-X data. The target was seen later in the day correctly tagged.

3.2 TIDS HUMAN FACTORS RESULTS: RATINGS

Controllers provided their responses to a series of questions focused on the accuracy, usability, acceptability, and other similar categories for the TIDS using Likert scales that ranged from completely disagree to completely agree.

Table 3-2 categorizes the responses to TIDS questions into “passed” or “did not pass” categories. “Passed” items refer to questions with an average rating of somewhat agree or above, that is, ≥ 4 out of 5 on a scale of 1 to 5, with 1 being worst and 5 being best. “Did not pass” items refer to questions with an average rating of neutral (3 on scale of 1 to 5) or below. “Did not pass items” failed to fulfill the success criteria. A detailed TIDS Chi Square analysis is provided in Appendix D.1. For a TIDS Chi Square results summary, see Appendix E.1.

3.2.1 DFW-2 Human Factors Survey Results for TIDS

Table 3-2 presents the TIDS items (both success criteria AND questionnaire ratings) that passed or did not pass the success criteria, defined in the *TFDM-SNT Field Demo Test Plan DFW-2 v2.2* as user feedback rating of at least 4 for any given question. The individual chi squares, along with the means and standard deviations are noted in Appendix D.

Table 3-2: TIDS human factors success criteria results

Category	Passed	Did Not Pass
Target Information	• Target position was accurate • Target heading was accurate • Displayed target was appropriate for all targets • Number of target types were appropriate to represent the traffic • No frozen icons or indications of stale data on TIDS • No false targets or tracks on the TIDS • No jumping targets on TIDS • State color presentation on the data block was accurate • Target’s indicated altitude was accurate	
User Interface	• TIDS user interface was easy to use • TIDS target icon color coding was useful • Data block color coding was useful	• It was easy to create and access TIDS user preference sets

Category	Passed	Did Not Pass
	• Target selection/highlighting on the TIDS was eye catching • User preference sets were useful • It was easy to access the TIDS menu functions • TIDS hot keys were useful	
Picture-in-Picture Window	• Picture-in-picture windows are useful	• Camera picture-in-picture window was useful • Picture-in-picture windows were easy to configure • Number of camera picture-in-picture windows were sufficient
Wind Information	• Using the wind display window did not distract them from other information on the TIDS • Wind information provided was sufficient for ATC purposes • Wind information presentation was acceptable • Wind display window was useful	
Display Features	• Runway hold bars were useful • Runway hold bars appeared at an appropriate time • Threshold hold bars were useful • Threshold hold bars appeared at an appropriate time • Closed runway indication was useful • Approach bar depiction was appropriate • Closed runway indication was eye catching • Countdown time provided by the wake turbulence timer was appropriate • Approach bars were useful	• Wake turbulence timer was useful • Aircraft types for which the wake turbulence timer was shown were sufficient • Optional runway pattern overlaid on the runway when the wake turbulence timer was active was useful • Restricted areas were useful • Overflight and traffic filters were useful • Overflight and traffic filters appropriately filtered out traffic controllers were not interested in • Creating a restricted area was simple • Overflight filters were simple to set up • Traffic filters were simple to set up
	• Easy to detect aircraft using the TIDS • TIDS helped maintain	• TIDS was effective in helping control traffic in the air • TIDS was effective in helping

Category	Passed	Did Not Pass
Display Usefulness	awareness of traffic identity • TIDS was effective in helping control traffic on the ground • TIDS will be beneficial to tower controllers • Easy to predict future aircraft locations using the TIDS • TIDS display was effective in helping controllers know the position of the aircraft • TIDS display was effective in helping controllers plan subsequent control actions • Easy to find necessary flight information using the TIDS • TIDS display was effective in helping controllers sequence aircraft	maintain separation

3.3 CONTROLLER COMMENTS AND REQUESTED MODIFICATIONS FOR TIDS

3.3.1 Controller Comments on TIDS

Controllers provided typed-in comments about the TIDS to augment their individual ratings as part of the TIDS evaluation questionnaires. A post-hoc analysis of their comments, categorized as positive, negative, and neutral or suggestion, is presented here.

Table 3-3: Controller comments on TIDS accuracy

Positive	Negative	Neutral or Suggestion
• I use the TIDS for organizing traffic that is on the ground, (to verify) plane has crossed the landing threshold and if it has crossed a certain taxiway on its take off roll. • The information on the TIDS is good information. • Thought the display was great. Wish we could be using it now!	• At times saw some "caterpillaring" One example was ASA670 who was told to change his code. • The jumping targets were only on the ramp as the aircraft was sitting still. • timing of when the aircraft turns to cyan color once airborne… it doesn't appear to be accurate with the aircrafts true state.	• would like to see more TIDS coverage/surveillance in the EL alleyway as GE controls all movement west of K on EL Ramp. • Time-share of alt and speed needs to have an additional space for clarification. • still information I can get from looking out the window better. Thus I think of the TIDS as more of an organizational piece of equipment.

Table 3-4: Controller comments on TIDS wind information

Positive	Negative	Neutral or Suggestion
• It was in a good location. It did not take away or distract from traffic. • Winds weren't updating today for whatever reason. But the concept is great.	• I found the font size to small for me. I guess I could have changed it, but did not.	• Need a filter to only see sector winds unless of a wind shear/microburst alert • Wind information was not available to me. • I didn't notice it and didn't use it; instead, I referred to the standard wind indicator. • I actually didn't even notice it being there for the first session. I didn't glance at the wind near as often as I would for each arrival in a normal work environment.

Table 3-5: Controller comments on TIDS features

Would Add	Would Delete	Neutral or Suggestion
• placement of ground stop, call for release, and swap routes that would catch the controllers eyes. • LAHSO operations incorporated into TIDS…entries would be made on FDM at Local…for each landing aircraft, hold bars (and RWSL Lights) would be dictated on this. • Adding a separation bubble or headlight for ac on final, heads up for potential conflicts such as an ac in position and an ac on final to the same runway	• Being able to look so far out on final, tower controllers only need to look out no more than 10 miles	• User prefs not used much, took a while, familiarity? • wasting time looking for the curser… helpful if curser could flash at first • When selecting strip on FDM (have) a/c and data block flash instead of outlining (it) • add scratch pad data… "No Load" in time-share (for)aircraft (awaiting) numbers. (have) EDCT or CFR times flash in timeshare to help awareness of taxiway availability for aircraft awaiting departure times

Table 3-6: Controller comments on TIDS usability

Positive	Negative	Neutral or Suggestion
• I think it was just right. Did not find anything that I would have needed that was not already on there. • There was enough information presented to me that I would not need anything else added.	• Timing of when the aircraft turns to cyan color once airborne… it doesn't appear to be accurate with the aircrafts true state. • The wake turbulence timer is ineffective when counting down the time an aircraft begins takeoff roll. Almost all controllers use distance (versus) minutes since it is more efficient.	• The 3 min should be calculated from rotation to provide a controller with the non-waverable time required for departure from the intersection. • There needs to be a way to set hold bars for 3 min wake turbulence for a small departing an intersection behind a large aircraft.

Table 3-7: Controller comments on TIDS usefulness

Positive	Negative	Neutral or Suggestion
• The TIDS needs to be implemented ASAP as a replacement for the ASDE-X. The presentation, user interface, and appearance are far above those of the ASDE-X display. • I feel it is a 100% step forward from the ASDE-X.	• I like the TIDS with the exception of monitoring traffic on the final.	• I like our current display for arrivals better. The current splat P entry (baseball bat) that we have should be included in whatever technology is used to monitor the finals. • Be able to send a flight strip back to ground control, easier way to sequence the aircraft at the end, put a check mark for a/c that require a release. (FDM comment but could be resolved by TIDS CHI update.) • Display should be mounted on an axis recessed into the counter so as not to obstruct the controllers view out the window. • Keyboard/mouse needs to be fixed directly below the display. • Closed Runway Outline is slightly similar to Hold Bars. The Bold White OR Red X should be sufficient in identifying a closed runway ALONG with a Red Bar in the Bay on FDM -- Currently we use a Red "RID" in our bay to denote a closed runway and White X's on the ASDE-X

3.3.2 Requested Modifications for TIDS

Table 3-8 summarizes the modifications that controllers requested for TIDS as a result of DFW-2. These suggestions were gathered during the daily post-evaluation discussion sessions and from the controllers' responses to the evaluation questionnaires. An expanded list of all TIDS modification suggestions can be found in Appendix F. Responses from the questionnaires are provided in Appendix G, and the discussion results are contained in Appendix H. General comments regarding TFDM as a whole can be found in Appendix I.

Table 3-8: Requested TIDS modifications

Affected Display	Capability/Issue	Requested Modification
System	Visual flight rules (VFR)/instrument flight rules (IFR) information needs	• Separate profiles for VFR/IFR weather
System	Improved workstation	• Adjustable workstation for seated/standing
TIDS	Additional information needed on TIDS	• Add altimeter, RVR, hat status • Add wind shear data when available
TIDS	Provide indication of flight status	• Data block color coding (green = cleared for takeoff, yellow = restricted, red = stopped)
TIDS	Provide information as to when a flight can safely take off	• Provide takeoff countdown timer or color coding
TIDS	Provide CFR/EDCT info on TIDS	• CFR/EDCT in scratchpad/data block
TIDS	Ability to close runways	• Runway closure capability on GC/LC TIDS
TIDS	Wake turbulence timer modifications	• Ability to set timer duration • Ability to toggle wake turbulence timer display • Timer should start when intersection departure is airborne
TIDS	Improved hold short bars during land and hold short operations (LAHSO)	• Inhibit hold bars past LAHSO points during LAHSO operations
TIDS	Font sizes inadequate	• Add more font size options
TIDS	Provide more information for sequencing during config change	• Highlight last arrival and departure aircraft in configuration
TIDS	Allow for different preferences in separation	• Provide ability to use miles and time for full-length departures
TIDS	Profile changes should be linked to configuration changes	• Automatically change profile when configuration is changed
TIDS	Ability to hide data blocks	• Hide data blocks when clicked
TIDS	Improved separation monitoring	• Add configurable distance-based "bats"

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4. FLIGHT DATA MANAGER

DFW-2 was the second demonstration of the FDM prototype. In DFW-1, suggested improvements to the initial prototype were made and the prioritized improvements were subsequently implemented for the DFW-2 prototype. In addition, new functionality was introduced to the FDM for the DFW-2 prototype to allow effective integration of the decision support tools and to improve overall FDM acceptance. An exhaustive description of the DFW-2 FDM Prototype functionality can be found in the *DFW-2 FDM Prototype User Manual 2.0*. Similar to the TIDS section, both technical performance of the FDM as well as controller feedback (through observations and questionnaires) were gathered. These results are also discussed in sections 4.1 and 4.2, respectively.

4.1 FDM TECHNICAL PERFORMANCE ANALYSES

Analyses were conducted to determine if the FDM's technical performance met the test plan's success criteria. These included FDE transfer latency and loss analyses, FDE/TIDS selection latency analysis, duplicate FDE analysis, and FDE information consistency with FDIO analysis. Pass/Fail results of these analysis are provided in Table 4-1. Further discussion of these analyses is provided in section 4.1.1 and the sections following.

Table 4-1: FDE success criteria results

Category	Passed	Did Not Pass
Data Sorting & Transfer	• No duplicate FDEs • Latency <0.5 sec in transferring flight data between positions	• No FDEs lost between positions
Notifications	• Prompt displayed for departure time nearing expiration & prompt displayed for airborne route unavailable due to weather • Aircraft/FDEs involved in notification events are highlighted or otherwise indicated • Record all triggered notifications	
Flight State Changes	• FDE state changes occur as required	
Airport Configuration	• Show current configuration consistently across TFDM displays	
Runway	• Show recommended runway	

Category	Passed	Did Not Pass
Assignment	assignments for departures on FDM display based on DST logic and runway-to-fix mapping • Input/modify arrival and departure runway assignments	
Sequencing & Scheduling	• Display estimated departure clearance times and approval required times on FDM • Display suggested spot release rate on FDM	
Taxi Routing	• Accurately display assigned taxi route (textual format) on FDM displays • Provide the ability to select standard taxi routes using one or two button presses • Edit taxi route with keyboard on FDM	
Concurrent Selection	• FDE selected on FDM results in selected target on TIDS in <1 second 80% of the time • Target selected on TIDS results in selected FDE on FDM in <1 second 80% of the time	
Congruent Data	• Flight data shown on TIDS matches that shown on the FDEs and vice versa	
Target Broker	• Flight data stored by TFDM/TIB matches flight data received from ASDE-X, FDIO, and other data sources	• All targets shown on TFDM have flight data information available in datablocks and FDEs
Data Archiving	• Data can be retrieved after each test session	
FDIO	• No discrepancies between FDIO and TFDM data	

4.1.1 No FDEs Lost between Positions

100% of the Local Control FDE transfers were successful to the other stations. 99.78% of the Ground Control FDE transfers to the other stations were successful. 99.68% of the Flight Data/Clearance Delivery FDE transfers to other stations were successful. Each very nearly achieved the 100% success criterion. However, a small percentage of FDE transfers failed to change ownership. Ownership changes tended to fail around the time when system restarts occurred. This relationship suggests that some ownership change messages got lost in the restart process. (Success criterion 2.2.1)

Details by FDM station for the failures is described in Table 4-2 and includes total failures, total transfer attempts (including the successful transfers from criterion 2.2.3 above), percent failure, and average time failures occurred near system restarts:

Table 4-2: FDE transfer success data

FDM Station	Total Failures	Total Attempted Transfers	% Failures	Average (SD) Failure Time Near Restarts in MM:SS
CD*	17	5,324	0.32%	02:52 (01:51)
GC**	8	3,581	0.22%	02:00 (01:22)
LC	0	1,175	0%	n/a

*A detailed breakdown of the FDM station to which the CD FDEs were being transferred is unavailable.

**All GC initiated transfers were to the LC station near times when the LC station hung.

4.1.2 All Targets Shown Have Flight Data Information in Datablocks and FDEs

During the demonstration, there were instances in which Flight Data and Ground Control were unable to find flight data associated with a taxiing flight. Occasionally, FDIO would send flights to print well before the typical 30 minutes before PDT, and therefore it is possible that flights would have been sent before startup of the TFDM prototype on the demonstration morning occurred, resulting in a “loss” of that flight data. These “losses” were addressed by Flight Data/Clearance Delivery simply manually creating FDEs on demand. (Success criterion 3.3.3)

4.1.3 FDE Transfer Latency and Loss Analyses

In the success criterion (2.2.3) for the FDE transfer latency, a success was defined if the latency average was less than 0.5 sec over 90% of the time. In the analysis conducted on the demonstration data, all successful FDE transfers had latencies under 0.5 seconds more than 99% of the time, as seen in Table 4-3.

Table 4-3: Details for successful transfers across all 6 days

FDM Station	Total Transfers	% with Latency <0.5 s
CD	5,307	99.66
GC	3,573	99.52
LC	1,175	99.83

An analysis was also performed on how many FDEs were lost during a transfer between FDM stations. The success criterion (2.2.1) for this analysis defined success as 100% of the FDE transfers were logged between GC-LC, LC-GC, GC-FD, FD-GC, LC-FD, and FD-CD (with 0% loss). In the analysis conducted, the system failed, with the following data:

FDE transfer success from each FDM station:

- LC: 100%
- GC: 99.78%
- CD: 99.68%

A small percentage of FDE transfers failed to change ownership. Upon further examination, ownership changes failed around the time when system restarts occurred. (The system restarts were required as a risk mitigation strategy to overall system stability.) This relationship suggests that some ownership change messages may have gotten lost in the restart process.

Details by FDM station for the failures is described in Table 4-4 and includes total failures, total transfer attempts (including the successful transfers from criterion 2.2.3 above), percent failure, and average time failures occurred near system restarts.

Table 4-4: Summary of FDE transfer failures

FDM Station	Total Failures	Total Attempted Transfers	% Failures	Average (SD) Failure Time Near Restarts (MM:SS)
CD*	17	5,324	0.32%	02:52 (01:51)
GC**	8	3,581	0.22%	02:00 (01:22)
LC	0	1,175	0%	n/a

*A detailed breakdown of the FDM station to which the CD FDEs were being transferred is unavailable.

**All GC initiated transfers were to the LC station near times when the LC station hung.

4.1.4 FDE/TIDS Selection Latency Analysis

An analysis was also conducted to determine the latency between the time that an FDE was selected and the subsequent highlighting on the TIDS datablock for the selected flight. The success criterion (2.4.1) stated that the time between the FDE selection and the highlighted target on the TIDS should be less than 1 sec at least 80% of the time. For this analysis, the time between when the FDM recognized the user action and the time that the TIDS received a selection message was measured. In the analysis conducted, 100% of FDE selections whose targets were found on the TIDS were highlighted on the TIDS in less than 1 second.

Note: In addition to the successful selections described above, there were situations in which a selected FDE's target was either not found on the TIDS* or was available on the TIDS but was not highlighted**. These data are organized by the physical station location, which are South Cab and North Cab on which a Ground or Local Station was configured based on the current airport configuration. In future TFDM iterations, this connection between TIDS target and FDE should be maintained, possibly through the ability to manually connect targets with flight data.

Table 4-5: Concurrent TIDS-FDM selection latency

Physical FDM-TIDS Location	% Total FDEs Matched on TIDS	% Unmatched, Controller-Created FDE	% Unmatched, No TIDS Target*	% Unmatched, TIDS Target Exists**
South Cab	90.3	1.4	2.7	5.6
North Cab	85.8	1.4	6.5	6.3

*Explanation for FDEs that were not found at all on the TIDS: FDEs created by hand showed up as "target not found" on the TIDS.

**Explanation of FDEs for which targets existed on the TIDS: Entity id changes are not picked up on the FDM but are propagated to the TIDS.

4.1.5 Duplicate FDE Analysis

An analysis was conducted to identify whether duplicate FDEs were created for any flight. The success criterion (2.2.2) stated that log files should not show TFDM creation of any FDEs with the same aircraft ID (ACID), destination, date, and predicted departure time (PDT). In the analysis conducted, it was determined that TFDM did not create duplicate FDEs at all.

Multiple IDs were identified, but were not true duplicates due to fact that some FDEs were manually created by a test participant or research personnel during the demonstration.

IDs did appear in the logs well after the flight had departed due to an issue that allowed a departed flight not to be deleted from the Target Broker, Flight Broker, and DSTs as long as it continued to receive

NAS updates. This issue has since been corrected with a “Flight Lifetime” enhancement, which deletes flights from TFDM when certain circumstances have been met after departure.

The questionable IDs were individually analyzed and the reason for the lingering/duplicate ID is included below:

- Hand-created: second FDE manually created by a participant/researcher
- System-created: system detected target and created FDE.
- Deleted: Controller deleted the FDE.
- Departed: Controller hit the DPT next state button.
- Ramp: Controller hit the RAMP next state button.
- Leaving airspace: Surface Monitor indicated flight was airborne and left airspace, but flight was subsequently detected and re-added (either due to a temporary loss and regain of a transponder signal or because a locally returning flight is re-assigned).

Table 4-6 summarizes all questionable FDEs and the reasons that they existed.

Table 4-6: Questionable FDEs

Date	ACID	Reason for Duplicate
4/26/11	AAL 1467	Leaving airspace
4/26/11	EGF 2827	Hand-created, system created
4/26/11	AAL 2058	Departed, system-created
4/26/11	AAL 2453	Leaving airspace
4/27/11	AAL 1112	Hand-created, departed, system created
4/27/11	AAL 1223	Hand-created, departed (hand-created FDE), system created
4/27/11	AAL 2058	Hand-created, system created.
4/27/11	EGF 3289	System-created, departed (system-created), hand-created, departed (hand-created)
4/28/11	AMF 1320	Deleted, system-created
4/28/11	AMF 1632	Deleted, system-created
4/28/11	AMF 1916	System-created (west side), deleted, system-created, leaving

Date	ACID	Reason for Duplicate
		airspace
4/28/11	AMF 1980	System-created (west side), deleted, system-created, leaving airspace
4/28/11	MRA 655	System-created, deleted, hand-created, departed
4/28/11	MRA 658	System-created, deleted, hand-created, departed
5/3/11	EGF 3205	Leaving airspace
5/3/11	BTA 5847	Leaving airspace
5/4/11	-	No duplicates
5/5/11	AAL 1660	Leaving airspace
5/5/11	COA 1728	System-created, ramp, hand-created, system-created, deleted (hand-created), departed (system-created)

In future TFDM iterations, a CONOPS for presentation of duplicate flight data to controllers and a method for resolution will be required to ensure that the single, correct flight plan is maintained in TFDM and ERAM.

4.1.6 Target Broker

The Target Broker has a single goal: to identify all the individual flights in the TFDM system, assign them unique identifiers, and tag every message on the TFDM Information Bus (TIB) with the identifier associated with its flight. To do this, it builds up an in-memory database of flight information, including:

- ACID
- Transponder codes (mode 3A and mode S)
- Arrival and departure airports
- ETA and ETD
- Surveillance track information

When a new message arrives at the Target Broker, it tries to match it against all the flights in its database. If it finds a match, then it assigns the flight's identifier to that message. If no flight in the database matches, then the Target Broker creates a new database entry and flight identifier, and assigns the new identifier to the message. Currently, the Target Broker can process messages from the following data sources:

- Flight Progress (FDIO)
- Flight Status (TFMS)
- Surveillance Radar (ASDE-X)
- Airport Information (AODB, FOC)

The mission of the Target Broker is complicated by the state of the input data. Data problems include:

- Missing data fields
- Incorrect data fields
- Contradictory data fields
- Data fields with incompatible formats

Therefore, the Target Broker has to do its matching in the presence of these errors and produce essentially perfect results. Most of the logic of the Target Broker is devoted to this fault-tolerant matching algorithm.

All targets and their associated flight data are assigned unique IDs that can be retrieved from the TFDM system and the TFDM Information Bus (TIB). The ID numbers assigned to targets are matched to the same ID number assigned to the flight data, linking the data to each other for display on the TFDM displays. However, due to problems retrieving logging data, it was unable to be determined if all IDs for flight data and target pairs were unique or if the IDs assigned to targets matched the IDs assigned to the associated flight data. (Success criteria 3.3.1, 3.3.2)

While the majority of targets shown on TFDM had correct flight data information displayed in their datablocks and FDEs during DFW-2, controllers and observers noted some instances where targets were lacking FDEs. Additionally, there were occasions where datablocks were absent from the display. Because of this, the success criterion that all targets have flight data information available in datablocks and FDEs did not pass. (Success criterion 3.3.3)

4.1.7 Data Archiving and Logging

The Supervisor Display and the FDM log messages whenever a notification prompt was received; it appeared that all messages were recorded correctly during a post-hoc review. All taxi times were logged, and time in runway queue was inferred from recorded ASDE-X data. (Success criteria 1.3.8, 1.3.9, 2.2.17)

The TIDS does not record when airport configuration changes take place, but the Supervisor Display provides a log message when it receives a configuration change prompt. These log messages were available, and based on observations at DFW-2, these configuration change logs appear to be correct. However, in future demonstrations, specific logging tools should be implemented to more concretely determine the accuracy of the logging. Similarly, the TIDS does not log runway closures or openings, but the Supervisor Display did log all runway closure prompts. The reopening of a runway caused the associated closure prompt to be removed. Again, however, logging tools should be implemented in the future to further verify this criterion. (Success criteria 1.1.13, 1.1.14)

4.1.8 FDIO

An analysis to compare the FDE output with the FDIO flight progress strip output was conducted to determine if FDM was effectively reproducing the FDIO information as it should. The success criterion (3.3.4, 4.2.1) stated that the data between flight progress strips and FDEs should be consistent 95% of the time. Because this is a highly manual process of visual comparison between paper flight strips and FDE counterparts requiring location of the individual flight strips and then comparison of the individual fields, a sampling process was utilized in which screen shots of the FDM were taken at points in the demonstration in which the flight strip count on the screen was high for use in comparison. Two screen shots were taken at different times of the day for each of the demonstration days. In the analysis of the sample selected, 98% of the flight data entries matched the flight progress strip exactly.

In the samples that were determined not to be consistent, the difference was in EDCT between the flight progress strip and the FDE. It could be that the time at which the FDE was compared was not the final flight information and the EDCT could have been subsequently updated by FDIO. Another difference was in final/requested altitude field for one flight. Again, this could have been subsequently updated by FDIO after this screenshot was taken.

4.1.9 FDM System Performance Issue: Missing EDCTs

On 28 April 2011, DAL8956 was issued an EDCT, but did not display one in its FDE. This issue was caused by a problem in the target broker where the target broker confused the arrival DAL8956 and the departure DAL8956, which resulted in the target broker assigning the EDCT to the arrival entry in its cache. Because of that, the departure flight strip was not notified of an EDCT. Since DFW-2, the target broker has been significantly reworked to remove issues such as this and will be tested to ensure that the problem no longer occurs.

4.2 FDM HUMAN FACTORS ANALYSES

To support the goal of determining user acceptability of the FDM and identifying areas in which design improvements can be made, both field observations and a series of questionnaires were used to assess acceptability and identify areas of improvement. These methods are complementary in the human factors assessment of the FDM. Questionnaires allow for quantitative assessments of the system by the controllers, unbiased by the field observer. The field observations captured awkward user interactions with the system and system uses that the controllers could not have or would not have identified themselves.

Table 4-7 outlines the pass/fail status of the human factors success criteria related to the FDM. (This table includes only the success criteria included in the DFW-2 test plan, as compared to the TIDS human factors results, which included questionnaire data as well.)

Table 4-7: FDM human factors success criteria results

Category	Passed	Did Not Pass
Flight State Changes	• User feedback on state changes rated 4 or higher on 5-point scale	
Data Sorting and Transfer	• User feedback on sorting and control transfer rated 4 or higher on a 5-point scale	
User Interaction	• User feedback on user interaction tasks rated 4 or higher on 5-point scale	
Overall FDM	• Subjective ratings of FDM rated 4 or higher on a 5-point scale	
Overall Interoperability	• User feedback on interoperability rated 4 or higher on 5-point scale	

4.2.1 FDM Questionnaire Results

Similar to the TIDS questionnaires, the FDM questionnaires were distributed to Ground and Local controller participants at the end of the shadow operations sessions. The questions presented were grouped in terms of FDE information questions, basic user interface questions, user interface features questions, notifications questions, DST information questions, and summary questions. Table 4-8 summarizes questionnaire results categorized into “Positive” results (scoring an average of 4 or higher on a 5-point scale) and “Needs Improvement” (scoring an average of less than 4 on a 5-point scale). The detailed questionnaire results are provided in Appendix J.

Table 4-8: FDM questionnaire results

Category	Positive	Needs Improvement
FDE Information	• FDE accuracy • FDE appropriate for GC • FDE appropriate for LC	
FDM User Interface	• FDM not cluttered • FDM easy to use • Use of appropriate color • FDE amendment easy • FDE transfer easy	• New FDE easy to create
FDM Notifications	• Appropriate information • Displayed appropriate amount of time • Displayed in appropriate location • EDCT prompt usefulness • TMI prompts usefulness	• Lacking needed notification
DSTs on FDM	• Runway assignments useful • Runway assignments logical • Runway assignments easy to modify	• Metering easy to integrate into GC ops • Metering recommendation easy to interpret • Metering in appropriate location
FDM Summary	• FDM beneficial to Towers	• FDM help sequence aircraft • FDM help plan control actions • FDE found as easily as finding a FPS in the bay • FDE modified as easily as modifying FPS

4.2.2 Controller Suggested Modifications to FDM

Controllers provided general suggestions to modify the FDM both on open-ended questions in the questionnaires as well as during the following verbal discussions. Below is a summary of the issues and modification suggestions provided by the controllers.

Table 4-9: FDM suggested modifications

Category	Issues	Suggested Modification
FDE Information	• Missing FPS information	• Add CID to FDE • Beacon code on minimized FDE
FDM User Interface	• Difficulty scrolling • Field-based highlighting/red text • Call for Release highlighting not salient enough • Lack of ability to edit a FDE (by a FD/CD controller) that a GC owns • Too many touches to accomplish task, leading to more heads down time than using paper strips	• Select FDE, then toggle through highlight/red text/normal text • CFR needs to flash • Needs shadow-editing capability of FDEs at other positions
Notifications	• Notifications area too small • Information window not appropriate place for MIT/CFR • Notifications font too small	• Need bigger notifications area • Need ability to disregard certain notifications • Need ability to call up all alerts/notifications that have occurred, even after acknowledgement • Want real-time departure interval time to use when calculating MIT • EDCT field should flash 5–10 min prior to EDCT so that an aircraft can be starting engines if shut down
FDM Features		• Move ATIS field on FDE to the right • Show updated runway assignment (blue field) only in Ready to Taxi queue or Active queue (but not in Pending queue) to reduce color clutter • Need easier way of modifying Pending queue and order • Modify taxiway holding instructions with more than 2 letters • Electronic request to transfer FDE from another controller • Safety feature questioning whether to put flights in Position and Hold if another flight is in certain positions on the runway • Want departure HAT status on FDM

4.2.3 Observed Issues with FDM Usage

Observations of FDM usage were conducted both during the demonstration and post-demonstration during audio/video playback analyses. Tables 4-10, 4-11, and 4-12 outline the observations made during the demonstration that were observed in the performance of 4 or more controllers. A comprehensive set of observations are available in Appendix K.

Table 4-10: FDM interface problems

#	Comment
5	Would like beacon code on minimized FDE
4	Did not notice prompts, would EDCT prompts to flash for a few seconds

Table 4-11: FDM functionality liked

#	Comment
4	Liked that MIT highlighted destination field
4	Liked that inputting CFR for individual flights would propagate to FDEs

Table 4-12: FDM functionality suggestions

#	Comment
5	Would want ability to indicate off-hat in runway to fix mapping (and turn dep fix to red text on FDEs) Black runway assignments should be consistent with HAT status, off-hats should always be in red (text or field), want red background, red text not salient enough, automatically show DP in red text for “off hat,” flights departing on nominal arrival runways with red runway (until coordination is finished?). (DFW-specific operations recommendation)
5	Would want a shadow-editing capability at FD/Sup/TMC positions, keeping FDE in GC or LC queues
4	Want ability to amend from GC & LC

In the post-demonstration analyses, both visual gaze and verbal communications were analyzed for indications of TFDM effect on controllers' performance. A thorough description of the method and results can be found in Appendix M. In summary, verbal communications analysis suggested that interacting with the FDEs (searching, moving, editing) affected participant controllers' abilities to respond as quickly as East Tower controllers in the shadow control task. The visual gaze analysis also indicated that searching for FDEs resulted in visual dwells of greater than 15 seconds per instance. In addition, visual gaze results suggested that highlighting/red texting an FDE and confusion due to a flight that should have been sent to the West Tower also resulted in long visual dwells. Continued effort to improve these FDM features should be exerted to reduce negative impact on controller performance (either heads-down time or untimely verbal communications).

5. DECISION SUPPORT TOOLS & SUPERVISOR DISPLAY

DFW-2 was the initial demonstration of the DSTs and the supervisor display prototype. An initial, reduced-functionality set of DSTs was prototyped to explore the technical feasibility of the concepts and to acquire initial controller/FLM/TMC feedback on the tools' operational usefulness. The purpose of the DSTs for DFW-2 was not to provide specific recommendations on controller/FLM/TMC actions (although metering does this); the goal was to provide an integrated set of information that is not currently available in the Tower to a standard that could be evaluated as operationally useful. As such, the tested DSTs and Supervisor Display were intermediate prototypes, with additional refinement and maturation planned to occur subsequent to and based off of the initial findings from DFW-2.

An exhaustive description of the DFW-2 DSTs and Supervisor Display Prototype functionality can be found in the *DFW-2 Supervisor Display Prototype User Manual 1.0*. Similar to the TIDS and FDM sections, both technical performance of the DSTs as well as controller feedback (through observations and questionnaires) were gathered and reported in this section.

Airport Configuration

The airport configuration capability delivered in DFW-2 prototype included the ability to set and schedule airport configuration changes and the ability to view the resultant traffic demand in different permissible airport configurations. In the airport configuration module, runways and other resources could be opened or closed to provide a more accurate picture of the traffic demand for a particular airport configuration.

The STBO airport configuration capability that the DFW-2 prototype in part accomplished was:

- [AC03] Provide queuing/congestion analysis for permissible airport configurations

Runway Assignment

The runway assignment capability delivered in DFW-2 prototype included the ability to view a TFDM suggested runway assignment in a runway assignment field in the FDE for departures, the capability for the controllers to easily change this runway assignment, and the ability to view arrival and departure demand by runways. The runway assignment DST updates the runway assignment field on the FDE for a flight whenever FDIO sends an updated route to TFDM unless it has already started taxiing. It also provided a capability for users to change the runway-to-departure-fix mapping on the Supervisor Display in accordance with DFW procedures; TFDM then subsequently propagates this change to the individual FDEs at GC and LC.

The STBO runway assignment capabilities that the DFW-2 prototype accomplished were:

- [RN01] Assign departure runway based on pre-defined rules
- [RN02] Provide advice to controller on manually entered assignment of departure runway

- [RN08] Provide real-time runway assignment “rule” creation by controller

Taxi Routing

The taxi routing capability delivered in DFW-2 prototype included the ability to quickly assign standard taxi routes through the use of FDM hot buttons and the ability to manually enter non-standard taxi routes through the Edit window on the FDM. Taxi route non-conformance was not implemented for the DFW-2 prototype due to concerns about lack of user acceptability of manually typing (rather than the TFDM user group-preferred verbal means) the non-standard taxi routes for each flight.

The STBO taxi routing capabilities that the DFW-2 prototype accomplished were:

- [TX01] Provide for manual assignment of pre-defined taxi routes by tower personnel
- [TX02] Provide operator entry of non-standard taxi routes by tower personnel
- [TX10] Manage and display real time state of runways and taxiways

Sequencing & Scheduling

The sequencing & scheduling capability delivered in DFW-2 prototype included the ability to view predicted departure sequences and expected arrival and departure demand on runway timelines, the ability to estimate a wheels off time for departures and wheels on time for arrivals, and the ability to manually enter MIT/MINIT/arrival rate constraints with the expected arrival/departure demand responding to the constraint. Prompts were also provided to the GC/LC who owned a flight when it was within 5 min of its EDCT, and EDCTs for affected flights were displayed on the appropriate FDEs. Sequencing and scheduling also responds in turn to airport configuration changes made and runway-to-fix mapping changes made through the Supervisor Display to provide the FLM/TMC with the most accurate expected demand possible. An additional capability that was provided in the DFW-2 prototype was surface metering from DFW spots, which provided the GC with recommendations on spot release rate to maintain departure queue at an optimal level. Controllers were also able to enter release times and other remarks into a remarks field on the FDEs.

The STBO sequencing and scheduling capabilities that the DFW-2 prototype in part accomplished were:

- [SS01] Generate a predicted runway sequence for all active runways for strategic use by the TMU or supervisor.
- [SS03] Display TFM constrained times, including if a constraint has not been met
- [SS05] Provide estimations for flight-specific event times to meet the planned surface schedule
- [SS13] Provide predicted and actual surface schedule non-compliance information
- [SS17] Manage departure queue length

Departure Routing

The departure routing capability delivered in the DFW-2 prototype included the ability to provide flight-specific departure route weather blockage information on the timelines, as well as the capability of viewing the estimated wheels off times by departure route in conjunction with departure route weather blockage information. Departure routing also supplied the GC or LC with a prompt on the FDM with information that a flight that is owned has a blocked departure route. The individual FDE of the affected flight would have its departure SID highlighted as an indication of a potential problem. Controllers also had the option to view departed flights on the departure routing tab. Each action or feature was performed or viewed successfully by both the staff and the participant FLMs/TMCs throughout the demonstration with acceptable results. (Success criteria 1.5.1, 1.5.2, 2.3.14, 2.3.15)

The STBO departure routing capability that the DFW-2 prototype accomplished was:

- [DR01] Flight-specific impact assessment and indication of constraints to departure route
- [DR03] Evaluate pre-coordinated routes for acceptability relative to weather and traffic flow constraints

5.1 DECISION SUPPORT TOOLS & SUPERVISOR DISPLAY TECHNICAL PERFORMANCE

The DSTs available for DFW-2 included airport configuration, runway assignment, taxi routing, sequencing & scheduling, and departure routing. Table 5-1 summarizes the pass/did not pass status of the technical performance success criteria for the DSTs and Supervisor Display.

Table 5-1: DSTs and SUP display success criteria results

Category	Passed	Did Not Pass
Airport Configuration	• Displayed configuration is the same on all TFDM displays • Configuration shown on displays represents configuration currently in use • Runway status is consistent on TIDS & Supervisor Displays • Runway status shown on displays reflects current status of runways • Show unavailable airport configurations accurately • Departure fix status is shown on Supervisor Display • Predict and display expected number of departures and arrivals at least 30 min into the future • Record scheduled airport configuration changes	• Predict & display expected number in departure queue at least 30 min into future with 80% accuracy, when comparing predicted departure queue with the departure queue that actually transpires

	• Record runway closures and openings • Show recommended runway assignments for departures on FDM display based on DST logic and runway-to-fix mapping • Provide ability to edit current configuration on Supervisor Display • Schedule new runway configuration on Supervisor Display • Cancel a scheduled runway configuration on Supervisor Display • Modify schedule runway configuration on Supervisor Display	
Runway Assignment	• Display predicted departure sequence for each runway • View runway-to-fix mapping • Show status of runways accurately on TIDS and Supervisor Display	• Automatic runway assignment at the queue is consistent 98% of the time with what runway the departure actually uses (moderating the result for variables known at the prediction time, e.g., off-hat, departure fix) • Automatic runway assignment at the spot is consistent 85% of the time with what runway the departure actually uses (moderating the result for variables known at the time, e.g., off-hat, departure fix)
Sequencing & Scheduling	• EDCTs for affected flights are displayed in the EDCT field on the FDE • Approved release times can be entered into the remarks field of the FDE • Display estimated wheels off and wheels on times on runway timelines on Supervisor Display • Display suggested spot release rate on FDM • Record taxi times from spot to runway queue for each departure • Record time spent in runway queue for each departure • Display predicted departure queue sequence for each runway • Display estimated wheels on time within 2 min 75% of the time on Supervisor Display (when 2 min from wheels off)	• Display estimated wheels on time within 1 min 98% of the time on Supervisor Display within 2 min of the flight becoming airborne or the flight landing • Display estimated wheels on time within 1 min 85% of the time and estimated wheels off times within 2 min 85% of the time on Supervisor Display within 15 min of the flight becoming airborne or the flight landing • Display expected number of departures and arrivals on runway timelines on Supervisor Display. Predict expected number of

		departures and arrivals at least 30 min into the future • Display estimated wheels on time within 1 min 75% of the time on Supervisor Display (when 2 min from wheels on)
Taxi Routing	• Accurately display assigned taxi route on FDM (textual) display • Change runway status on TIDS and Supervisor Display	
Departure Routing	• RAPT route blockage color is associated with each flight on Sequencing & Scheduling tab • Timelines of wheels-off times of individual flights associated with each RAPT departure route are shown in DR tab • Upon flight departing, flight is removed from all lists and timelines on DR tab • Display constraints from destination airport that impact each departure • Show/modify status of departure fixes on Supervisor Display (closures & MIT) • View/edit list of MIT/MINIT programs for other airports	
RAPT	• No discrepancies between TFDM and RAPT data	
ITWS	• Display of centerfield wind data	
External Data	• No discrepancies are found between recorded D-ATIS data and the D-ATIS data stored on the TIB • No discrepancies are found between recorded NOTAMs and the NOTAMs stored on the TIB • No discrepancies are found between recorded RVR data and the RVR data stored on the TIB • The time elapsed between receiving NOTAMs and NOTAMs being available on the TIB is less than 1 sec • The time elapsed between receiving RVR data and the RVR data being available on the TIB is less than 1 sec	• The time between receiving D-ATIS data and the D-ATIS data being available on the TIB is less than 1 sec

5.1.1 Predict and Display Expected Number of Departures and Arrivals

The expectation was that the timeline display would provide an accurate reflection of the current arrival and departure demand up to 30 min into the future. In video-based post analysis, while the timelines did display flight information 30 minutes into the future on the timelines, several instances were observed indicating that the information was not accurate. Arrival and departure demand was assessed at both 5 minutes before expected wheels off/on time and 30 min before expected wheels off/on time. Inaccuracies were observed both at 30 minutes and at 5 minutes. This criterion was aimed at assessing visual accuracy of the arrival/demand flight information. Quantitative assessments of wheels on and wheels off accuracies are discussed in more detail below. (Success criterion 2.3.10)

5.1.2 Automatic Runway Assignment Consistent 98% (for queue) and 85% (for spot) of the Time with Runway Used

The default runway assignment logic in TFDM maps all flights with departure fixes on the east side of the airport to runway 17R/35L, and all flights with departure fixes on the west side of the airport to runway 18L/36R. Whenever one of these primary departure runways is unavailable, the logic assigns secondary and tertiary runways as alternates according to a static logic set. The supervisor can also override the default logic by modifying the runway-to-fix mapping through the Supervisor display. Over the course of the six days of DFW-2 involving several thousand flights and numerous (simulated and actual) instances of closed runways and runway-to-fix mapping changes during Supervisor display testing, no instances of runway assignments on the FDEs being inconsistent with the DST logic were observed. There was one instance of an uncommon departure procedure (JACKY4) being mapped to the wrong runway in the default logic. This resulted in erroneous runway assignments for flights filing that procedure (because the assignment was consistent with the incorrect logic), but they accounted for less than 0.1% of the total flight events analyzed. (Success criterion 1.1.16, 2.2.8, 2.2.10)

Success criteria 1.2.1 and 1.2.2 were developed to evaluate how well the logic mapped to the actual runway assignments used at DFW during the demonstration. Assessment of these two success criteria were combined owing to the fact that the runway assignment on the FDE did not change between the spot and departure queue unless the departure procedure changed during taxi, in which case the runway assignment would also automatically change consistent with the DST logic (both events would be flagged to the controller).

Table 5-2 presents the runway assignment statistics as a function of departure procedure over the course of all the flight events on the first day of DFW-2 (26 April 2011). The shading identifies the default runway assignment logic in TFDM, assuming all runways are available and no runway-to-fix mapping changes were made through the Supervisor display (as discussed in success criterion 1.1.16). When the results were weighted by the proportion of flights filing different departure procedures, over 84% of the runway assignments were consistent with the default logic.

Runway closure and runway-to-fix mapping change logs were not readily available for this analysis and therefore it was not possible to say what increased proportion of flights would have departed on runways consistent with the TFDM runway assignment logic if these important events had been accounted for. However, due to the Supervisor training being conducted throughout the DFW-2 test days, there were numerous instances of simulated runway closures and runway-to-fix mapping changes, which would have altered the FDE runway assignments and potentially made them inconsistent with the actual operational state of the DFW. If it had been possible to account for these events, the proportion of flights for which the automatic TFDM runway assignment was consistent with the runway actually used would be greater than 84.3%, but it is difficult to say how much greater.

Note that it is quite common for aircraft to depart “off hat” at DFW, i.e., on runways different from the default mappings (and different from other aircraft filing a given departure procedure) in order to balance demand across the airport or to reduce taxi distances for certain flights. For example, BLECO3 departures typically depart from 18L/36R. If that runway had a lot more demand in a given time period than 17R/35L and a BLECO flight left terminal A on the east side of the airport, the east side ground controller could coordinate with the west tower to keep a “one off” BLECO3 aircraft for departure on 17R/35L. These types of tactical decisions would account for any remaining differences between the TFDM automatic runway assignment and the runways actually used.

The results in the table also highlight the issue with the JACKY4 default runway assignments discussed earlier in this section.

Table 5-2: Runway assignment statistics for DFW-2

Departure Procedure	% Flights	18L	36R	17R	35L	Other Rwys	% Default	% Not Default
AKUNA3	11.0%	0%	7%	20%	60%	13%	80%	20%
ARDIA3	1.0%	0%	3%	15%	74%	8%	90%	10%
BLECO3	8.7%	27%	47%	3%	12%	12%	73%	27%
CEOLA4	1.8%	37%	49%	0%	0%	14%	86%	14%
CLARE2	7.8%	0%	0%	26%	67%	7%	93%	7%
CYOTE5	0.3%	0%	67%	0%	0%	33%	67%	33%
DALL9	0.2%	0%	20%	20%	60%	0%	80%	20%
DARTZ3	3.7%	5%	4%	13%	73%	5%	86%	14%
FERRA4	3.3%	21%	73%	0%	0%	6%	94%	6%
GARL3	0.6%	0%	0%	8%	67%	25%	75%	25%
GRABE3	1.5%	3%	8%	16%	67%	5%	84%	16%
HUBB6	2.5%	0%	1%	17%	64%	18%	81%	19%
JACKY4	0.1%	0%	0%	0%	0%	100%	0%	100%

Departure Procedure	% Flights	18L	36R	17R	35L	Other Rwys	% Default	% Not Default
JASPA2	2.3%	18%	61%	0%	11%	10%	79%	21%
JPOOL4	0.1%	0%	0%	20%	80%	0%		
KEENE6	2.2%	19%	53%	2%	9%	17%	72%	28%
KING7	1.8%	14%	59%	3%	0%	25%	73%	27%
LOWGN3	4.9%	23%	55%	0%	9%	14%	78%	23%
NELYN2	3.8%	22%	57%	1%	10%	11%	79%	21%
NOBLY3	9.8%	0%	1%	16%	74%	9%	90%	10%
PODDE3	11.4%	27%	60%	1%	1%	10%	87%	13%
SLOTT3	3.3%	25%	58%	0%	0%	16%	84%	16%
SOLDO2	12.9%	0%	1%	22%	69%	7%	91%	9%
TAMMY3	0.1%	0%	0%	0%	60%	40%		
TEX1	0.2%	14%	14%	0%	43%	29%		
TGATE6	0.9%	0%	0%	13%	63%	24%	76%	24%
TRISS3	3.7%	1%	1%	24%	70%	5%	93%	7%
WORTH5	0.0%	100%	0%	0%	0%	0%	100%	0%
WYLIE5	0.1%	0%	0%	0%	100%	0%	100%	0%
Weighted fraction							84.3%	15.7%

5.1.3 Display of Wheels-On/Off Times

Analyses were performed to assess these success criteria using TFDM data from across four of the six demonstration days. In Table 5-3, the wheels off criteria were assessed. None of the days analyzed met the wheels off success criterion of 98% correct wheels off time within 2 min of takeoff. Beyond 2 min from wheels off, TFDM coverage of the departing flights became an issue. Figure 5-1 illustrates how flight coverage is significantly less between 15 min from departure and 30 min from departure. This is important because many operational decisions about sequencing aircraft and any future recommendations of airport configuration would require accurate estimates 15–30 min from takeoff, at a minimum. The primary cause for the low flight coverage was a “suspend flight” logic for flights for which no surveillance or schedule updates had been received in the past 10 minutes.

Table 5-3: TFDM wheels-off estimation error in the DFW-2 Prototype

	04/26/2011			04/27/2011			05/03/2011			05/05/2011		
	Error< 2 min	Number of Flights	Percent of Total SDSS Flights	Error< 2 min	Number of Flights	Percent of Total SDSS Flights	Error< 2 min	Number of Flights	Percent of Total SDSS Flights	Error< 2 min	Number of Flights	Percent of Total SDSS Flights
2 min to WOFF	55%	686	81%	91%	487	81%	94%	402	68%	93%	540	96%
15 min to WOFF	15%	213	25%	14%	81	14%	5%	41	7%	22%	54	10%
30 min to WOFF	1%	92	11%	6%	32	5%	0%	19	3%	4%	24	4%
Total Flights SDSS	845			599			588			562		
SDSS coverage time	4/25/2011 11:58:16 PM to 4/26/2011 10:29:49 PM			4/27/2011 11:42:23 AM to 4/27/2011 9:46:17 PM			5/2/2011 11:59:12 PM to 5/3/2011 10:03:19 PM			5/5/2011 11:41:45 AM to 5/5/2011 9:08:15 PM		
Total Flights PASSUR	895			935			951			947		

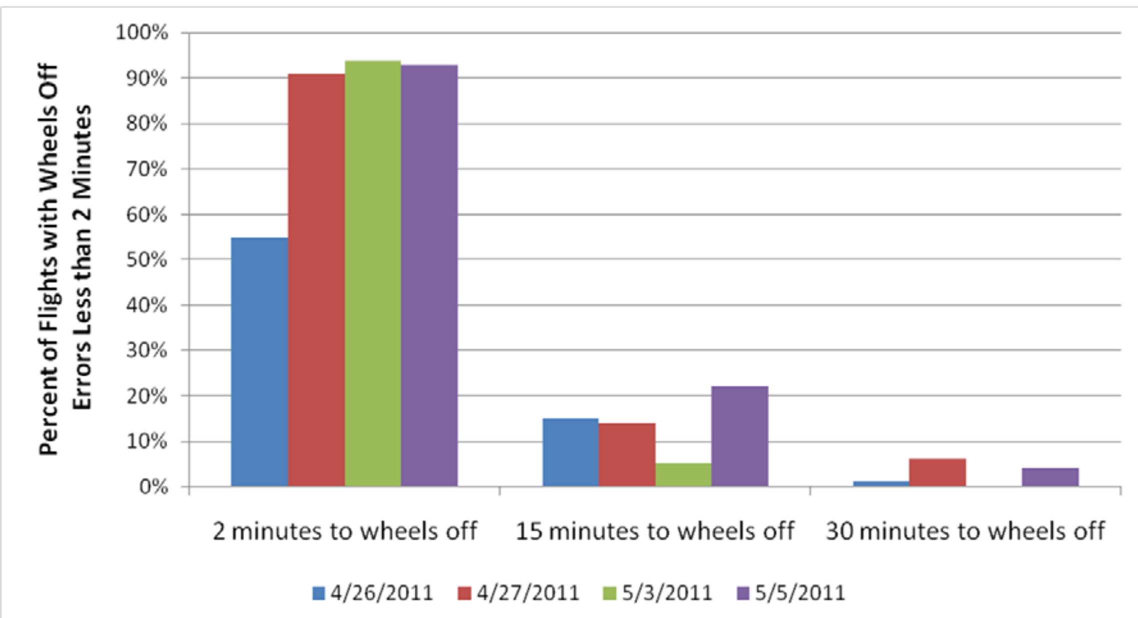


Figure 5-1: Wheels-off flight coverage in the TFDM DFW-2 Prototype

Wheels-on estimates were also assessed. In Table 5-4, the wheels on estimates with an error of less than 2 min were evaluated at 2 min, 15 min, and 30 min until the flights landed wheels on. In Table 5-5, the wheels on estimates of less than 1 min were evaluated (as per the success criterion). With 1 min error, the criterion was not met, but with 2 min error, the criterion was very close to being met. However, as with the wheels-off estimates, flight coverage for the arrivals (shown in Figure 5-2) was also very low with the exception of 5/5/11. Thus, the sequencing and scheduling algorithms used in the DFW-2 prototype were not adequate as assessed by the current success criteria.

Table 5-4: TFDM wheels-on estimates with 2 min error until wheels-on in the DFW-2 Prototype

	04/26/2011			04/27/2011			05/03/2011			05/05/2011		
	Error< 2 min	Number of Flights	Percent of Total SDSS Flights	Error< 2 min	Number of Flights	Percent of Total SDSS Flights	Error< 2 min	Number of Flights	Percent of Total SDSS Flights	Error< 2 min	Number of Flights	Percent of Total SDSS Flights
2 min to WON	98%	605	76%	99%	487	85%	94%	426	77%	99%	534	98%
15 min to WON	3%	36	5%	0%	4	1%	0%	3	1%	0%	3	1%
30 min to WON	8%	12	2%	7%	15	3%	0%	9	2%	0%	11	2%
Total Flights SDSS	796			575			555			545		
SDSS coverage time	4/25/2011 11:58:16 PM to 4/26/2011 10:29:49 PM			4/27/2011 11:42:23 AM to 4/27/2011 9:46:17 PM			5/2/2011 11:59:12 PM to 5/3/2011 10:03:19 PM			5/5/2011 11:41:45 AM to 5/5/2011 9:08:15 PM		
Total Flights PASSUR	881			913			956			954		

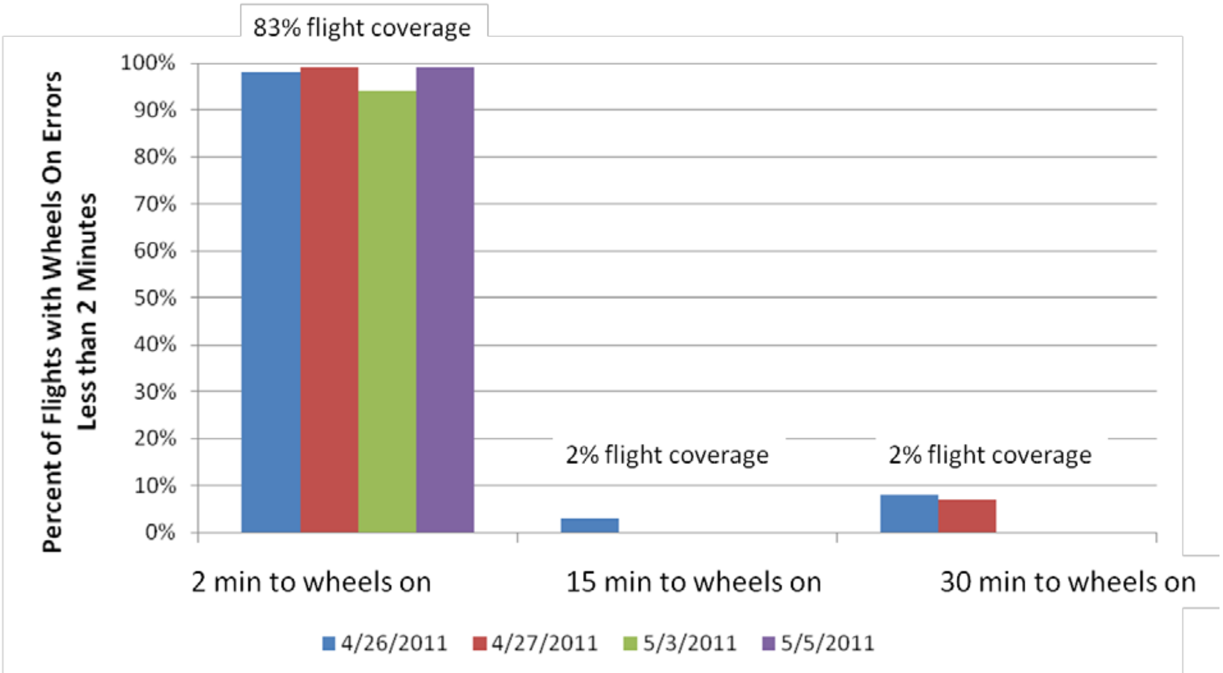


Figure 5-2: Flight coverage for wheels-on time estimates (error less than 2 min) for the DFW-2 Prototype

Table 5-5: TFDM wheels-on estimates with 1 min error for the DFW-2 Prototype

	04/26/2011			04/27/2011			05/03/2011			05/05/2011		
	Error< 2 min	Number of Flights	Percent of Total SDSS Flights	Error< 2 min	Number of Flights	Percent of Total SDSS Flights	Error< 2 min	Number of Flights	Percent of Total SDSS Flights	Error< 2 min	Number of Flights	Percent of Total SDSS Flights
2 min to WON	55%	605	76%	76%	487	85%	45%	426	77%	73%	534	98%
15 min to WON	0%	36	5%	0%	4	1%	0%	3	1%	0%	3	1%
30 min to WON	0%	12	2%	7%	15	3%	0%	9	2%	0%	11	2%
Total Flights SDSS	796			575			555			545		
SDSS coverage time	4/25/2011 11:58:16 PM to 4/26/2011 10:29:49 PM			4/27/2011 11:42:23 AM to 4/27/2011 9:46:17 PM			5/2/2011 11:59:12 PM to 5/3/2011 10:03:19 PM			5/5/2011 11:41:45 AM to 5/5/2011 9:08:15 PM		
Total Flights PASSUR	881			913			956			954		

The analysis of the metering algorithm is presented to review the sequencing and scheduling performance across these technical performance criteria. The purpose of surface metering is to absorb as much taxi-out delay as possible at the gate (with engines off) for the purposes of fuel conservation and emissions reduction without adversely affecting runway throughput. In the DFW-2 prototype, the metering algorithm was designed to maintain six aircraft in the departure queue at runway 17R/35L, by projecting departure demand forward by 10-20 min. The possible spot release recommendations GC could receive included “no metering required,” “5 per 5 min,” “4 per 5 min,” “3 per 5 min,” “2 per 5 min,” and “1 per 5 min.”

The success criteria 1.3.6 and 2.2.13 state, “Metering recommendation is displayed on GC FDM when estimated departure queue exceeds 6 flights for more than seven one-minute intervals 10-20 minutes into the future.” Figure 5-3 shows that the SDSS-estimated queue size for runways 17R/35L over the entire DFW-2 period. It only exceeded the departure queue size threshold of six flights on two occasions: at 20:29 UTC on 26 April 2011 and 12:23 UTC on 4 May 2011.

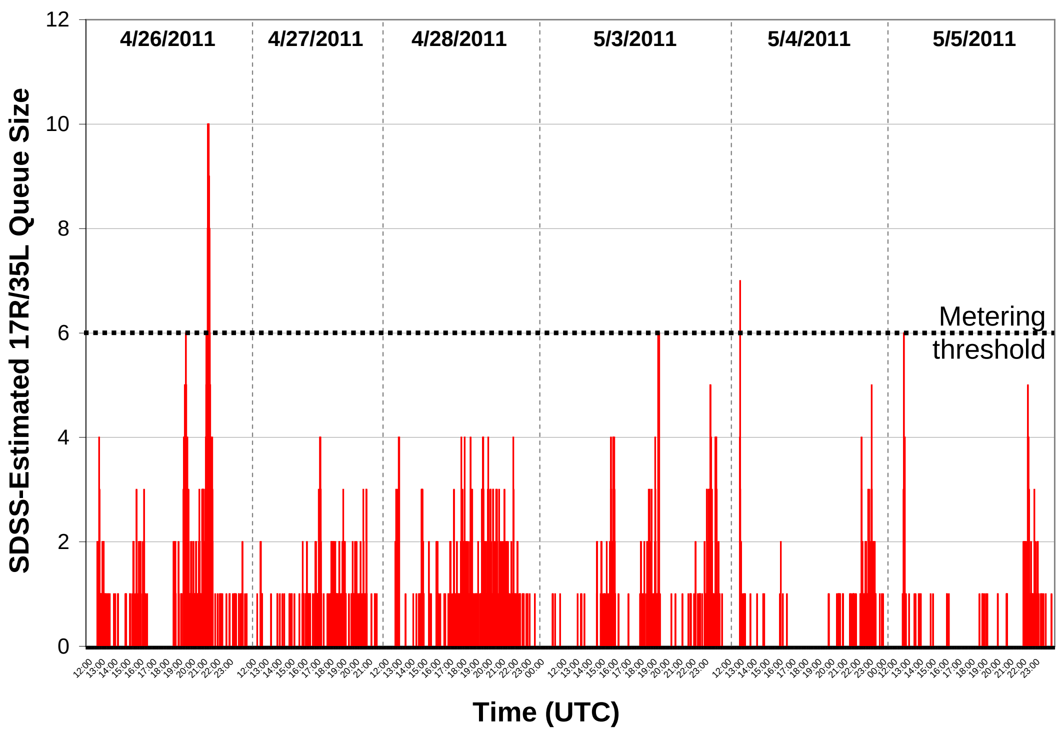


Figure 5-3: Estimated queue size for runway 17R/35L for DFW-2

For the second event, the estimated queue size exceeded the threshold for only one minute and hence was not sufficient to trigger any metering recommendations, which required the threshold to be exceeded for at least seven of the one-minute intervals between 10 and 20 minutes into the future. However, this criterion was met for the first event, as shown in Figure 5-4.

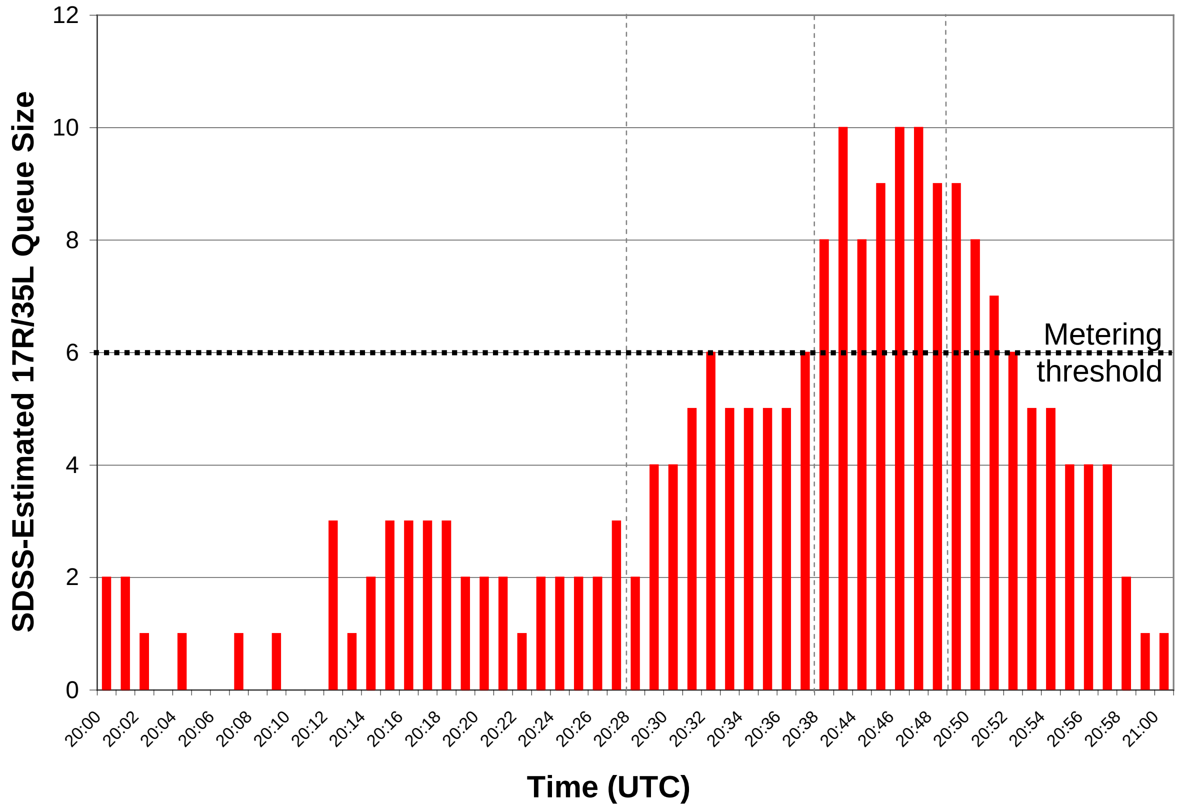


Figure 5-4: Queue size for 17R/35L, 5/4/2011 at 12:23 UTC

At 20:29 UTC, the metering algorithm used the SDSS-estimated queue length for 10 minutes in the future, at which point it exceeded the metering threshold. It then used the estimated queue size for 10-20 minutes into the future and determined that the estimated queue size exceeded the threshold for more than seven minutes in that interval, and hence issued a metering recommendation for 0 aircraft per five minutes to be released from the spot until the queue size was estimated to drop below the threshold. Examination of the DFW-2 logs show there was only one metering recommendation issued during DFW-2 at 20:29 UTC on 4/26/2011 for a rate of 0 aircraft per five minutes, and this was properly cancelled five minutes later.

These data show that the TFDM metering algorithm worked as designed given the *estimated* departure queue sizes. However, further analysis of the ASDE-X surveillance data showed that there were several other instances during DFW-2 when the *actual* queue sizes exceeded the threshold number for a long enough period to warrant metering recommendations, but the estimated queue sizes were too low. An example of this is shown in Figure 5-5: the metering threshold (the black horizontal line at y=6) was exceeded at around 13:18 and the queue length remained above (or at) the threshold for the next 30 minutes. The sequencing & scheduling estimate of queue length made at 13:18 was well below the saturation level, and did not subsequently exceed the threshold for a long enough period for the metering algorithm to make a recommendation. More generally, Figure 5-5 illustrates a low correlation between the actual queue length and the queue length predicted by the sequencing & scheduling algorithm within the TFDM prototype system. Accurate projections of queue length are required in order for the departure metering algorithm to be effective.

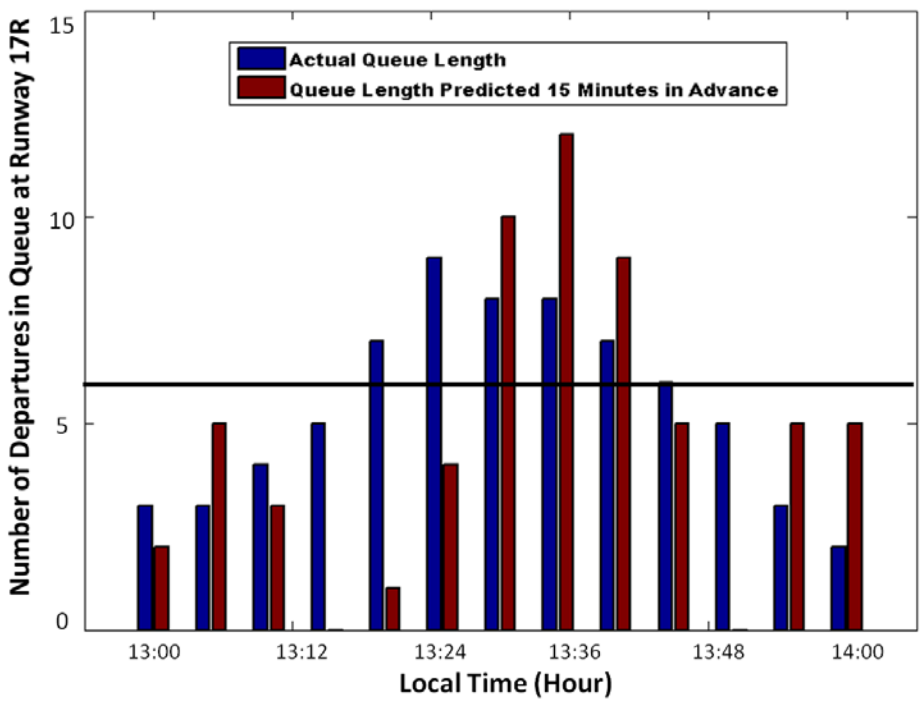


Figure 5-5: 17R/35L queue sizes (actual/estimated queue length)

Thus, the metering algorithm passed the success criterion in that it worked properly given the inputs available to it, but queue size estimate inputs need to be significantly improved for the metering recommendations to be accurate relative to the actual operation. (Success criterion 1.1.9)

5.1.4 The Time between Receiving D-ATIS Data and the D-ATIS Data Being Available on the TIB Is Less Than 1 sec

Each of the ATIS changeovers for the six demonstration days were analyzed to identify the time between D-ATIS data being received in TFDM and when it was available to the (FDM) component to display. In 73 ATIS changeovers, the average delay time was 0.983 seconds, however the latency exceed 1 second in nearly half of the cases (35 instances) with a maximum latency of 1.521 seconds. The minimum latency was 0.462 seconds.

To remedy the D-ATIS latency issue in future TFDM prototypes, the data source for D-ATIS should be the local TDLS system which would significantly reduce the message transport delay. (For DFW-2, the message was sent from MIT LL once it was received to DFW.)

5.1.5 Success Criteria Not Applicable to Final DFW-2 Prototype Demonstration & Success Criteria with Inconclusive Results

A select number of success criteria outlined in the DFW-2 Test Plan were no longer applicable at the time of the demonstration due to final design decisions made regarding the DFW-2 prototype after the test plan was submitted. These success criteria and the relevant design decisions are described in this section.

Taxi Route Non-Conformance

Prior to the demonstration, it was determined that taxi route non-conformance DST was not sufficiently mature to demonstrate. Thus, the criteria related to taxi route input evaluation and non-conformance prompts were not relevant to evaluate in the demonstration with the absence of this DST. (Success criteria 1.4.1, 1.4.2, 1.4.3, 1.1.4, 2.2.4, 2.2.5)

EDCT Prompt Using Estimated Wheels-Off Times

An EDCT prompt reliant on the wheels off time estimates was determined to be at risk of becoming nuisance to the controllers, because the wheels off estimates were themselves unreliable prior to the DFW-2 demonstration. Thus, a simpler EDCT prompt that was presented to controllers 5 min prior to the EDCT time was implemented. Thus, the criterion analyzing and evaluating the performance of the EDCT prompts was not required for this demonstration. (Success criterion 1.3.7)

External Data

For the DFW-2 demonstration, AODB and FOC data was not integrated into the DFW-2 prototype. Thus, criteria evaluating the performance of these interfaces were not required. (Success criteria 4.5.3, 4.5.4, 4.5.10, 4.5.11)

Microburst and windshear data were available in the wind display in DFW-2, but no instances occurred during the demonstration evaluation period. Thus, the criteria addressing this capability were not evaluated. (Success criteria 4.4.2, 4.4.3)

ATIS Prompt

No prompt was issued upon transitioning to a new ATIS. Thus, the criterion evaluating the ATIS prompt was not required. (Success criterion 2.2.4)

Notification User Feedback

Notifications were not fully tested during DFW-2, so this topic was not included in the controller evaluation questionnaires. (Success criteria 2.2.19, 2.2.21, 2.2.22)

Taxiway Open/Closure

The ability to open and close individual taxiways was not enabled in DFW-2, so the criteria addressing this capability were not evaluated. (Success criteria 2.1.9, 2.1.10)

A number of criteria were unable to be evaluated due to deficiencies in truth data or logging data. Deficiencies in truth data included departure fix closures and MIT restrictions. Deficiencies in logging data included lack of data available to assess TIDS-initiated concurrent selection/highlighting, lack of ability to retrieve TFDM logging files (unique IDs, RAPT timestamps, ITWS timestamps and data, ASDI timestamps and data), and raw camera data (Searidge and Cohu). (Success criteria 1.1.7, 1.1.8, 2.4.2, 3.3.1, 3.3.2, 4.3.2, 4.4.5, 4.5.1, 4.5.7, 4.5.14, 5.1.1.2, 5.1.2.2, 5.2.1.4)

5.1.6 DSTs/Supervisor Display System Performance Issues

Active Flights Freeze

The active flights table froze for an unknown reason at 15:18 and 15:22 on 3 May 2011. In this case, the term “froze” means that the data at the top of the active flight table became garbled, but the clock was still ticking and the active table continued to get updated. There were no error messages in the log file that could point to a cause. The active flight table eventually fixed itself without requiring a restart.

Multiple Prompts

On 3 and 5 May 2011, some of the Supervisor actions, such as switching airport configurations or closing runways, were causing duplicate prompts to be sent out and displayed in the Info area. These occurrences can be seen in the logs, but there were no errors that point to a cause and was not seen on any other days. This issue is currently under investigation.

Stuck/Late Timeline

On 4 May 2011, the arrival timeline for 17C showed the wheels-on time for AAL721 as 1748, but the flight did not actually land until 1752. DSTs schedule the flights based on the ASDI data and the surveillance data, so it is possible that the flight had surveillance briefly and then lost it only to be picked up at a later time. This would have assigned the flight a different entity id. It is thought that the DSTs prevent the flight from moving below the current time if there is no indication that the flight has taken off, resulting in the flight remaining tied to the current time on the arrival table. This had been seen frequently when the target broker had more problems with matching times, but had been seen less often as the code matured closer to DFW-2. As a work around for this problem, the supervisor provided the option to right-click on the flight in the timeline to move it to the right side of the timeline to move it out of the way.

Scheduled Closure Not Displayed

On 4 May 2011, it was noticed that a scheduled runway closure was not displayed. After further analysis, a bug was discovered where if the scheduled time crosses over into the next day, the supervisor display will not schedule it. In this case, the scheduled time was for 13 hours beyond the current time of 13:41, which went into the next day. This error is currently being tracked.

5.1.7 External Interfaces Performance

RAPT

RAPT provides information about flight route blockages due to weather to controllers through the Supervisor display and prompts shown on the FDM. Route blockage information displayed on the TFDM displays were consistent with the data from the RAPT feed 100% of the time, meeting the requirement that RAPT data be consistent with the route data on TFDM 95% of the time. (Success criterion 3.3.4, 4.3.1)

RAPT data logs were unable to be retrieved from the diagnostic log files, and therefore the requirement that the delay between the receipt of RAPT data and its display on TFDM displays was unable to be evaluated. (Success criterion 4.3.2)

ITWS

Centerfield wind data were available on the TIDS ribbon display and could be toggled for display by means of hot keys. Microburst and wind shear data from ITWS were available for DFW-2 and had the capability of being shown textually on the TIDS ribbon display. (Success criteria 4.4.1, 4.4.2, 4.4.3)

No discrepancies between ITWS data and the data shown on TFDM were noted by controllers or observers during DFW-2. Due to time constraints, ITWS data was unable to be analyzed and so success criteria 4.4.4 and the ITWS portion of 3.3.4 were not tested. Similarly, log files were not analyzed in time and success criterion 4.4.5 was not tested.

Other

A number of external data feeds were used to provide information to TFDM. The requirements for these feeds were that no discrepancies exist between the data feed and the corresponding data shown on the TFDM displays, and that the time elapsed between receipt of the data and its display on TFDM was less than one second.

Table 5-6: External data feed success criteria

Data Feed	Success Criteria	Discrepancies	Delay Time
ASDI	4.5.1, 4.5.8	Inconclusive: unable to retrieve log files	Inconclusive: unable to retrieve log files
D-ATIS	4.5.2, 4.5.9	None seen; verified at DFW-2	Average: 0.983 s Max: 1.521
FOC	4.5.3, 4.5.10	Not used in DFW-2	Not used in DFW-2
AODB	4.5.4, 4.5.11	Not used in DFW-2	Not used in DFW-2
NOTAMS	4.5.5, 4.5.12	None seen; verified at DFW-2	Average: 0.206 s Max: 0.578
RVR	4.5.6, 4.5.13	None seen; verified at DFW-2	Average: 0.594 Max: 0.9
Winds data	4.5.7, 4.5.14	Inconclusive: unable to retrieve log files	Inconclusive: unable to retrieve log files

5.2 SUPERVISOR DISPLAY HUMAN FACTORS ANALYSES

To support the goal of determining user acceptability of the Supervisor Display and identifying areas in which design improvements can be made, functionality demonstrations, accompanied by verbal ratings and post-demonstration written questionnaires, were used to assess acceptability and identify areas of improvement. These methods are complementary in the human factors assessment of the Supervisor Display. Questionnaires allow for quantitative assessments of the system by the controllers, unbiased by the field observer. The verbal ratings quantitatively capture the user assessment of the Supervisor Display capabilities within the context of using them.

Table 5-7: SUP Display verbal rating results

Category	Passed	Did Not Pass
Airport Configuration	• Collect Supervisor reasoning behind each airport configuration change that occurred (including other facilities involved in each decision and process followed) • User feedback on DST performance rated 4 or 5 on 5-point scale • User feedback on airport configuration user interface and presentation rated 4 or higher on 5-point scale	• User feedback on clarity, accuracy, and relevance of performance forecasts rated 4 or 5 on 5-point scale
Runway Assignment	• Collect user explanations for departures using runways contrary to the algorithm's recommendation • User feedback on clarity, accuracy and relevance of runway assignments rated 4 or 5 on 5-point scale • User feedback on DST performance rated 4 or 5 on 5-point scale *(Pass from controllers)* • User feedback on runway assignment user interface and presentation rated 4 or higher on a 5-point scale	• User feedback on DST performance rated 4 or 5 on 5-point scale *(Fail from FLMs/TMCs)*
Sequencing & Scheduling	• User feedback is collected on method of display and recommendations for improvement.	• User feedback on departure sequence clarity, accuracy, and relevance over different timeframes (e.g., 1 h, 15 min, 5 min ahead) rated 4 or 5 on 5-point scale • User feedback on utility of spot release rate recommendation is rated 4 or 5 on a 5-point scale • User feedback on DST performance rated 4 or 5 on 5-point scale • User feedback on Sequencing & Scheduling user interface and presentation rated 4 or higher on a 5-point scale
Taxi Routing	• User feedback on taxi routing user interface and presentation rated 4 or higher on a 5-point scale	
Departure Routing		• User feedback on clarity,

		accuracy, and relevance of route availability information rated 4 or 5 on 5-point scale • User feedback on DST performance rated 4 or 5 on 5-point scale • User feedback on departure routing user interface rated 4 or higher on a 5-point scale
Overall Supervisor Display		• User feedback on Supervisor Display rated 4 or higher on 5-point scale

5.2.1 User Feedback on Airport Configuration Forecast Performance

Since forecast performance was heavily related to estimates in wheels off and wheels on times produced by Sequencing & Scheduling, refer to the discussion (below) regarding departure sequence feedback.

5.2.2 User Feedback on Runway Assignment DST Performance

Rated by the controllers as 4.25 out of 5 on the FDM questionnaire, the runway assignment module provided logical runway assignments and passed this criterion. However in the DST questionnaire, FLMs, TMCs and controllers were asked to evaluate whether runway assignment provided logical runways for jet departures, jet arrivals, prop arrivals, and prop departures. The ratings for each of these categories are shown in Figure 5-6. Jet departures, prop arrivals, and prop departures fell somewhere between "Neutral" and "Somewhat agree" responses. Jet arrivals were slightly higher between "Somewhat agree" and "Completely agree." Departure runway assignments were based on simplified runway-to-fix mappings which could be tailored through the TFDM supervisor display. Arrival runway assignment logic was based on a multi-tiered logic involving arrival fix and surveillance data identifying which runway an aircraft was lined up on. These simple rules were appropriate for the vast majority of flights, however more complex criteria are sometimes used by controllers given operational circumstances, for example to better balance departure demand between runways. Several controllers highlighted this operational complexity affecting a minority of flights during the DFW-2 observations and could be the reason for not completely agreeing with the logic of the TFDM runway assignments. (Success criteria 1.2.5, 1.3.12, 1.4.4, 1.5.5)

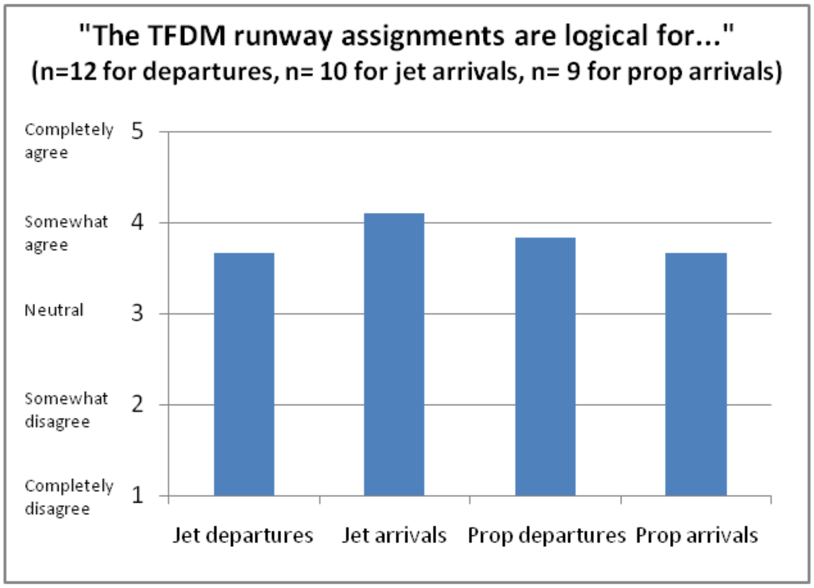


Figure 5-6: Controller feedback on logical runway assignments

5.2.3 User Feedback on Departure Sequence Clarity, Accuracy, and Relevance

FLMs and TMCs were introduced to the sequencing and scheduling timelines on the Supervisor Display, and were then asked to rate the usefulness and accuracy of the information presented. While interested in the information in aggregate (e.g., demand load graphs), the FLMs/TMCs appeared less interested in the flight-specific information presented in the timeline format. This is reflected in the low "usefulness" rating of the wheels-off data in Figure 5-7. It is possible that the usefulness of information presented in this way would be rated higher when coupled with the ability to act on individual flights (e.g., reprioritizing departures which then propagate to GC and LC) or perform other functions (e.g., evaluate whether departure restrictions are being met from the timelines by having the datablocks include departure fix and/or restrictions). Accuracy of the wheels off data was also rated relatively low, likely due to the overall unreliability of the wheels off estimations described in detail in the following sections. (Success criterion 1.3.10)

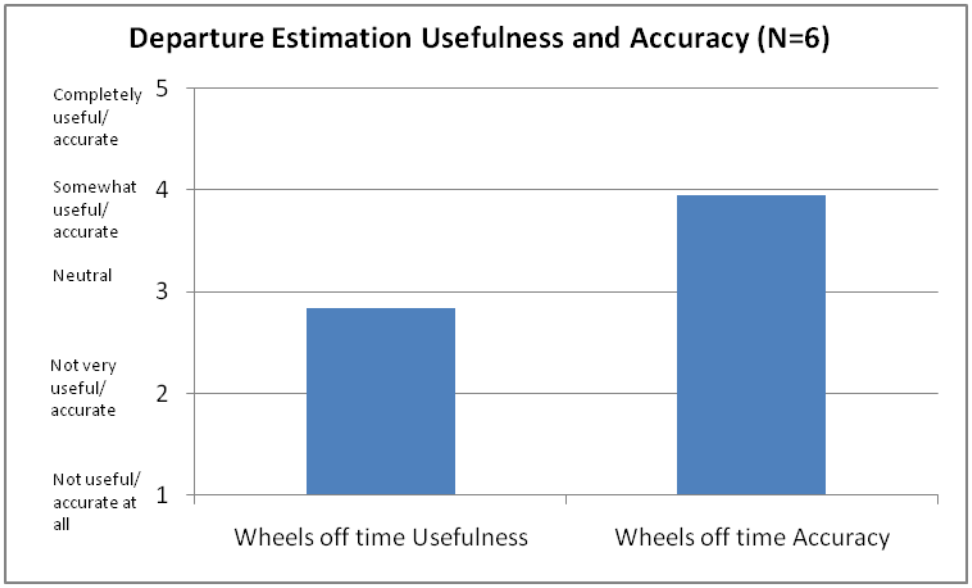


Figure 5-7: Controller feedback on wheels-off time

5.2.4 User Feedback on Spot Release Rate Utility

User feedback on the metering utility was rated 2.57 out of 5 in the post-demonstration DST questionnaire provided to controllers and FLMs/TMCs. During the post-demonstration discussion period, it was determined that some of the participant controllers had a negative impression of metering due to past controlling experience during a metering operation at STL. It was some controllers' opinions that metering starved the departure runway and that the metering does not take into account which aircraft should be released over others (due to active departure restrictions). Others thought that metering should occur in the ramp areas, and not by Tower controllers. During the demonstration period, the algorithmic estimate of traffic demand at DFW only briefly triggered the metering algorithm on one occasion, thus the controllers had minimal experience with the metering capability in action to personally evaluate its effectiveness during operations. In addition, relatively little training on the purposes of metering, the metering algorithm, and procedure for spot holding were given before the shadow operation, which also could have contributed to the negative impression left on controllers. (Success criterion 1.3.11)

5.2.5 User Feedback on Sequencing and Scheduling

FLMs and TMCs were asked in the DST questionnaire to rate the clarity and information sufficiency of the sequencing and scheduling timelines. Figures 5-8 and 5-9 provide the questionnaire results. The average ratings were approaching, but did not achieve, the success criterion of 4. Two reasons existed for the slightly lower ratings from FLMs and TMCs. Several of the users mentioned verbally during the demonstration that they would prefer an aggregate display of expected arrival and departure demand, akin to the Flight Schedule Monitor presentation. They were familiar with the timeline presentation of flight information because DFW uses Traffic Management Advisor; however Tower TMCs and FLMs struggled to find operational use for the current implementation of the timeline format. They did have suggestions to make the flight-specific timelines more useful, including providing information about the departure fix and the applicable restrictions relating to specific flights. By having this information, at a glance the users could identify whether flights were meeting the traffic management restrictions imposed by the TRACON and the users could monitor whether ground control and local control positions were implementing effective sequencing strategies for departures. (Success criterion 2.3.20)

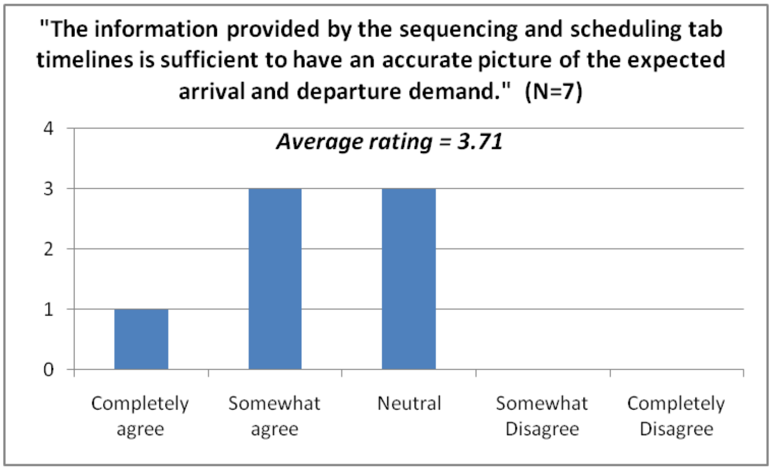


Figure 5-8: FLM/TMC response to sequencing/scheduling information sufficiency

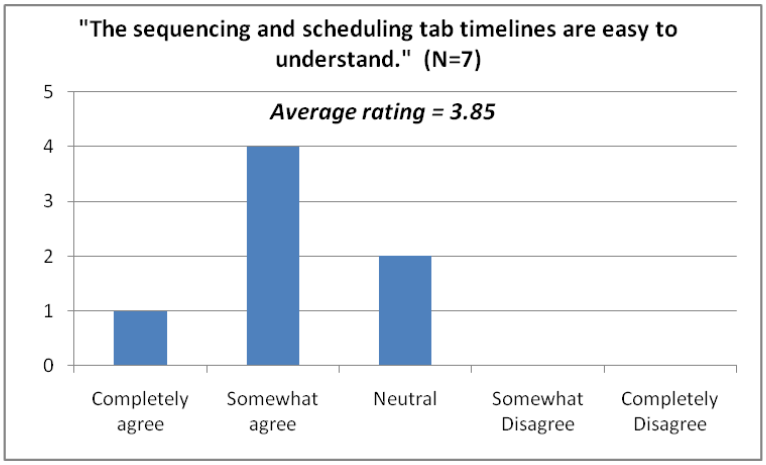


Figure 5-9: FLM/TMC responses to sequencing/scheduling comprehension

5.2.6 User Feedback on Departure Routing

A variety of measures including DST questionnaire and verbal questions during the demonstration were used to assess the above criterion. The graphs in Figure 5-10 illustrate the results. The top two graphs were data from the DST questionnaire. The results indicated that the FLMs, TMCs, and controllers who answered the DST questionnaire appeared to be indifferent to the information provided about departure routing. (Success criterion 1.5.4)

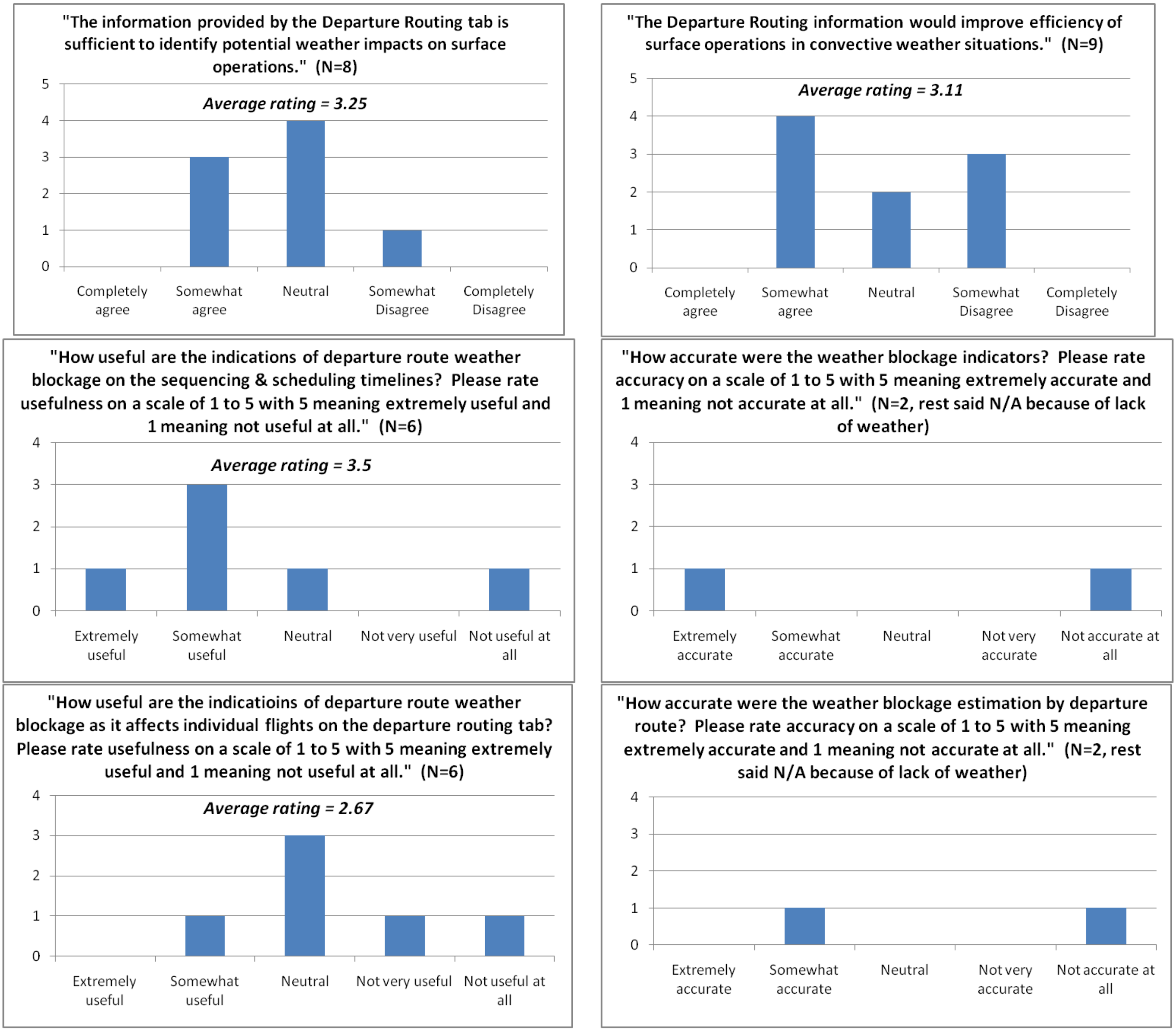
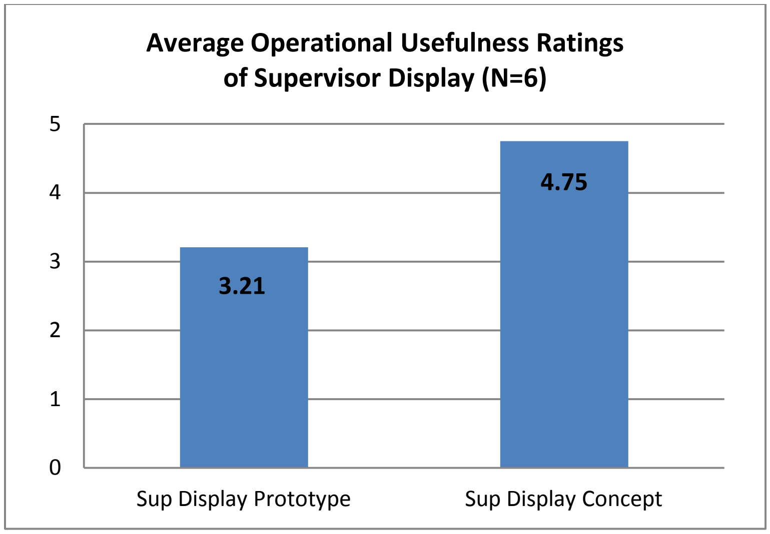


Figure 5-10: Controller responses to weather blockages

In general, the users felt that the departure routing information in the DFW-2 prototype was not sufficient for the DFW operation. This was partially due to the fact that the departure routes presented in the prototype were based on an initial cut from historical data without iteration from the facility to ensure departure route consistency with the operation. Another reason for the ratings is that DFW does not have access to CIWS or RAPT in its current operation and the TFDM departure routing DST builds on these capabilities. There is a significant amount of training and trust-building in weather tools that is required for operational acceptance and effective integration into the operation that would continue to be required in TFDM. (In New York operations, for example, it has taken years of in-situ training to demonstrate during convective weather how the weather tools can provide operational benefit.) In addition, historically, Tower facilities have had little information and therefore procedural control over departure airspace. Introducing departure route information to Towers is only the first step in achieving greater efficiency. Towers also require aid in knowing how and when to use this departure route information to improve the operation. In addition, convective weather was only present for a short period on 4/26 during the entirety of the DFW-2 demonstration. Thus, most of the controllers, TMCs and FLMs did not get a chance to evaluate the departure routing DST in a situation that would have illuminated its capabilities. (Success criterion 2.3.22)

5.2.7 User Feedback on Supervisor Display

FLMs and TMCs were verbally asked to rate both the concept and the prototyped Supervisor Display to get a better understanding of how these users viewed the overall concept for the Supervisor Display as well as how far the prototype fell short of the ideal concept. Initially, FLMs and TMCs were asked, “How useful is the concept of a Supervisor Display to an operationally deployed TFDM system? Please rate usefulness on a scale of 1 to 5 with 5 meaning extremely useful and 1 meaning not useful at all.” The users had a very positive response to the overall concept, with an average response of 4.75 across 6 users. The prototype implementation of the concept rated lower than the concept itself with an average of 3.21 across the 6 users. The types of information that the current prototype was lacking included the ability to view all restrictions affecting particular flights, appropriate departure route information, the ability to combine routes during SWAP, and aggregate demand estimates (similar to that on Flight Schedule Monitor). Other user suggestions for Supervisor Display improvement are itemized in the Supervisor Display section of this document. (Success criterion 2.3.17)



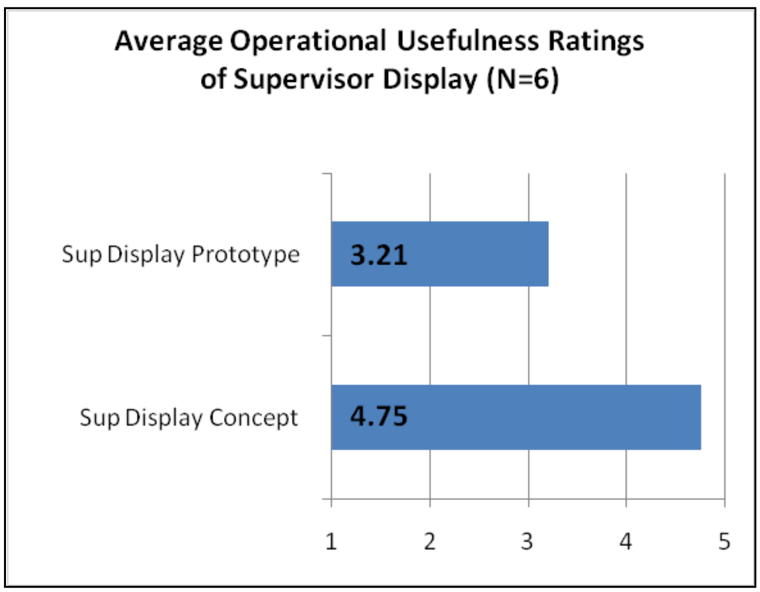


Figure 5-11: FLM/TMC responses to supervisor display utility

5.2.8 Supervisor Display/DST Questionnaire Results

Similar to the TIDS and FDM questionnaires, the Supervisor Display/DST questionnaires were distributed to Ground and Local controllers, and TMC and FLM participants at the end of the shadow operations sessions. Additional questions were posed to the TMC and FLM participants verbally. Table 5-8 summarizes questionnaire results categorized into "Positive" results (scoring an average of 4 or higher on a 5-point scale) and "Needs Improvement" (scoring an average of less than 4 on a 5-point scale). The detailed questionnaire results are provided in Appendix M.

Table 5-8: Supervisor display and DSTs questionnaire results

Category	Positive	Needs Improvement
Supervisor Display Concept	• Supervisor display concept is useful	• Supervisor display functionality useful • Supervisor display user interface easy to use • Supervisor display prototype is useful
Supervisor Display Features	• RVR usefulness • Call for release usability • NOTAMs usefulness • NOTAMs accuracy • Active flights usefulness • Active flights accuracy	• Supervisor Checklist usefulness • Call for release usefulness
Airport Configuration	• Runway open/close usefulness • Runway open/close usability • Runway open/close scheduling usability • Departure fix open/close usability • Airport configuration change usefulness • Airport configuration change usability	• Departure fix open/close usefulness • Effective DST propagation to TIDS/FDM • Information sufficient to recommend a/p config changes • Beneficial for TFDM to recommend a/p configuration and timing • Beneficial to enable a/p config change from sup display to GC & LC FDMs • Beneficial to view a/p config change effect on future demand & delay • Beneficial to graphically view historical airport delay & throughput • Beneficial to graphically view predicted airport delay & throughput
Runway Assignment	• Runway to fix mapping usefulness • Runway to fix mapping usability • Beneficial to recommend optimal runway assignments	• TFDM runway assignments logical for jet departures • TFDM runway assignments logical for prop departures • TFDM runway assignments logical for jet arrivals • TFDM runway assignments logical for prop arrivals • Runway to fix mapping sufficient
Taxi Routing	• Inputting taxi route easy	• Taxi non-conformance prompts improve safety • Beneficial for taxi non-conformance to use standard taxi routes
Sequencing & Scheduling	• MIT/MINIT scheduling usability • Arrival rate setting/scheduling usability	• MIT/MINIT scheduling usefulness • Arrival rate setting/scheduling usefulness • Wheels off estimation usefulness

		• Wheels off estimation accuracy • Wheels on estimation usefulness • Wheels on estimation accuracy • Timelines easy to understand • Timeline information sufficient for understanding expected arrival/departure demand • Timeline information enables reduced delay • Seq & sched timeline information improves ability to schedule airport config. changes to maximize operational efficiency • Metering effective means of maintaining optimal departure queue • Adequate metering information provided • Beneficial for TFDM to recommend optimal departure sequences and spot release times
Departure Routing		• Flight specific indications of departure route blockage usefulness • Flight specific indications of departure route blockage accuracy • Departure route blockage on departure routing tab usefulness • Departure route blockage on departure routing tab accuracy • Departure routing tab information sufficient to identify weather impacts on surface • Departure routing info would improve efficiency of surface operations in convective weather • Beneficial to have means to view which departure routes closed by ZFW in departure routing tab • Desirable to have means to view and allocate available departure slots based on existing traffic management constraints to individual departures

5.2.9 Controller Suggested Modifications to DSTs/Supervisor Display

Controllers provided general suggestions to modify the DSTs/Supervisor Display both on open-ended questions in the questionnaires as well as during the following verbal discussions. Below is a summary of the issues and modification suggestions provided by the controllers. A more detailed view of controller comments can be found in Appendix N.

Table 5-9: SUP/DSTs controller suggested modifications

Issue/Suggestion	Potential TFDM Improvement
Need to confirm scheduled resource changes	• Add Y/N confirmation dialog
Ability to combine routes and fixes (generalizable recommendation to all 4-cornerpost airports)	• Add ability to combine routes, fixes
Ability to SWAP routes	• Add ability for SWAP
Additional information needed on Supervisor display	• Add ability to enter GS, GDP, AFP • Show EDCT status
Need ability to add TMIs to combinations of airports, routes, FCAs	• Add ability to add TMIs to combinations of airports, routes, FCAs
CFR times need validity times	• Add ability to set CFR valid/expiration times on relevant FDEs
Need information on number of flights affected by fix changes	• Provide count of affected flights over 30-60 min period by runway and fix
Off-hat flights should be more visible (DFW-specific recommendation)	• Off-hat assignments should automatically be highlighted red in FDEs
Automatic updates to checklist to reflect current configuration	• Checklists populated automatically with relevant info for current configuration
RVR information should be segregated by flow and side	• Separate RVR information by flow direction and east/west side
Timelines are unreliable	• Improve timeline reliability • Improve wheels on/off time accuracy
Too many departure fixes shown in departure routes	• Restrict routes to 16 departure fixes, not downstream routes
Include information for departure fix, TMIs in active flight list	• Add columns for departure fix, TMIs to active flight list
Include more information for departing flights	• Add wheels-off times to active flight list • Show E-times when appropriate in active flight list

Include information on canceled flights	• Show canceled flights
Improved search ability in active flight list	• Add ability to search by multiple criteria
Provide summary screen	• Add summary screen similar to IDS
Need better logic to deal with runway closures and configuration changes	• Improve runway assignment logic to account for runway closures and config changes
Ability to access delay statistics	• Track and display delay statistics
Ability to close fixes, set arrival rates, and schedule TMIs/MINITs is unrealistic for DFW (DFW-specific recommendation)	• Remove abilities to close fixes, set arrival rates, schedule TMI/MINIT

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6. SCENARIOS AND AWARENESS PROBES

As part of the human factors evaluation, specific scenarios and awareness probes were conducted with each set of controllers to help determine the usefulness of the TFDM system for identifying aircraft and off-nominal but not uncommon situations.

Test observers watched controller activities during the scenarios to gather subjective data on controller workload and situational awareness. The observers gathered data by issuing awareness probes, where controllers were asked to locate a specific aircraft, and noting the timing of controllers' shadow clearances compared to the East Tower controllers' clearances. Controllers were also asked to comment on scenarios and display components with respect to workload. Controller comments can be found in Appendix O.

6.1 AWARENESS PROBES

Each controller was exposed to a number of awareness probes at each position through the course of the day. These probes tested the controller's ability to locate an aircraft in a specific spot on the airfield. The time taken to locate the aircraft was recorded; along with the tools the controller reported using to help find the target.

Not all awareness probes were issued to each controller. A summary of the probes issued and the average response time for each probe type is given in Table 6-1.

Table 6-1: DFW-2 controller awareness probes response times

	GC		LC	
Awareness Probe	**Count**	**Avg (s)**	**Count**	**Avg (s)**
Non-standard departure assignment	0	N/A	0	N/A
Aircraft at spot	6	5.1	N/A	N/A
Departure runway assignment	5	3.6	3	7.4
Departure fix	3	5.8	6	4.9
Taxi route deviation	0	N/A	N/A	N/A
Incorrect beacon code	2	5.8	2	9.2
Aircraft on final	N/A	N/A	6	6.3
All probes	**17**	**5.5**	**21**	**5.9**

Controller response time averaged 5.9 seconds for all awareness probes, with a standard deviation of 4.1 seconds. Overall, controllers responded more quickly to ground control probes (5.5 seconds) than to local control probes (6.3 seconds).

Controllers also provided information on their primary means of information when responding to the awareness probes. Local controllers were more likely to use more than one tool to determine the answer to the question, and also made use of non-TFDM tools more frequently. Table 6-2 summarizes the tool usage for the awareness probes. Within the table body, shaded cells indicate local control responses, while non-shaded cells indicate ground control responses.

Table 6-2: Tools used to identify awareness probe situations

Awareness Probe	Position	Tools Used				
		TIDS	FDM	Cameras	RACD/DBRITE	Other
Aircraft at spot	GC	3	2	1	0	1
Departure runway assignment	LC	1	2	0	0	0
	GC	1	4	0	0	0
Departure fix	LC	1	6	0	0	1
	GC	0	3	0	0	0
Beacon code	LC	0	2	0	0	0
	GC	0	2	0	0	0
Aircraft on final	LC	4	0	1	4	2
GC totals/percent		4/24%	11/65%	1/6%	0/0%	1/6%
LC totals/percent		6/25%	10/42%	1/4%	4/17%	3/13%

Not surprisingly, controllers utilized the FDM most often when asked about flight data (runway/fix assignment, beacon code) and the TIDS more when asked about aircraft position. Also notable was that controllers used existing long-range displays (RACD/DBRITE) when they were asked to find targets on final, indicating that this information is a good candidate for integration into the surveillance information received by TFDM.

6.2 SCENARIOS

Four scenarios were evaluated during DFW-2: aircraft monitoring, which included an aircraft flyby and monitoring of target arrivals and departures, a flight plan change, beacon code changes, and a taxi route deviation. These scenarios were selected to evaluate controller responses to typical off-nominal situations that could be seen during a controller's shift. Each day, all scenarios were performed in variable sequences to assess controller performance and response to the situations. These scenarios and the locations at which they occurred are shown on the map in Figure 6-1.

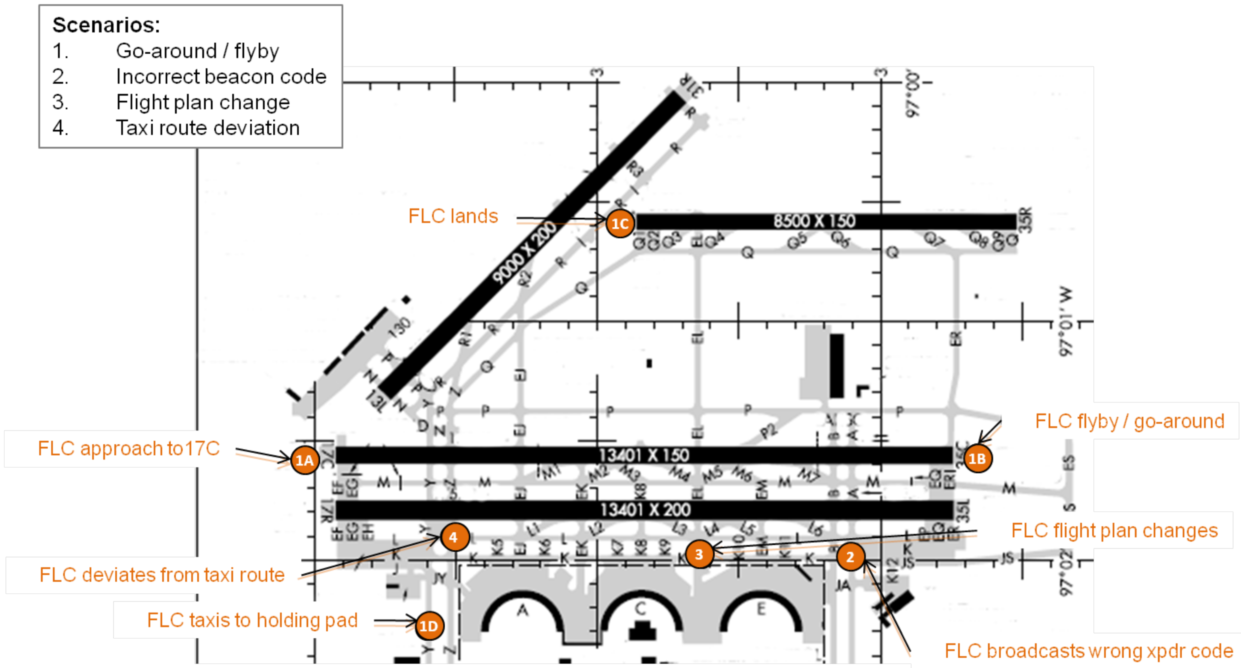

Figure 6-1: Flight test scenarios map

Controllers were observed during the scenarios to determine how long it took them to identify each of the situations. However, the results of this were inconclusive, as it was difficult for observers to specifically pinpoint the time at which each situation started. Additionally, controllers did not always report seeing abnormal situations, despite being asked to do so.

Controllers had mixed feelings as to the ease of identifying the flight test scenarios. Figure 6-2 shows the distribution of controllers' ratings on the simplicity of identifying each flight test scenario.

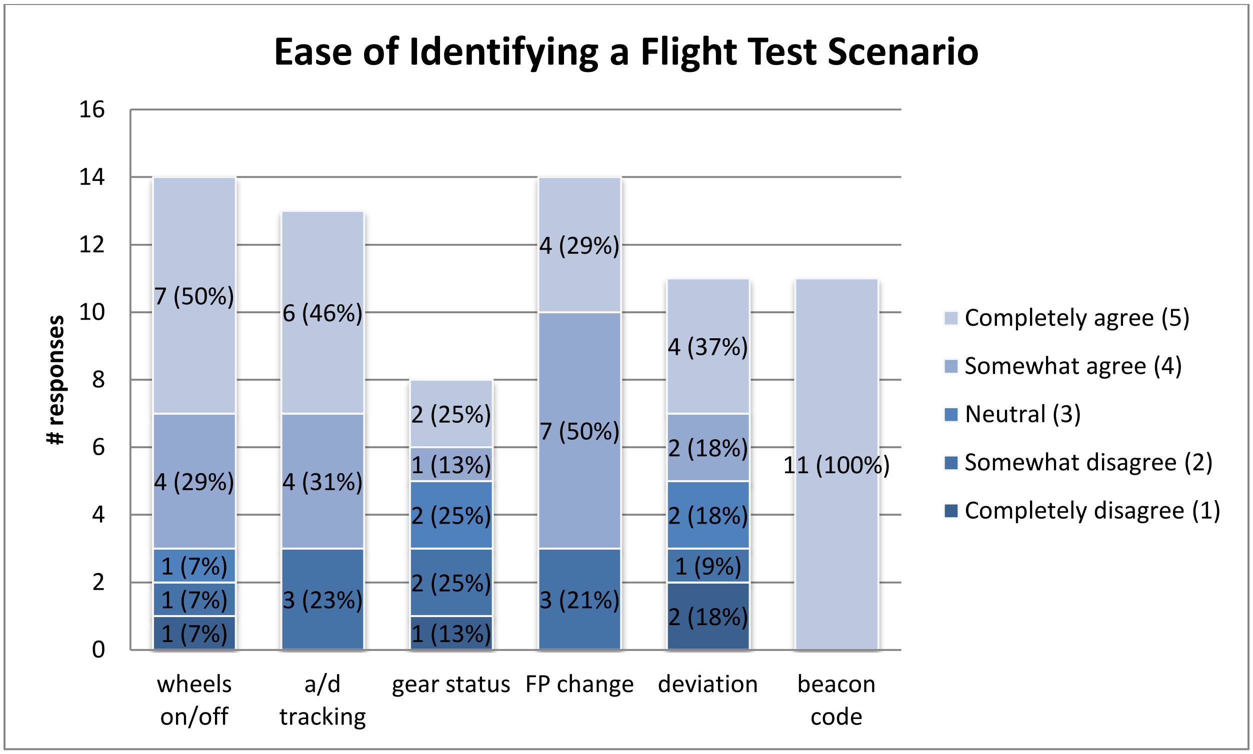

Figure 6-2: Ease of flight test scenario identification

6.2.1 Resource Utility

As in the awareness probes, controllers found the TIDS to be most useful in identifying aircraft position situations and the FDM to be more useful in identifying incorrect flight data. A notable exception to this was the preference of TIDS over the FDM when identifying an incorrect beacon code. Table 6-3 summarizes the percentage of respondents who agreed or completely agreed that a display was useful in identifying each situation.

Table 6-3: Perceived resource utility for flight test scenarios

	Monitoring Arrivals/ Departures				Flyby (%, n)		Flight Plan Change (%, n)		Taxi Route Deviation (%, n)		Incorrect Beacon Code (%, n)	
	Aircraft State (%, n)		Aircraft Tracking (%, n)									
TIDS	78.6	14	85.7	14	63.6	11	75	12	83.3	12	100	12
FDM	27.3	11	--		--	--	71.4	14	33.3	9	60	10
Scanning camera	50	12	35.7	14	66.7	12	--	--	30	10	--	--
OTW	100	14	100	14	100	11	--	--	81.8	11	--	--

When asked which display they preferred for monitoring arrivals and departures, controllers overwhelmingly stated that they preferred the TIDS. However, they did indicate a number of misgivings and problems with the display, including a lack of trust in the display when crossing aircraft and problems with the intuitiveness of watching a display to determine whether an aircraft is airborne. Two controllers indicated that they did not care for TIDS when monitoring arriving aircraft, though one of these two stated that the TIDS would be more useful for monitoring departures.

Controllers were more balanced in their responses to the display preferred for identifying a flyby, with four controllers each preferring TIDS and the camera displays, versus two who preferred the FDM and two who preferred the OTW view. Table 6-3 shows that the TIDS had a slight edge over the FDM in recognizing flight plan changes, while the TIDS was preferred for taxi deviation recognition. However, controllers' freeform responses as to which display component provided the most useful information in helping to recognize the flight plan change overwhelmingly favored the FDM, with nine of 13 controllers selecting it as the most useful display in this situation.

The controllers' indicated preference for TIDS in identifying an incorrect beacon code might have been an artifact of target "caterpillaring," where a target with an incorrect code appeared as a series of icons instead of a single target. This issue is further discussed in Section 3.1.11. However, the caterpillaring targets are not necessarily responsible for this preference, and this result may warrant further investigation.

Controllers also provided some suggestions to improve scenario monitoring using TFDM. Most suggestions were related to improving the visibility of information on the displays. These suggestions included flashing or other eye-catching methods, color changes and highlighting, and improved alerts and notifications.

6.2.2 Information Appropriateness

Of the TFDM displays, controllers found the TIDS to provide the most appropriate information for identifying and acting on the flight test scenarios. When the OTW view was available and useful, they found it to provide the most appropriate information; whether this is because of familiarity is unclear. Table 6-4 provides the percentage of controllers who agreed (rated 4 or 5) that a display provided appropriate information to identify and act on a flight test scenario.

Table 6-4: Percent of controllers who agreed displayed information was appropriate

	Monitoring Arrivals/Departures (%, n)		Flyby (%, n)		Flight Plan Change (%, n)		Taxi Route Deviation (%, n)		Incorrect Beacon Code (%, n)	
TIDS	92.9	14	72.7	11	76.9	13	81.8	11	91.7	12
FDM	66.7	12	37.5	8	71.4	14	30	10	63.6	11
Scanning camera	38.5	13	54.5	11	--	--	18.2	11	--	--
OTW	100	14	100	11	--	--	83.3	12	--	--

Controllers indicated that some additional information would be useful in helping to identify the scenario situations. For the flyby situation, glideslope information and aircraft attitude were cited; for flight plan change recognition, controllers noted that knowledge of discrepancies between route and hat status would be useful, as would notification that a flight plan is about to time out.

Although no definite quantitative conclusions could be made from the scenarios evaluation, suggestions and ideas were collected from the controllers and will be taken into consideration for inclusion in future TFDM and SNT work.

7. SUMMARY AND CONCLUSIONS

The DFW-2 field demonstration was a proof of concept for an intermediate version of the TFDM prototype. This demonstration evaluated the performance and acceptance of a prototype TFDM that included the TIDS, FDM, and Supervisor Display human-machine interfaces as well as basic decision support tools. This field demonstration involved professional air traffic controllers observing live traffic during shadow operations to assess the functionality and usability of the TFDM prototype.

The TIDS technical performance during DFW-2 was satisfactory, with 42 items passing the success criteria. All categories aside from the Target Broker had passing criteria, and many of these categories had no failures. The wake turbulence timer had two criteria that did not pass and the ASDE-X category had three. The Target Broker and the Surveillance Processor categories each had one criterion that did not pass. Overall, 69% of the TIDS technical performance success criteria passed. Fifteen percent did not, and 16% were unable to be tested.

The FDM technical performance during DFW-2 was satisfactory, with 22 items passing the success criteria. The primary technical issue with the FDM was the rare loss of FDEs during transfer of control. There was also the issue with the Target Broker that prevented 100% match between targets and flight data. Overall, 83% of the technical performance criteria passed with 8% (2 criteria) unable to be tested.

The prototype DSTs & Supervisor Display technical performance was also satisfactory, with 40 items passing the success criteria. Estimation of sufficiently accurate wheels off departure time resulted in a majority of the success criteria failures. A single misallocation of a seldom-used departure procedure to a fix resulted in a failure of a runway assignment criterion as well. Overall, 70% of the Supervisor Display/DST technical performance criteria were met, and 16% (9 criteria) were unable to be tested.

Human factors data from observations, questionnaire ratings, and controller comments indicated that the TIDS is likely to be accepted as operationally suitable and useful for the air traffic control tower. However, technical results revealed issues that will need to be resolved, along with the code being made production level. Controller comments about the TIDS were mostly positive.

The human factors data collected for the FDM also rated highly, and most of the functionality on the FDM was considered highly usable and useful. Overall the FDM was considered beneficial to the Tower, and features requiring improvement included FDE creation and the ground metering DST on the FDM. Despite the consistently positive usability and usefulness ratings, when compared directly to paper flight progress strips, the FDM received mixed reviews, indicating some resistance in the transition to electronic flight information.

While the prototype Supervisor Display and DSTs met most of the technical performance criteria, fewer than half of the success criteria were met regarding acceptability. A majority of the success criteria for airport configuration, runway assignment, and taxi routing DSTs were met, however few of the success criteria for sequencing & scheduling and departure routing DSTs were met. Further iterations on the concept of operations, functionality, and information presentation were suggested for each of the DSTs and the Supervisor Display by the FLMs, TMCs, and controllers.

Validation of the TFDM operational concept was supported by a thorough analysis of data collected during the DFW-2 demonstration. Many performance issues were identified, for the TIDS and FDM software and the DST technology, leading to refinement in the functional and performance requirements for TFDM. Technical, operational, and cultural challenges all must be addressed and resolved before TFDM is realized for the provision of next generation tower air traffic control services.

In conclusion, DFW-2 testing has indicated that controllers are receptive to the use of the next generation of air traffic control tools, especially the TIDS and FDM, for tower operations. The results from this demonstration indicated that some of the functional capability exhibited at the DFW-2 demonstration could provide definitive enhancements to Tower operations, and user feedback will be reflected in written requirements for a production level system. Further consideration of the DSTs and Supervisor Display is required (and had been planned) beyond this first iteration of the prototype to achieve the operational benefits desired. This demonstration has highlighted many issues, both technical and human factors, which need to be addressed prior to fielding TFDM in operational towers. As these issues are addressed and the technology improves, further development and evaluation of future iterations of the TFDM prototype is recommended.

APPENDIX A
DFW-2 SUCCESS CRITERIA

Appendix A provides a listing of all success criteria for DFW-2 and their status. Items in *italics* were not included in DFW-2 (N/A) or were unable to be tested in DFW-2 (Inconclusive). Items in **bold** did not meet their success criteria during DFW-2.

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
1	**DSTs**						
1.1	**Airport Configuration**	Airport configuration options shown on displays	pPRD 3.3.1.8, 3.4.4.4	Show current configuration consistently across TIDS, FDM, Supervisor displays	1.1.1	Displayed configuration is the same on all TFDM displays.	Pass: Configuration on the displays was 100% consistent with one another during the shadow operation.
					1.1.2	Configuration shown on displays represents configuration currently in use.	Pass: Configuration on the displays was 100% consistent with the operational configuration during the shadow operation.
				Show status of runways accurately to controller, supervisor or traffic management coordinator on TIDS, Supervisor displays	1.1.3	Runway status is consistent on TIDS and supervisor displays.	Pass: Runway statuses were displayed consistently across displays 100% of the time.
					1.1.4	Runway status shown on displays reflects current status of runways.	Pass: Runway statuses on the TFDM displays accurately reflected the runways in

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
							operational use.
				Show unavailable airport configurations accurately	1.1.5	Unavailable runways shown on displays reflect current status of runways.	Pass: Runway statuses on the TFDM displays accurately reflected the runways operationally closed.
				Show status of departure fixes on Supervisor display (closures & MIT)	1.1.6	Departure fix status is shown on Supervisor display.	Pass: Verified at DFW-2
					1.1.7	*Departure fix status indicates MIT restrictions and fix closures.*	*Inconclusive: Truth data did not capture departure fix closures/ restrictions for comparison.*
					1.1.8	*Departure fix status on display reflects current status of departure fixes.*	*Inconclusive: Truth data did not capture departure fix closures/restrictions for comparison.*
		AC03: Provide queuing/congestion analysis for permissible airport configs.	STBO AC03	Predict and display expected number in departure queue	**1.1.9**	**Predict and display expected number in departure queue at least 30 min into future with 80% accuracy, when comparing predicted departure queue with the departure queue that actually transpires**	**Fail: Only 80% of flights had error <2min when 2 min from wheels off.**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
				Predict and display expected number of departures and arrivals at least 30 min into future	1.1.10	Predict and display expected number of departures and arrivals at least 30 min into future in Sequencing & scheduling tab of Supervisor Display	Pass: Flight demand was always visually displayed 30 min into the future.
				User feedback on clarity, accuracy, and relevance of performance forecasts rated 4 or 5 on 5-point scale	**1.1.11**	**Average user feedback rates at least 4.**	**Fail: Performance forecasts rated under 4**
		Acceptability	MIT/LL	Collect supervisor reasoning behind each airport configuration change that occurred (including other facilities involved in each decision and process followed)	1.1.12	Feedback collected that aids improvement of design.	Pass: Feedback collected.
				User feedback on DST performance rated 4 or 5 on 5-point scale	1.1.15	Average user feedback rates at least 4.	Pass: Usefulness of airport configuration: 4.16/5; Usability of airport configuration: 4.67/5
		Logging	MIT/LL	Record scheduled airport configuration changes	1.1.13	100% airport configuration changes logged	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
				Record runway closures and openings	1.1.14	100% runway closures & openings logged.	Pass: Verified at DFW-2
1.2	**Runway Assignment**	RN01: Assign departure runway based on pre-defined rules	STBO RN01	Show recommended runway assignments for departures on FDM display based on DST logic and runway-to-fix mapping	1.1.16	Observe runway assignments on FDEs consistent with DST logic and runway to fix mapping.	Pass: Runway assignments were 100% consistent with the DST logic. One departure procedure JACKY4 was mapped incorrectly to a runway.
				Automatic runway assignment is consistent with what runway the departure actually uses	**1.2.1**	**Automatic runway assignment in queue is consistent 98% of the time with what runway the departure actually uses (moderating the result for variables known at the prediction time, e.g., off-hat, departure fix)**	**Fail: 83% of flights were consistent with runway assignment.**
				Automatic runway assignment is consistent with what runway the departure actually uses	**1.2.2**	**Automatic runway assignment at the spot is consistent 85% of the time with what runway the departure actually uses (moderating the result for variables known at the prediction time, e.g., off-hat, departure fix)**	**Fail: 83% of flights were consistent with runway assignment.**
				Collect user explanations for departures using runways contrary to the algorithm's recommendation	1.2.3	Feedback collected that aids improvement of design.	Pass: Feedback collected.
		Acceptability	MIT/LL	User feedback on clarity, accuracy, and relevance of runway assignments rated 4 or 5 on 5-point scale	1.2.4	Average user feedback rates at least 4.	Pass: Timesharing of the departure fix and assigned runway in the data block was useful =4.57/5,

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
							24.57,*(p=.001)*
				User feedback on DST performance rated 4 or 5 on 5-point scale	**1.2.5**	**Average user feedback rates at least 4.**	Pass (from controllers): User feedback on Runway Assignment DST performance = 4.25/5 **Fail (from FLMs/TMCs): User feedback on Runway Assignment DST performance = 3.68/5**
1.3	**Sequencing and Scheduling**	SS01: Generate a predicted runway sequence for all active runways for strategic use by the TMU or supervisor.	STBO SS01	Display predicted departure sequence for each runway	1.2.6	Predicted departure sequence for each runway is shown in Sequencing & Scheduling tab.	Pass: Verified at DFW-2
				Display estimated departure clearance times and approval required times on FDM	1.3.1	EDCTs for affected flights are displayed in the EDCT field on the FDE.	Pass: Verified at DFW-2
					1.3.2	Approved release times can be entered into the remarks field of the FDE.	Pass: Verified at DFW-2
		SS03: Display TFM constrained	STBO SS03	Display estimated wheels on time and estimated wheels off times	1.3.3	Display estimated wheels on and off times on runway timelines on Supervisor Display.	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
		times to tower controller, including if a constraint may not be/has not been met			**1.3.4**	**Display estimated wheels on time within 1 min 98% of the time and estimated wheels off times within 2 min 98% of the time on Supervisor displays within 2 min of the flight becoming airborne or the flight landing**	**Fail:** **Only 80% of flights had error <2min when 2 min from wheels off.** **Only 63% of flights had error <1min when 2 min from wheels on.**
					1.3.5	**Display estimated wheels on time within 1 min 85% of the time and estimated wheels off times within 2 min 85% of the time on Supervisor displays within 15 min of the flight becoming airborne or the flight landing**	**Fail:** **Only 15% of flights had error <2min when 15 min from wheels off.** **0% of flights had error <1 min when 15 min from wheels on.**
		SS17: Manage departure queue length through allocation by FO of aircrafts allowed entry to AMA SS05: Provide estimations	STBO SS17, SS05	Display suggested spot release rate on FDM.	1.3.6	Metering recommendation is displayed on GC FDM when estimated departure queue exceeds 6 flights. Collect actual push-rate and queue size data to allow post-processing analysis of accuracy of recommended spot release rate and potential impacts on queue size for further refinement of concept.	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
		for flight-specific event times to meet the planned surface schedule					
		SS13: Provide predicted and actual surface schedule non-compliance information	STBO SS13	Provide accurate notification for when flights have missed release time	*1.3.7*	*Provide accurate notification for when flights have missed release time with less than 5% false alarm rate*	*N/A: Did not compare EDCT with estimated taxi times for DFW-2.*
		Logging		Record taxi times from spot to runway queue for each departure	1.3.8	100% taxi times logged	Pass: 100% taxi times logged.
				Record time spent in runway queue for each departure	1.3.9	100% logging of time spent in runway queue	Pass: Time spent in runway queue could be inferred from ASDE-X data.
		Acceptability	MIT/LL	User feedback on departure sequence clarity, accuracy, and relevance over different timeframes (e.g., 1h, 15 min, 5 min ahead) rated 4 or 5 on 5-point scale	**1.3.10**	**Average user feedback rates at least 4.**	**Fail:** **Wheels off usefulness: 2.83/5** **Wheels off accuracy: 3.95/5**
				User feedback on utility of spot release rate recommendation is rated 4 or	**1.3.11**	**Average user feedback rates at least 4.**	**Fail: User feedback on metering utility:**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
				5 on a 5-point scale.			**2.57/5**
				User feedback on DST performance rated 4 or 5 on 5-point scale	**1.3.12**	**Average user feedback rates at least 4.**	**Fail: User feedback on Sequencing & Scheduling DST performance = 3.88/5**
				User feedback is collected on method of display and recommendations for improvement.	1.3.13	Feedback collected that aids improvement of design.	Pass: Feedback collected.
1.4	**Taxi Routing**	TX01: Provide for manual assignment of pre-defined taxi routes by tower personnel	STBO TX01	Accurately display assigned taxi route on FDM (textual) displays	1.3.14	Manually entered taxi route is shown, as entered, in the flight's Full Flight Edit window on the FDM.	Pass: Verified at DFW-2
		TX11: Monitor conformance to 2D routes and provide alerts	STBO TX11	Notifications for taxi route deviations	*1.4.1*	*Notifications for taxi route deviations with false alarm rate of less than 5% of the time when the taxi route is manually entered.*	*N/A: Taxi conformance monitoring not included in DFW-2*
					1.4.2	*Notifications for taxi route deviations are never generated when the taxi route is not manually entered.*	*N/A: Taxi conformance monitoring not included in DFW-2*

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
		Logging	MIT/LL	Record discrepancies between taxi routes assigned and followed by each departure	*1.4.3*	*Taxi route deviations are logged 95% of the time when the taxi route is manually entered.*	*N/A: Taxi conformance monitoring not included in DFW-2*
		Acceptability	MIT/LL	User feedback on DST performance rated 4 or 5 on 5-point scale	*1.4.4*	*Average user feedback rates at least 4.*	*N/A: Taxi conformance monitoring not included in DFW-2*
1.5	**Departure Routing**	DR01: Flight-specific impact assessment and indication of weather or traffic flow constraints for filed departure route	STBO DR01	RAPT route blockage color is associated with each flight on Sequencing & Scheduling tab	1.4.5	RAPT color block is displayed next to ACID of each flight on Supervisor Display Sequencing & Scheduling runway timeline.	Pass: During the one time weather occurred during the demo, appropriate color blocks were present.
				Timelines of wheels-off times of individual flights associated with each RAPT departure route are shown in the DR tab	1.5.1	Timelines of wheels-off times overlaid on RAPT departure routes displayed on DR tab of Supervisor Display	Pass: Verified at DFW-2
				Upon flight departing, flight is removed from all lists and timelines on DR tab	1.5.2	No departed flights are shown on lists/timelines on DR tab.	Pass: The ability to view or not view departed flights on the DR tab was made a controller preference. If they chose not to view the departed flights, they would not have to.
		DR03: Evaluate pre-coordinated routes for acceptability relative to	STBO DR03	Display constraints from destination airport that impact each departure (see list in AC)	1.5.3	View MIT restrictions manually inputted for an airport.	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
		weather and traffic flow constraints					
		Acceptability	MIT/LL	User feedback on clarity, accuracy, and relevance of route availability information rated 4 or 5 on 5-point scale	**1.5.4**	**Average user feedback rates at least 4.**	**Fail:** **Dep. Routing info sufficiency: 3.25/5** **Usefulness of RAPT colors on S&S timelines: 3.5/5** **Accuracy of RAPT colors on S&S timelines: 3/5** **Usefulness of DR tab:** **2.67/5** **Accuracy of DR tab: 2.5/5**
				User feedback on DST performance rated 4 or 5 on 5-point scale	**1.5.5**	**Average user feedback rates at least 4.**	**Fail: Dep. Routing info sufficiency: 3.25/5; Usefulness of RAPT colors on S&S timelines: 3.5/5; Accuracy of RAPT colors on S&S timelines: 3/5; Usefulness of DR tab: 2.67/5; Accuracy of DR tab: 2.5/5**
2	**Displays**						
2.1	**TIDS**						

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
	Surveillance object	Technical performance	pPRD 3.1.1, 3.2.2, 3.4.2; TPS 6210, 6213	Displayed icons match actual aircraft weight class/type	2.1.1	Icon types shown on TIDS match aircraft type, weight class provided by ASDE-X data.	Pass: Verified at DFW-2
					2.1.2	Icon types shown on TIDS match aircraft type, weight class seen OTW.	Pass: Verified at DFW-2
		Technical performance	pPRD 3.1.1, 3.2.2, 3.4.2	No missing targets	**2.1.3**	**All targets seen OTW have icons on TIDS.**	**Fail: three instances of a missing target were reported**
					2.1.4	**All targets provided by ASDE-X have icons on TIDS.**	**Fail: three instances of a missing target were reported**
	Datablocks	Technical performance	pPRD 3.1.1; TPS 6214, 6217, 6892, 6893, 6894, 6895	All targets have an associated data block with correct data elements (e.g., ground/airborne, fix/runway, type, speed, altitude)	2.1.5	All icons on TIDS have a datablock that can be selected for display.	Pass: Verified at DFW-2
					2.1.6	Content of each datablock matches the OTW information observed for each target.	Pass: Verified at DFW-2
					2.1.7	Content of each datablock matches the information received from ASDE-X, FDIO, and TFDM for each target.	Pass: Verified at DFW-2 when datablocks available
	Airport adaptation	Technical performance	TPS 6161, 6171	No anomalies identified between TIDS representation and actual airport layout	2.1.8	Depiction of airport adaptation is consistent with what's seen OTW.	Pass: Verified at DFW-2
	User interaction	Taxiway status	TPS 6364	Users are able to open and close individual taxiway segments	*2.1.9*	*Taxiway segments can be opened independently of adjacent segments.*	*N/A: Not tested at DFW-2*
					2.1.10	*Taxiway segments can be closed independently of adjacent segments.*	*N/A: Not tested at DFW-2*
		User settings	TPS 6284,	Users are able to create and save personalized preference	2.1.11	Users can select a customized preference set.	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
			6287, 6011, 6012, 6016	sets	2.1.12	Users can create a customized preference set based on their preferred display settings.	Pass: Verified at DFW-2
					2.1.13	Users can save a customized preference set.	Pass: Verified at DFW-2
			TPS 6014	Users are able to select from defined profile types	2.1.14	Users can select a user profile based on runway configuration and control position.	Pass: Verified at DFW-2
	Winds	Advisory tools	TPS 6205, 631, 6302; User group	Wind information is displayed in a text box on the TIDS.	2.1.15	A wind PiP is displayed on the TIDS.	Pass: Verified at DFW-2
					2.1.16	The wind PiP contains data for wind speed and direction for each runway threshold.	Pass: Verified at DFW-2
					2.1.17	The wind data is received from the external weather data interfaces.	Pass: Verified at DFW-2
	Runway closures	Advisory tools	User group	Closed runways are displayed with red outline and Xes on ends	2.1.18	Closed runways are outlined in red.	Pass: Verified at DFW-2
					2.1.19	Closed runways have a red X displayed on each threshold.	Pass: Verified at DFW-2
	Hold bars	Advisory tools	TPS 6184, 6275; User group	Runway hold bars displayed as on ASDE-X	*2.1.20*	*Runway hold bars on TIDS are displayed within 1 s of when runway hold bars on ASDE-X are shown.*	*Inconclusive: ASDE-X hold bar data unavailable*
				Threshold hold bars are displayed on TIDS	2.1.21	Threshold hold bars are shown on TIDS	Pass: Verified at DFW-2
	Wake turbulence timers	Advisory tools	User group	Wake turbulence timers displayed when aircraft begins takeoff roll	**2.1.22**	**Wake turbulence timers are displayed within 1 s of when aircraft begins takeoff roll.**	**Fail: Average time to display 14 s; Max time to display 26 s**
			User group	Wake turbulence timers displayed for all required aircraft.	2.1.23	All B757s and heavy aircraft trigger the display of the wake turbulence timer.	Pass: Verified at DFW-2 once process added to configuration manager

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
	Filtering	Technical performance	User group	Overflights do not appear on display	2.1.24	Aircraft overflying the airport at or above 500' AGL are absent from the TIDS.	Pass: Verified at DFW-2 when filters set correctly.
		Technical performance	TPS 6288; User group	Flights filtered by active filter parameters do not appear on display	2.1.25	Aircraft that meet user-defined filtering criteria are absent from the TIDS.	Pass: Verified at DFW-2
	Airport Configuration	TX10: Manage and display real time state of runways & taxiways	pPRD 3.3.1.8, 3.4.4.4	Show current configuration consistently across TFDM displays	2.1.26	Displayed configuration is the same on all TFDM displays.	Pass: Configuration on the displays was 100% consistent with one another during the shadow operation.
					2.1.27	Configuration shown on displays represents configuration currently in use.	Pass: Configuration on the displays was 100% consistent with the operational configuration during the shadow operation.
			pPRD 3.3.1.8, 3.4.4.4	Show status of runways accurately on TIDS and Supervisor displays	2.1.28	Runway status is consistent on TIDS and Supervisor displays.	Pass: Runway statuses were displayed consistently across displays 100% of the time.
					2.1.29	Runway status shown on displays reflects current status of runways.	Pass: Runway statuses on the TFDM displays accurately reflected the runways in operational use.
			pPRD 3.3.1.8.	Change runway status on TIDS and Supervisor	2.1.30	User is able to change runway status on TIDS.	Pass: Users were able to open/close

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
			1	displays			runways using the Sup Display.
	Filtering	Acceptability	MIT/LL	User feedback on filtering rated 4 or higher on 5-point scale	**2.1.31**	**Average user feedback rates at least 4.**	**Fail: Overflight and traffic filters were useful = 3.6/5 *(p=.092)***
	User interaction	Acceptability	MIT/LL	User feedback on user interaction rated 4 or higher on 5-point scale	2.1.32	Average user feedback rates at least 4.	Pass: TIDS user interface was easy to use = 4.43/5 *(p=.001)*
	Hold bars	Acceptability	MIT/LL	User feedback on runway and threshold hold bars rated 4 or higher on 5-point scale	2.1.33	Average user feedback rates at least 4.	Pass: Runway hold bars were useful = 4.42/5 *(p=.008)*
	Wake turbulence timers	Acceptability	MIT/LL	User feedback on wake turbulence timer accuracy rated 4 or higher on 5-point scale	**2.1.34**	**Average user feedback rates at least 4.**	**Fail: Wake turbulence timer was useful = 3.91/5 *(p=.151)***
	Overall TIDS	Acceptability	MIT/LL	Subjective ratings of TIDS rated 4 or higher on 5-point scale	2.1.35	Average user feedback rates at least 4.	Pass: Majority of TIDS responses were over 4/5
	Weather	Acceptability	MIT/LL	User feedback on the weather display is rated 4 or higher on 5-pt scale.	2.1.36	Average user feedback rates at least 4.	Pass: Wind information presentation is acceptable, 4.17/5*(p=.011)*
2.2	**FDM**						
	Data sorting and transfer	Technical performance	TPS 6417	No FDEs lost between positions	**2.2.1**	**100% FDE transfers logged between GC-LC, LC-GC, GC-FD, FD-GC, LC-FD, FD-LC**	**Fail: FDE transfer success from each FDM station is as follows:** **LC: 100%** **GC: 99.78%**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
							CD: 99.68%
		Technical performance	User group	No duplicated FDEs	2.2.2	Log files do not show creation of any FDEs with same ACID, destination, date, & PDT	Pass: Duplicate entity IDs identified attributed to manual FDE creation.
		Usability	MIL-STD 1472f 5.4.6.4	Latency < 0.5 s in transferring flight data between positions	2.2.3	Time recorded between logging transfer of FDE and logging FDE receipt is <0.5 sec 90% of the time.	Pass: All successful FDE transfers had latencies under 0.5 seconds more than 99% of the time.
	Notifications	Usability	pPRD 3.3.1.10 .4, 3.3.1.10 .5	Prompts displayed for new ATIS; taxi route deviation for manually assigned taxi routes; delay past 15 minutes; departure time expiration; departure time nearing expiration; airborne route unavailable due to weather	*2.2.4*	*Prompt displayed when new ATIS submitted. Prompt shown when flight deviates from manually assigned taxi route.* Prompt shown when EDCT expires. Prompt shown when a departure route is blocked RED on RAPT.	*ATIS prompt: N/A because it was determined that there would not be a prompt when a new ATIS was issued.* *Taxi route prompt: N/A because taxi route non-conformance was not implemented.* EDCT prompt: Pass: EDCT prompts verified at DFW. RAPT RED prompt: Pass: When a flight with

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
							a RAPT RED departure route was shown on an FDM, a prompt for that flight was issued.
			pPRD 3.3.1.10 .5	Aircraft/FDEs involved in notification events are highlighted or otherwise indicated	2.2.5	ATIS field on FDE displays salmon when reported ATIS is outdated. Hold short point field on FDE highlighted on flight deviating from manually assigned taxi route. EDCT field highlighted on FDE when EDCT expires.	Pass: Verified at DFW-2
	Flight state changes	Usability	User group	FDE state changes occur as required	2.2.6	Observe transfer of FDE to GC "Ready to Taxi" queue when surveillance determines that aircraft arrives at spot or transfer point on bridge.	Pass: Verified at DFW-2
	Airport configuration	TX10: Manage and display real time state of runways & taxiways	pPRD 3.3.1.8, 3.4.4.4; STBO TX10	Show current configuration consistently across TFDM displays	2.2.7	Observe the configuration displayed consistently on all TIDS, FDM, and Supervisor displays.	Pass: Verified at DFW-2
	Runway assignment	RN01: Assign departure runway based on pre-defined rules	pPRD 3.3.1.7, 3.4.4.3; STBO RN01	Show recommended runway assignments for departures on FDM display based on DST logic and runway-to-fix mapping	2.2.8	Observe runway assignments on FDEs consistent with DST logic and runway to fix mapping.	Pass: Runway assignments were 100% consistent with the DST logic. One departure procedure
		[RN02] Provide advice to controller on manually entered assignment of departure	pPRD 3.3.1.7. 1; STBO RN02	Input/modify arrival and departure runway assignments	2.2.9	Departure runway assignment field on the FDE changes and remains changed when runway assignment is manually changed.	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
		runway					
		RN01: Assign departure runway based on pre-defined rules	User group	View runway-to-fix mapping	2.2.10	Runway to fix mapping is displayed on Supervisor Display.	Pass: Verified at DFW-2
	Sequencing and scheduling	SS03: Display TFM constrained times to tower controller, including if a constraint may/has not been met	pPRD 3.4.4.2; STBO SS03	Display estimated departure clearance times and approval required times on FDM	2.2.11	EDCTs for affected flights are displayed in the EDCT field on the FDE. Approved release times can be entered into the remarks field of the FDE.	Pass: Verified at DFW-2
		SS01: Controller 1rate a predicted runway sequence for active runways to the TMU or supervisor	pPRD 3.4.4.2; STBO SS01	Display predicted departure sequence for each runway	2.2.12	Predicted departure sequence for each runway is shown in Sequencing & Scheduling tab.	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
		SS17: Manage departure queue length through allocation by FO of aircrafts allowed entry to AMA	pPRD 3.3.1.6.2; STBO SS17	Display suggested spot release rate on FDM.	2.2.13	Metering recommendation is displayed on GC FDM when estimated departure queue exceeds 6 flights.	Pass: Verified at DFW-2
	Taxi routing	TX01: Provide for manual assignment of pre-defined taxi routes by tower personnel. TX02: Provide operator entry of non-standard taxi routes by tower personnel.	pPRD 3.3.1.10.3; STBO TX01	Accurately display assigned taxi route on FDM (textual) displays	2.2.14	Manually entered taxi route is shown, as entered, in the flight's Full Flight Edit window on the FDM.	Pass: Verified at DFW-2
		TX01: Provide for manual assignment of pre-defined taxi routes by tower personnel.	pPRD 3.3.1.10.2; STBO TX01	Provide ability to select standard taxi routes using one to two button presses	2.2.15	Assign hold short point (with taxi route in letter of agreement) using FDM hot button.	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
		TX02: Provide operator entry of non-standard taxi routes by tower personnel.	pPRD 3.3.1.10 .2; STBO TX02	Edit taxi route with keyboard on FDM	2.2.16	Manually enter a taxi route for a flight on the flight's Full Flight Edit window on the FDM.	Pass: Verified at DFW-2
	Notifications	Logging	pPRD 3.4.9.1	Record all triggered notifications	2.2.17	All notifications are logged as they occur.	Pass: Verified at DFW-2
	Flight state changes	Acceptability	MIT/LL	User feedback on state changes rated 4 or higher on 5-point scale	2.2.18	Average user feedback rates at least 4.	Pass: Data block's aircraft state indications were accurate= 4.50/5 *(p=.001)*, and Data block color coding was useful, 4.43/5 *(p=.003)*
	Notifications	Acceptability	MIT/LL	User feedback on notification behavior rated 4 or higher on 5-point scale	*2.2.19*	*Average user feedback rates at least 4.*	*N/A: Notifications not available for DFW-2*
	Data sorting and transfer	Acceptability	MIT/LL	User feedback on sorting and control transfer rated 4 or higher on 5-point scale	2.2.20	Average user feedback rates at least 4.	Pass: Data sorting 4.67/5; transfer 4.2/5
	Notifications	Acceptability	MIT/LL	User feedback on perceived missed notifications rated 4 or higher on 5-point scale	*2.2.21*	*Average user feedback rates at least 4.*	*N/A: Notifications not available for DFW*
	Notifications	Acceptability	MIT/LL	User feedback on accuracy, timeliness, and appropriateness of each type of notification for each control position rated 4 or higher on 5-point scale	*2.2.22*	*Average user feedback rates at least 4.*	*N/A: Notifications not available for DFW*

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
	User interaction	Acceptability	MIT/LL	User feedback on user interaction tasks rated 4 or higher on 5-point scale	2.2.23	Average user feedback rates at least 4.	Pass: TIDS user interface was easy to use = 4.43/5
	Overall FDM	Acceptability	MIT/LL	Subjective ratings of FDM rated 4 or higher on 5-point scale	2.2.24	Average user feedback rates at least 4.	Pass: FDM rated beneficial 4.41/5 *(p=.001)*
2.3	**Supervisor Display**						
	Airport configuration	TX10: Manage and display real time state of runways & taxiways	pPRD 3.3.1.8, 3.4.4.4; STBO TX10	Show current configuration consistently across TFDM displays	2.3.1	Observe the current configuration displayed consistently on all TIDS, FDM, and Supervisor displays.	Pass: Verified at DFW-2
			pPRD 3.3.1.8.1; STBO TX10	Provide ability to edit current runway configuration on Supervisor display	2.3.2	Change runway configuration in the Resources tab of the Supervisor Display.	Pass: Verified at DFW-2
			pPRD 3.3.1.8.1; STBO TX10; User Group	Schedule new runway configuration on Supervisor display	2.3.3	Schedule runway configuration change on Supervisor Display.	Pass: Verified at DFW-2
			pPRD 3.3.1.8.1; STBO TX10; User Group	Cancel scheduled runway configuration on Supervisor display	2.3.4	Cancel a scheduled configuration change on Supervisor Display.	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
			pPRD 3.3.1.8.1; STBO TX10; User Group	Modify scheduled runway configuration on Supervisor display	2.3.5	Modify scheduled configuration change on Supervisor Display.	Pass: Verified at DFW-2
		TX10: Manage and display real time state of runways & taxiways	pPRD 3.3.1.7.2; STBO TX10	Show status of runways accurately on TIDS and Supervisor displays	2.3.6	Status of runways on TIDS and Supervisor Display accurately reflects the operation 100% of the time.	Pass: The status of the runways on the TIDS and Sup displays accurately reflected the operation 100% of the time.
		TX10: Manage and display real time state of runways & taxiways	pPRD 3.3.1.8.1; STBO TX10	Change runway status on TIDS and Supervisor displays	2.3.7	Change runway status on Supervisor Display.	Pass: Verified at DFW-2
		DR01: Flight-specific impact assessment and indication of weather or	pPRD 3.4.4.5, 3.3.1.9.2; STBO DR01	Show/modify status of departure fixes on Supervisor display (closures & MIT)	2.3.8	State of the departure fixes are shown on Supervisor Display. View any MIT/MINIT restrictions affecting departure fixes. Change the state of departure fixes on Supervisor Display. Change the MIT/MINIT over a departure fix.	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
		traffic flow constraints to filed departure route.					
		DR01: Flight-specific impact assessment and indication of weather or traffic flow constraints to filed departure route.	pPRD 3.4.4.5, 3.3.1.9.2; STBO DR01	View/edit list of MIT/MINIT airport programs for other airports	2.3.9	View MIT restrictions manually inputted for an airport. Add a MIT restriction for a destination airport.	Pass: Verified at DFW-2
		SS01: Controller 1rate a predicted runway sequence for active runways to the TMU or supervisor	pPRD 3.3.1.6.1, 3.3.1.6.3; STBO SS01	Predict and display expected number of departures and arrivals.	**2.3.10**	**Display expected number of departures and arrivals on runway timelines on Supervisor Display. Predict expected number of departures and arrivals at least 30 min into future**	**Fail: Instances found in which Sup Display predictions and actual demand did not match both 30 min in advance and 5 min in advance.**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
	Sequencing and scheduling	Technical performance	pPRD 3.3.1.6.1, 3.3.1.6.3; STBO SS01	Display estimated wheels on time and estimated wheels off times	**2.3.11**	Display estimated wheels on and off times on runway timelines on Supervisor Display. **Display estimated wheels on time within 1 min 75% of the time** and estimated wheels off times within 2 min 75% of the time on Supervisor displays	Pass: Only 80% of flights had error <2min when 2 min from wheels off. **Fail:** **Only 63% of flights had error <1min when 2 min from wheels on.**
		SS01: Controller 1rate a predicted runway sequence for active runways to the TMU or supervisor	pPRD 3.3.1.6.2; STBO SS01	Display predicted departure sequence for each runway	2.3.12	Departure sequence is shown on runway timelines in Sequencing & Scheduling tab on Supervisor Display.	
	Departure routing	DR01: Flight-specific impact assessment and indication of weather or traffic flow constraints to filed departure route.	pPRD 3.3.1.9.1, 3.4.4.5; STBO DR01	RAPT route blockage color is associated with each flight on Sequencing & Scheduling tab	2.3.13	RAPT color block is displayed next to ACID of each flight on Supervisor Display Sequencing & Scheduling runway timeline.	Pass: During the one time weather occurred during the demo, appropriate color blocks were present.
		DR03:	pPRD	Timelines of wheels-off	2.3.14	Timelines of wheels-off times overlaid	Pass: Verified at

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
		Evaluate pre-coordinated routes for acceptability relative to weather and traffic flow constraints.	3.3.1.9.1, 3.4.4.5; STBO DR03	times of individual flights associated with each RAPT departure route are shown in the DR tab		on RAPT departure routes displayed on DR tab of Supervisor Display	DFW-2
		Usability	pPRD 3.4.4.5	Upon flight departing, flight is removed from all lists and timelines on DR tab	2.3.15	No departed flights are shown on lists/timelines on DR tab.	Pass: The ability to view or not view departed flights on the DR tab was made a controller preference. If they chose not to view the departed flights, they would not have to.
		SS03: Display TFM constrained times to tower controller, including if a constraint may/has not been met. DR03: Evaluate pre-coordinated routes for acceptability relative to weather and	pPRD 3.3.1.9.2, 3.4.4.1; STBO SS03, DR03	Display constraints from destination airport that impact each departure (see list in AC)	2.3.16	View MIT restrictions manually inputted for an airport.	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
		traffic flow constraints.					
	Overall Supervisor display	Acceptability	MIT/LL	User feedback on Supervisor display rated 4 or higher on 5-point scale	**2.3.17**	**Average user feedback rates at least 4.**	**Fail: Sup Display prototype rated 3.21/5; Concept of Sup Display rated 4.75/5**
	Airport Configuration	Acceptability	MIT/LL	User feedback on airport configuration user interface and presentation rated 4 or higher on 5-point scale	2.3.18	Average user feedback rates at least 4.	Pass: Usefulness of airport config.: 4.17/5 Usability of airport config.: 4.67/5
	Runway assignment	Acceptability	MIT/LL	User feedback on runway assignment user interface and presentation rated 4 or higher on 5-point scale	2.3.19	Average user feedback rates at least 4.	Pass: Runway to fix mapping usability: 5/5 Runway assignment modification usability: 4.67/5
	Sequencing and scheduling	Acceptability	MIT/LL	User feedback on sequencing and scheduling user interface and presentation rated 4 or higher on 5-point scale	**2.3.20**	**Average user feedback rates at least 4.**	**Fail: Sequencing & scheduling information sufficiency: 3.71/5 Sequencing & scheduling timeline clarity: 3.85/5**
	Taxi routing	Acceptability	MIT/LL	User feedback on taxi routing user interface and presentation rated 4 or higher on 5-point scale	2.3.21	Average user feedback rates at least 4.	Pass: Ease of inputting a taxi route: 4.27/5

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
	Departure routing	Acceptability	MIT/LL	User feedback on departure routing user interface and presentation rated 4 or higher on 5-point scale	**2.3.22**	**Average user feedback rates at least 4.**	**Fail: Dep. Routing info sufficiency: 3.25/5; Usefulness of RAPT colors on S&S timelines: 3.5/5; Accuracy of RAPT colors on S&S timelines: 3/5; Usefulness of DR tab: 2.67/5; Accuracy of DR tab: 2.5/5**
2.4	**Display Interoperability**						
	Concurrent selection	Display interaction	MIL-STD 1472f 5.4.6.4	FDE selected on FDM results in selected target on TIDS in < 1 second 80% of the time	2.4.1	The time elapsed between when the FDE was selected and when the highlight appeared on the correct target on TIDS is 1 second or less.	Pass: A full 100% of FDE selections whose targets were found on the TIDS were highlighted on the TIDS in less than 1 second.
			MIL-STD 1472f 5.4.6.4	Target selected on TIDS results in selected FDE on FDM in < 1 second 80% of the time	*2.4.2*	*The time elapsed between when the TIDS target was selected and when the highlight appeared on the correct FDE is 1 second or less.*	*Inconclusive: Sufficient logging is not available to assess TIDS-initiated selections.*
	Congruent data	Display interaction	TPS 9586	Flight data shown on TIDS matches that shown on the FDEs and vice versa	2.4.3	No discrepancies are found between data displayed on both the TIDS datablocks and the FDEs.	Pass: Verified at DFW-2
	Overall interoperability	Acceptability	MIT/LL	User feedback on interoperability rated 4 or higher on 5-point scale	2.4.4	Average user feedback rates at least 4.	Pass: All interoperability categories rated 4 or higher

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
3	**TFDM Surveillance Components**						
3.1	**Surveillance Processor**	Creep velocity algorithm	TPS 6655; Surv 7	Aircraft position accuracy is < 20' (1σ) for all taxiways and runways up to 300' AGL at speeds < 15 kts	3.1.1	Aircraft position accuracy for the flight check aircraft on runways and taxiways up to 300' AGL is less than 20' 1σ.	Pass: Verified at DFW-1
		Centerline snapping algorithm	TPS 6655; User group	< 0.5 m offset from centerline as displayed on TIDS	3.1.2	ASDE-X position data for flight check aircraft traveling in a straight line on centerlines is < 0.5 m offset from centerline after being processed by CSA	Pass: Verified at DFW-1
		Altitude conditioning	TPS 6655; Surv 5	Displayed Mode C altitude matches ASDE-X Mode C altitude	3.1.3	Mode C altitudes stored by TFDM for each aircraft match Mode C altitudes provided by ASDE-X.	Pass: Stored altitudes match ASDE-X altitudes
		Fusion track algorithm	Surv 7	Displayed tracks composed of fused surveillance data	3.1.4	ASDE-X position reports include MLAT, ADS-B, SMR, ASR data.	Pass: Verified in post-hoc analysis
			TPS 6628, 6629; Surv 5	Aircraft position accuracy is < 20' (1σ) for all taxiways and runways up to 300' AGL	3.1.5	Aircraft position accuracy for the flight check aircraft on runways and taxiways up to 300' AGL is less than 20' 1σ.	Pass: Verified at DFW-1
				Aircraft position accuracy is < 120' (1σ) for all arrival and departure corridors out to 1.7 nm	3.1.6	Aircraft position accuracy for the flight check aircraft on approach and departure corridors out to 1.7 nm is less than 120' 1σ.	Pass: Verified at DFW-1
				Aircraft position accuracy is < 180' (1σ) for all arrival and departure corridors out to 5nm	3.1.7	Aircraft position accuracy for the flight check aircraft on approach and departure corridors out to 5 nm is less than 180' 1σ.	Pass: Verified at DFW-1
				Aircraft position accuracy is < 600' (1σ) for all arrival and departure corridors out to 20 nm	3.1.8	Aircraft position accuracy for the flight check aircraft on approach and departure corridors out to 20 nm is less than 600' 1σ.	Pass: Verified at DFW-1

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
		False and split track and target removal	TPS 6657; Surv 14	False target rate of 2% or less	3.1.9	The number of false targets detected by ASDE-X is 2% or less for the entire data collection period.	Pass: False target rate is less than 0.01% for data collection period
			TPS 6657; Surv 15	False track rate of 1 per 2400h or less	**3.1.10**	**ASDE-X detects 1 or fewer false tracks per 2400h of collected data.**	**Fail: false tracks detected at DFW-2**
3.2	**Surface Monitor**	Advisory tools	User group	Runway hold bars displayed in accordance with ASDE-X	*3.2.1*	*Hold bars on TIDS are displayed within 1 s of when hold bars on ASDE-X are shown.*	*Inconclusive: ASDE-X hold bar data unavailable*
				Wake turbulence timers displayed when aircraft initiates takeoff roll	**3.2.2**	**Wake turbulence timers are displayed within 1 s of when aircraft begins takeoff roll.**	**Fail: Average time to display 14 s; Max time to display 26 s**
				Timer is within 5 seconds of required delay time	**3.2.3**	**Duration of wake turbulence timer is within 5 seconds of the required time (2 min, 3 min, etc.).**	**Fail: Wake turbulence timer is always 3 minutes**
3.3	**Target Broker**	Unique flight ID	TPS 6902; pPRD 3.2.3	All targets are assigned unique IDs throughout test period	*3.3.1*	*All targets and their flight data receive unique IDs that can be retrieved from TFDM/TIB.*	*Inconclusive- Insufficient logging available to assess TIDS IDs*
			TPS 6905; pPRD 3.2.3	IDs match between TIDS and FDM displays	*3.3.2*	*IDs assigned to targets on TIDS match IDs assigned to the associated FDEs on FDM.*	*Inconclusive- Insufficient logging available to assess TIDS IDs*
		Flight and track data reconciliation	pPRD 3.2.2	All targets are associated with accurate flight data	**3.3.3**	**All targets shown on TFDM have flight data information available in datablocks and FDEs.**	**Fail: There were instances identified in which TIDS targets did not have a corresponding FDE.**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
					3.3.4	Flight data stored by TFDM/TIB matches flight data received from ASDE-X, FDIO, and other data sources.	Passed: Verified at DFW-2 and in post-hoc analysis
3.4	**Data Archiving**	Data archiving	pPRD 3.1.7, 3.2.4	Data can be retrieved after each test session.	3.4.1	All recorded test data can be opened and viewed with the appropriate viewers/readers/etc after each test session is complete and all data is saved.	Pass: Verified during analysis
4	**Interfaces**						
4.1	**ASDE-X**	Surveillance performance	pPRD 3.1.1, 3.2.3; TPS 6651	ASDE-X data successfully extracted and passed to TFDM	4.1.1	ASDE-X data is available and recorded on the TIB.	Pass: Verified at DFW-2
					4.1.2	Surveillance data is shown on TIDS.	Pass: Verified at DFW-2
			pPRD 3.2.3; TPS 6591	No discrepancies between ASDE-X and TFDM data	4.1.3	No discrepancies are found between recorded ASDE-X data and the ASDE-X data stored on the TIB.	Pass: Verified at DFW-2
				No delay of data between ASDE-X and presentation on display.	4.1.4	The time elapsed between receiving data from ASDE-X and showing it on the display is 1 second or less.	Pass: Verified at DFW-2
				ASDE-X ASTERIX Category 10 & 11 messages successfully read, reformatted, and published to TIB	4.1.5	ASTERIX Cat 10 and 11 data are available and recorded on the TIB.	Pass: Verified at DFW-2
					4.1.6	ASTERIX Cat 10 and 11 data are displayed in TFDM format when it's retrieved from the TIB.	Pass: Verified at DFW-2
			TPS 6638, 6591	No delay of data between ASDE-X and TIB.	4.1.7	The time elapsed between receiving data from ASDE-X and its being available on the TIB is 1 second or less.	Pass: Analysis of time stamps from SGF headers and ASDE-X adapter shows elapsed time

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
							< 1 s.
			Surv 3	< 120 feet coverage gaps	4.1.8	Any gaps in the ASDE-X surveillance coverage are less than 120' in length.	Pass: Verified at DFW-1
			TPS 6638; Surv 9	Surveillance latency < 0.5 seconds (95%)	4.1.9	Latency between ASDE-X position data and DGPS truth data is less than 0.5 s for 95% of the position reports received for the flight check aircraft.	Pass: Verified at DFW-1
4.2	**FDIO**	Flight data performance	MIT/LL	No discrepancies between FDIO and TFDM data	4.2.1	Data is consistent between paper flight strips and FDEs 95% of the time	Pass: 98% flight data entry information matched collected flight progress strips.
4.3	**RAPT**	Flight-specific impact assessment and indication of weather or traffic flow constraints for filed departure route	STBO DR01; TPS 6683	No discrepancies between TFDM and RAPT data	4.3.1	Blockage indicated on Supervisor display and in FDM prompts is 95% consistent with RAPT feed	Pass: Of blockage indicated, 100% was consistent with RAPT feed.
				No delay of displayed RAPT data.	*4.3.2*	*Delay between logged entrance of RAPT data and display on TFDM is < 1 sec.*	*Inconclusive: Unable to retrieve diagnostic log files*
4.4	**ITWS**	Display of wind data	TPS 9581; User group	Display of centerfield wind data	4.4.1	Centerfield wind data is displayed on TIDS ribbon display	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
			TPS 9581; User group	Display microburst data	*4.4.2*	*Microburst data is displayed on TIDS ribbon display when appropriate.*	*N/A: Not available at DFW-2*
			TPS 9581; User group	Display wind shear data	*4.4.3*	*Wind shear data is displayed on TIDS ribbon display when appropriate.*	*N/A: Not available at DFW-2*
			User group	No discrepancies between TFDM and ITWS data	*4.4.4*	*TFDM and ITWS winds data consistent 95% of the time*	*Inconclusive*
			MIT/LL	No delay of displayed ITWS data	*4.4.5*	*Delay between logged entrance of ITWS data and display on TFDM is < 1 sec.*	*Inconclusive: Unable to retrieve diagnostic log files*
4.5	**External Data**	Flight-specific impact assessment and indication of weather or traffic flow constraints for filed departure route	TPS 6665, 6689, 6690; User group	No discrepancies between TFDM and external data (ASDI, D-ATIS, FOC, AODB, NOTAMs, RVR, Integrated Winds)	*4.5.1*	*No discrepancies are found between recorded ASDI data and the ASDI data stored on the TIB.*	*Inconclusive: Unable to retrieve diagnostic log files in a reasonable amount of time.*
					4.5.2	No discrepancies are found between recorded D-ATIS data and the D-ATIS data stored on the TIB.	Pass: ATIS data accuracy was verified at DFW.
					4.5.3	*No discrepancies are found between recorded FOC data and the FOC data stored on the TIB.*	*N/A: Not available at DFW-2*
					4.5.4	*No discrepancies are found between recorded AODB data and the AODB data stored on the TIB.*	*N/A: Not available at DFW-2*

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
					4.5.5	No discrepancies are found between recorded NOTAMs and the NOTAMs stored on the TIB.	Pass: NOTAM data accuracy was verified at DFW.
					4.5.6	No discrepancies are found between recorded RVR data and the RVR data stored on the TIB.	Pass: RVR data accuracy was verified at DFW.
					4.5.7	*No discrepancies are found between recorded winds data and the winds data stored on the TIB.*	*Inconclusive: Unable to retrieve data*
			MIT/LL	No delay of displayed external data.	*4.5.8*	*The time elapsed between receiving ASDI data and ASDI data being available on the TIB is less than 1 s.*	*Inconclusive: Unable to retrieve diagnostic log files in a reasonable amount of time.*
					4.5.9	The time elapsed between receiving D-ATIS data and D-ATIS data being available on the TIB is less than 1 s.	**Fail: The average time between TIB receiving the data and the display of the data is 0.983 sec with a maximum time observed of 1.521 sec.**
					4.5.10	*The time elapsed between receiving FOC data and FOC data being available on the TIB is less than 1 s.*	*N/A: FOC data was not utilized in DFW-2*
					4.5.11	*The time elapsed between receiving AODB data and AODB data being available on the TIB is less than 1 s.*	*N/A: AODB data was not utilized in DFW-2*
					4.5.12	The time elapsed between receiving NOTAMs and NOTAMs being available on the TIB is less than 1 s.	Pass: Time elapsed between receiving NOTAMs and NOTAMs being

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
							displayed averaged 0.206 sec with a maximum of 0.578 sec.
					4.5.13	The time elapsed between receiving RVR data and RVR data being available on the TIB is less than 1 s.	Pass: Time elapsed averaged 0.594 sec with a maximum of 0.9 sec.
					4.5.14	*The time elapsed between receiving winds data and winds data being available on the TIB is less than 1 s.*	*Inconclusive: Unable to retrieve diagnostic log files*
5	**Cameras**						
5.1	**Cohu Cameras**						
5.1.1	**TIDS Picture-in-Picture**	PiP display of Cohu data	TPS 6165	Image shown on TIDS, external display	5.1.1.1	Long-range camera image is shown on TIDS camera PiP.	Pass: Verified at DFW-2
				Camera data displayed on TIDS and external display matches camera feed	*5.1.1.2*	*Images shown on TIDS camera PiP match data recorded from long-range camera.*	*Inconclusive: Unable to play back raw camera data*
		Cohu tracking capabilities	TPS 9539	Selected image is tracked on TIDS and external display	**5.1.1.3**	**Aircraft can be selected and tracked out to 5nm by clicking on target in PiP.**	**Fail: Small a/c not consistently able to be selected and tracked by visual observation at DFW-2.**
					5.1.1.4	**Tracking initiation coincides with time of target selection in PiP.**	**Fail: Tracking time may coincide with target selection, but numerous attempts often required to actually select**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
							target
					5.1.1.5	The tracked target is displayed in the TIDS camera window until it is deselected by the user.	Pass: Verified at DFW-2
		Cohu control interface	TPS 9539	Users can pan, tilt, zoom, focus, slew Cohu camera through camera PiP window on TIDS	**5.1.1.6**	**Users can pan the Cohu by interacting with the camera PiP.**	**Fail: Users experienced significant problems with camera controls**
					5.1.1.7	**Users can tilt the Cohu by interacting with the camera PiP.**	**Fail: Users experienced significant problems with camera controls**
					5.1.1.8	**Users can zoom the Cohu by interacting with the camera PiP.**	**Fail: Users experienced significant problems with camera controls**
					5.1.1.9	**Users can focus the Cohu by interacting with the camera PiP.**	**Fail: Users experienced significant problems with camera controls**
					5.1.1.10	**Users can slew the Cohu by interacting with the camera PiP.**	**Fail: Users experienced significant problems with camera controls**
		Acceptability	MIT/LL	User feedback for PTZF rated 4 or higher on 5-point scale	**5.1.1.11**	**Average user feedback rates at least 4.**	**Fail: Track a target = 4.91/7; Camera's tracking capability was**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
							useful using PiP = 3/5
		Acceptability	User group	User feedback for video appearance rated 4 or higher on 5-point scale	**5.1.1.12**	**Average user feedback rates at least 4.**	**Fail: Overall picture-in-picture presentation = 4.67/7**
		Acceptability	MIT/LL	User feedback for camera interface on TIDS and external display rated 4 or higher on 5-point scale	**5.1.1.13**	**Average user feedback rates at least 4.**	Pass: Ratings of at least 5/7 for: Select a viewing area = 5.09/7, Select a target (aircraft,vehicle) = 5.09/7 **Fail: Resize a viewing area = 4.5/7**
		Acceptability	MIT/LL	User feedback for tracking rated 4 or higher on 5-point scale	**5.1.1.14**	**Average user feedback rates at least 4.**	**Fail: Camera tracking is sufficiently smooth = 2.92/5 for both scanning camera external display and PiP.**
		Acceptability	MIT/LL	Subjective ratings of camera vs. binoculars rated 4 or higher on 5-point scale	**5.1.1.15**	**Average user feedback rates at least 4.**	**Fail: The camera performance is equivalent to or better than binoculars = 1.92/5 *(p=.033)* for scanning camera external display, and 2/5 *(p=.033)* for PiP**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
		Acceptability	MIT/LL	Subjective ratings of camera displays rated 4 or higher on 5-point scale	**5.1.1.16**	**Average user feedback rates at least 4.**	**Fail: Overall functionality of picture-in-picture = 4.67/7**
		Acceptability	User group	User feedback on camera utility rated 4 or higher on 5-point scale	**5.1.1.17**	**Average user feedback rates at least 4.**	**Fail: The camera's tracking capability is useful for supplemental SNT = 3.55/5 *(p=.151)*and 3.5/5 *(p=.127)* for PiP**
		Usability	MIT/LL	Data on controller usage of OTW, displays, tools collected	5.1.1.18	Video, observational data collected and analyzed to determine controller tool usage.	Pass: video and observational data collected
					5.1.1.19	Controller feedback on tool, OTW, display usage collected.	Pass: controller feedback collected
					5.1.1.20	Average user feedback rates at least 4.	Pass: At least one display received an average rating of 4 or better for scenario display usage
5.1.2	**External Camera Display (Cohu)**	External display for Cohu	TPS 6165	Image shown on TIDS, external display	5.1.2.1	Long-range camera image is shown on external camera display.	Pass: Verified at DFW-2
				Camera data displayed on TIDS and external display matches camera feed	*5.1.2.2*	*Images shown on external camera display match data recorded from long-range camera.*	*Inconclusive: Unable to play back raw camera data*
		Cohu tracking capabilities	TPS 9539	Selected image is tracked on TIDS and external display	*5.1.2.3*	*Aircraft can be selected and tracked out to 5 nm by clicking on target in external display.*	*Fail: Small a/c not consistently able to be selected and tracked by visual observation at*

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
							DFW-2.
					5.1.2.4	**Tracking initiation coincides with time of target selection in external display.**	**Fail: Tracking time may coincide with target selection, but numerous attempts often required to actually select target**
					5.1.2.5	The tracked target is displayed in the external camera display until it is deselected by the user.	Pass: Verified at DFW-2
		Cohu control interface	TPS 9539	Users can control Cohu camera through external camera display	**5.1.2.6**	**Users can pan the Cohu by interacting with the Cohu image on the external display.**	**Fail: Users experienced significant problems with camera controls**
					5.1.2.7	**Users can tilt the Cohu by interacting with the Cohu image on the external display.**	**Fail: Users experienced significant problems with camera controls**
					5.1.2.8	**Users can zoom the Cohu by interacting with the Cohu image on the external display.**	**Fail: Users experienced significant problems with camera controls**
					5.1.2.9	**Users can focus the Cohu by interacting with the Cohu image on the external display.**	**Fail: Users experienced significant problems with**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
							camera controls
					5.1.2.10	**Users can slew the Cohu by interacting with the Cohu image on the external display.**	**Fail: Users experienced significant problems with camera controls**
		Acceptability	MIT/LL	User feedback for PTZF rated 4 or higher on 5-point scale	**5.1.2.11**	**Collected user feedback on PTZF capabilities for Cohu external display is 4 and 5 on 5-point scale**	**Fail: Camera's tracking capability was useful using PiP = 3.09/5**
		Acceptability	User group	User feedback for video appearance rated 4 or higher on 5-point scale	**5.1.2.12**	**Average user feedback rates at least 4.**	**Fail: Overall camera ratings were less than 4/5**
		Acceptability	MIT/LL	User feedback for camera interface on TIDS and external display rated 4 or higher on 5-point scale	**5.1.2.13**	**Average user feedback rates at least 4.**	**Fail: Overall external display presentation = 4.27/7**
		Acceptability	MIT/LL	User feedback for tracking rated 4 or higher on 5-point scale	**5.1.2.14**	**Average user feedback rates at least 4.**	**Fail: Camera tracking is sufficiently quick for supplemental SNT = 2.83/5 (p=.429) for External Camera**
		Acceptability	MIT/LL	Subjective ratings of camera displays rated 4 or higher on 5-point scale	**5.1.2.15**	**Average user feedback rates at least 4.**	**Fail: Overall camera ratings were less than 4/5**
		Acceptability	MIT/LL	Subjective ratings of camera vs. binoculars rated 4 or higher on 5-point scale	**5.1.2.16**	**Average user feedback rates at least 4.**	**Fail: The camera performance is equivalent to or better than**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
							binoculars=1.92/5 (p=.033) for camera external display and 2.00/5 (p=.033) for PiP.
		Acceptability	User group	Subjective ratings of camera displays rated 4 or higher on 5-point scale	5.1.2.17	Average user feedback rates at least 4.	**Fail: Overall camera ratings were less than 4/5**
5.1.3	**Cohu ViPS**	Cohu camera control	TPS 9539	PTZF, camera control capabilities demonstrated	**5.1.3.1**	**Cohu camera can be panned, tilted, zoomed, focused, slewed, and image can be tracked.**	**Fail: Users experienced significant problems with camera controls**
			MIL-STD 1472f 5.4.6.4	Camera control latency < 0.5 second	**5.1.3.2**	**The time elapsed between VIPS sending a control message to the Cohu and the desired position being achieved is less than 0.5 s.**	**Fail: Observation at DFW-2 revealed variable latencies in control response**
			MIL-STD 1472f 5.4.6.4	< 1 s latency on TIDS and external display	5.1.3.3	The time elapsed between the Cohu's timestamp of an image and the time the image is shown on the Cohu external display is less than 1 s.	Pass: Verified at DFW-2
					5.1.3.4	The time elapsed between the Cohu's timestamp of an image and the time the image is shown on the Cohu PiP is less than 1 s.	Pass: Verified at DFW-2
		Cohu tracking capabilities	TPS 9539	Tracking capabilities demonstrated	5.1.3.5	The selected target is followed by the Cohu camera until it is deselected by the user.	Pass: Verified at DFW-2
				Tracked image is the same on both PiP and external display	5.1.3.6	No discrepancies exist between the tracked image shown on the PiP and the external Cohu display.	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
			MIL-STD 1472f 5.4.6.4	< 1 s tracking latency	5.1.3.7	The time elapsed between the Cohu's timestamp of a tracked target image and the time the tracked target image is shown on the Cohu PiP is less than 1s.	Pass: Verified at DFW-2
					5.1.3.8	The time elapsed between the Cohu's timestamp of a tracked target image and the time the tracked target image is shown on the Cohu external display is less than 1s.	Pass: Verified at DFW-2
5.1.4	**Cohu Independence**	Local Control Cohu display	User group	LC Cohu camera operates independently of GC Cohu	**5.1.4.1**	**LC control inputs (PTZF, track, slew) are reflected on LC Cohu PiP and external displays only**	**Fail: LC/GC cameras are independent but Supervisor position sometimes fights for control with LC/GC**
		Ground Control Cohu display	User group	GC Cohu camera operates independently of LC Cohu	**5.1.4.2**	**GC control inputs (PTZF, track, slew) are reflected on GC Cohu PiP and external displays only**	**Fail: LC/GC cameras are independent but Supervisor position sometimes fights for control with LC/GC**
5.2	**Searidge Cameras**						
5.2.1	**External Camera Display (Searidge)**	External display of Searidge data	TPS 6165	Image shown on external display	5.2.1.1	Searidge fixed array main fused image is shown on the external camera display.	Pass: Verified at DFW-2
					5.2.1.2	Searidge north threshold is shown on the external camera display.	Pass: Verified at DFW-2
					5.2.1.3	Searidge south threshold is shown on the external camera display.	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
				Camera data displayed on external display matches camera feed	*5.2.1.4*	*Images shown on external camera display match data recorded from Searidge array.*	*Inconclusive: Unable to play back raw camera data*
		Acceptability	MIT/LL	User feedback for panoramic and threshold image extent rated 4 or higher on 5-point scale	**5.2.1.5**	**Average user feedback rates at least 4.**	**Fail: Overall camera ratings were less than 4/5**
		Acceptability	MIT/LL	User feedback for video appearance rated 4 or higher on 5-point scale	**5.2.1.6**	**Average user feedback rates at least 4.**	**Fail: Overall camera ratings were less than 4/5**
		Acceptability	MIT/LL	User feedback for camera interface on external display rated 4 or higher on 5-point scale	**5.2.1.7**	**Average user feedback rates at least 4.**	**Fail: Overall camera ratings were less than 4/5**
		Acceptability	MIT/LL	Subjective ratings of camera displays rated 4 or higher on 5-point scale	**5.2.1.8**	**Average user feedback rates at least 4.**	**Fail: Overall camera ratings were less than 4/5**
5.3	**Camera Coverage**	Taxiways	MIT/LL	Camera coverage provided on all taxiways.	**5.3.1**	**Targets can be seen using fixed-array camera image on farthest perimeter taxiways.**	Pass: Large/heavy a/c seen; verified at DFW-2 **Fail: Difficult to identify small a/c**
					5.3.2	Targets can be seen using long-range camera image on farthest perimeter taxiways.	Pass: Verified at DFW-2
		Runways	MIT/LL	Camera coverage provided on all runways.	**5.3.3**	**Targets can be seen using fixed-array camera image on all runways.**	Pass: Large/heavy a/c seen; verified at DFW-2 **Fail: Difficult to identify small a/c**
					5.3.4	Targets can be seen using long-range camera image on all runways.	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass/Fail
		Arrival/departure	MIT/LL	Camera coverage provided in arrival and departure corridors.	**5.3.5**	**Targets can be seen using long-range camera image on approach and departure out to 5 nm.**	**Fail: Targets visible only to 1-2 nm**

APPENDIX B
EVALUATION QUESTIONNAIRES[2]

B.1 DFW-2 Biographical Questionnaire

DFW-2 TFDM/SNT Evaluation
Biographical Questionnaire

Welcome to the DFW-2 Staffed NextGen Tower and Tower Flight Data Manager Field Demonstration evaluation surveys.

Please respond to the following biographical questionnaire. Any button or text box may be left unchecked or unfilled, respectively, at your discretion. Use your browser BACK button to return to the previous survey page. Click SUBMIT at the end of this page to be directed to the appropriate set of questions based on your experience with this field demonstration.

All your answers will be kept confidential and will be used by MIT Lincoln Laboratory for research purposes only.

Question 1 Please provide the date of the session you participated in at DFW-2.

Question 2 Which position did you work during DFW-2?

Question 3 What is your age?

Question 4 How long have you worked as a certified professional controller for the FAA?

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[2] All questions displayed with a five-point Likert scale ranging from negative using a five-point Likert scales ranging from negative to positive with response selections of completely disagree (1), somewhat disagree (2), neutral (3), somewhat agree (4), completely agree (5), except where noted. All questionnaires closed with the following closing statement:

Thank you for your responses! Your feedback is important to us and your participation is appreciated.

This work is sponsored by the Federal Aviation Administration under Air Force Contract FA8721-05-C-0002. Opinions, interpretations, recommendations, and conclusions are those of the author and are not necessarily endorsed by the United States Government.

Question 5 How long have you worked as a CPC for other employees (military, etc)?

Question 6 How long have you actively controlled traffic in an airport control tower?

Question 7 How many of the past 12 months have you actively controlled traffic in an airport control tower?

Question 8 How long have you actively controlled traffic at DFW?

Question 9 Rate your knowledge of the Staffed NextGen Tower/Tower Flight Data Manager concepts.

Question 10 How comfortable are you with new and/or unfamiliar technology?

Question 11 How often do you play video or computer games?

Question 12 Have you participated in previous TFDM/SNT demonstrations at DFW and/or at the FAA Technical Center in Atlantic City?

Question 13 Did you participate in the TFDM/SNT HITL-2 at NIEC in May 2011?

Question 14 Would you be interested in participating in future SNT/TFDM demonstrations at DFW?

B.2 TIDS Questionnaire

DFW-2 TFDM/SNT Evaluation

Tower Information Display System Questionnaire

Welcome to the DFW Staffed NextGen Tower (SNT) and Tower Flight Data Manager (TFDM) Field Demonstration #2 evaluation surveys. The following survey questions address the performance and appearance of the Tower Information Display System (TIDS) and are for analytical purposes only.

Please respond and comment about your assessment of TIDS and its use in SNT and TFDM at DFW. Any button or text box may be left unchecked or unfilled, respectively, at your discretion. Use your browser BACK button to return to the previous survey page. Click SUBMIT at the end of this page to be directed to the appropriate set of questions based on your experience with this first field demonstration.

All your answers will be kept confidential and will be used by MIT Lincoln Laboratory for research purposes only.

The Tower Information Display System (TIDS) provides graphical surveillance information overlaid on an airport map. Information such as aircraft call sign, speed, and altitude are provided in data block format and are associated with surveillance targets.

Target Information

Question 1 The target position is accurate (lat/long).

Question 2 The target's indicated altitude is accurate.

Question 3 The state (airborne/ground) color representation on the data block is accurate.

Question 4 The target heading is accurate.

Question 5 The displayed target type (aircraft type/wake class) is appropriate for all targets.

Question 6 The number of target types is appropriate to represent the traffic seen today.

Question 7 There were no frozen icons or indications of stale data on the TIDS.

Question 8 There were no false targets or tracks shown on the TIDS.

Question 9 No jumping targets were seen on the TIDS.

Question 10 Please provide any additional comments about the target information displayed on TIDS.

Information Accuracy and Availability

Question 11 The TIDS provides appropriate information for ground control.

Question 12 The TIDS provides appropriate information for local control.

Question 13 Data block information is accurate.

Question 14 Timesharing the departure fix and the assigned runway in the data block is useful.

Question 15 The data block's aircraft state indications are accurate.

Question 16 The airport configuration information is accurate.

Question 17 Taxiway status information is accurate.

Question 18 The information provided on TIDS accurately reflects the operational environment.

Question 19 Please provide any additional comments about the accuracy of the information shown on TIDS.

User Interface

Question 20 The TIDS user interface is easy to use.

Question 21 The TIDS target icon color coding is useful.

Question 22 The TIDS data block color coding is useful.

Question 23 The hot keys are useful.

Question 24 Target selection/highlighting on the TIDS is eye catching.

Question 25 It's easy to access the TIDS menu functions.

Question 26 User preference sets are useful.

Question 27 It is easy to create and access TIDS user preference sets.

Question 28 Please provide any additional comments about the TIDS user interface.

Picture-in-Picture Windows

Question 29 The picture-in-picture windows are useful.

Question 30 The camera picture-in-picture window is useful.

Question 31 The picture-in-picture windows (including the camera picture-in-picture window) are easy to configure.

Question 32	The number of camera picture-in-picture windows is sufficient.
Question 33	Please provide any additional comments about the TIDS picture-in-picture windows.

Wind Information

Question 34	The wind display window is useful.
Question 35	The wind display window does not distract me from other information on the TIDS.
Question 36	The wind information provided is sufficient for ATC purposes.
Question 37	Wind information is updated in a timely manner.
Question 38	The wind information presentation is acceptable.
Question 39	Please provide any additional comments about the wind information displayed on TIDS.

Display Features

Question 40	The wake turbulence timer is useful.
Question 41	The countdown time provided by the wake turbulence timer is appropriate.
Question 42	The aircraft types for which the wake turbulence timer is shown are sufficient.
Question 43	The optional runway pattern overlaid on the runway when the wake turbulence timer is active is useful.
Question 44	The approach bars are useful.
Question 45	The approach bar depiction is appropriate.
Question 46	The restricted areas are useful.
Question 47	Creating a restricted area is simple.
Question 48	The runway hold bars are useful.
Question 49	The runway hold bars appear at an appropriate time.
Question 50	The threshold hold bars are useful.
Question 51	The threshold hold bars appear at an appropriate time.
Question 52	The closed runway indication is useful.

Question 53 The closed runway indication is eye catching.

Question 54 The closed runway indication should be shown as a:

- ❍ Thin white X
- ❍ Thick white X
- ❍ Thin red X
- ❍ Thick red X

Question 55 The overflight and traffic filters are useful.

Question 56 The overflight and traffic filters appropriately filter out traffic I am not interested in.

Question 57 The overflight filters are simple to set up.

Question 58 The traffic filters are simple to set up.

Question 59 Please provide any additional comments about the TIDS display features.

Display Usefulness

Question 60 It was easy to detect aircraft using the TIDS.

Question 61 It was easy to predict future aircraft locations using the TIDS.

Question 62 It was easy to find necessary flight information using the TIDS.

Question 63 The TIDS helped maintain awareness of traffic identity.

Question 64 The TIDS was effective in helping control traffic on the ground.

Question 65 The TIDS was effective in helping control traffic in the air.

Question 66 The TIDS display was effective in helping me know the position of the aircraft.

Question 67 The TIDS display was effective in helping me sequence aircraft.

Question 68 The TIDS display was effective in helping me plan subsequent control actions.

Question 69 The TIDS was effective in helping maintain separation.

Question 70 TIDS will be beneficial to tower controllers.

Question 71 TIDS will be beneficial to TRACON controllers.

Question 72 Please provide any additional comments about the usefulness of the TIDS.

Summary Questions

Question 73 Is there anything that would improve the TIDS for controllers' use?

Question 74 Are there any additional information or features that should be considered on the TIDS?

Question 75 Are there any existing features that should be removed from the TIDS?

B.3 FDM Questionnaire

DFW-2 TFDM/SNT Evaluation

Flight Data Manager Questionnaire

Welcome to the DFW Staffed NextGen Tower (SNT) and Tower Flight Data Manager (TFDM) Field Demonstration #2 evaluation surveys. The following survey questions address the Flight Data Manager (FDM) presentation and performance.

Please respond and comment about your assessment of the FDM and its role in TFDM and SNT at DFW. Any button or text box may be left unchecked or unfilled, respectively, at your discretion. Use your browser BACK button to return to the previous survey page. Click SUBMIT at the end of this page to be directed to the appropriate set of questions based on your experience with this first field demonstration.

All your answers will be kept confidential and will be used by MIT Lincoln Laboratory for research purposes only.

The Flight Data Manager (FDM) provides flight data information in the form of electronic flight data entries (FDEs) and allows interaction and control exchange with controllers via the FDMs.

Controller 1ral Information

Question 1

The flight data entry (electronic flight strip) information is accurate.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 2

The FDM flight data entry (electronic flight strip) provides appropriate information for ground control.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 3

The FDM flight data entry (electronic flight strip) provides appropriate information for local control.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)

- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

User Interface

Question 4

The FDM display is uncluttered.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 5

The FDM user interface is easy to use.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 6

The FDM's use of color is appropriate and not overly distracting.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 7

Entering information for a NEW flight data entry (electronic flight strip) on the FDM is easy.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 8

Amending information on a flight data entry (electronic flight strip) is easy.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 9

It is easy to transfer control of a flight data entry (electronic flight strip) using the FDM.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 10

The sorting feature on the FDM is useful.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 11

The surveillance-based arrivals tables are useful. ☐

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 12

The surveillance-based arrivals tables were accurate. ☐

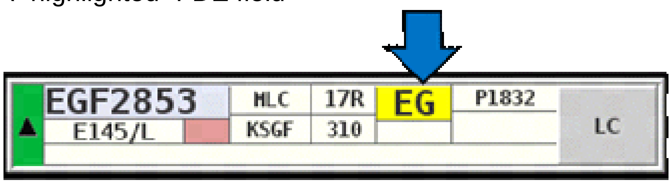
- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 13

Noting on the FDM arrivals tables that a flight has been cleared to land was easy.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

A “highlighted” FDE field



Question 14

The ability to highlight (turning an electronic flight strip’s field background yellow) is useful.

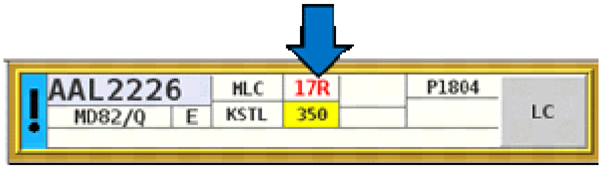
- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 15

The process of highlighting a field on the FDE (electronic flight strip) is simple.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Red text in an FDE field



Question 16

The ability to modify text to red text (turning the color of an electronic flight strip's text in a particular field to red) is useful.

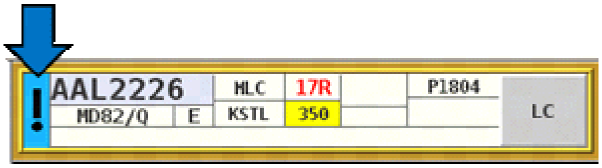
- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 17

The process to turn text red in a field on the FDE (electronic flight strip) is simple.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

FDE flag



Question 18

The ability to "flag" an FDE (electronic flight strip) is useful.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 19

The process to “flag” an FDE (electronic flight strip) is simple.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 20

The surveillance-based automatic movement of FDEs from the “Pending” bay in Ground Control to “Ready to Taxi” bay is useful.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 21

The surveillance-based automatic movement of FDEs from the “Pending” bay in Ground Control to “Ready to Taxi” bay is accurate.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 22

Please provide any additional comments on the FDM's user interface.

Notifications

Question 23

Notifications provide appropriate information for the situation.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)

- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 24

Notifications are displayed for an appropriate amount of time.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 25

Notifications are displayed in an appropriate location.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 26

There was never a situation in which a notification should be present but was not.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 27

The departure route weather blockage prompt is useful.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 28

The EDCT expiration prompt is useful.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 29

The taxi non-conformance prompt is useful.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 30

The traffic management restriction prompts (Call for Release, MIT, MINIT) prompts are useful.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 31

Please provide any additional comments on the notifications shown on the FDMs.

Decision Support Tools on the FDM

Question 32

Suggested runway assignments for individual flights presented on the FDM were useful.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 33

Suggested runway assignments for individual flights presented on the FDM were logical.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 34

Runway assignments for individual flights presented on the FDM were easy to modify.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 35

The departure metering spot release rate recommendations can be effectively integrated into ground control operations.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 36

The departure metering spot release rate recommendation is easily interpreted by ground control.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 37

The departure metering spot release rate recommendation is in the appropriate location.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 38

The taxi route non-conformance decision support tool accurately notified non-conformance when the taxi route was manually entered.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 39

The taxi routing decision support tool notifying controllers of non-conformance is useful.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 40

Please provide any additional comments on the DSTs as presented on the FDM.

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Summary Questions

Question 41

The FDM display was effective in helping me sequence aircraft.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 42

The FDM display was effective in helping me plan subsequent control actions.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 43

The FDM will be beneficial to tower controllers.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 44

A flight data entry (electronic flight strip) can be found on the FDM as easily as finding a paper flight progress strip in strip bays.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 45

A flight data entry (electronic flight strip) can be amended as easily as amending a paper flight progress strip.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 46

Is there anything that would improve the FDM for controllers' use?

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Question 47

Are there any additional information or features that should be considered on the FDM?

Question 48

Are there any existing features that should be removed from the FDM?

Thank you for your feedback on TFDM and SNT! Your feedback is important to us and your participation is appreciated.

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B.4 DST/Supervisor Display Questionnaire

DFW-2 TFDM/SNT Evaluation

Supervisor Display and DST Questionnaire

Welcome to the DFW Staffed NextGen Tower (SNT) and Tower Flight Data Manager (TFDM) Field Demonstration #2 evaluation surveys. The following survey questions address the Supervisor display and the decision support tools (DSTs), and are for analytical purposes only.

Please respond and comment about your assessment of the Supervisor display and DSTs. Any button or text box may be left unchecked or unfilled, respectively, at your discretion. Use your browser BACK button to return to the previous survey page. Click SUBMIT at the end of this page to be directed to the appropriate set of questions based on your experience with this first field demonstration.

All your answers will be kept confidential and will be used by MIT Lincoln Laboratory for research purposes only.

The Supervisor display provides access to decision support tools (DSTs) that provide tower supervisors with predictions of upcoming airport events and suggests possible actions to improve airport operations. These DSTs include Runway Assignment, Taxi Routing, Departure Routing, Sequencing and Scheduling, and Airport Configuration.

Question 1

The Supervisor display functionality is useful.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 2

The Supervisor display user interface is easy to use.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 3

The functionality provided in the Resource Control tab is useful.

	Completely disagree (1)	Somewhat disagree (2)	Neutral (3)	Somewhat agree (4)	Completely agree (5)	N / A
Airport configuration change	☐	☐	☐	☐	☐	☐
Runway open/close	☐	☐	☐	☐	☐	☐
Departure fix open/close	☐	☐	☐	☐	☐	☐
Scheduled resource changes table	☐	☐	☐	☐	☐	☐

Question 4

The Active Flights tab is a useful means of viewing flight data.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Airport Configuration

Question 5

The functionality provided in the Resource Control tab (airport configuration change, runway open/close, departure fix open/close, scheduled resource changes table) is useful.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 6

The actions taken in the Resource Control tab (airport configuration change, runway open/close, departure fix open/close, scheduling resource changes) effectively propagate to other information tabs in the supervisor display (e.g., sequencing & scheduling timelines) and to other TFDM displays (e.g., TIDS, FDM).

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 7

The functionality provided in the Resource Control tab (airport configuration change, runway open/close, departure fix open/close, scheduled resource changes table) is easy to use.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 8

The information provided by the Resource Control tab is sufficient to provide TFDM with the information required to recommend airport configuration changes.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 9

It would be desirable for TFDM to recommend when an airport configuration change should occur and to what configuration.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 10

It would be desirable for a change in airport configuration from the supervisor display to enable a change in airport configuration on the Ground Control and Local Control FDMs.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 11

It would be desirable to be able to view the effect of a potential airport configuration change on future demand and to see the effect on airport delay.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 12

It would be desirable to be able to graphically view the historical airport delay and throughput.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)

- Completely agree (5)
- Not applicable (N/A)

Question 13

It would be desirable to be able to graphically view the predicted future airport delay and throughput.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 14

Please provide any additional comments about the Airport Configuration DST on the Supervisor display.

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Runway Assignment

Question 15

The TFDM runway assignments are logical for departures.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 16

The TFDM runway assignments are logical for arrivals.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 17

The Runway to Fix Mapping tab provides useful functionality.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)

- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 18

The Runway to Fix Mapping tab user interface is easy to use.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 19

The functionality provided by the Runway to Fix Mapping tab is sufficient to ensure logical departure runway assignments.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 20

It would be desirable for TFDM to recommend the optimal runway assignment for individual flights to balance East/West Tower demand, minimize delay and minimize fuel burn/emissions.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 21

Please provide any additional comments about the Runway Assignment DST on the Supervisor display.

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Sequencing and Scheduling

Question 22

The Sequencing and Scheduling tab timeline information is useful for departures.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)

- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 23

The Sequencing and Scheduling tab timeline information is useful for arrivals.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 24

The Sequencing and Scheduling tab timeline predictions are accurate for departures.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 25

The Sequencing and Scheduling tab timeline predictions are accurate for arrivals.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 26

The Sequencing and Scheduling tab timelines are easy to understand.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 27

The information provided by the Sequencing and Scheduling tab timelines is sufficient to have an accurate picture of the expected arrival and departure demand.

- Completely disagree (1)
- Somewhat disagree (2)

- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 28

The information provided by the Sequencing and Scheduling tab timelines would enable Tower to reduced delay in operations.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 29

The information provided by the Sequencing and Scheduling tab timelines would improve the ability to schedule airport configuration changes to maximize efficiency of the operation.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 30

The departure metering functionality is an effective means of maintaining an optimal departure queue.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 31

Adequate information on departure metering is provided.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 32

It would be desirable for TFDM to recommend optimal departure sequences and spot release times to balance East/West Tower demand, minimize delay, and minimize fuel burn/emissions.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 33

Please provide any additional comments about the Sequencing and Scheduling DST on the Supervisor display.

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Taxi Routing

Question 34

The taxi route non-conformance prompts are useful.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 35

The taxi route non-conformance prompts are accurate for manually entered routes.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 36

Inputting taxi route for a flight is easy.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)

- Not applicable (N/A)

Question 37

Taxi non-conformance prompts would improve safety.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 38

It would be desirable to perform taxi conformance monitoring using the standard taxi routes as outlined in Letters of Agreement.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 39

Please provide any additional comments about the Taxi Routing DST on the Supervisor display.

Departure Routing

Question 40

The Departure Routing tab information is useful.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 41

The Departure Routing tab information is easy to understand.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)

- Completely agree (5)
- Not applicable (N/A)

Question 42

The Departure Routing weather blockage predictions are accurate.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 43

The information provided by the Departure Routing tab is sufficient to identify potential weather impacts on surface operations.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 44

The Departure Routing information would improve efficiency of surface operations in convective weather situations.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 45

It would be desirable to have a means to view which departure routes have been procedurally “closed” by ZFW in the Departure Routing tab.

- Completely disagree (1)
- Somewhat disagree (2)
- Neutral (3)
- Somewhat agree (4)
- Completely agree (5)
- Not applicable (N/A)

Question 46

It would be desirable to have a means to view and allocate available departure slots based on existing traffic management constraints to individual departure flights.

- Completely disagree (1)
- Somewhat disagree (2)

- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 47

Please provide any additional comments about the Departure Routing DST on the Supervisor display.

Summary Questions

Question 48

Is there anything that would improve the supervisor display for the FLM's or TMC's use?

Question 49

Are there any additional information or features that should be considered on the supervisor display or in the DSTs?

Question 50

Are there any existing features that should be removed from the supervisor display or the DSTs?

Thank you for your feedback on TFDM and SNT! Your feedback is important to us and your participation is appreciated.

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B.5 TFDM Integration Questionnaire

DFW-2 TFDM/SNT Evaluation

TFDM Integrated Display Questionnaire

Welcome to the DFW Staffed NextGen Tower (SNT) and Tower Flight Data Manager (TFDM) Field Demonstration #2 evaluation surveys. The following survey questions address the shared features of and interaction between the TFDM displays and their use in supplemental SNT, and are for analytical purposes only.

Please respond and comment about your assessment of the interoperability of the TFDM displays at DFW. Any button or text box may be left unchecked or unfilled, respectively, at your discretion. Use your browser BACK button to return to the previous survey page. Click SUBMIT at the end of this page to be directed to the appropriate set of questions based on your experience with this first field demonstration.

All your answers will be kept confidential and will be used by MIT Lincoln Laboratory for research purposes only.

The Tower Flight Data Manager (TFDM) refers to the integrated display system consisting of the TIDS, the FDM, and the supervisor display.

The Tower Information Display System (TIDS) provides graphical surveillance information overlaid on an airport map. Information such as aircraft callsign, speed, and altitude are provided in data block format and are associated with surveillance targets.

The Flight Data Manager (FDM) provides flight data information in the form of electronic flight data entries (FDEs) and allows interaction and control exchange with the FDEs.

The Supervisor display provides access to decision support tools (DSTs) that provide tower supervisors with predictions of upcoming airport events and suggests possible actions to improve airport operations. These DSTs include Runway Assignment, Taxi Routing, Departure Routing, Sequencing and Scheduling, and Airport Configuration.

SNT is planned to be implemented in three phases: supplemental, flexible, and full. Supplemental SNT provides tower controllers with the TFDM and camera displays in current operational towers; these displays are used to supplement the out-the-window view provided by traditional towers. This implementation is the one currently being investigated in this user group and in field demonstrations DFW-1 and DFW-2.

The flexible phase will allow controllers to utilize the TFDM and camera displays in situations where all airport surfaces may not be visible via the out-the-window view; the full SNT phase will use TFDM and camera displays to provide air traffic control at a tower-level caliber from remotely-located control facilities.

Question 1

Interaction between the displays occurs quickly enough to provide ATC services.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)

- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 2

Information is consistent between the displays.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 3

The information presented by TFDM is consistent.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 4

When data was changed, the changes were reflected on all displays.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 5

The coordinated selection highlighting on the TIDS and FDM is useful.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 6

TFDM will be beneficial to the NAS as a whole.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)

- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 7

TFDM will be beneficial to tower controllers.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 8

Supplemental SNT will be beneficial to the NAS as a whole.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Question 9

Supplemental SNT will be beneficial to tower controllers.

- ❍ Completely disagree (1)
- ❍ Somewhat disagree (2)
- ❍ Neutral (3)
- ❍ Somewhat agree (4)
- ❍ Completely agree (5)
- ❍ Not applicable (N/A)

Thank you for your feedback on TFDM and SNT! Your feedback is important to us and your participation is appreciated.

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B.6 Flight Test Scenarios Questionnaire

DFW-2 TFDM/SNT Evaluation

Flight Test Scenarios

Welcome to the DFW Staffed NextGen Tower and Tower Flight Data Manager Field Demonstration #2 evaluation surveys. The following survey questions address the integrated display system of the SNT and TFDM displays and their performance in specific ATC scenarios, and are for analytical purposes only.

Please respond and comment about your assessment of SNT and TFDM at DFW. Any button or text box may be left unchecked or unfilled, respectively, at your discretion. Use your browser BACK button to return to the previous survey page. Click SUBMIT at the end of this page to be directed to the appropriate set of questions based on your experience with this first field demonstration.

All your answers will be kept confidential and will be used by MIT Lincoln Laboratory for research purposes only.

Tower Information Display System (TIDS) provides graphical surveillance information overlaid on an airport map. Information such as aircraft call sign, speed, and altitude are provided in data block format and are associated with surveillance targets.

Flight Data Manager (FDM) provides flight data information in the form of electronic flight data entries (FDEs) and allows interaction and control exchange with the FDEs.

The Tower Flight Data Manager (TFDM) refers to the integrated display system consisting of the TIDS and the FDM.
Long-range and fixed-array camera displays are provided to assist controllers in control tasks as part of the supplemental Staffed NextGen Tower display suite evaluation.

These scenario questions refer to the specific scenarios that are included in the shadow operations evaluation session for DFW-2.

Aircraft Tracking

Question 1 It was easy to recognize when the aircraft became airborne or touched down.

Question 2 The display was useful in helping to recognize that the aircraft was airborne or had touched down.

- TIDS
- FDM
- Scanning camera
- Panoramic display
- OTW

Question 3 It was easy to track the aircraft on arrival and departure.

Question 4 The display was useful in helping to track the aircraft on arrival and departure.
TIDS
FDM
Scanning camera
OTW

Question 5 The display provided appropriate information to monitor arrivals and departures.
TIDS
FDM
Scanning camera
Panoramic display
OTW

Question 6 What display features provided the most useful information for monitoring arriving and departing aircraft? Why?

Question 7 What information could be provided on the displays to improve arrival and departure monitoring?

Flyby

Question 8 It was easy to observe the aircraft gear status during the flyby.

Question 9 The display was useful in helping to recognize the aircraft state.
TIDS
Scanning camera
Panoramic display
OTW

Question 10 The display provided appropriate information to deal with the situation.
TIDS
FDM
Scanning camera
Panoramic display
OTW

Question 11 What display component provided the most useful information for helping to recognize the situation? Why?

Question 12 What information could be provided on the TIDS or FDM to improve the ability to recognize this situation?

Flight Plan Amendment

Question 13 It was easy to recognize that the aircraft's flight plan had changed.

Question 14 The display was useful in helping to recognize that the flight plan had changed.
- TIDS
- FDM

Question 15 The display provided appropriate information to deal with the situation.
- TIDS
- FDM

Question 16 The display provided information about the situation in a timely manner.
- TIDS
- FDM

Question 17 What display component provided the most useful information for helping to recognize the situation? Why?

Question 18 What display component provided the least useful information for helping to recognize the situation? Why?

Question 19 What information could be provided on the displays to improve the ability to recognize this situation?

Taxi Route Deviation

Question 20 It was easy to recognize the aircraft's deviation from the assigned taxi route.

Question 21 The display was useful in helping to recognize the taxi route deviation.
- TIDS
- FDM
- Scanning camera
- Panoramic display
- OTW

Question 22 The display provided appropriate information to deal with the situation.
- TIDS
- FDM
- Scanning camera
- Panoramic display
- OTW

Question 23 What display component provided the most useful information for helping to recognize the situation? Why?

Question 24 What information could be provided on the displays to improve the ability to recognize this situation?

Incorrect Beacon Code

Question 25 It was easy to recognize the incorrect beacon code.

Question 26 The display was useful in helping to recognize the incorrect beacon codes.
TIDS
FDM

Question 27 The display provided appropriate information to deal with the situation.
TIDS
FDM

Question 28 What display component provided the most useful information for helping to recognize the situation? Why?

Question 29 What information could be provided on the displays to improve the ability to recognize this situation?

B.7 Workload Assessment Questionnaire

DFW-2 TFDM/SNT Evaluation

Workload Assessment

Welcome to the DFW-2 TFDM/SNT workload assessment survey. All your answers will be kept confidential and will be used by MIT Lincoln Laboratory for research purposes only.

This survey addresses controller workload and effort incurred by the TFDM and SNT systems and how it affected your performance. Please answer the following questions based on your experiences with the TFDM and SNT displays.

Situational Awareness

Question 1 Rate the average demand you experienced while maintaining situational awareness during the day.
- Mental demand
- Physical demand
- Time demand

Question 2 On average, how successful were you in maintaining situational awareness throughout the day?

Question 3 On average, how hard did you have to work to maintain situational awareness throughout the day?

Question 4 On average, how insecure, discouraged, irritated, stressed, and annoyed were you while maintaining situational awareness throughout the day?

Question 5 Were there any points during the day where your effort, performance, frustration, or demand was higher than average while maintaining your situational awareness? If so, what occurred to increase the levels, and how high were they?

Information Monitoring

Question 6 Rate the average demand you experienced while monitoring traffic and compliance during the day.
- Mental demand
- Physical demand
- Time demand

Question 7 On average, how successful were you in monitoring traffic and compliance throughout the day?

Question 8 On average, how hard did you have to work to monitor traffic and compliance throughout the day?

Question 9 On average, how insecure, discouraged, irritated, stressed, and annoyed were you while monitoring compliance throughout the day?

Question 10 Were there any points during the day where your effort, performance, frustration, or demand was higher than average while monitoring traffic and compliance? If so, what occurred to increase the levels, and how high were they?

Workload

Question 11 To what degree did the following elements contribute to your level of workload?

OTW view
TIDS
FDM
Scanning camera
Panoramic display
Supervisor display

Question 12 On average, rate your overall workload throughout the day.

Question 13 Were there any points during the day where your workload was higher than average? If so, what occurred to increase the levels, and how high were they?

Question 14 Please provide any additional comments on your workload and the effect of TFDM/SNT systems on it during this evaluation.

APPENDIX C
REPORTED SURVEILLANCE PROBLEMS

Date	Time	Problem Type	Cause	Comments
4/26/2011	13:14	Incorrect aircraft state	Surface Monitor Crash	N235MC shown in cyan on Y bridge; definitely not airborne
4/26/2011	13:21	Missing target	Not reproducible	AAL1185 missing target @EJ
4/26/2011	13:23	Incorrect aircraft state	Surface Monitor Crash	COA1708 issue
4/26/2011	15:25	Flashing target	Target shows drop messages near takeoff	EGF2919 flashing on departure
4/26/2011	16:10	Incorrect aircraft state	Issue w/track merge/split logic. Fixed in latest code.	Target w/beacon code 2372 showing cyan @EK—not airborne. Also frozen in position.
4/26/2011	16:11	Caterpillar	Known Target Broker issue	Target w/beacon code 5274 caterpillaring on west side
4/26/2011	16:11	Unknown target	Lost system track	EGF2715 changed to unknown, then retagged on departure
4/26/2011	16:18	Caterpillar	Known Target Broker issue	AAL1430 caterpillaring. Changed to beacon code 6270, which was incorrect.
4/26/2011		Data tag loss	Machine was IO bound due to incorrect logging settings.	North side TIDS lost all data tags twice
4/26/2011		Surface monitor crash	Unknown – Scripts put in place to Monitor and restart	Surface monitor crash
4/27/2011	13:09	Aircraft orientation	Track number changes multiple times. System has trouble merging tracks.	AMF1320 cockeyed on runway.

4/27/2011	13:41	Frozen target	Issue w/track merge/split logic. Fixed in latest code.	Overflight target 2225 frozen over C terminals. Overflight filter possibly not turned on.
4/27/2011	14:43	Missing target	Not reproducible	AAL1185, AAL817 w/runway assignments for 36R on east side; not seen on TIDS
4/27/2011	15:48	Caterpillar	Known Target Broker issue	FLC caterpillaring while crossing 35L at A.
4/27/2011	16:14	Flashing target	Not reproducible	COM275 arrival flashing at 35C; disappearing for 3-4 updates at one time
4/28/2011	13:00	Split target	System track split. System has trouble merging tracks.	FIV431 split on departure rwy; left unknown target on threshold which disappeared shortly after a/c started t/o roll
4/28/2011	13:05	Flashing target	Multiple track drop messages sent	EGF2727 flashing while exiting west side ramp
4/28/2011	13:10	Flashing target	Not reproducible. Target w/call sign AAL660 not found.	AAL660 flashing in front of terminal A while taxiing north
4/28/2011	13:16	Caterpillar	Known Target Broker issue	5165 caterpillaring
4/28/2011	13:29	Flashing target	Multiple track drop messages sent	Unknown target flashing by M5/M6; no a/c in that location
4/28/2011	13:48	Unknown target	Not enough information to reproduce. Likely lost system track.	Unknown target shown
4/28/2011	14:09	Caterpillar	Known Target Broker issue	AL393 caterpillaring. Going across bridge to west side.
4/28/2011	14:45	Flashing target	Multiple track drop messages sent	DAL811 flashing during taxi; intermittent, inconsistent flashing.
4/28/2011	15:00	Jumping target	Multiple track drop messages sent	AAL1609 jumping/dancing in C gate area.
4/28/2011	15:17	Unknown target	Lost system track	Departure from 35L turned to unknown once airborne.
4/28/2011	15:40	Flashing target	Multiple track drop messages sent	AAL1209 jumping/flashing in A gate area.

4/28/2011	15:52	Caterpillar	Known Target Broker issue	FLC caterpillaring; beacon code changed to 1204.
4/28/2011	16:04	Unknown target	Target not associated with flight ID	AAL708 not tagged. No target seen when pushing back; had nose-to-nose situation w/target that missed intersection.
4/28/2011	17:26	Caterpillar	Known Target Broker issue	Unknown overflight leaving trail from east to west across E gate area.
4/28/2011	17:33	Flashing target	Multiple track drop messages sent	AAL1705 blinking in A gate area.
4/28/2011	17:33	Lost data block	May be due to machine being IO bound	Data block dropped on TIDS due to click on FDE; left click returns data block.
4/28/2011	17:43	Lost data block	Machine was IO bound due to incorrect logging settings.	Data block dropped again
4/28/2011	17:45	Caterpillar	Known Target Broker issue	Target w/xpdr off during taxi. Tagged up w/beacon code 0552 and started caterpillaring. Tagged up as TCF7539 once beacon code set correctly as 0562.
5/3/2011	13:03	Display freeze	Kernel panic	FDM freeze
5/3/2011	14:40	Display freeze	Kernel panic	Displays froze—TIDS, FDM, camera.
5/3/2011	15:17	Dual data tag	Dropped arrival track linked to active departure track	AAL1113/AAL567—single target has two data tags. 1113 is a departure and has an FDE; 567 is arrival. 567 tag gone once target moved to west side.
5/3/2011	15:19	Flashing target	Multiple track drop messages sent	AAL1743 flashing in A gates, west side.
5/3/2011	15:26	Flashing target	Multiple track drop messages sent	EGF3319 flashing in B gates
5/3/2011	15:43	Dual target	Dropped arrival track is incorrectly filled in with taxiing departure track	AAL2050 has double target with AAL1629 on twy K

5/3/2011	17:31	Flashing target, caterpillar	Known Target Broker issue	EGF2863 flashing, caterpillaring on departure from 17R.
5/4/2011	12:30	Caterpillar	Known Target Broker issue	Unknown target
5/4/2011	12:52	Caterpillar	Known Target Broker issue	5320 unknown on west side
5/4/2011	13:17	Caterpillar	Known Target Broker issue	3254 caterpillaring
5/4/2011	15:23	Caterpillar	Known Target Broker issue	1200 caterpillaring
5/4/2011	15:40	Stuck camera	Cause unknown. Investigation ongoing.	South scanning camera stopped tracking
5/4/2011	15:55	Caterpillar	Known Target Broker issue	6550 caterpillaring
5/4/2011	16:18	Inconsistent views	Cause unknown. Investigation ongoing.	Flights shown in PiP flashing; targets in main window were not. Visible on north display.
5/4/2011	17:26	Flashing target	Multiple track drop messages sent	DAL1791 flashing
5/4/2011	19:31	Flashing target	Not reproducible	AAL1625 flashing on 9nm arrival to 17C. Stopped blinking once established
5/5/2011	13:43	Caterpillar	Known Target Broker issue	Unknown target caterpillaring in A gates. Tagged up as AAL540.
5/5/2011	14:41	Caterpillar	Known Target Broker issue	AAL1841 caterpillaring at C gates. Also no FDE available. Target tagged up w/incorrect beacon code (2223). Caterpillar removed once beacon code corrected.
5/5/2011	14:46	Flashing target	Multiple track drop messages sent	EGF3318 flashing at D gates
5/5/2011	14:48	Caterpillar	Known Target Broker issue	CJC3252 incorrect beacon code (2415) resulted in caterpillar. Correcting code to 2212 removed caterpillar.

5/5/2011	15:19	Caterpillar	Known Target Broker issue	MES3087 caterpillaring as unknown on L by C and A gates. Tagged up with ACID at departure end of rwy.

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APPENDIX D
CHI SQUARE AND AVERAGE RESULTS FOR TIDS

The following is a detailed report of the chi square and averages results for TIDS in both supplemental and contingency/flexible SNT contexts. For all charts, the Y axis (ordinate) was configured to depict maximum observed frequencies.[3]

Chi Square analysis to test for statistical significance of the average response, along with means and standard deviations are presented here. Significant Chi Square results are highlighted in gray and indicate that at least one response option was statistically significant. Note that non-significant Chi Square results indicate that participants, as a whole, did not prefer any particular response option. The TIDS questionnaire consisted of agreement Likert scale items. The success criteria for the agreement scale was somewhat agree or above.

D.1 Tower Information Display System

The following is a detailed report of the chi square results for TIDS. For a general summary with means and standard deviations, see Table D-1.

[3] Observed frequencies are not consistent across analyses since not all participants answered all questions, and not all questions applied to all participants. Questions that were not applicable, marked as N/A, were identified with § and omitted from the Chi Square statistical analyses.

D.1.1 Target Information

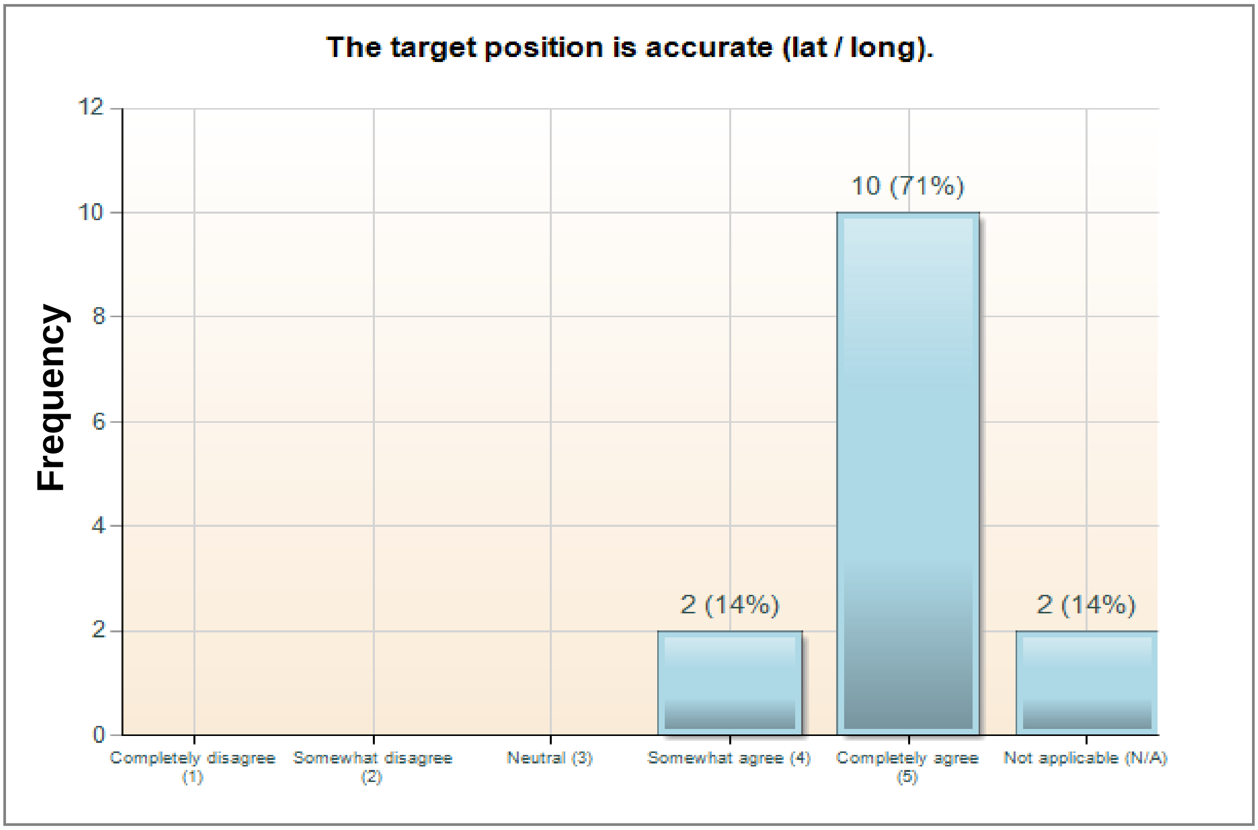

Figure D-1: Accuracy of target position

As shown in Figure D-1, there was a significant difference between observed ratings and expected ratings for perceived accuracy of target position (lat/long). More participants than expected completely agreed that the target position was accurate, χ^2 (4, N = 12[§]) = 31.33, $p < .05$.

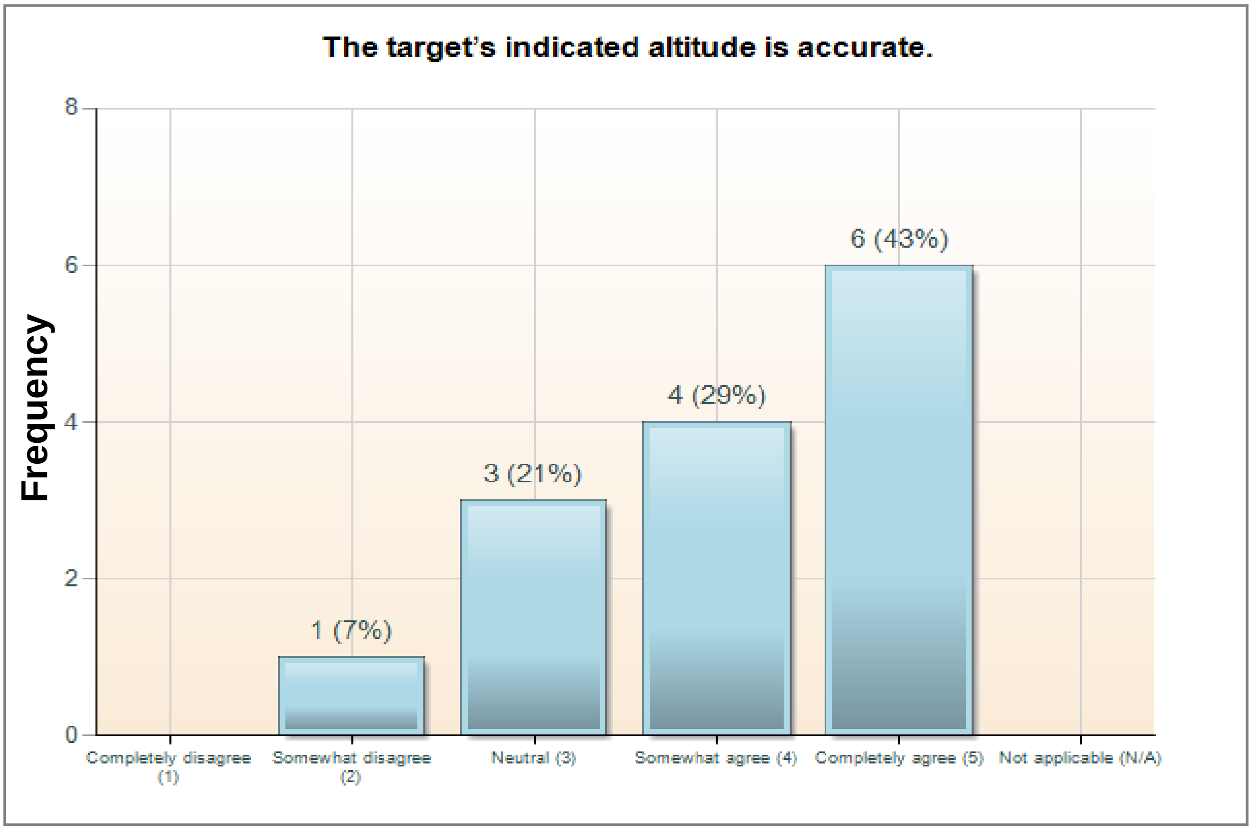

Figure D-2: Accuracy of indicated altitude

As shown in Figure D-2, there was no significant difference between observed ratings and expected ratings for perceived accuracy of target indicated altitude, χ^2 (4, N = 14) = 8.14, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or somewhat disagree with the perceived accuracy.

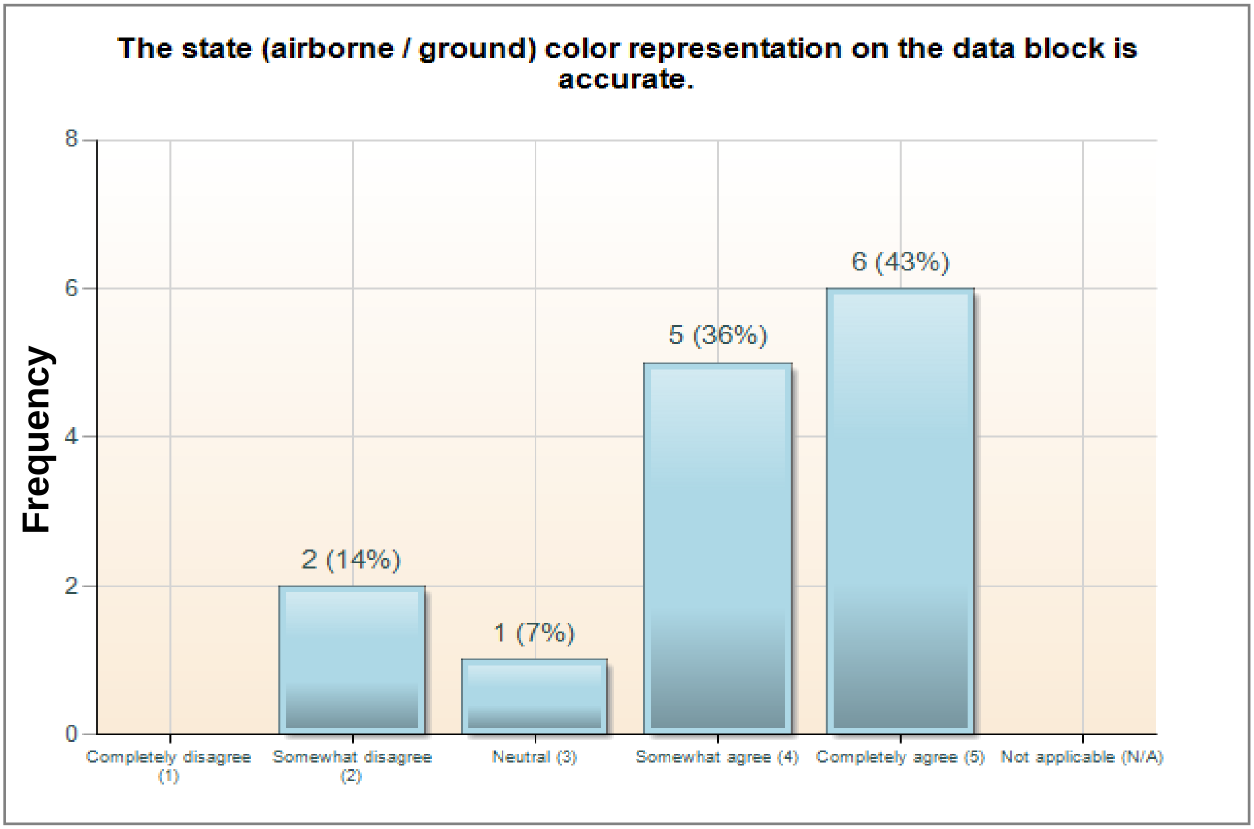

Figure D-3: Accuracy of the state color presentation on the data block

As shown in Figure D-3, there was a significant difference between observed ratings and expected ratings for perceived accuracy of the state (airborne/ground) color presentation on the data block. More participants than expected completely agreed or somewhat agreed that the color presentation was accurate, χ^2 (4, N = 14) = 9.57, p < .05.

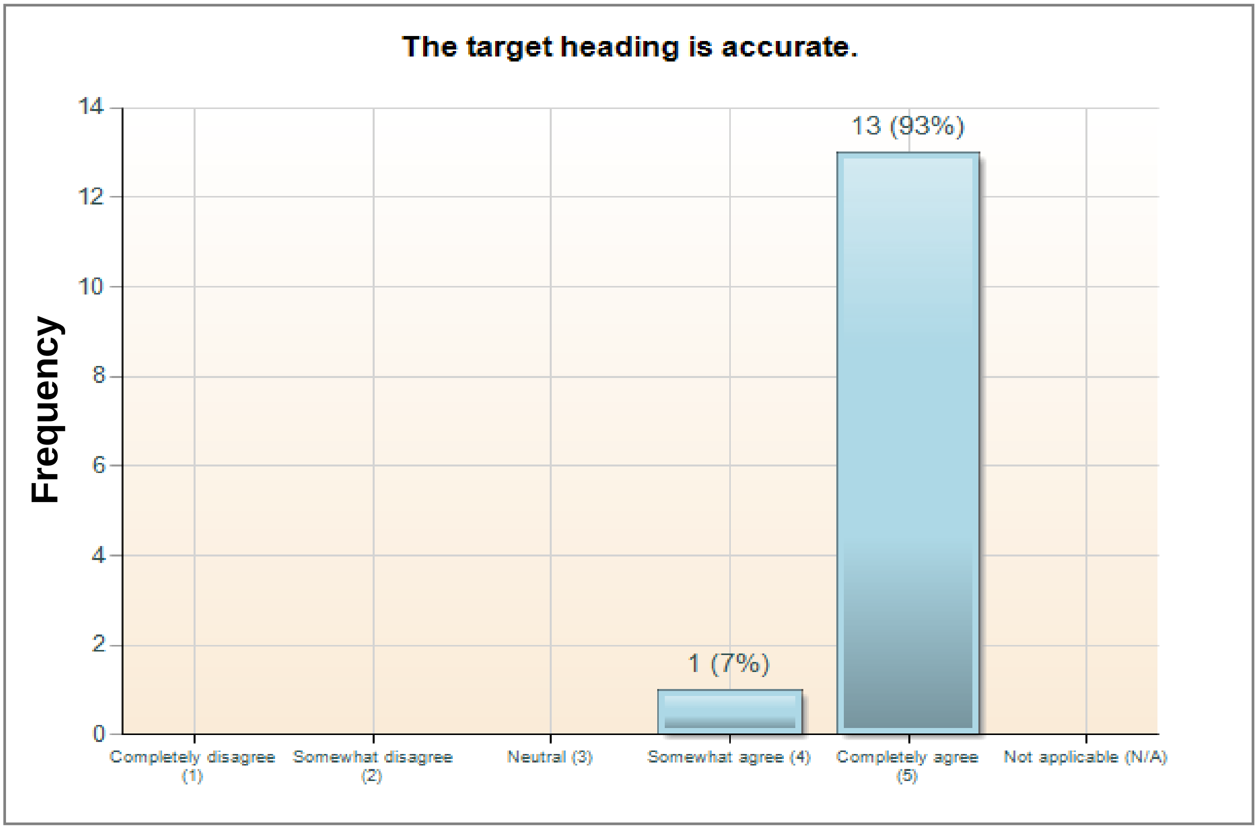

Figure D-4: Accuracy of the target heading

As shown in Figure D-4, there was a significant difference between observed ratings and expected ratings for perceived accuracy of the target heading. More participants than expected completely agreed that the target heading was accurate, χ^2 (4, N = 14) = 46.71, p < .05.

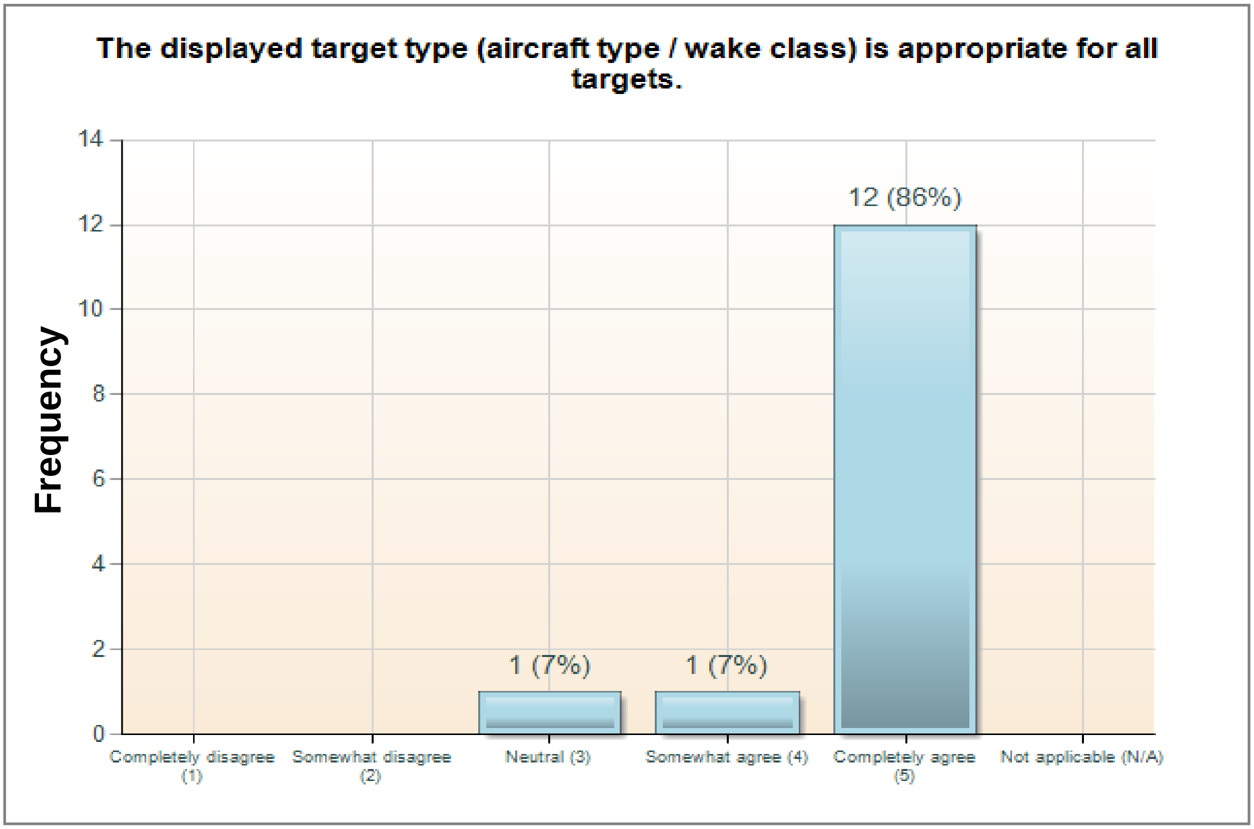

Figure D-5: Accuracy of the target type.

As shown in Figure D-5, there was a significant difference between observed ratings and expected ratings for perceived appropriateness of the displayed target type (aircraft type/wake class) for all targets. More participants than expected completely agreed that the displayed target type was appropriate for all targets, χ^2 (4, N = 14) = 38.14, p < .05.

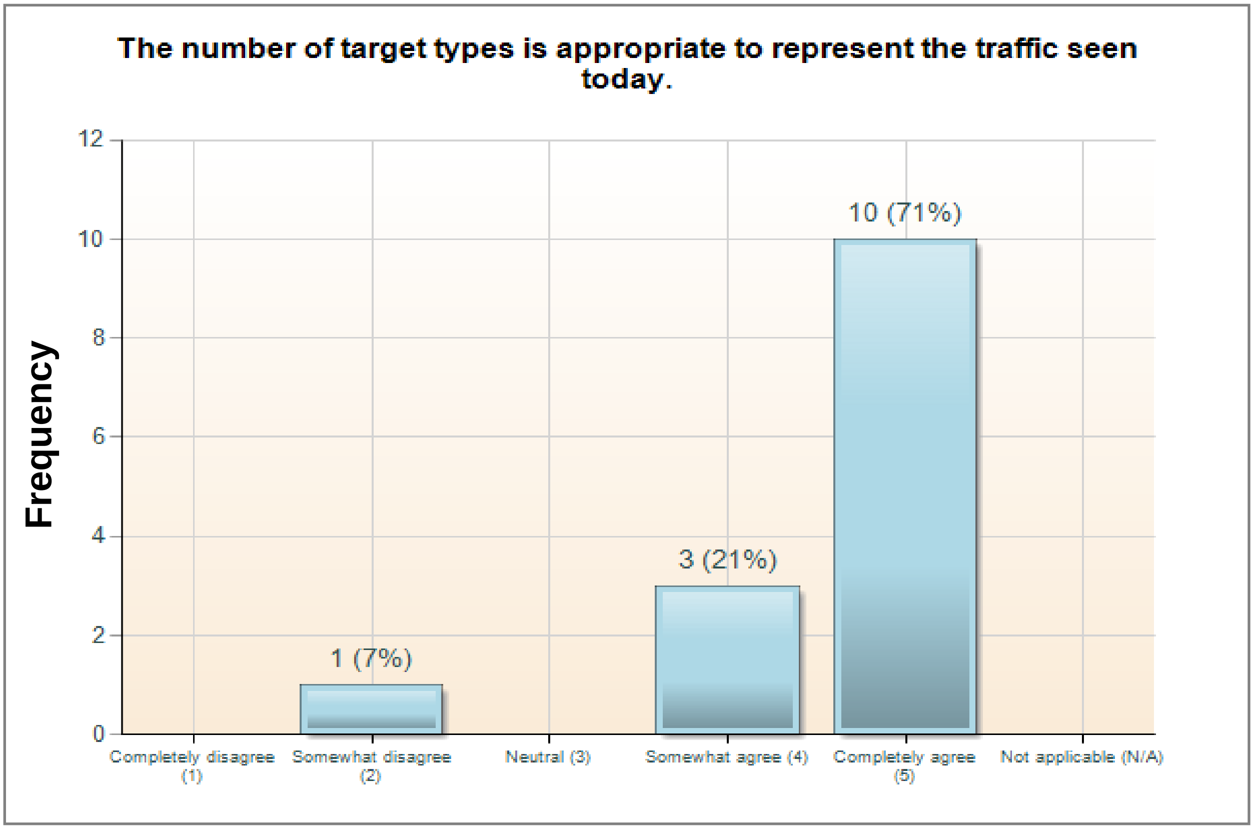

Figure D-6: Appropriateness of display target type.

As shown in Figure D-6, there was a significant difference between observed ratings and expected ratings for perceived appropriateness of the number of target types to represent the traffic seen today. More participants than expected completely agreed that number of target types were appropriate, χ^2 (4, N = 14) = 25.28, $p < .05$.

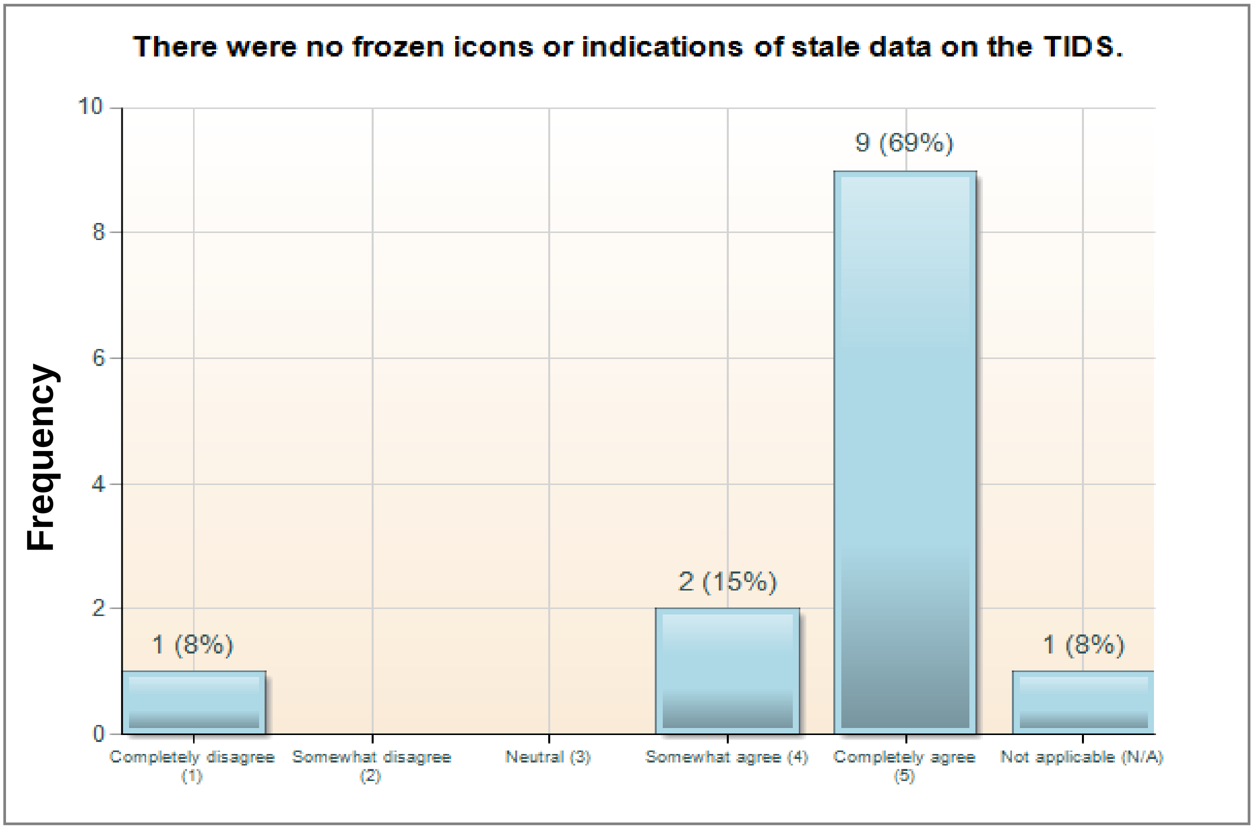

Figure D-7: Lack of number of stale data

As shown in Figure D-7, there was a significant difference between observed ratings and expected ratings for perceived lack of frozen icons or indications of stale data on the TIDS. More participants than expected completely agreed that there were no frozen icons or indications of stale data, χ^2 (4, N = 12[§]) = 23.83, p < .05.

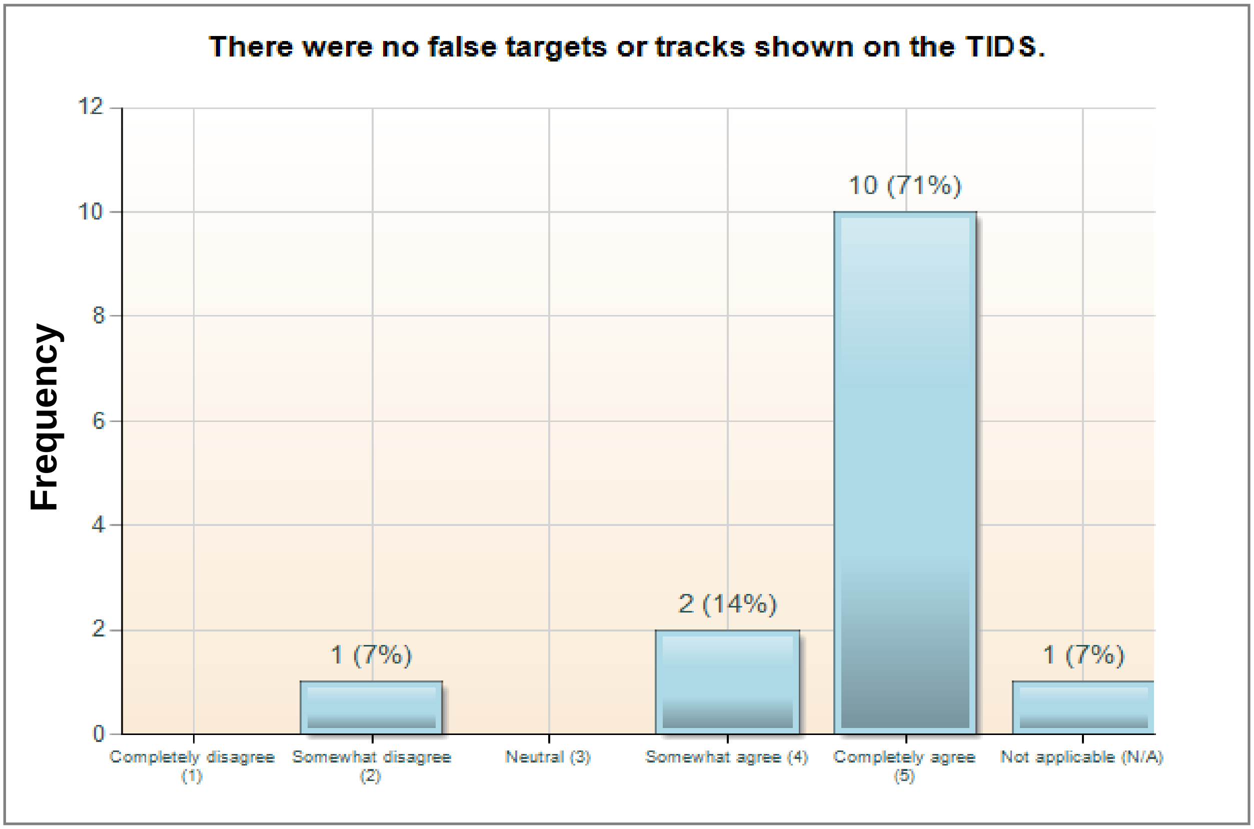

Figure D-8: Lack of false icons or tracks shown

As shown in Figure D-8, there was a significant difference between observed ratings and expected ratings for perceived lack of false targets or tracks shown on the TIDS. More participants than expected completely agreed that there were no false targets or tracks, χ^2 (4, N = 13[§]) = 27.38, $p < .05$.

D.1.2 Information Accuracy and Availability

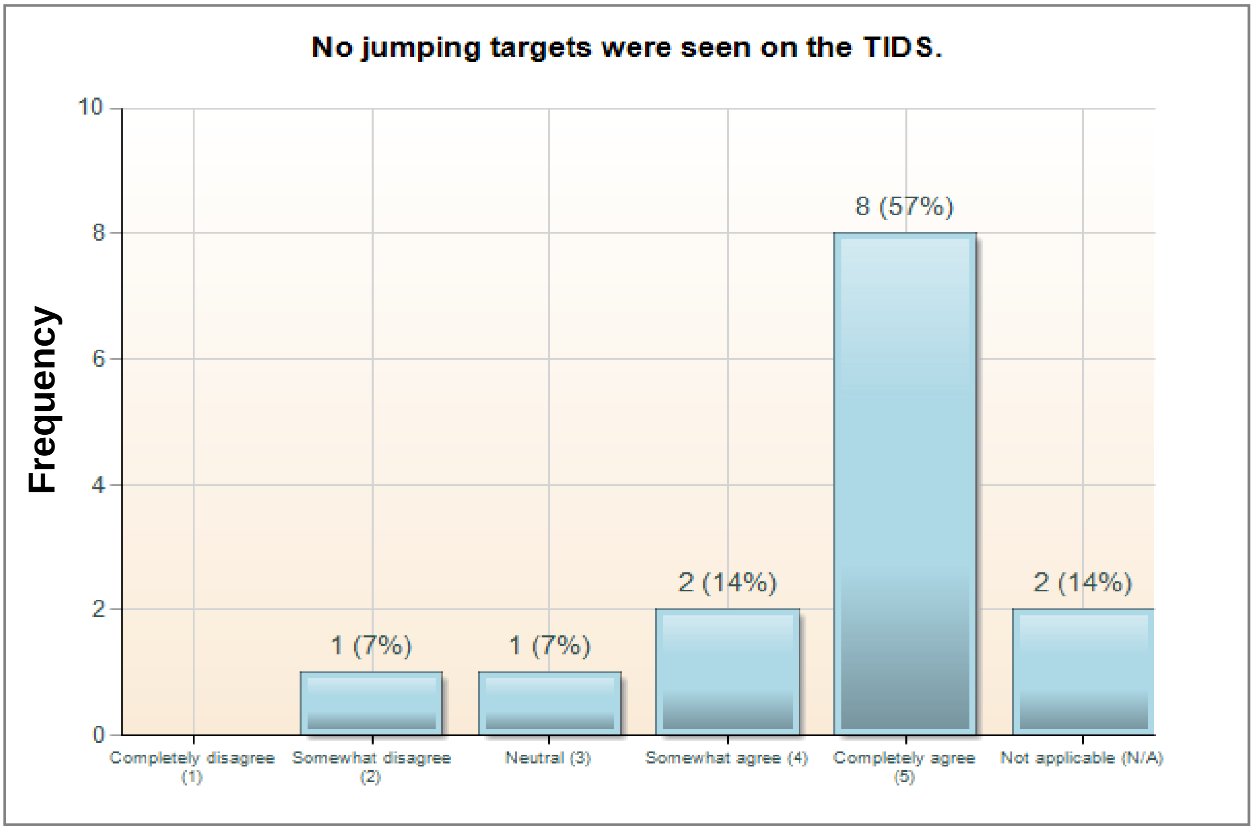

Figure D-9: Lack of jumping targets

As shown in Figure D-9, there was a significant difference between observed ratings and expected ratings for perceived lack of jumping targets seen on the TIDS. More participants than expected completely agreed that there were no jumping targets, χ^2 (4, N = 12[§]) = 17.16, $p < .05$.

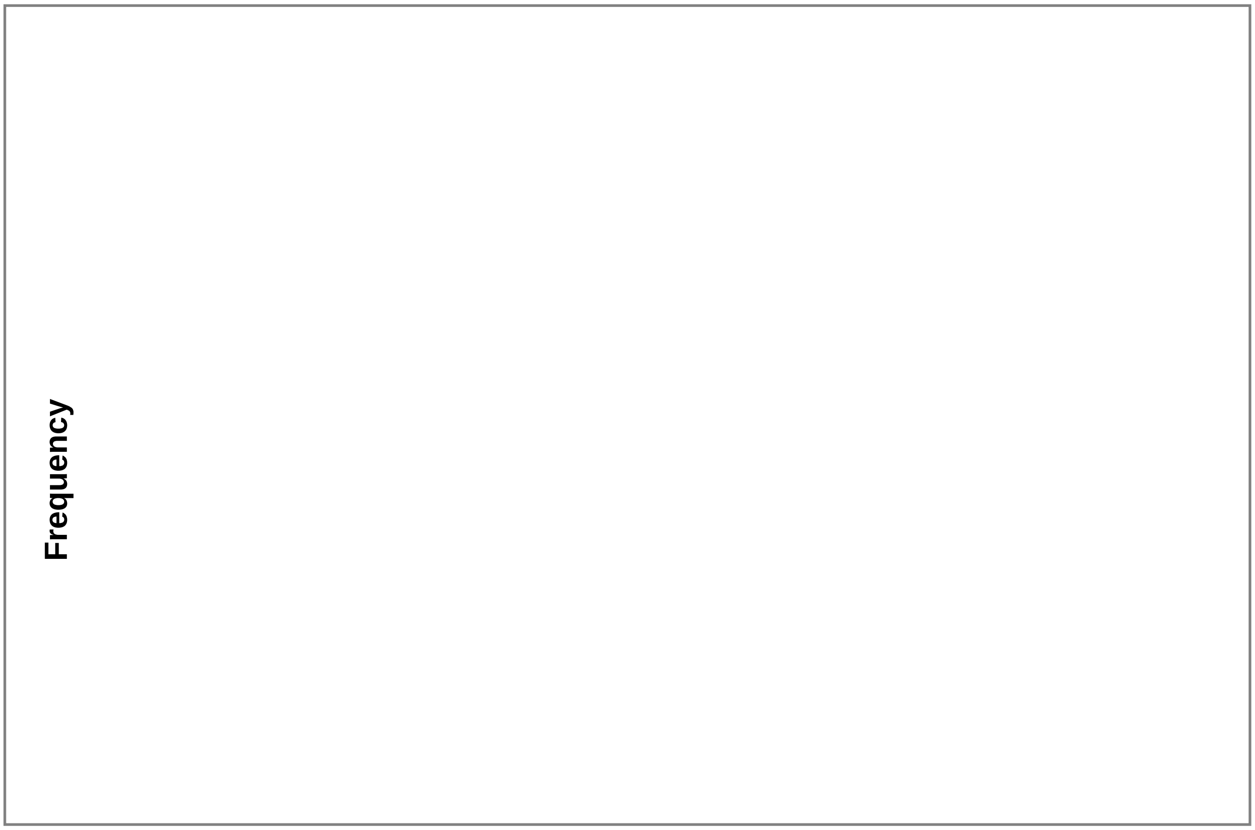

Figure D-10: Appropriateness of TIDS information to ground controllers

As shown in Figure D-10, there was a significant difference between observed ratings and expected ratings for perceived appropriateness of TIDS information to ground controllers, χ^2 (4, N = 14) = 25.28, $p < .05$. More participants than expected completely agreed that TIDS provides appropriate information.

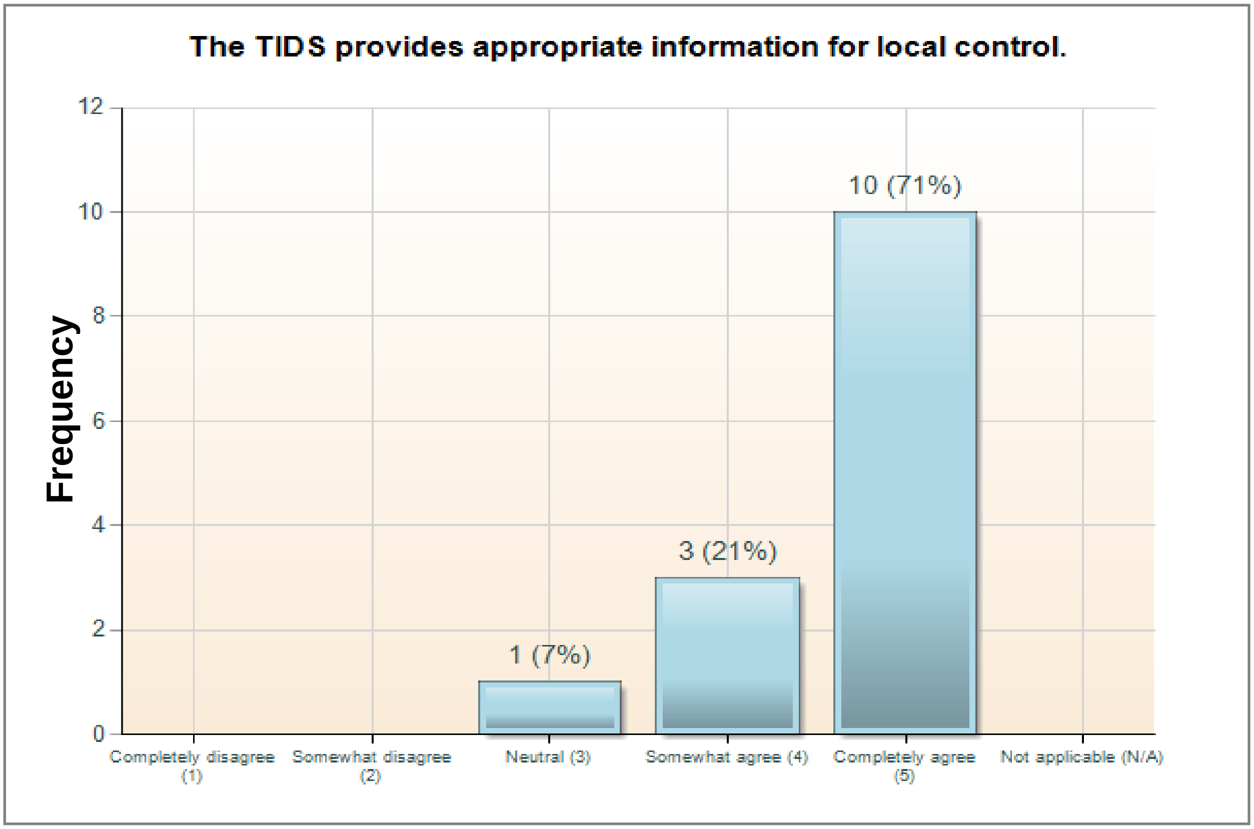

Figure D-11: Appropriateness of TIDS information to local controllers

As shown in Figure D-11, there was a significant difference between observed ratings and expected ratings for perceived appropriateness of TIDS information to local controllers, χ^2 (4, N = 14) = 25.28, p < .05. More participants than expected completely agreed that TIDS provides appropriate information.

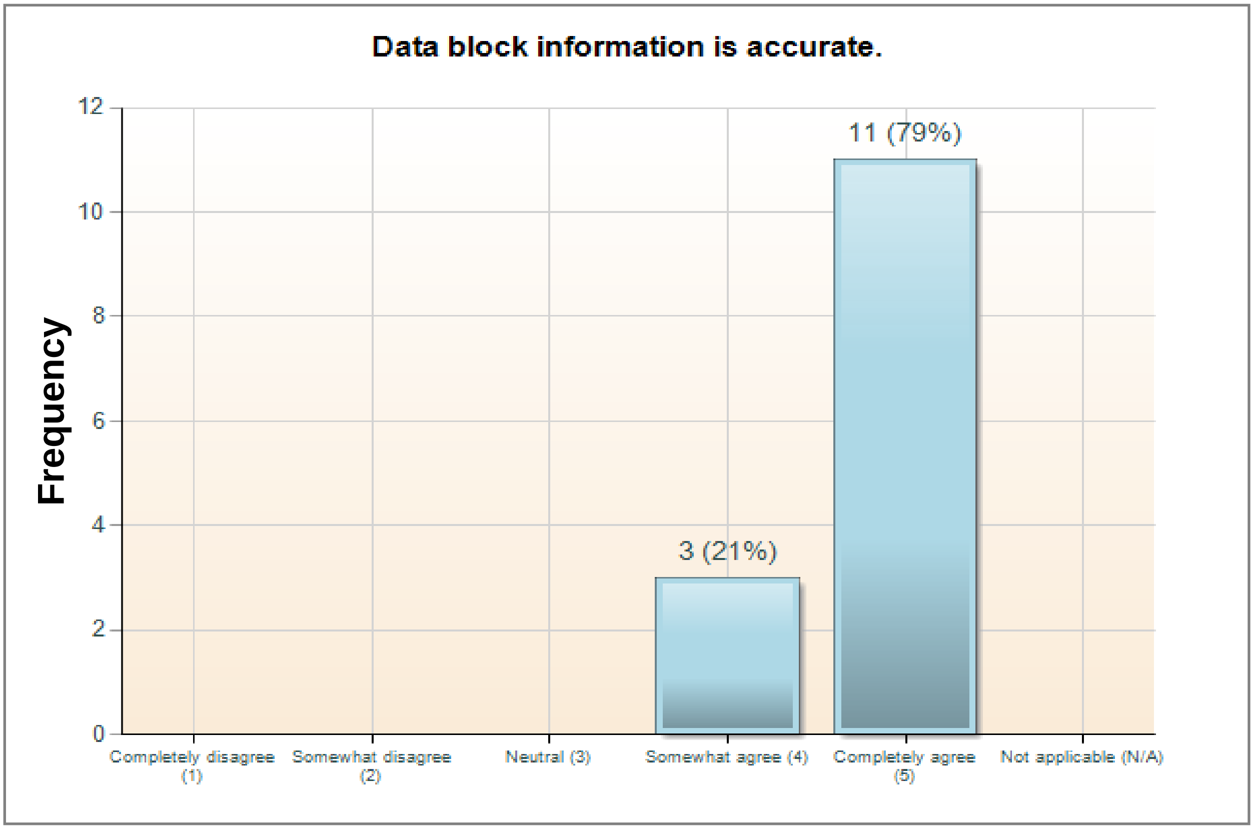

Figure D-12: Accuracy of TIDS information

As shown in Figure D-12, there was a significant difference between observed ratings and expected ratings for perceived accuracy of data block information, χ^2 (4, N = 14) = 32.42, $p < .05$. More participants than expected completely agreed that the data block information was accurate.

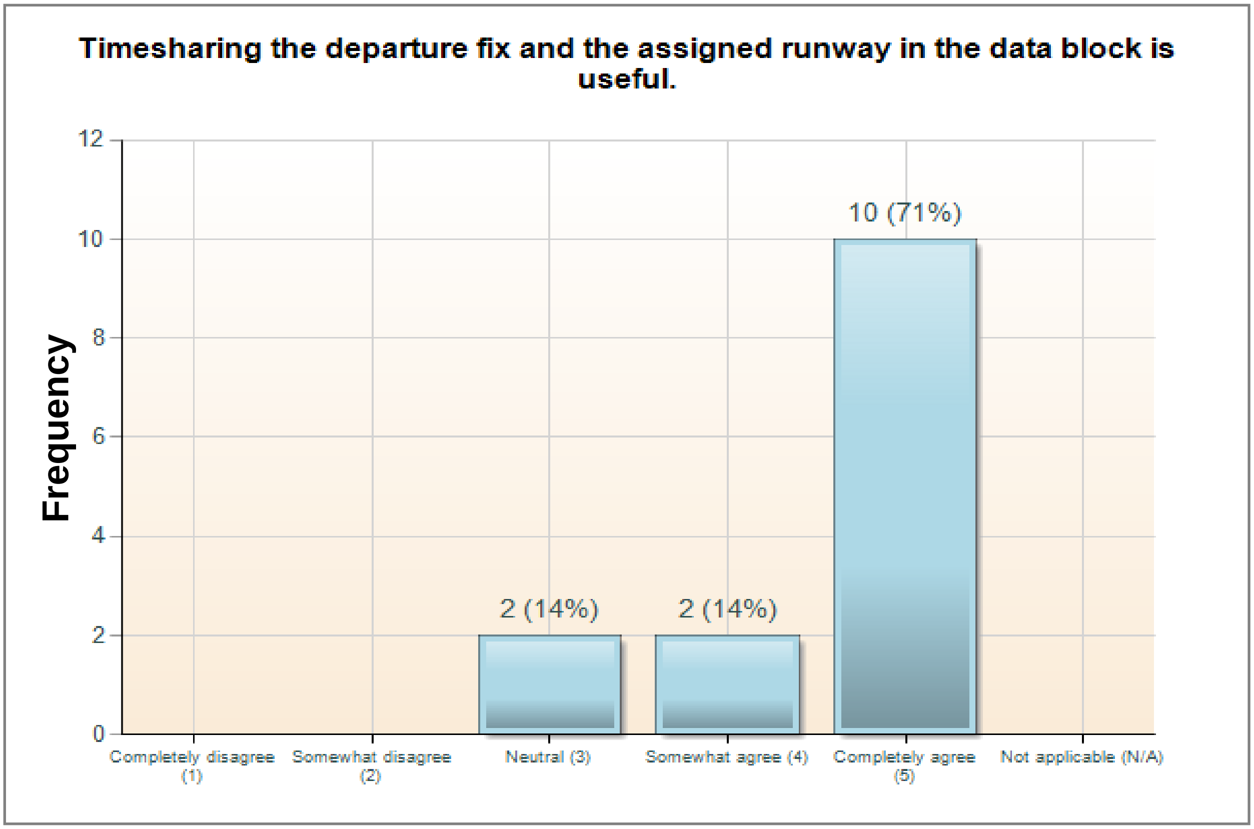

Figure D-13: Accuracy of data block

As shown in Figure D-13, there was a significant difference between observed ratings and expected ratings for perceived usefulness of timesharing the departure fix and the assigned runway in the data block, $\chi^2(4, N = 14) = 24.57$, $p < .05$. More participants than expected completely agreed that timesharing the departure fix and the assigned runway was useful.

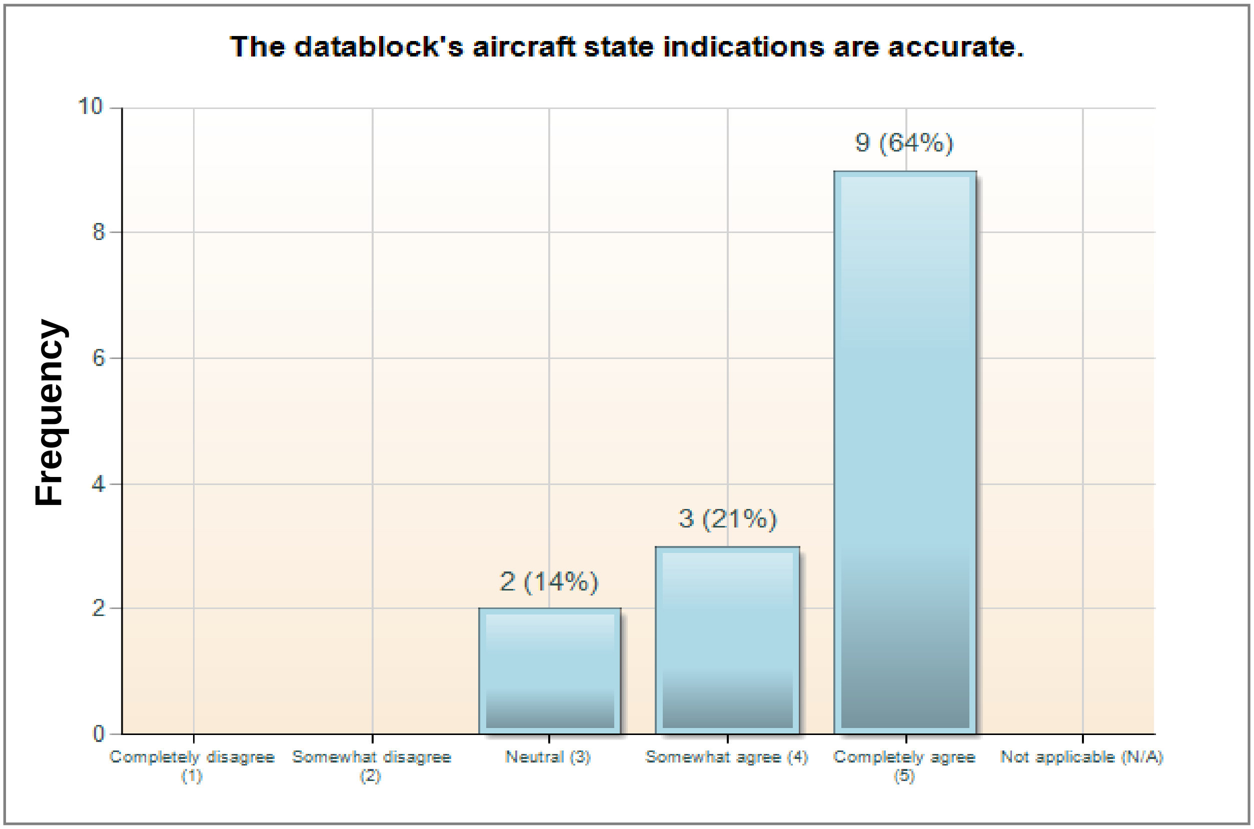

Figure D-14: Accuracy of data block

As shown in Figure D-14, there was a significant difference between observed ratings and expected ratings for perceived accuracy of the data block's aircraft state indications, χ^2 (4, N = 14) = 19.57, p < .05. More participants than expected completely agreed that the state indications were accurate.

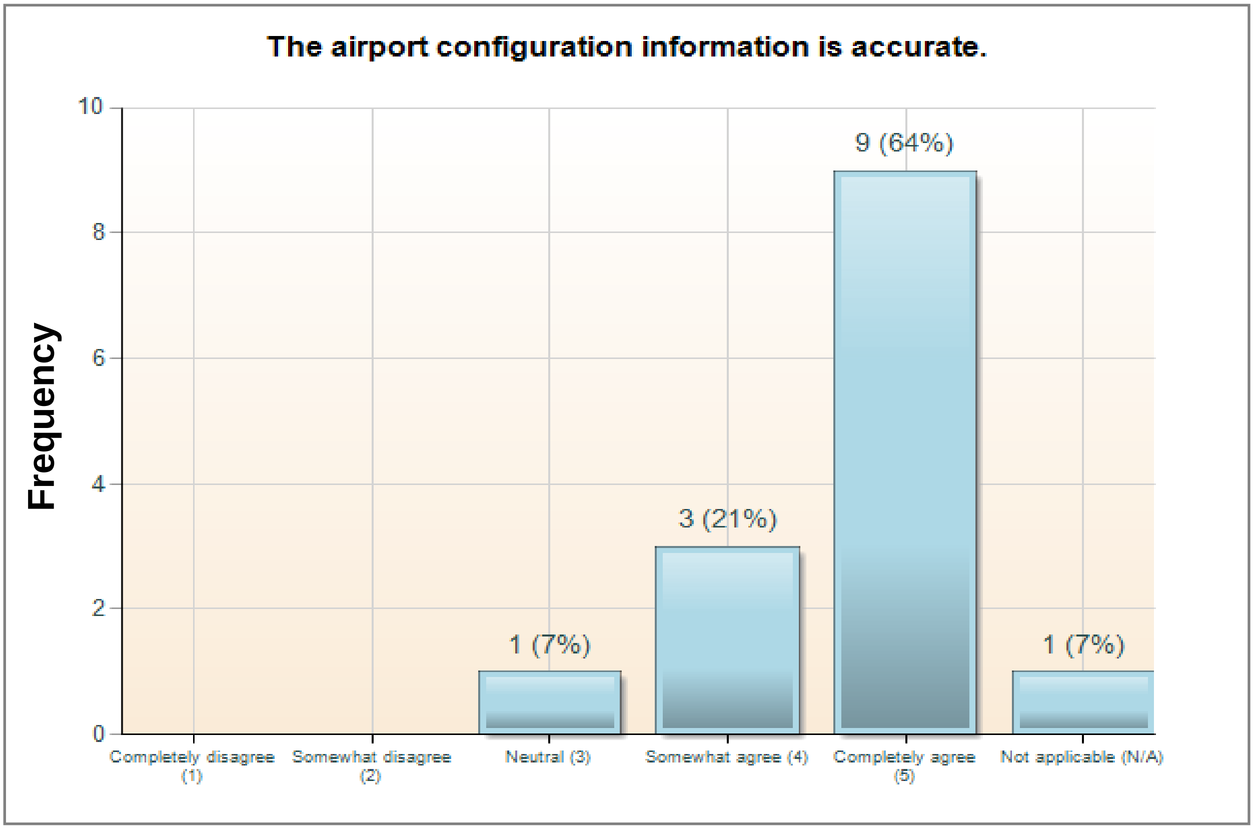

Figure D-15: Accuracy of airport configuration information

As shown in Figure D-15, there was a significant difference between observed ratings and expected ratings for perceived accuracy of the airport configuration information, χ^2 (4, N = 13[§]) = 22.00, p < .05. More participants than expected completely agreed that the airport configuration information was accurate.

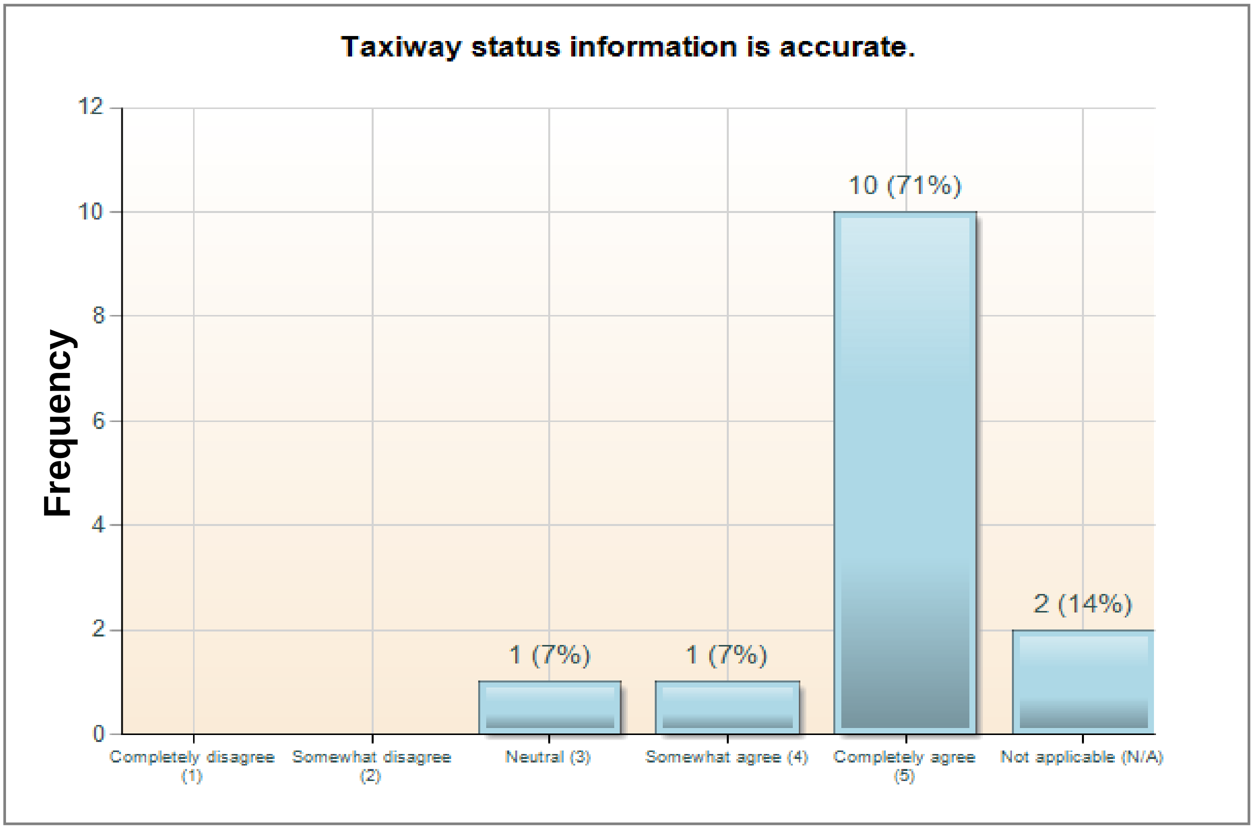

Figure D-16: Accuracy of taxiway status information

As shown in Figure D-16, there was a significant difference between observed ratings and expected ratings for perceived accuracy of the taxiway status information, χ^2 (4, N = 12§) = 30.50, p < .05. More participants than expected completely agreed that the taxiway status information was accurate.

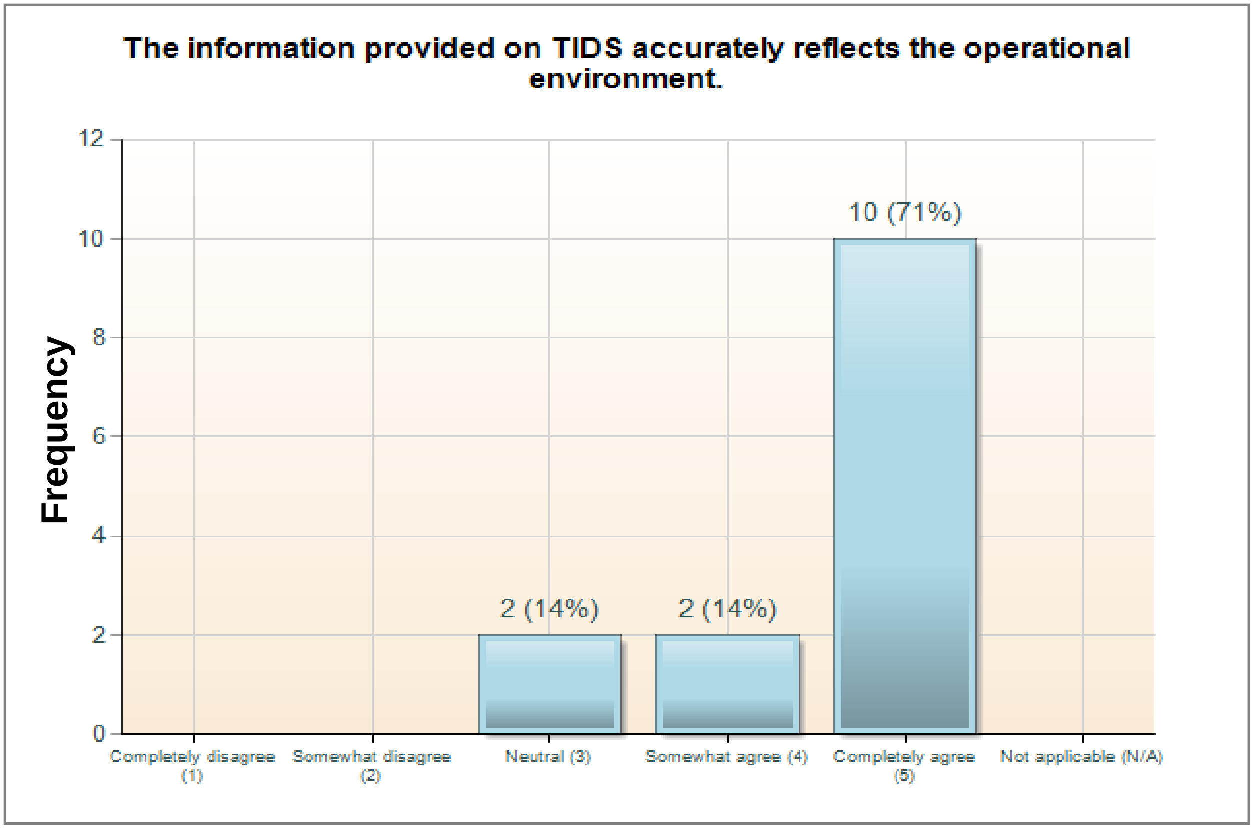

Figure D-17: Accuracy of the operational environment information

As shown in Figure D-17, there was a significant difference between observed ratings and expected ratings for perceived accuracy of the operational environment information provided on TIDS, χ^2 (4, N = 14) = 24.57, $p < .05$. More participants than expected completely agreed that the information accurately reflected the operational environment.

D.1.3 User Interface

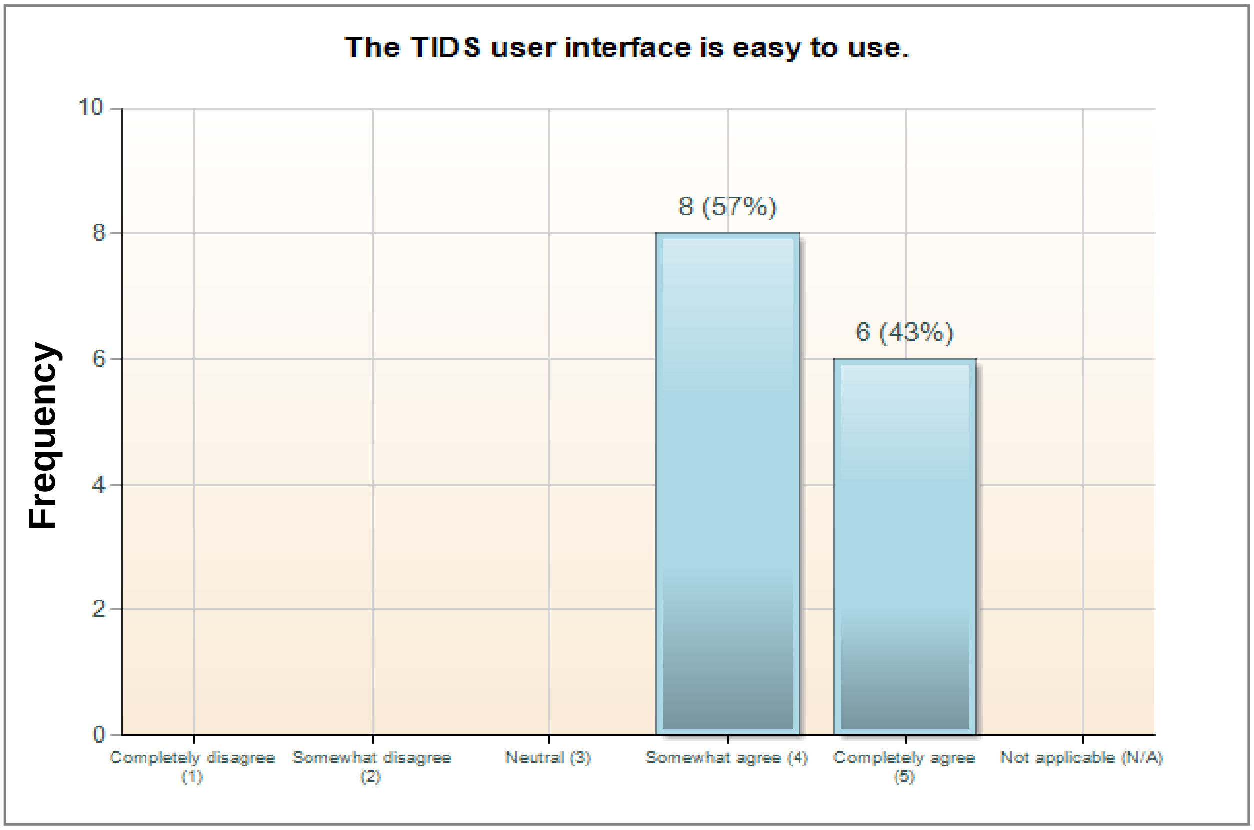

Figure D-18: Ease of use of the TIDS user interface

As shown in Figure D-18, there was a significant difference between observed ratings and expected ratings for perceived ease of use of the TIDS user interface, χ^2 (4, N = 14) = 21.71, p < .05. More participants than expected somewhat agreed or completely agreed that the TIDS user interface was easy to use.

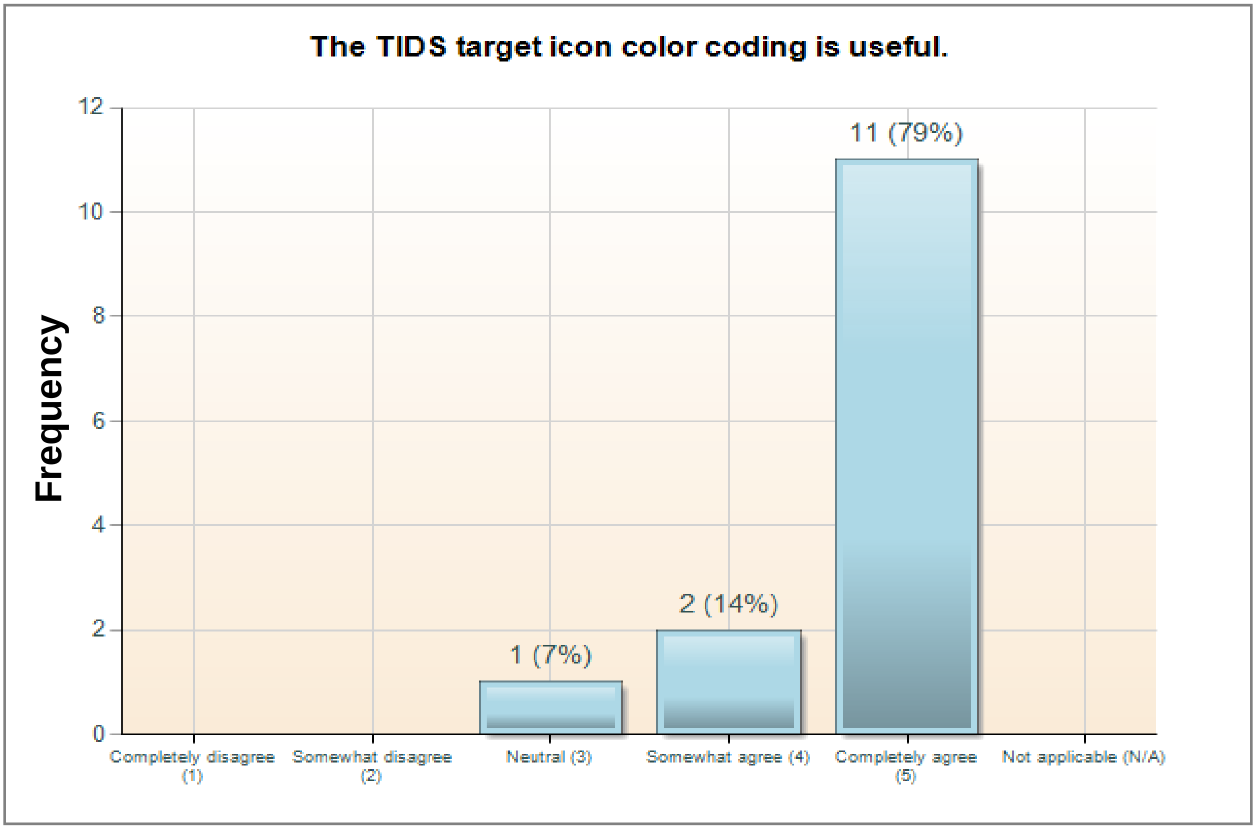

Figure D-19: Usefulness of the TIDS user interface

As shown in Figure D-19, there was a significant difference between observed ratings and expected ratings for perceived usefulness of the TIDS target icon color coding, χ^2 (4, N = 14) = 31.00, p < .05. More participants than expected completely agreed that the target icon color coding was useful.

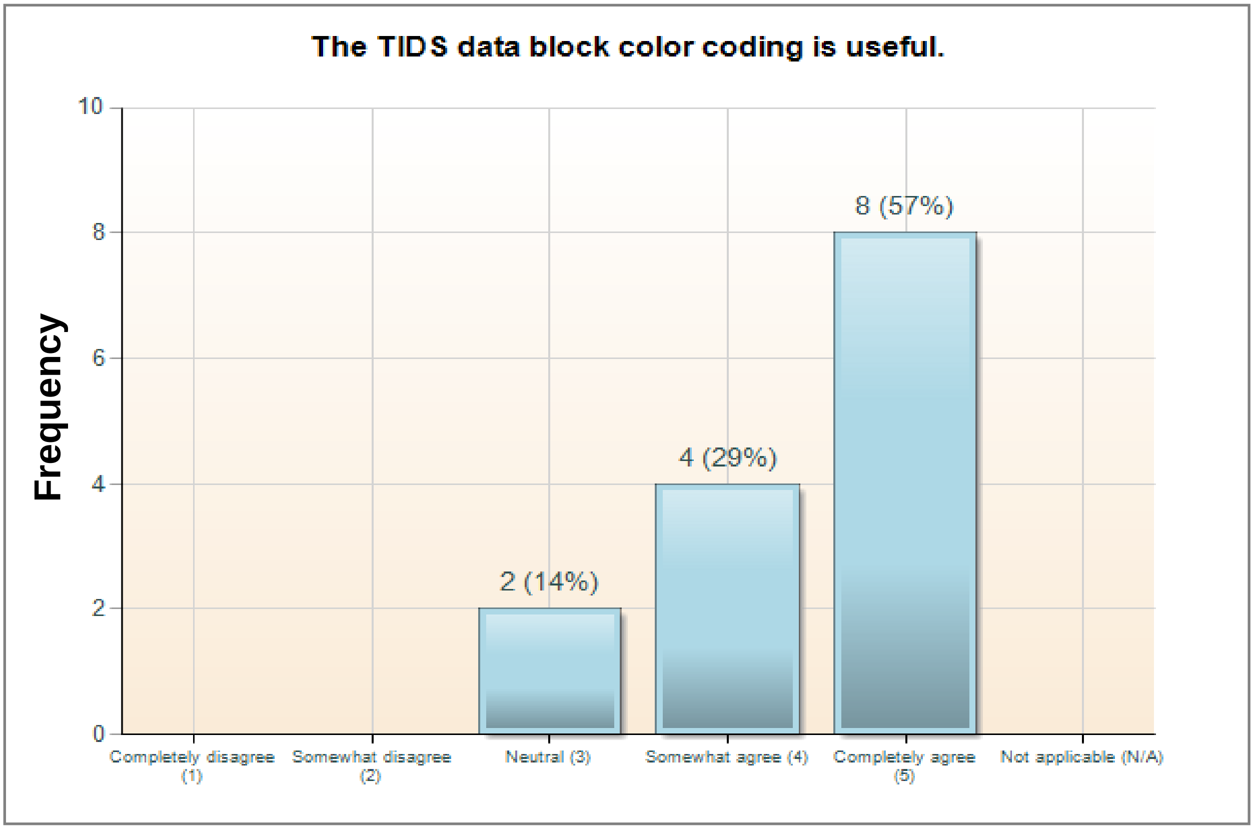

Figure D-20: Usefulness of the TIDS data block color coding

As shown in Figure D-20, there was a significant difference between observed ratings and expected ratings for perceived usefulness of the TIDS data block color coding, χ^2 (4, N = 14) = 16.00, p < .05. More participants than expected completely agreed that the data block color coding was useful.

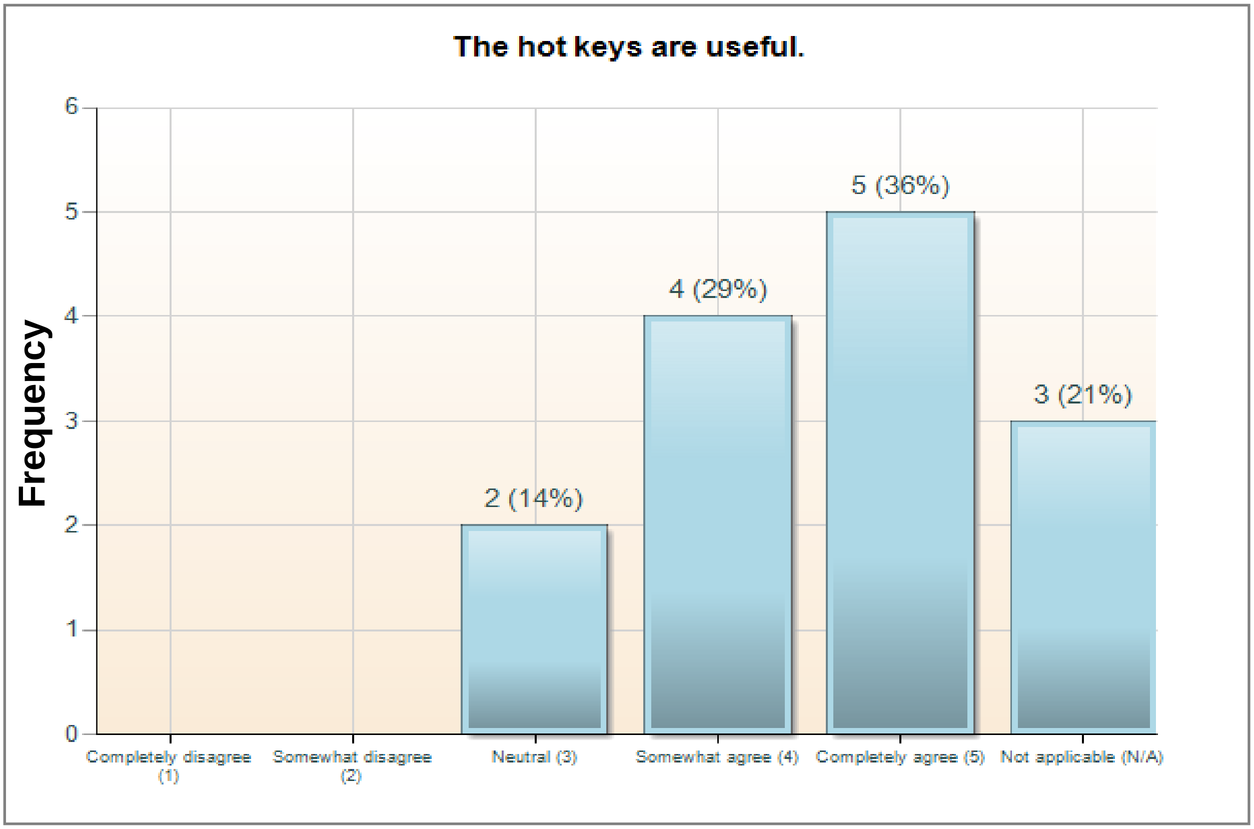

Figure D-21: Usefulness of hot keys

As shown in Figure D-21, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the hot keys, $\chi^2(4, N = 11^{§}) = 9.45$, $p > .05$. Participants were as likely to completely agree, somewhat agree, or be neutral with the perceived usefulness of the hot keys.

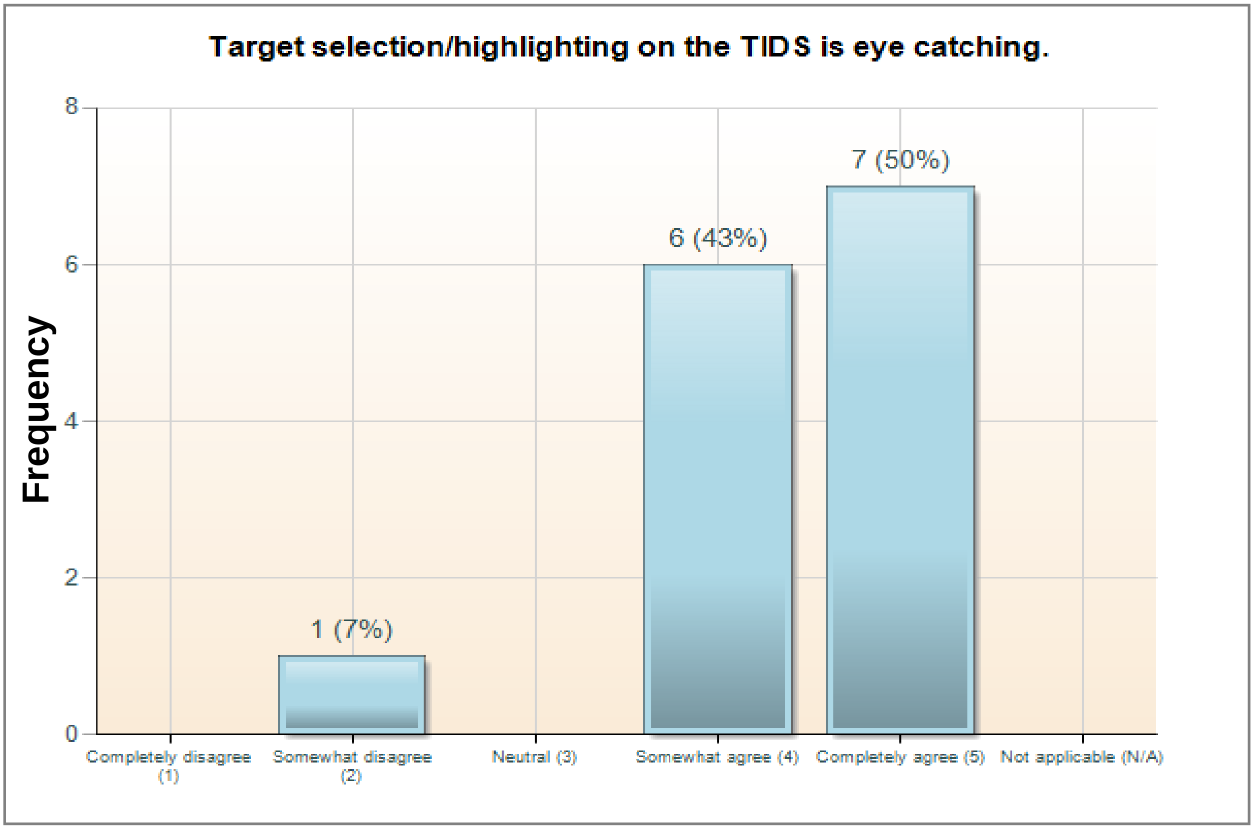

Figure D-22: Salient target selection highlighting

As shown in Figure D-22, there was a significant difference between observed ratings and expected ratings for perceived salience of the target selection/highlighting on the TIDS, χ^2 (4, N = 14) = 16.71, p < .05. More participants than expected completely agreed or somewhat agreed that the target selection or highlighting was eye catching.

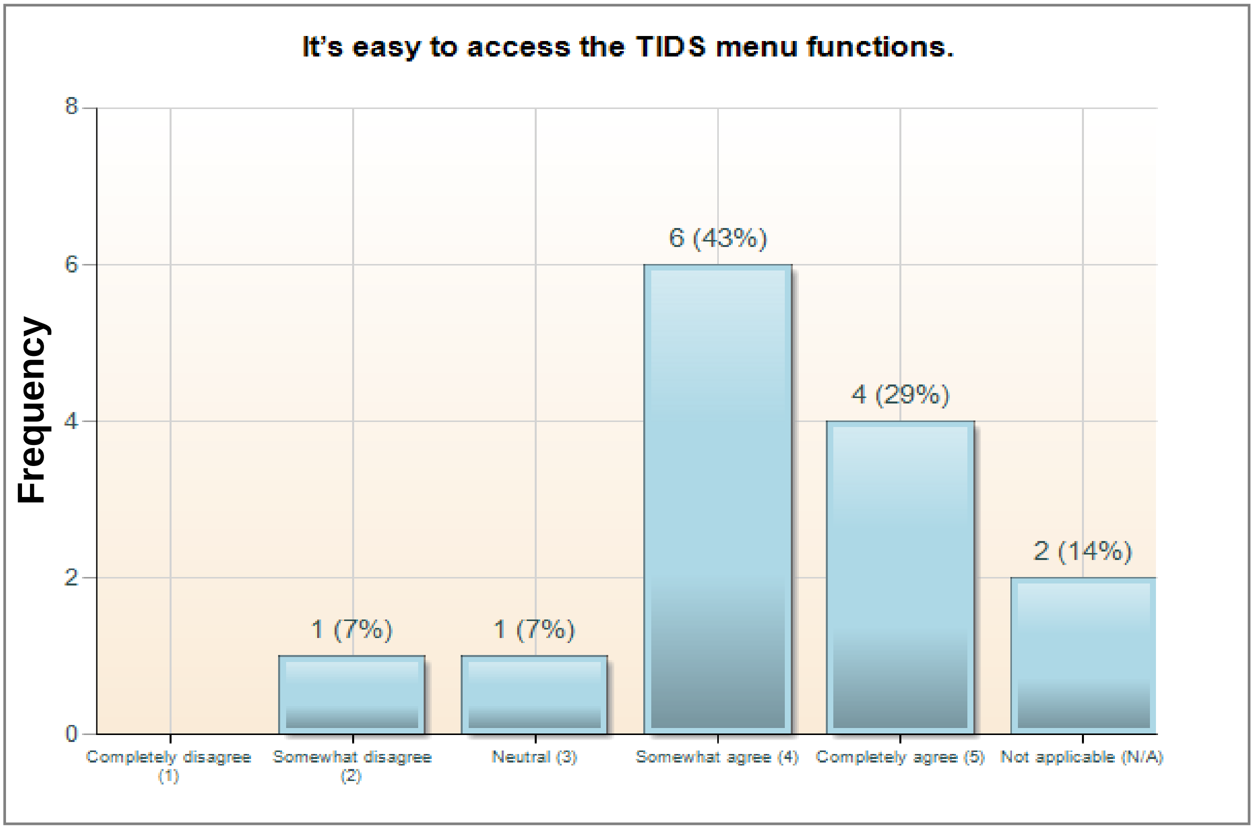

Figure D-23: Ease of accessing the TIDS menu functions

As shown in Figure D-23, there was a significant difference between observed ratings and expected ratings for perceived ease to access the TIDS menu functions, χ^2 (4, N = 12[§]) = 10.50, $p < .05$. More participants than expected somewhat agreed or completely agreed that it was easy to access the TIDS menu functions.

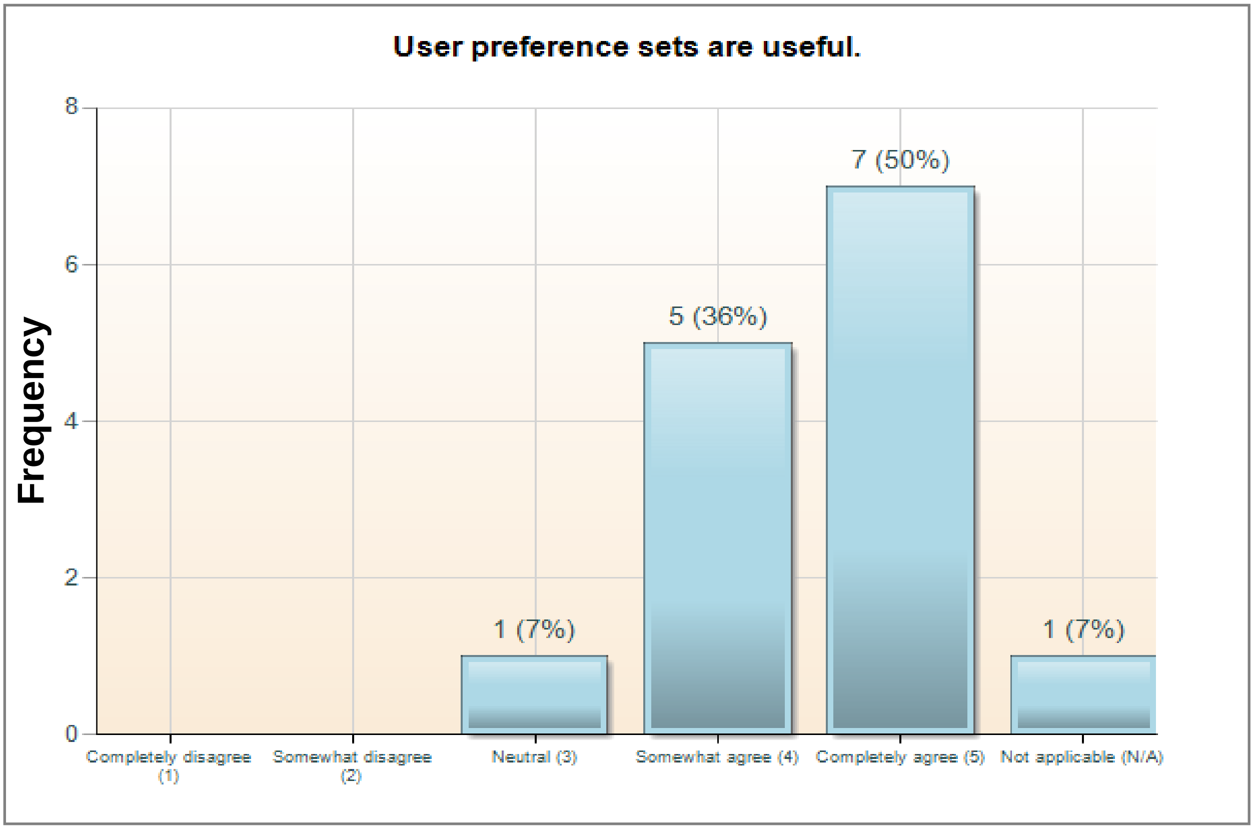

Figure D-24: Ease of user preferences sets

As shown in Figure D-24, there was a significant difference between observed ratings and expected ratings for perceived usefulness of user preference sets, χ^2 (4, N = 13[§]) = 15.84, $p < .05$. More participants than expected completely agreed or somewhat agreed that the user preferences sets were useful.

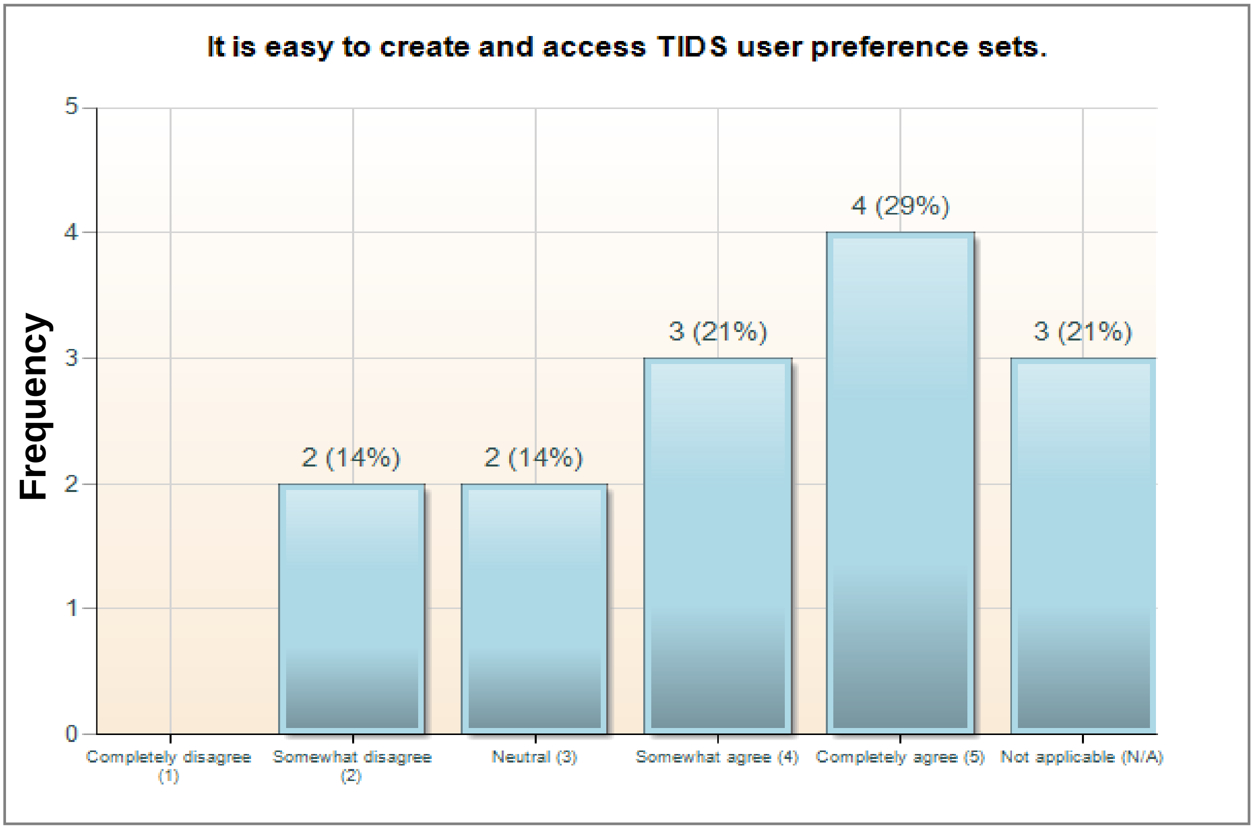

Figure D-25: Ease of creating and accessing user preference sets

As shown in Figure D-25, there was no significant difference between observed ratings and expected ratings for perceived ease of creating and accessing TIDS user preference sets, χ^2 (4, N = 11[§]) = 4.00, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or somewhat disagree with the perceived ease of creating and accessing user preference sets.

D.1.4 Picture-in-Picture Windows

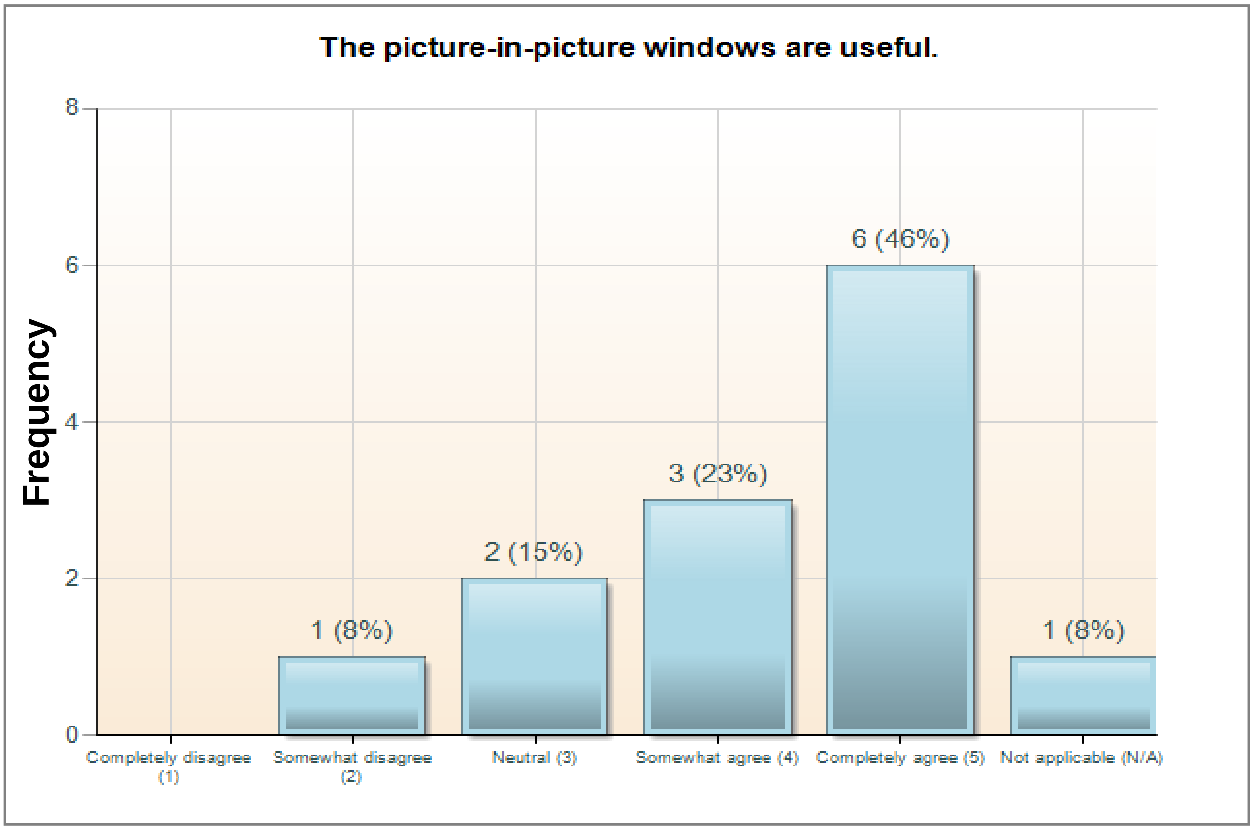

Figure D-26: Usefulness of TIDS picture-in-picture windows

As shown in Figure D-26, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the picture-in-picture windows, χ^2 (4, N = 12[§]) = 8.83, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or somewhat disagree with the perceived usefulness of the picture-in-picture windows.

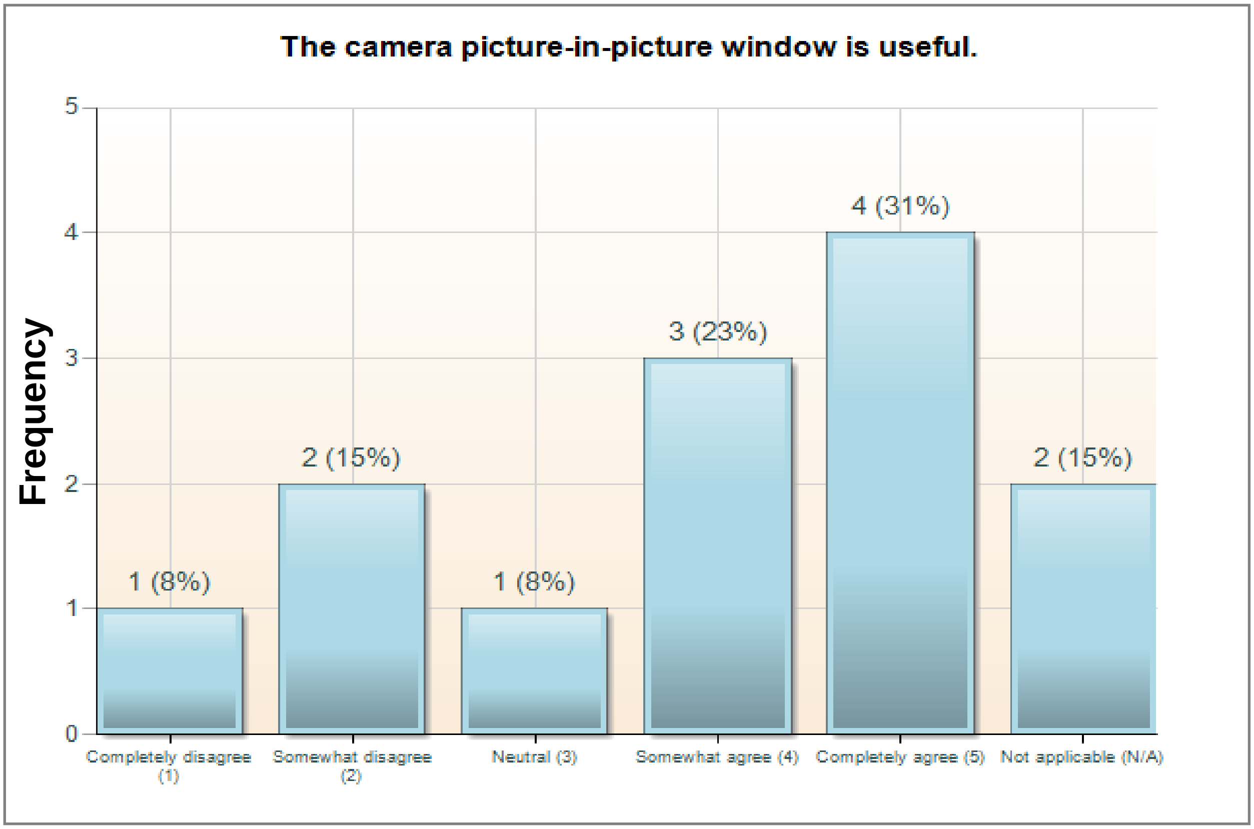

Figure D-27: Usefulness of camera picture-in-picture window

As shown in Figure D-27, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the camera picture-in-picture window, χ^2 (4, N = 11[§]) = 3.09, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived usefulness of the camera picture-in-picture window.

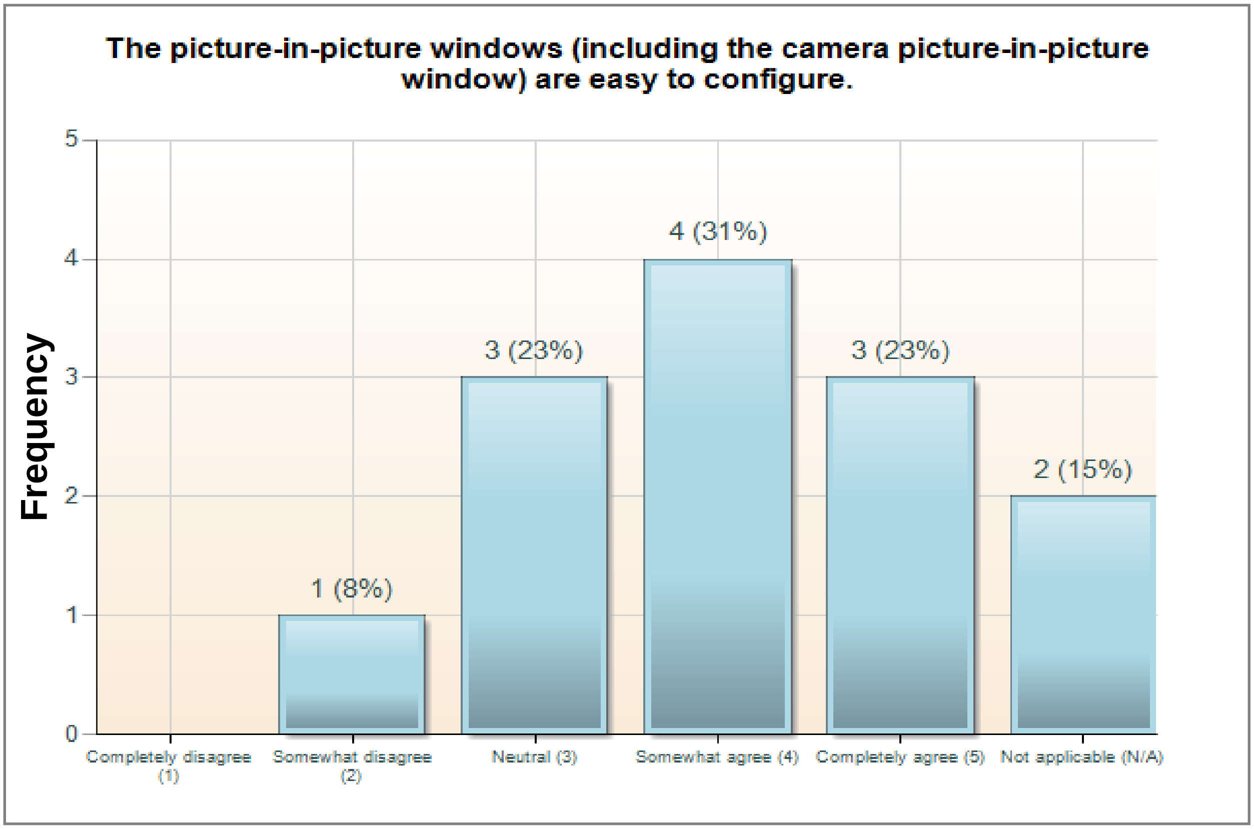

Figure D-28: Ease of configuration of picture-in-picture windows

As shown in Figure D-28, there was no significant difference between observed ratings and expected ratings for perceived ease of configuring the picture-in-picture windows (including the camera picture-in-picture window), χ^2 (4, N = 11[§]) = 4.90, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or somewhat disagree with the perceived ease of configuring the picture-in-picture windows.

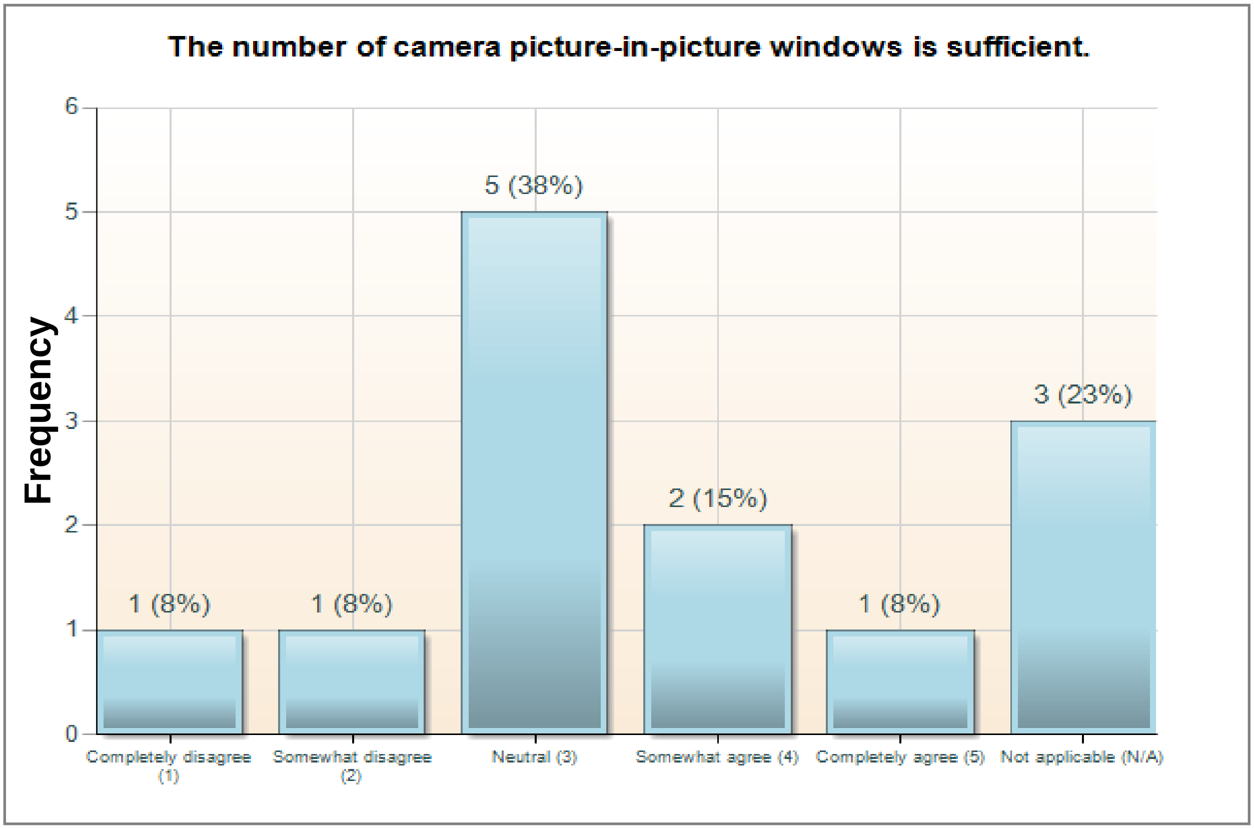

Figure D-29: Sufficiency of number of camera picture-in-picture windows

As shown in Figure D-29, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the number of camera picture-in-picture windows, χ^2 (4, N = 10[§]) = 6.00, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree or completely disagree with the perceived sufficiency of the camera picture-in-picture windows number.

D.1.5 Wind Information

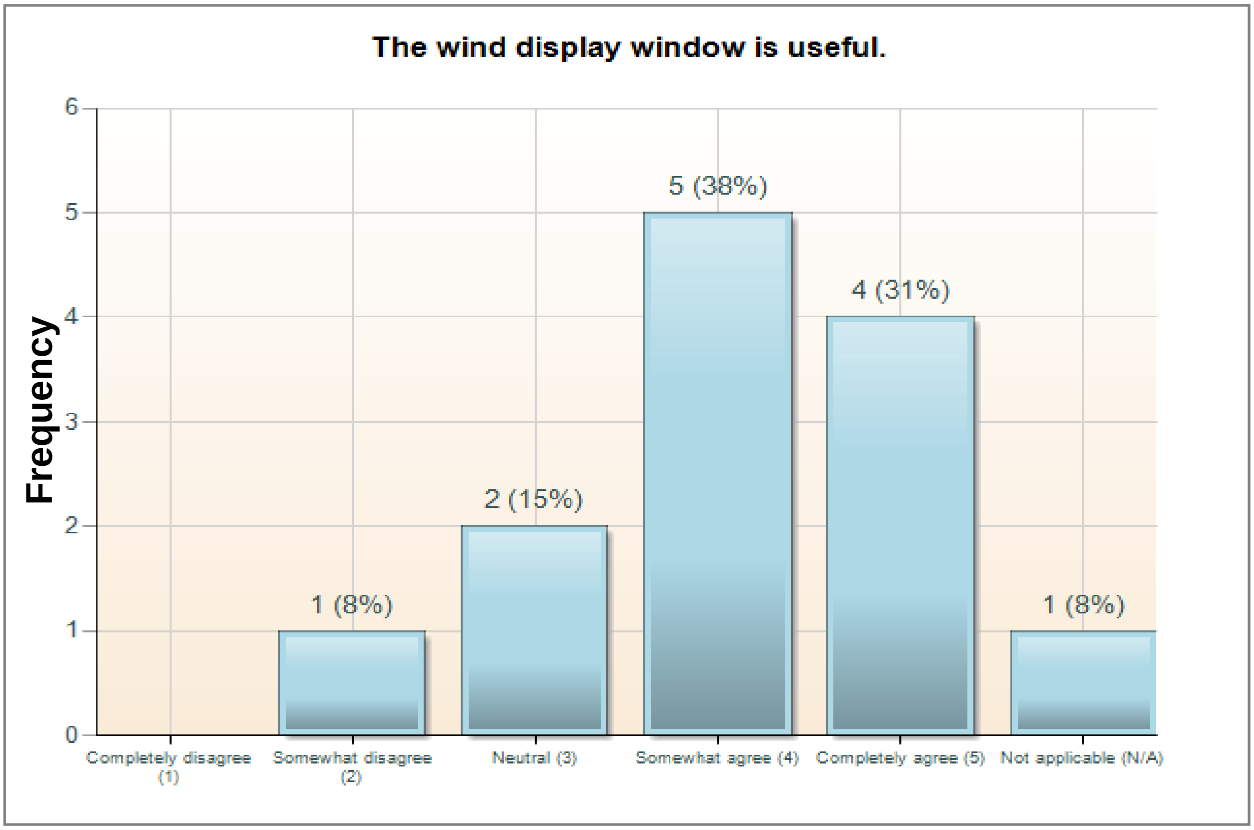

Figure D-30: Usefulness of the wind display window

As shown in Figure D-30, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the wind display window, χ^2 (4, N = 12[§]) = 7.16, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or somewhat disagree with the perceived usefulness of the wind display window.

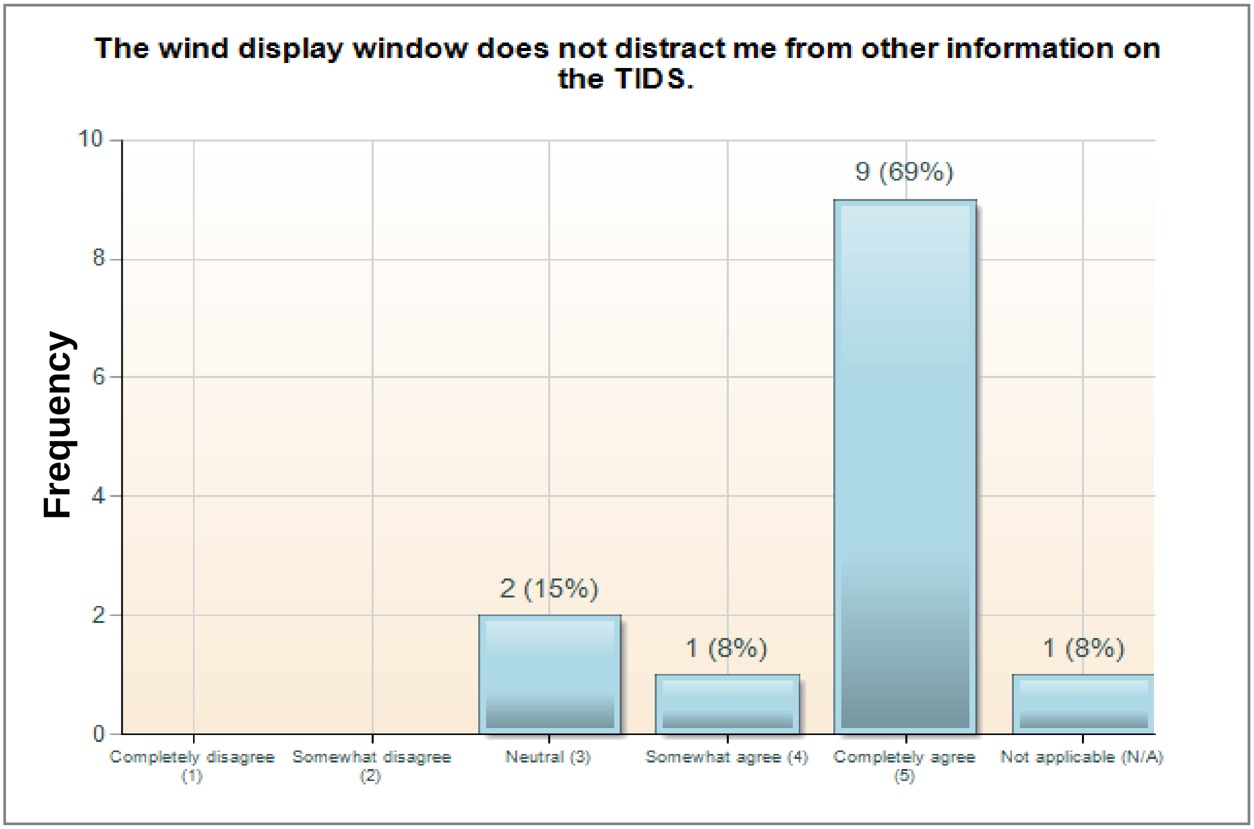

Figure D-31: Distraction of the wind display window

As shown in Figure D-31, there was a significant difference between observed ratings and expected ratings for perceived lack of distraction while using the wind display window, χ^2 (4, N = 12[§]) = 23.83, p < .05. More participants than expected completely agreed that using the wind display window did not distract them from other information on the TIDS.

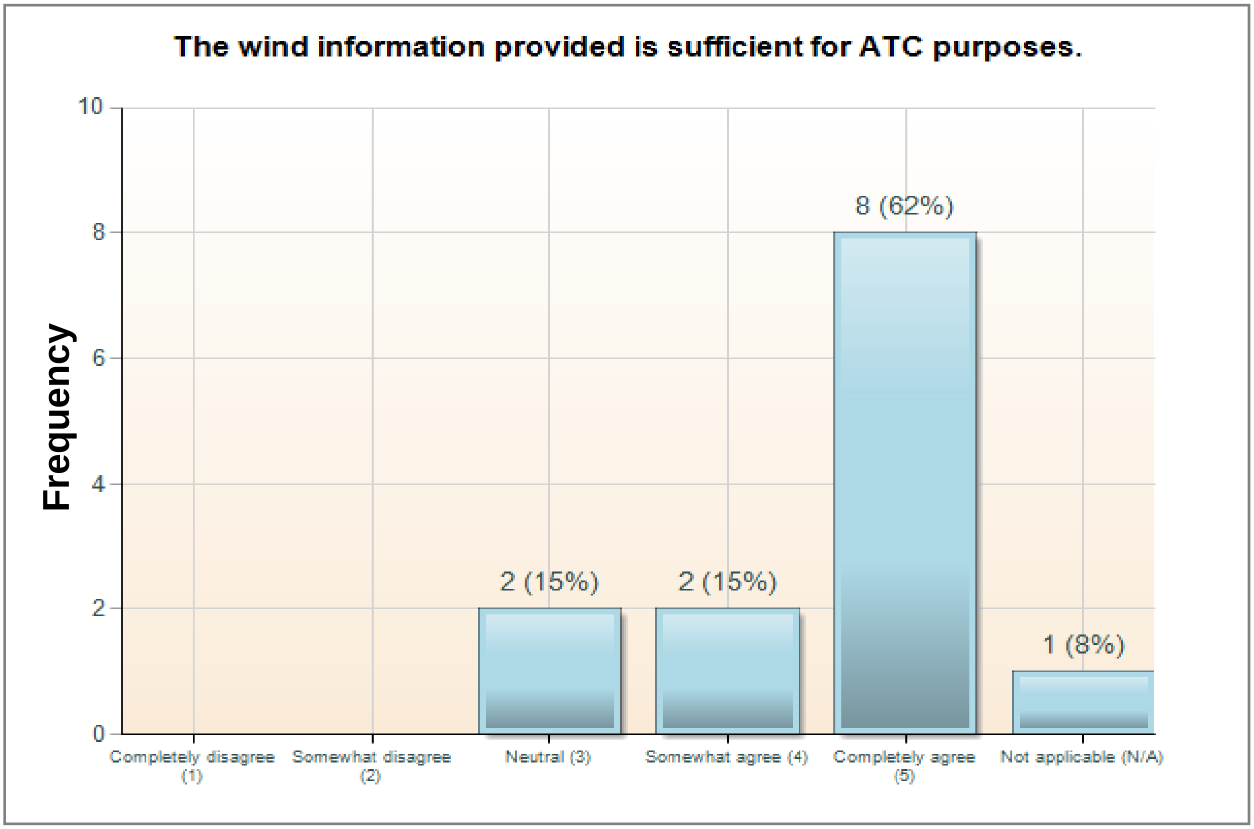

Figure D-32: Wind display sufficiency

As shown in Figure D-32, there was a significant difference between observed ratings and expected ratings for perceived sufficiency of the wind information provided for ATC purposes, χ^2 (4, N = 12[§]) = 18.00, p < .05. More participants than expected completely agreed that the wind information provided was sufficient for ATC purposes.

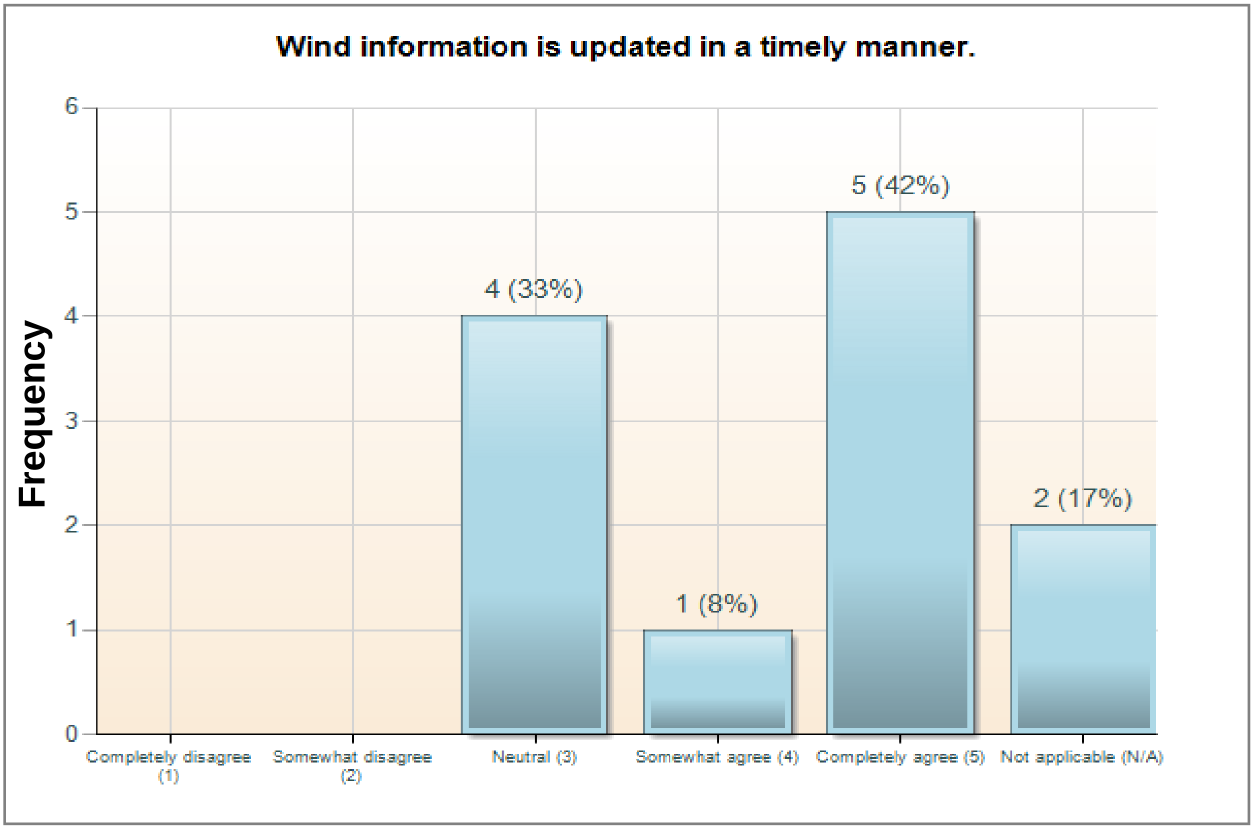

Figure D-33: Timeliness of wind information update

As shown in Figure D-33, there was a significant difference between observed ratings and expected ratings for perceived timeliness of wind information update, χ^2 (4, N = 10[§]) = 11.00, $p < .05$. More participants than expected completely agreed or were neutral when asked if the wind information was updated in a timely manner.

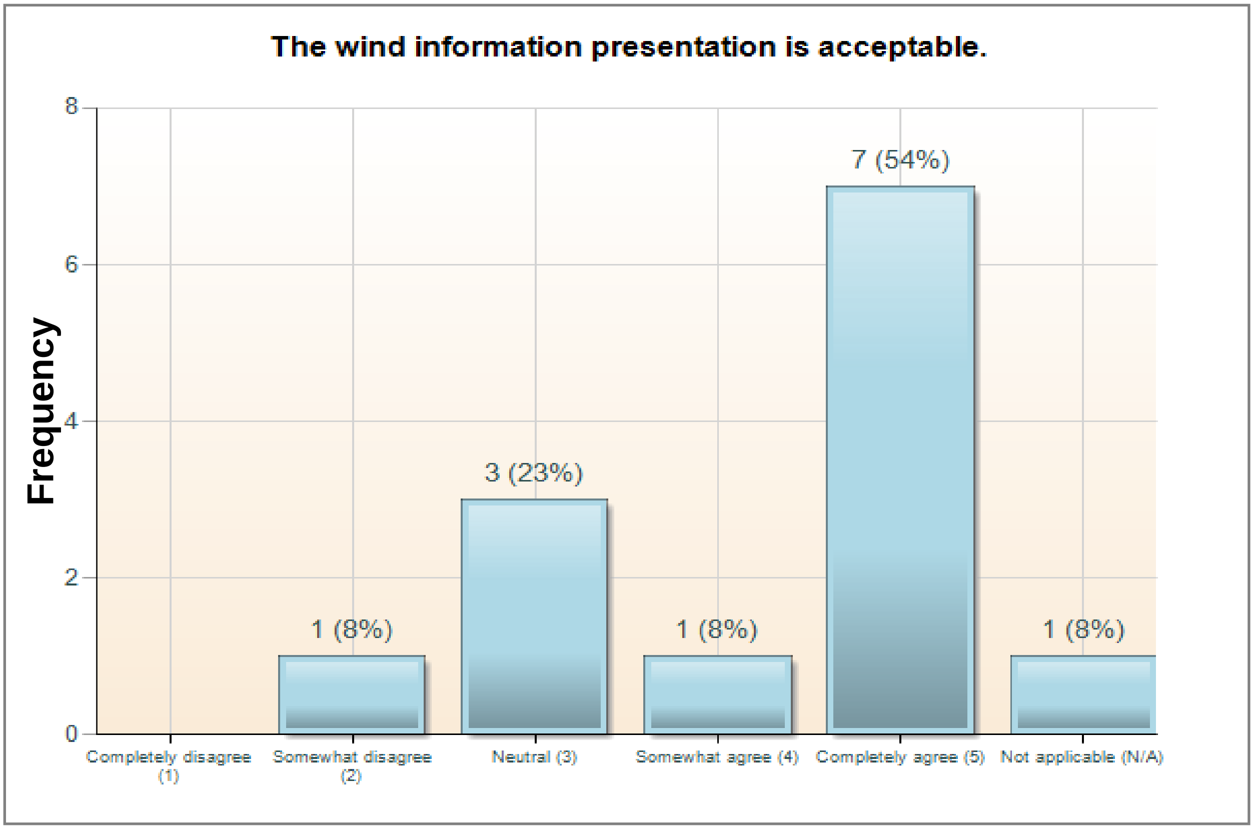

Figure D-34: Acceptability of wind information display

As shown in Figure D-34, there was a significant difference between observed ratings and expected ratings for perceived acceptability of wind information presentation, χ^2 (4, N = 12[§]) = 13.00, $p < .05$. More participants than expected completely agreed that the wind information presentation was acceptable.

D.1.6 Display Features

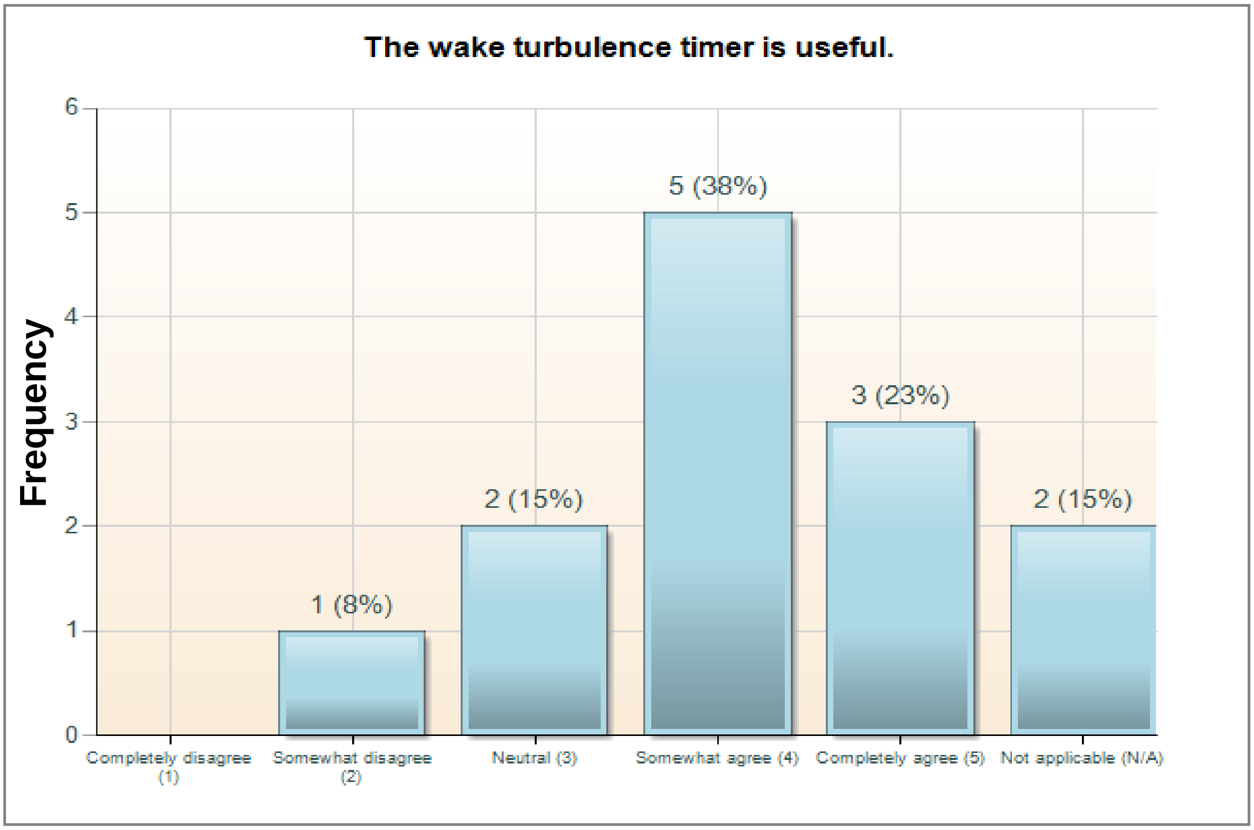

Figure D-35: Usefulness of the wake turbulence timer

As shown in Figure D-35, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the wake turbulence timer, χ^2 (4, N = 11[§]) = 6.72, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or somewhat disagree with the perceived usefulness of the wake turbulence timer.

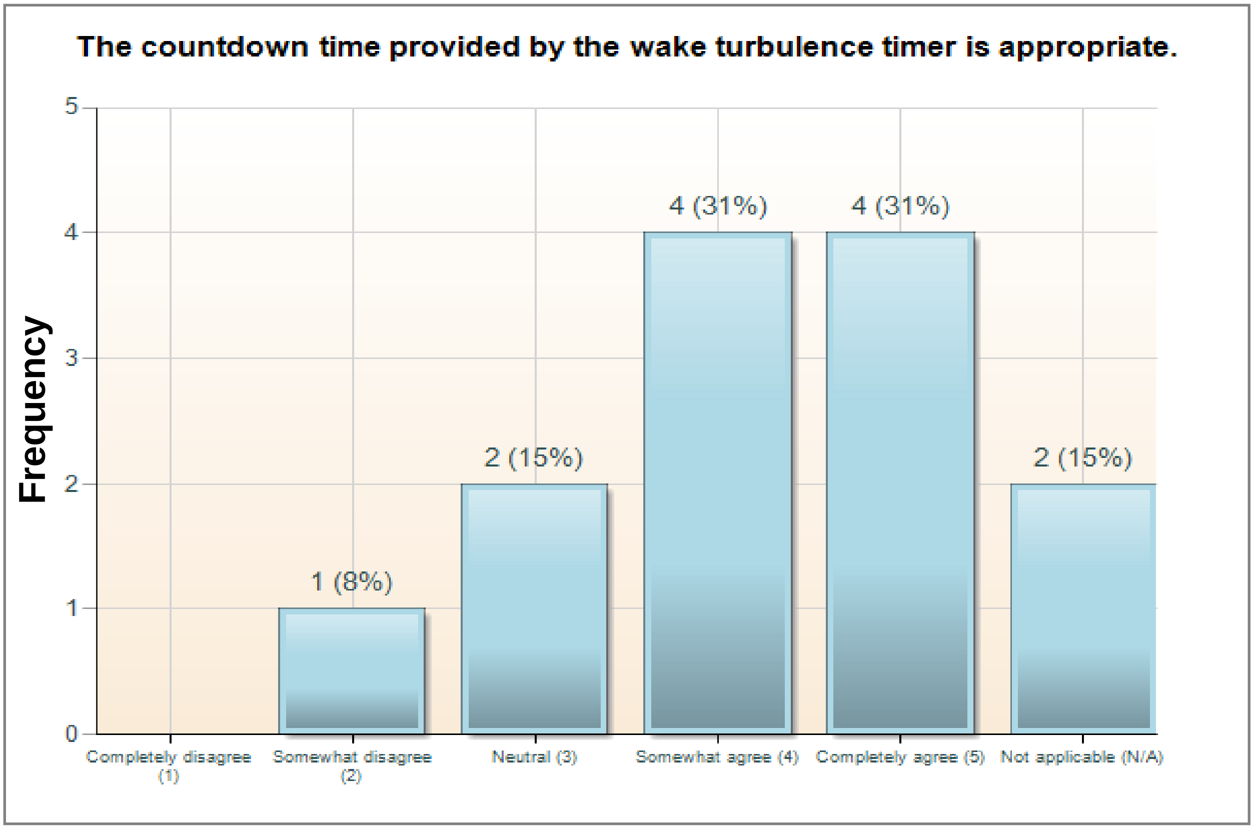

Figure D-36: Appropriateness of wake turbulence timer duration

As shown in Figure D-36, there was no significant difference between observed ratings and expected ratings for perceived appropriateness of the countdown time provided by the wake turbulence timer , χ^2 (4, N = 11[§]) = 5.81, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or somewhat disagree with the perceived appropriateness of the wake turbulence timer countdown time.

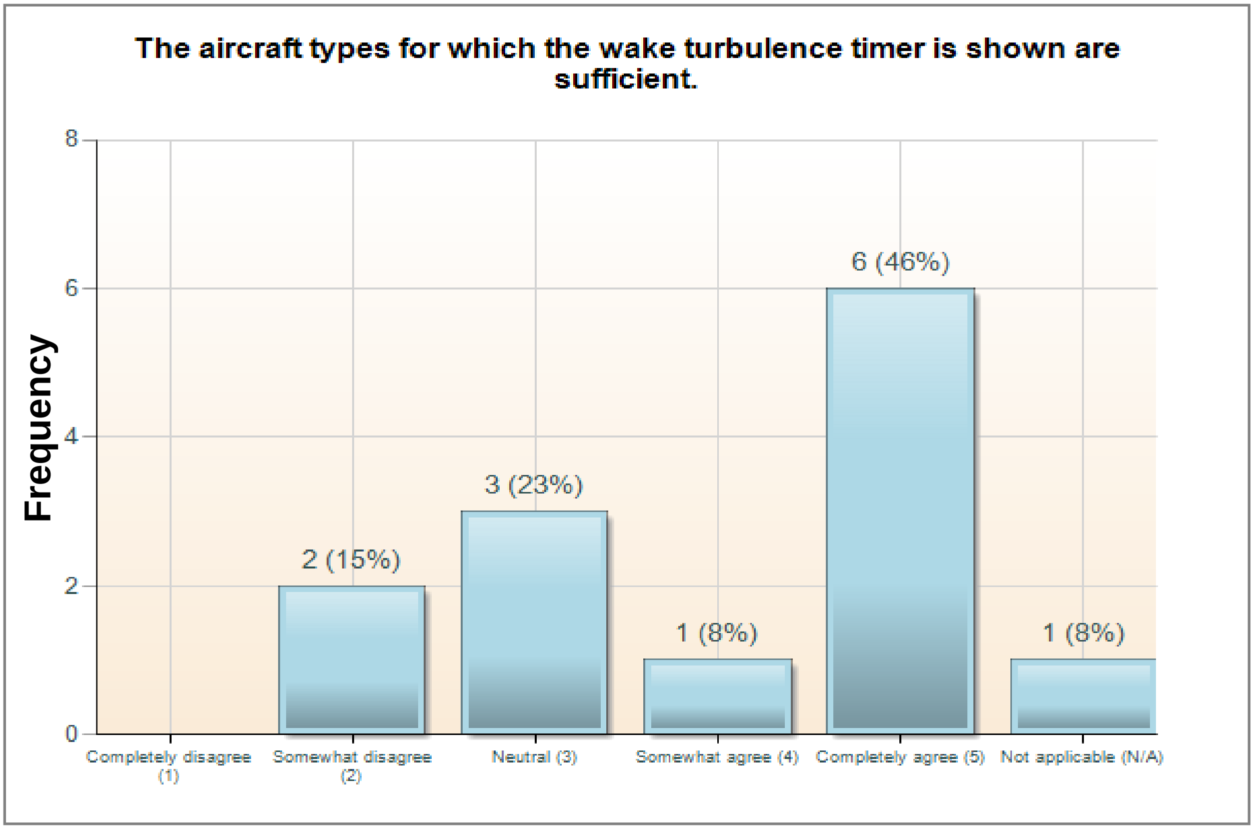

Figure D-37: Sufficiency of aircraft types triggering the wake turbulence timer

As shown in Figure D-37, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the aircraft types for which the wake turbulence timer was shown, χ^2 (4, N = 12[§]) = 8.83, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or somewhat disagree with the perceived sufficiency of the aircraft types.

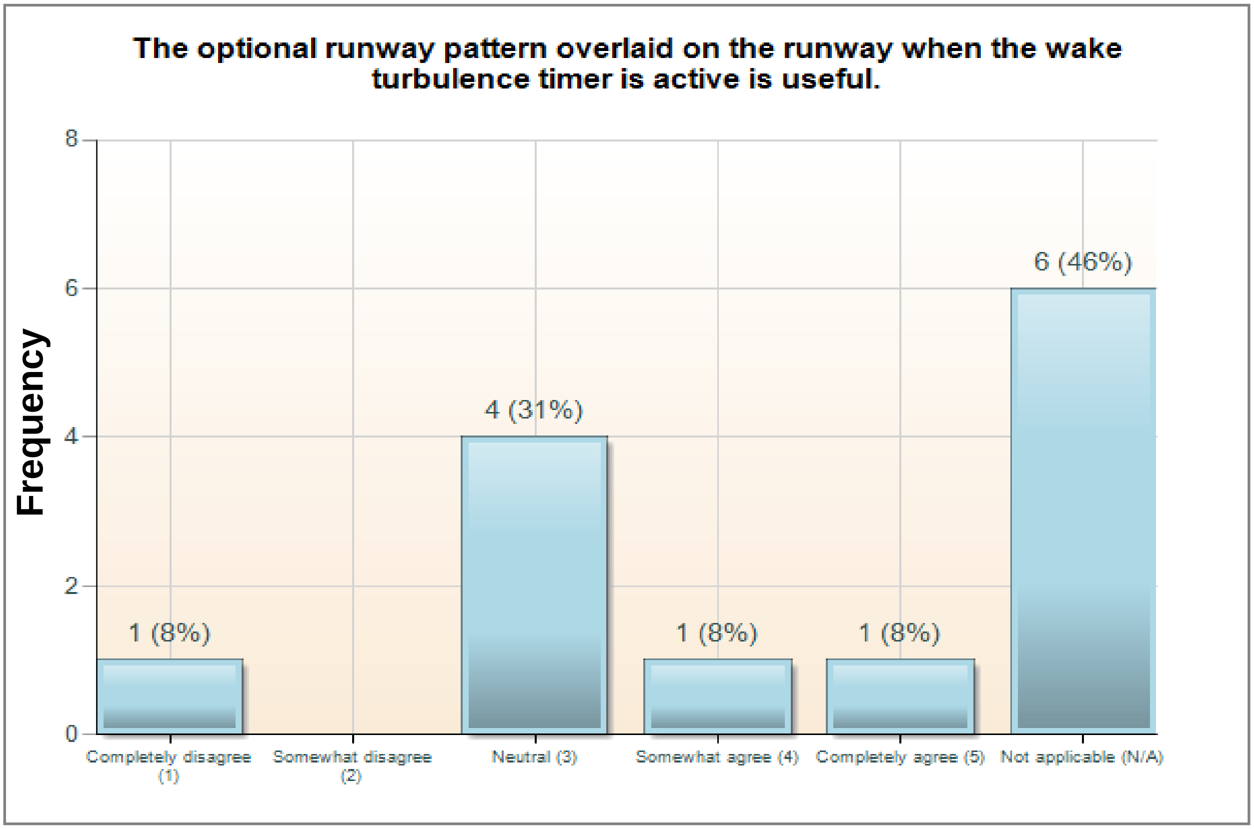

Figure D-38: Usefulness of runway overlay pattern

As shown in Figure D-38, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the optional runway pattern overlaid on the runway when the wake turbulence timer was active, χ^2 (4, N = 7[§]) = 6.57, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or completely disagree with the perceived usefulness of the optional runway pattern overlay.

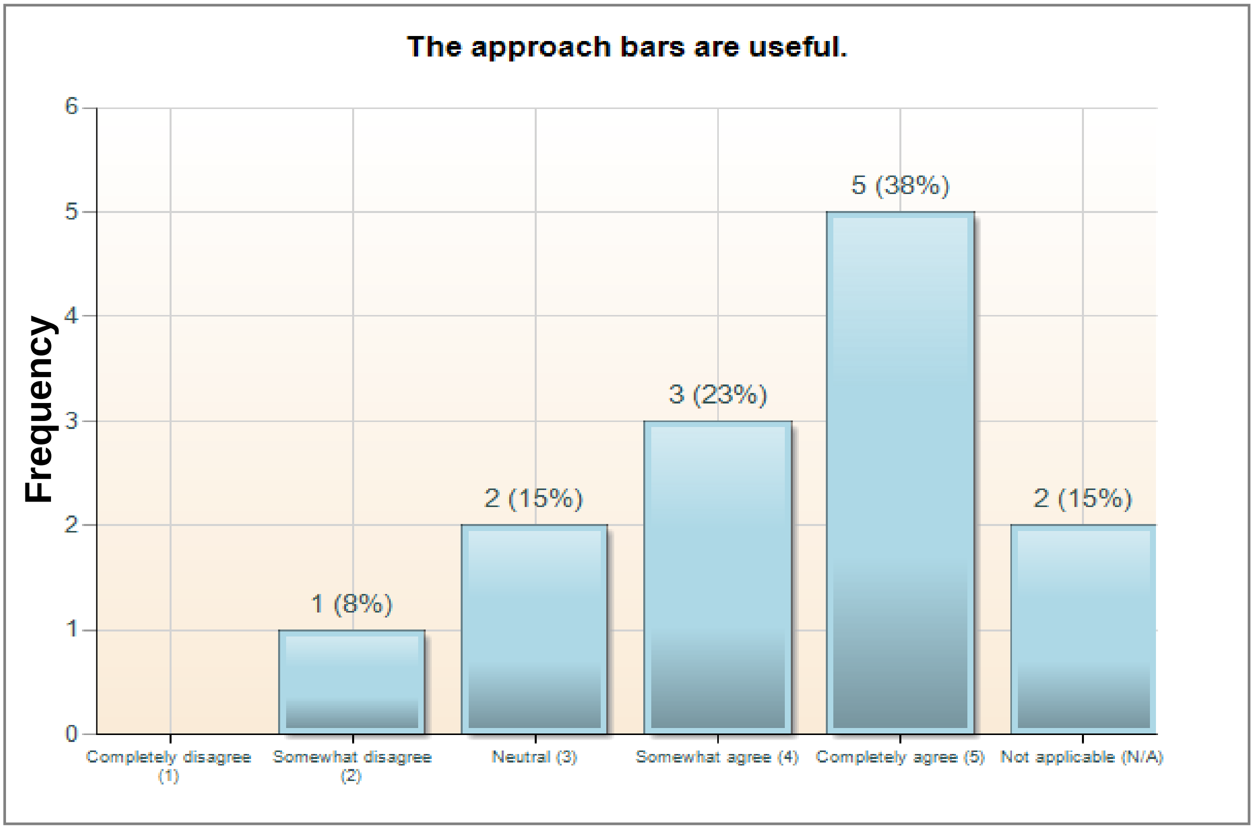

Figure D-39: Usefulness of the approach bars

As shown in Figure D-39, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the approach bars, χ^2 (4, N = 11[§]) = 6.72, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or somewhat disagree with the perceived usefulness of the approach bars.

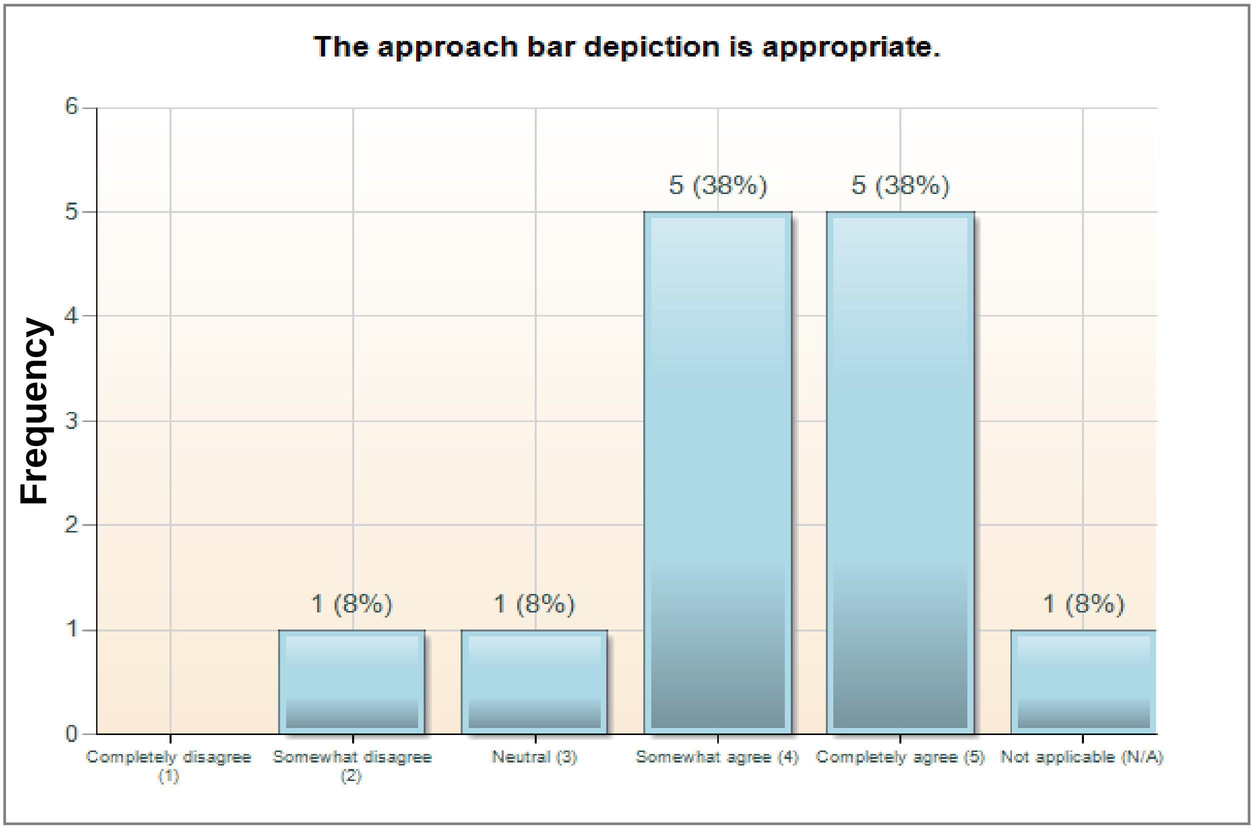

Figure D-40: Appropriateness of the approach bar depiction

As shown in Figure D-40, there was a significant difference between observed ratings and expected ratings for perceived appropriateness of the approach bar depiction, χ^2 (4, N = 12[§]) = 9.66, p < .05. More participants than expected completely agreed or somewhat agreed that the approach bar depiction was appropriate.

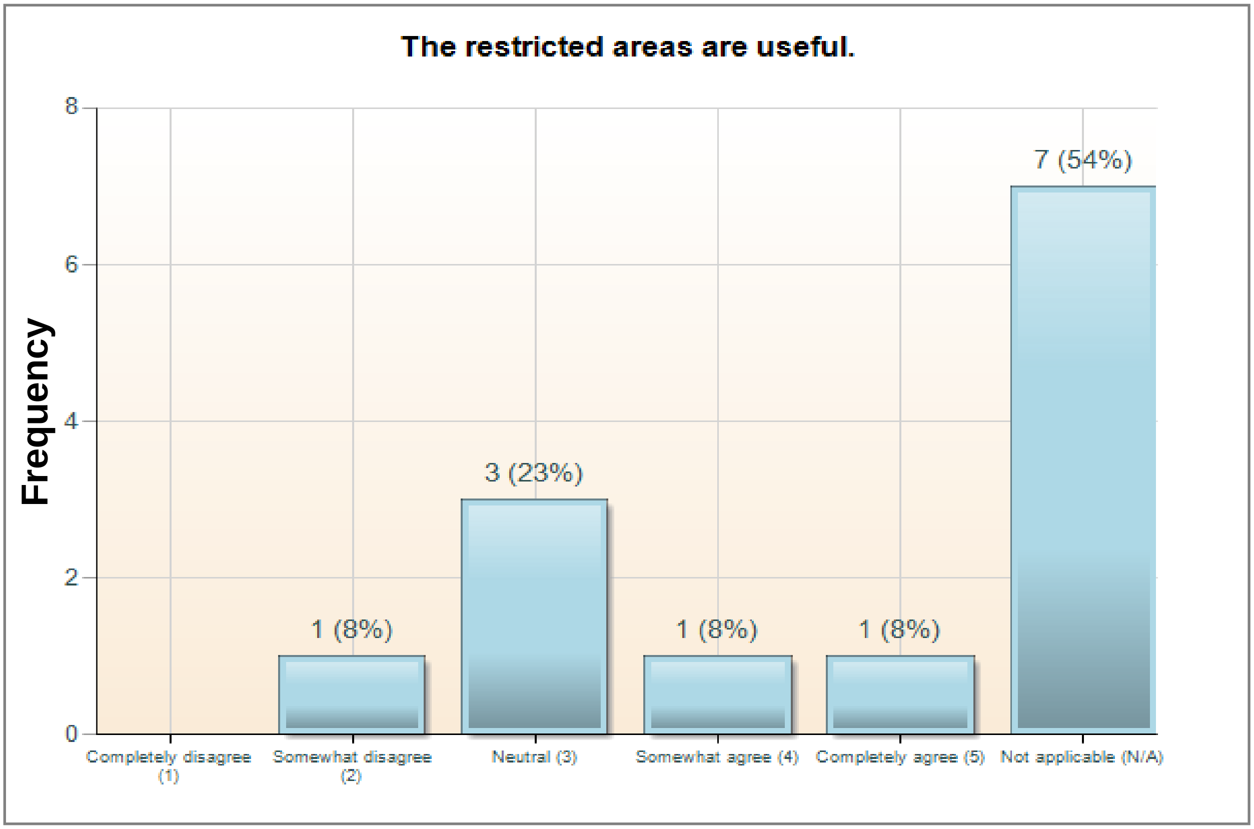

Figure D-41: Usefulness of the restricted areas

As shown in Figure D-41, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the restricted areas, χ^2 (4, N = 6[§]) = 4.00, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or somewhat disagree with the perceived usefulness of the restricted areas.

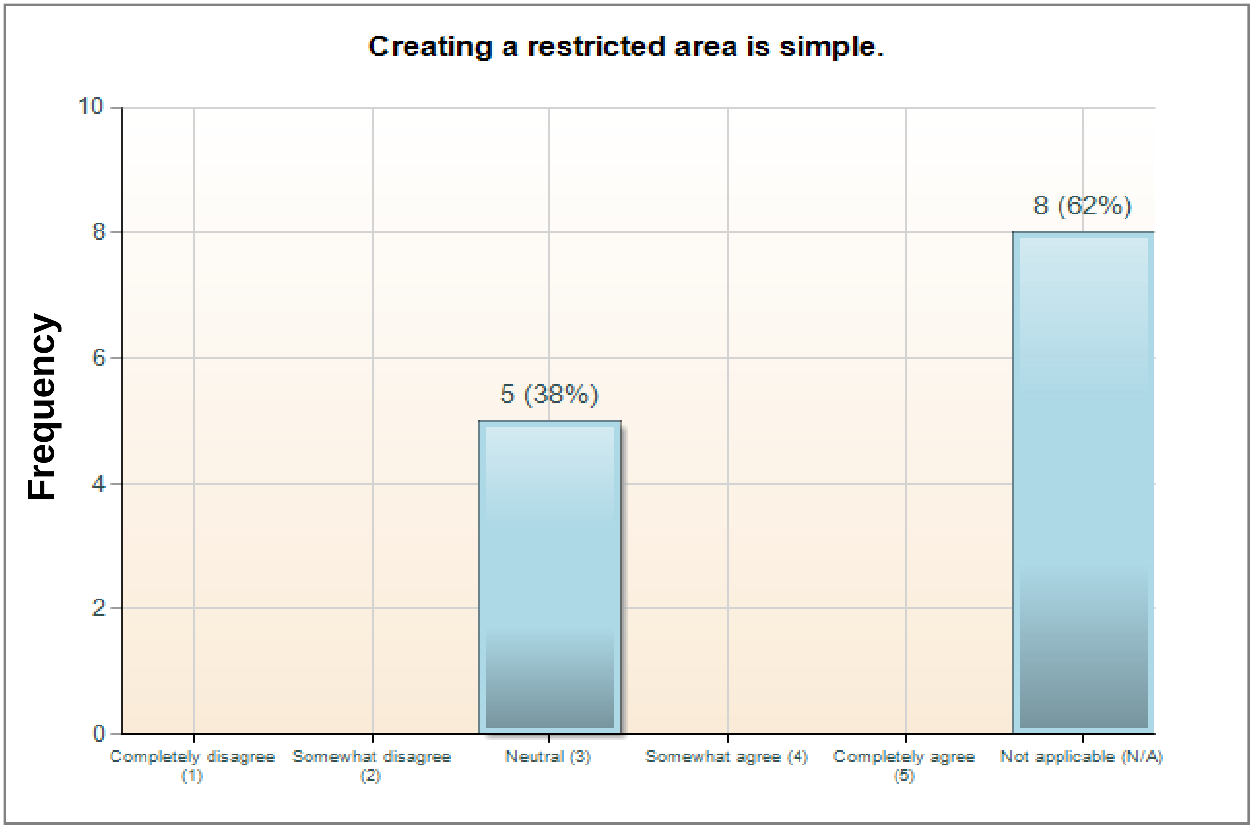

Figure D-42: Simplicity of creating a restricted area

As shown in Figure D-42, there was a significant difference between observed ratings and expected ratings for perceived simplicity in creating a restricted area, χ^2 (4, N = 5[§]) = 20.00, p < .05. More participants than expected were neutral with the perceived simplicity in creating a restricted area.

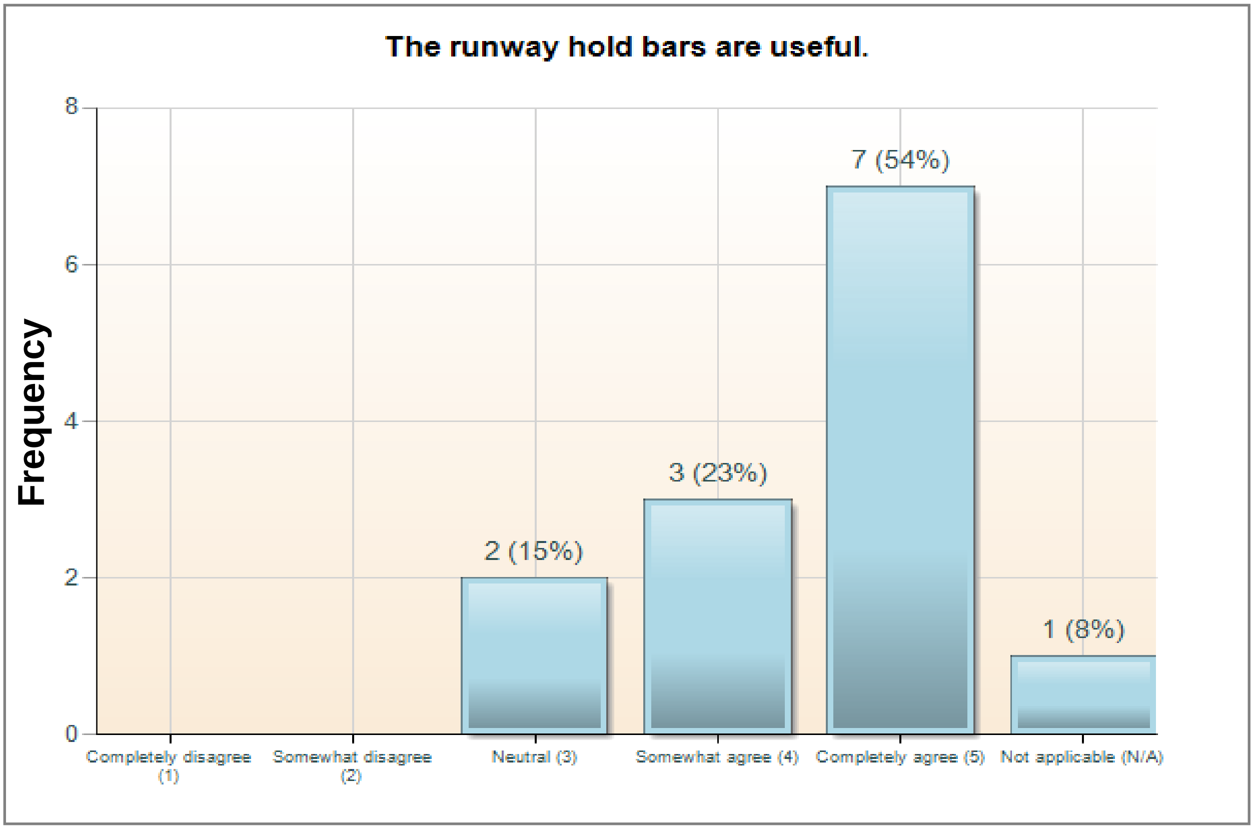

Figure D-43: Usefulness of the runway hold bars

As shown in Figure D-43, there was a significant difference between observed ratings and expected ratings for perceived usefulness of the runway hold bars, χ^2 (4, N = 12[§]) = 13.83, p < .05. More participants than expected completely agreed with the perceived usefulness of the runway hold bars.

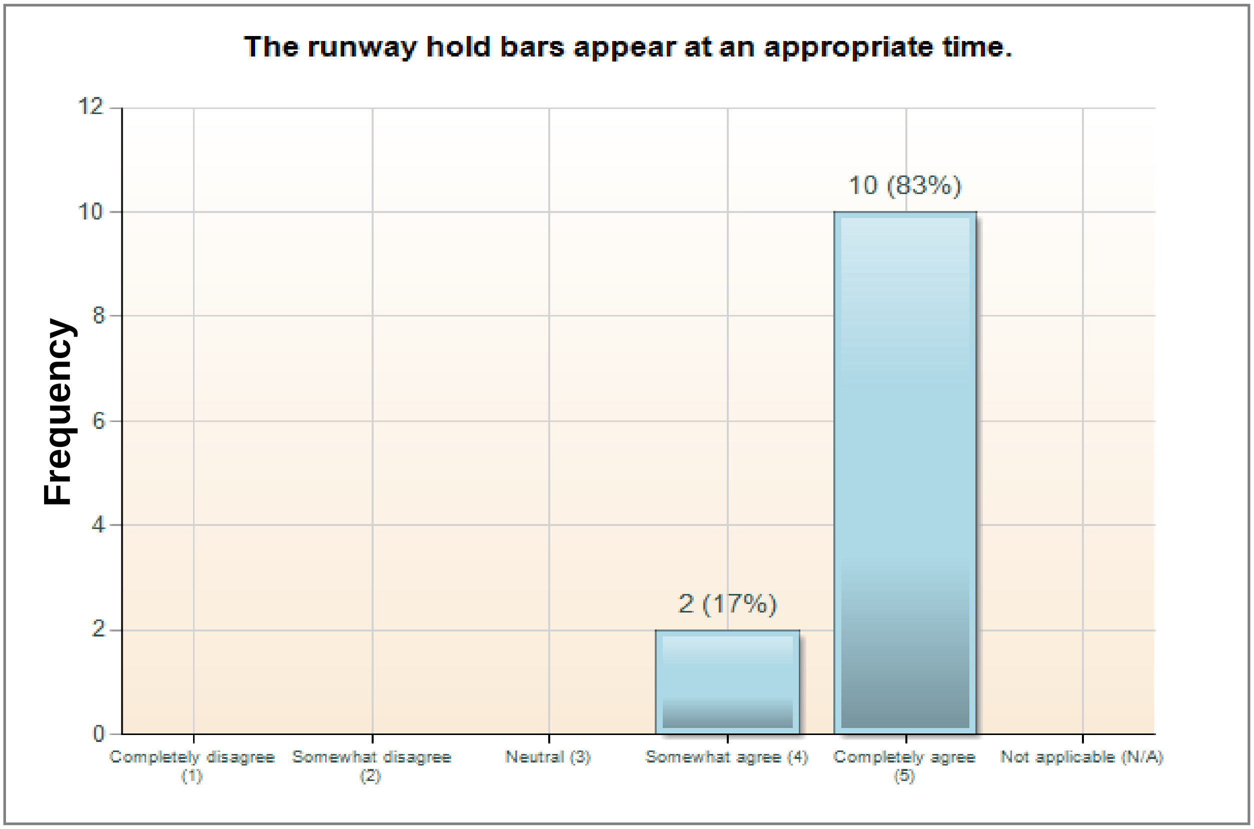

Figure D-44: Appropriateness of the runway hold bar timing

As shown in Figure D-44, there was a significant difference between observed ratings and expected ratings for perceived appropriateness of the runway hold bars appearance time, $\chi^2(4, N = 12) = 31.33$, $p < .05$. More participants than expected completely agreed with the perceived appropriateness of the runway hold bars appearance time.

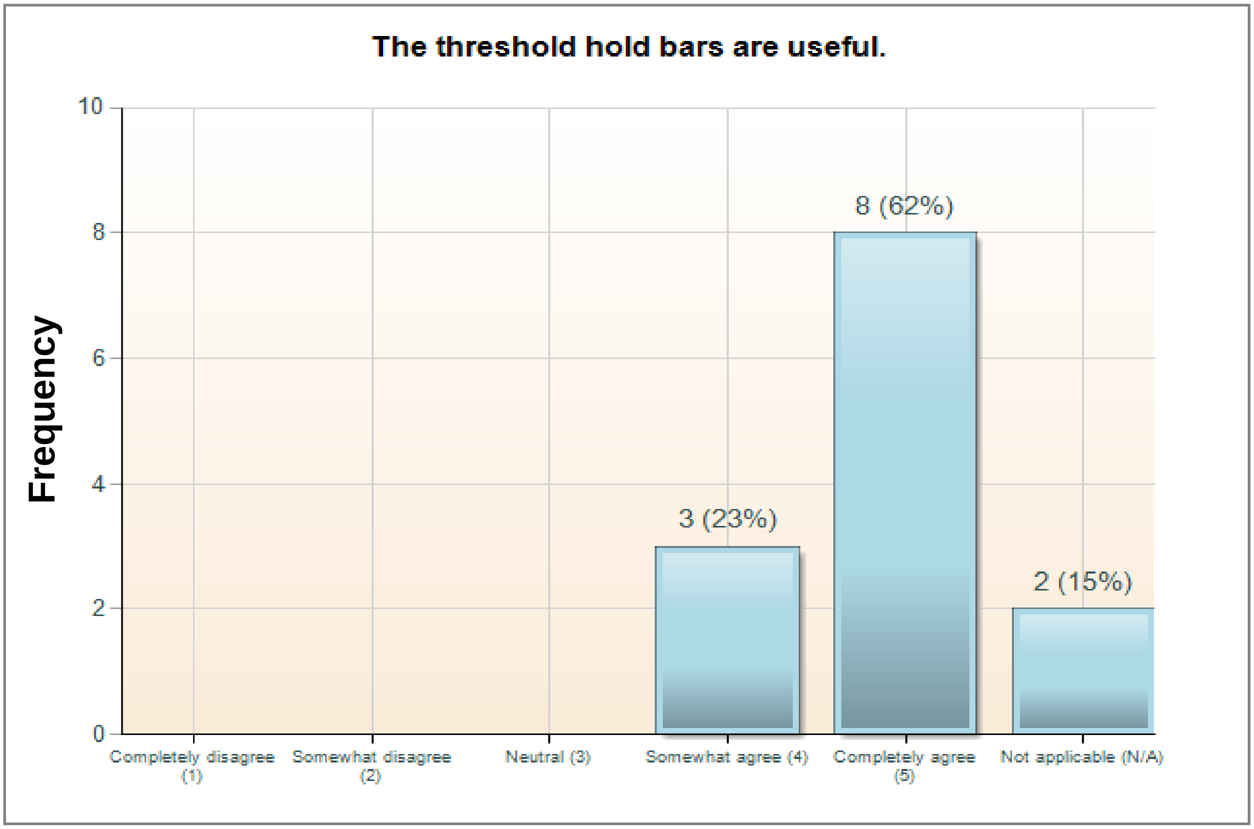

Figure D-45: Usefulness of the threshold hold bars

As shown in Figure D-45, there was a significant difference between observed ratings and expected ratings for perceived usefulness of the threshold hold bars, χ^2 (4, N = 11[§]) = 22.18, p < .05. More participants than expected completely agreed with the perceived usefulness of the threshold hold bars.

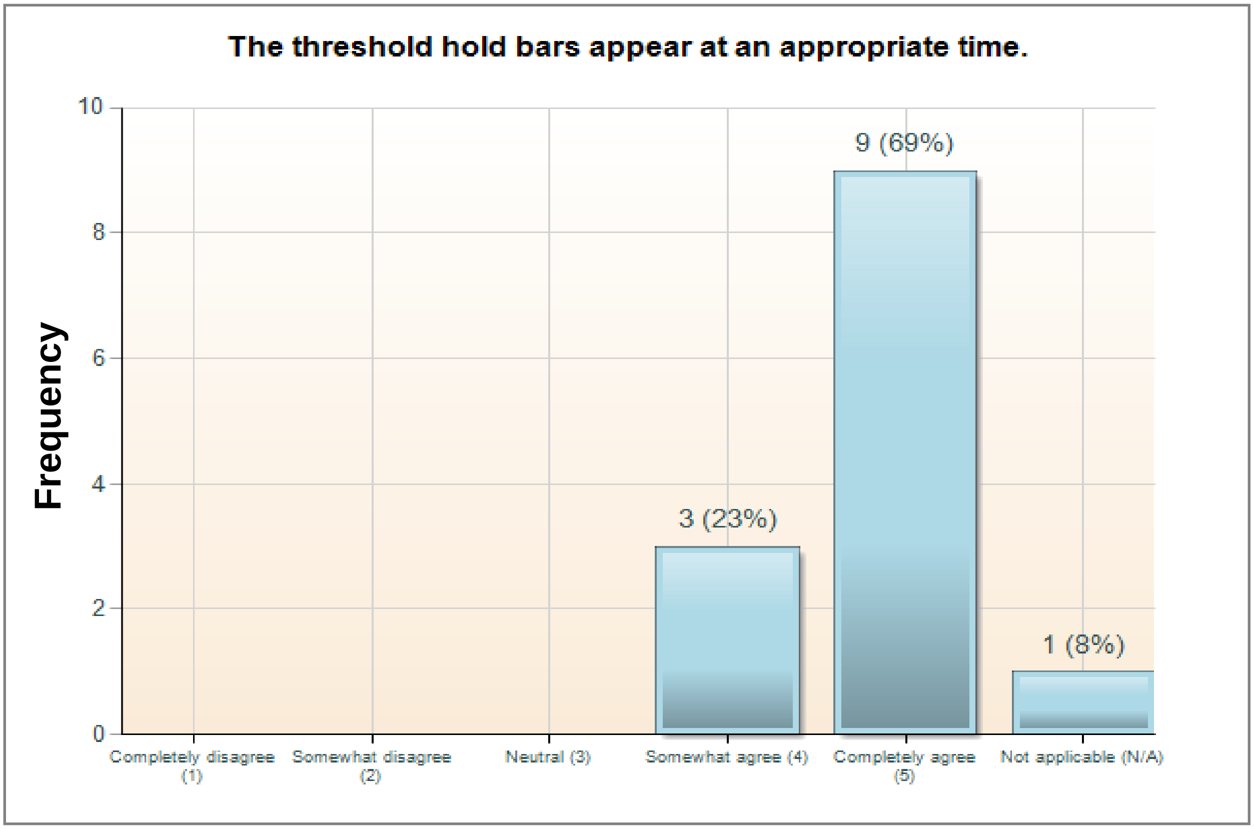

Figure D-46: Appropriateness of the threshold hold bar timing

As shown in Figure D-46, there was a significant difference between observed ratings and expected ratings for perceived appropriateness of the threshold hold bars appearance time, χ^2 (4, N = 12[§]) = 25.50, p < .05. More participants than expected completely agreed with the perceived appropriateness of the threshold hold bars appearance time.

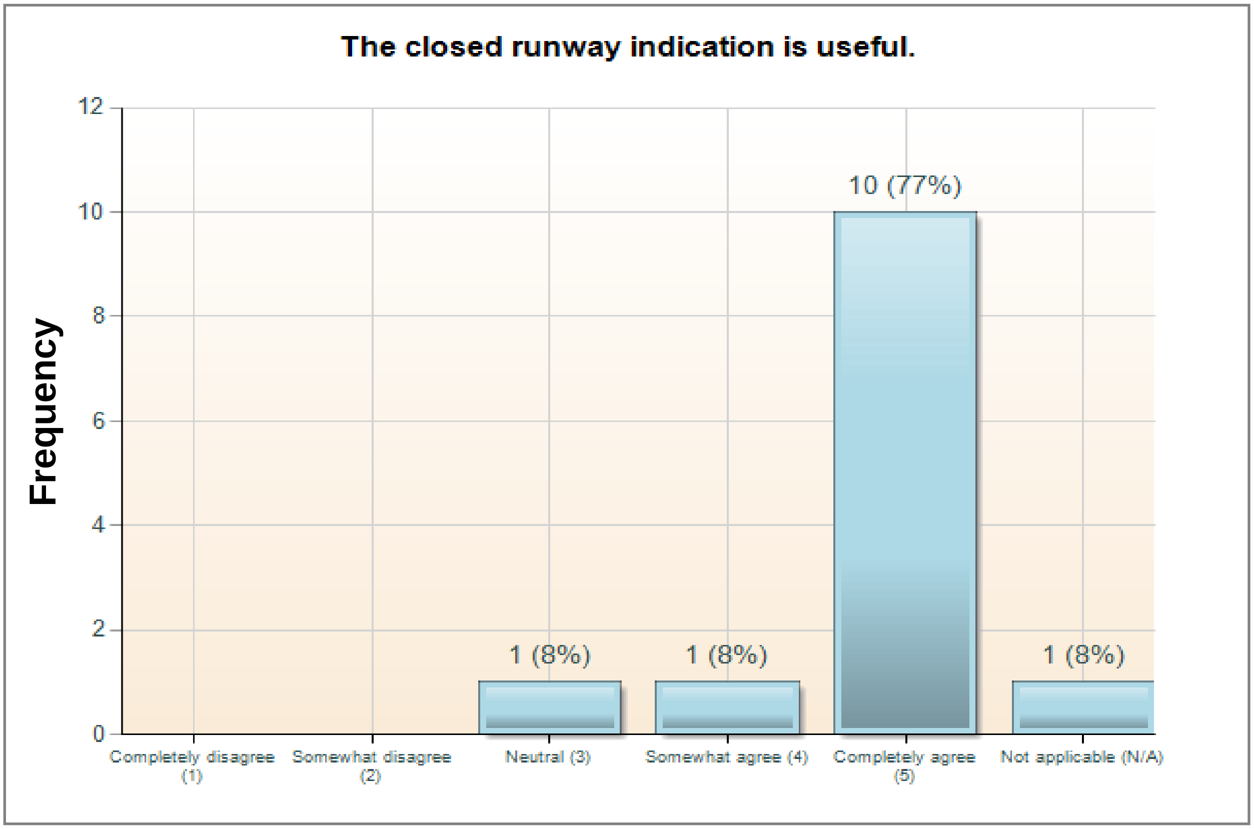

Figure D-47: Usefulness of the closed runway indication

As shown in Figure D-47, there was a significant difference between observed ratings and expected ratings for perceived usefulness of the closed runway indication, χ^2 (4, N = 12[§]) = 30.50, p < .05. More participants than expected completely agreed with the perceived usefulness of the closed runway indication.

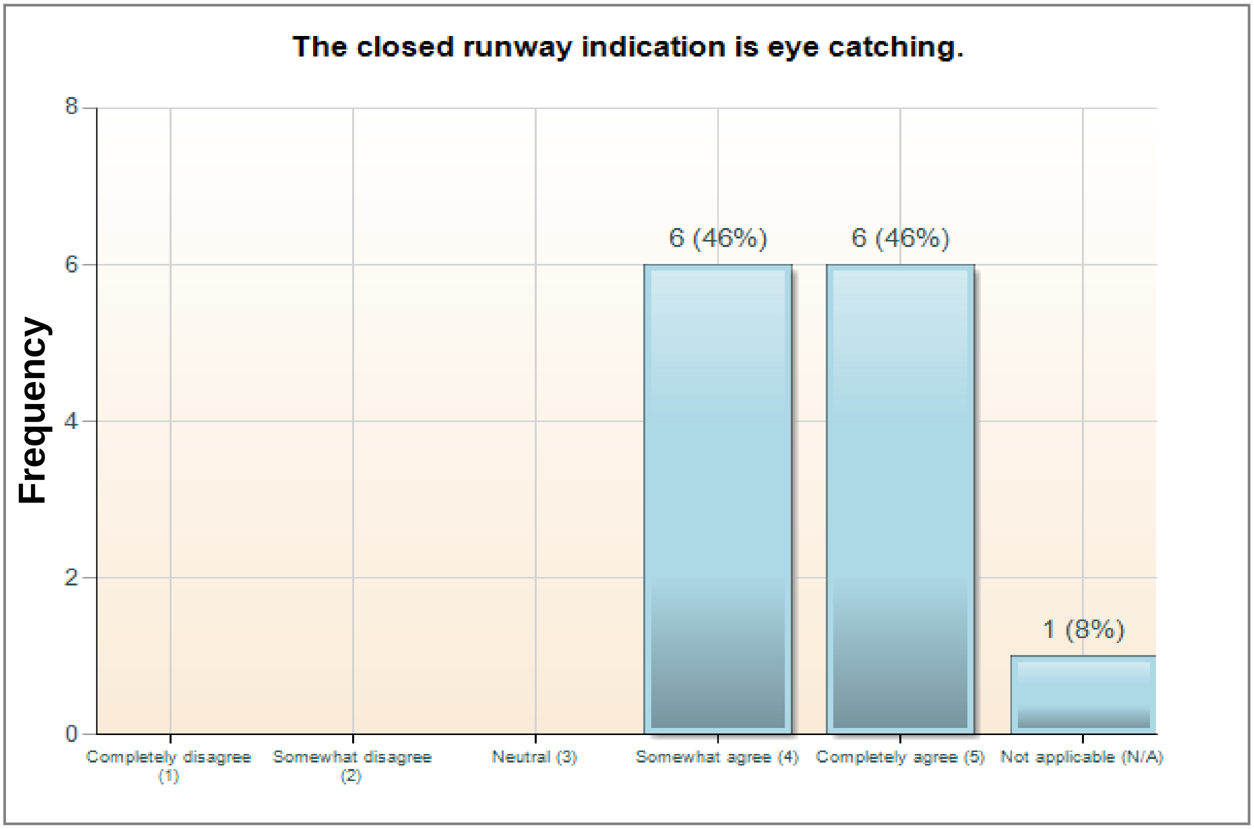

Figure D-48: Salience of the closed runway indication

As shown in Figure D-48, there was a significant difference between observed ratings and expected ratings for perceived salience of the closed runway indication, χ^2 (4, N = 12[§]) = 18.00, p < .05. More participants than expected completely agreed or somewhat agreed that the closed runway indication was eye catching.

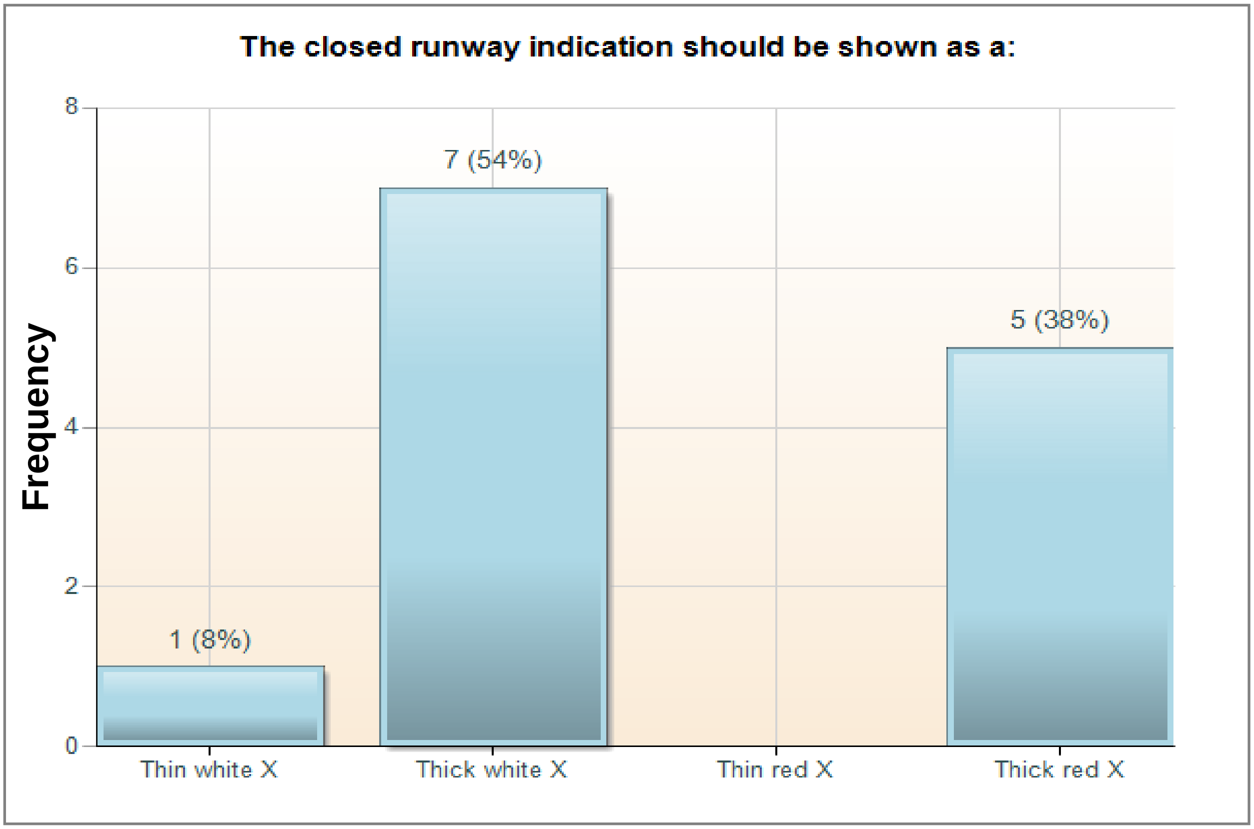

Figure D-49: Salience of the closed runway indication

As shown in Figure D-49, there was a significant difference between observed ratings and expected ratings for perceived preference for a closed runway indication, χ^2 (3, N = 13) = 13.24, p < .05. More participants than expected preferred a thick white X or a thick red X closed runway indication.

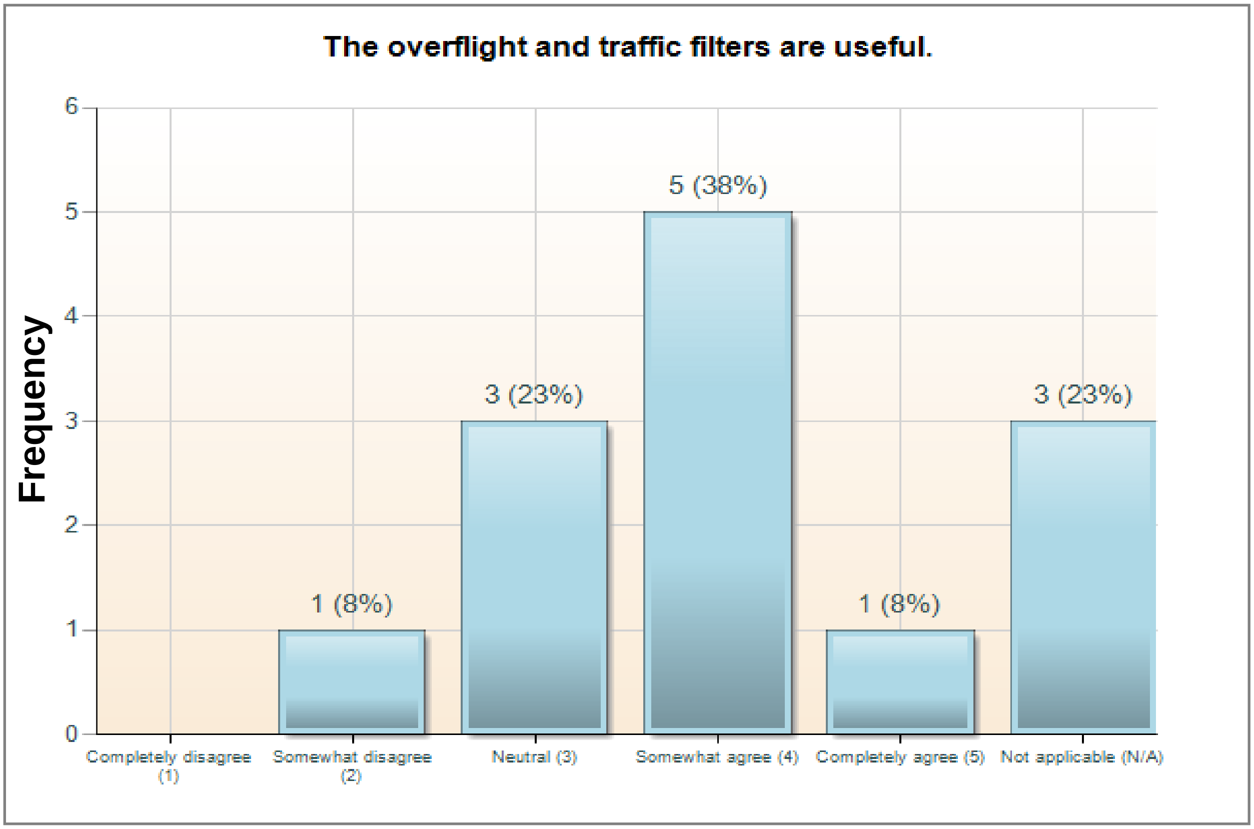

Figure D-50: Usefulness of the overflight and traffic filters

As shown in Figure D-50, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the overflight and traffic filters, χ^2 (4, N = 10[§]) = 8.00, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or somewhat disagree with the perceived usefulness of the overflight and traffic filters.

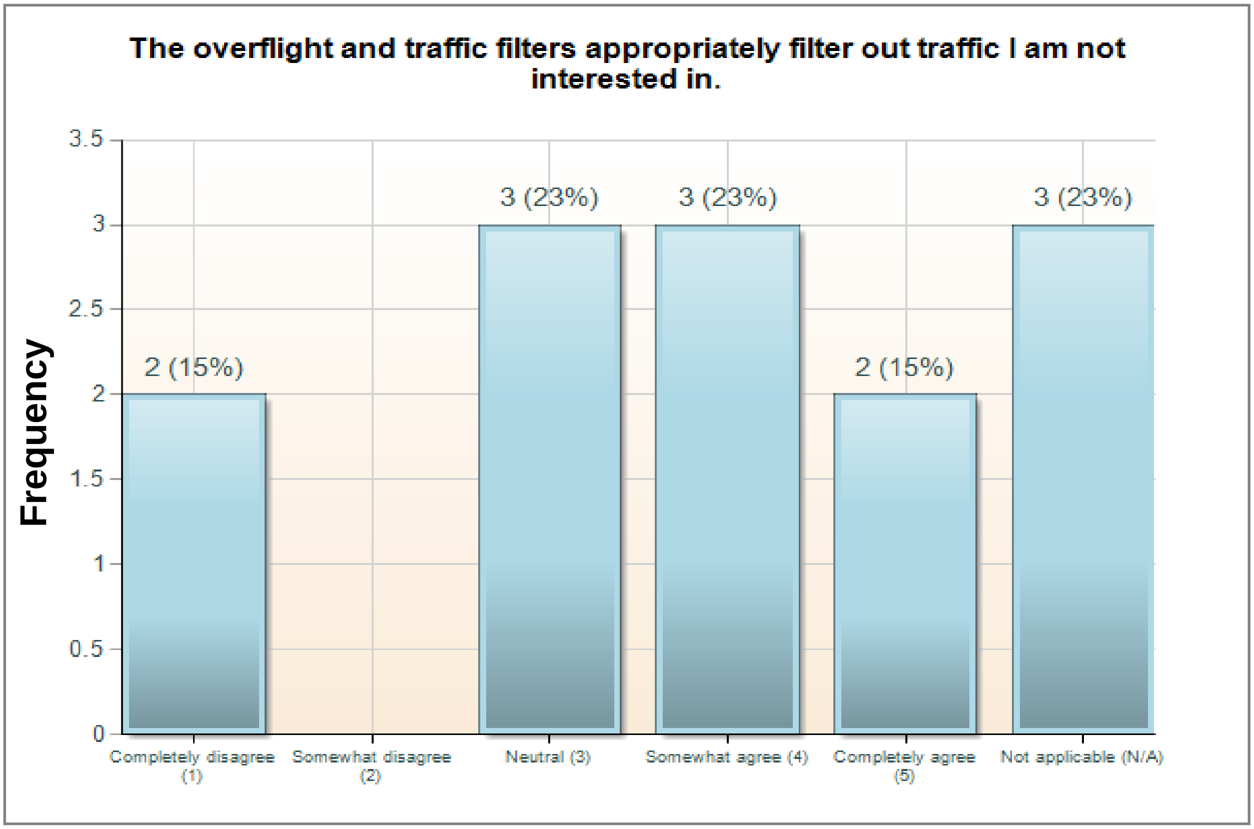

Figure D-51: Ability of overflight and traffic filters

As shown in Figure D-51, there was no significant difference between observed ratings and expected ratings for the perceived ability of overflight and traffic filters to appropriately filter out traffic controllers were not interested in , χ^2 (4, N = 10[§]) = 3.00, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or completely disagree with the perceived ability of the overflight and traffic filters to appropriately filter out traffic.

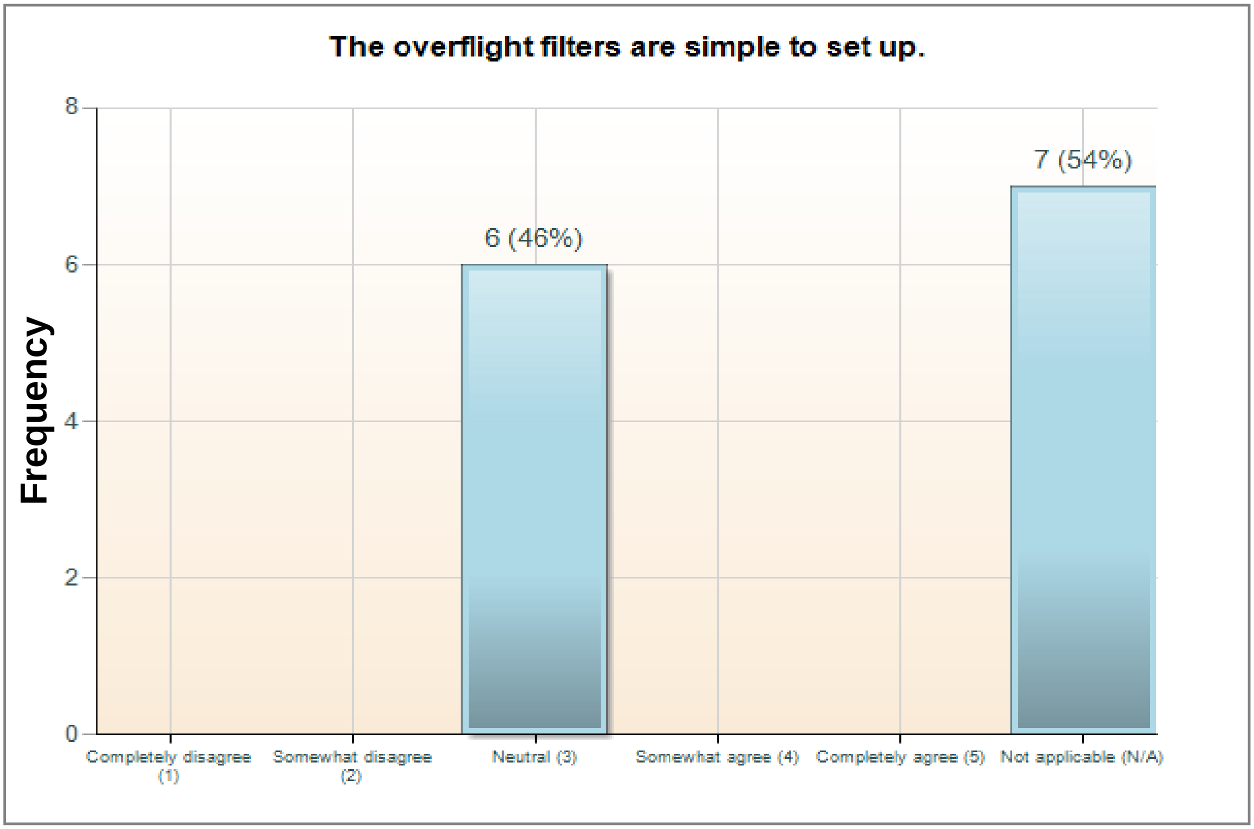

Figure D-52: Simplicity of overflight filters setup

As shown in Figure D-52, there was a significant difference between observed ratings and expected ratings for perceived simplicity to set up the overflight filters, χ^2 (4, N = 6[§]) = 24.00, p < .05. More participants than expected were neutral regarding the simplicity to set up the overflight filters.

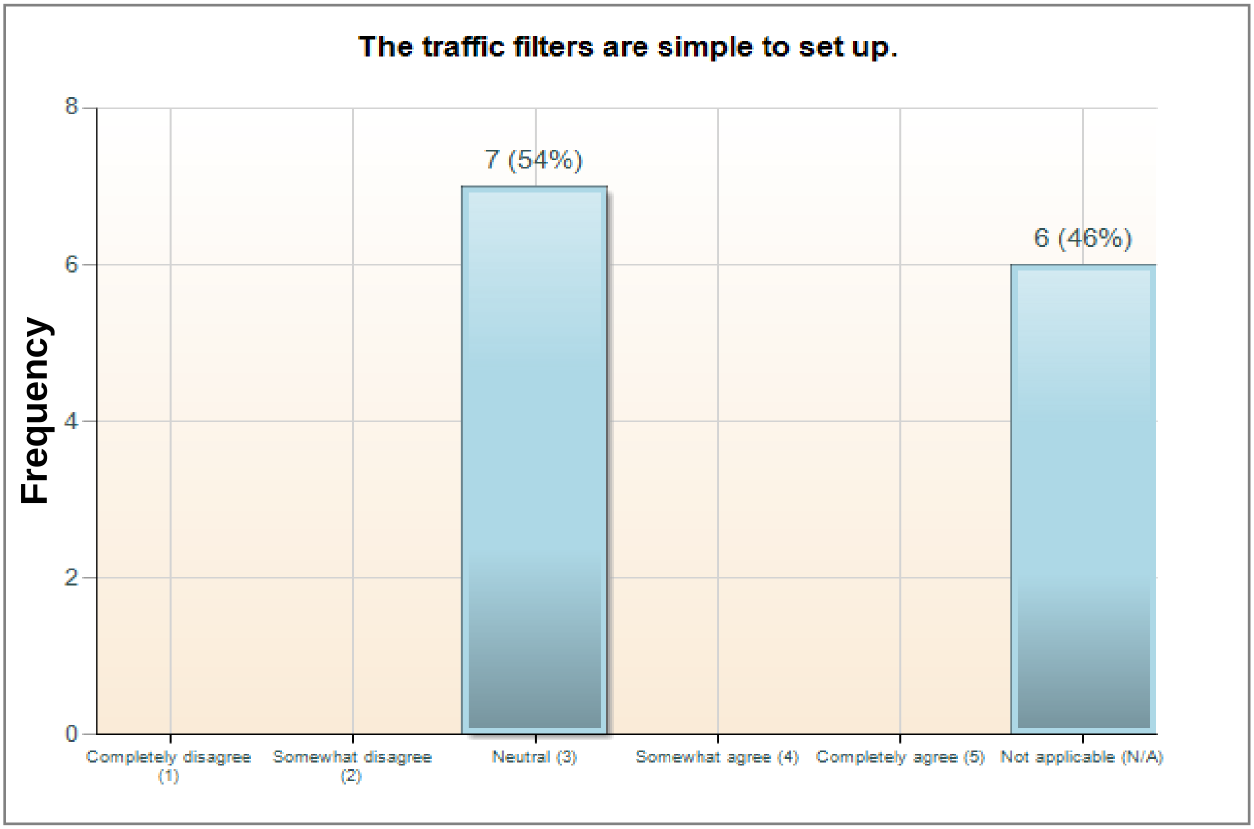

Figure D-53: Simplicity of traffic filter setup

As shown in Figure D-53, there was a significant difference between observed ratings and expected ratings for perceived simplicity to set up the traffic filters, χ^2 (4, N = 7[§]) = 28.00, p < .05. More participants than expected were neutral regarding the simplicity to set up the traffic filters.

D.1.7 Display Usefulness

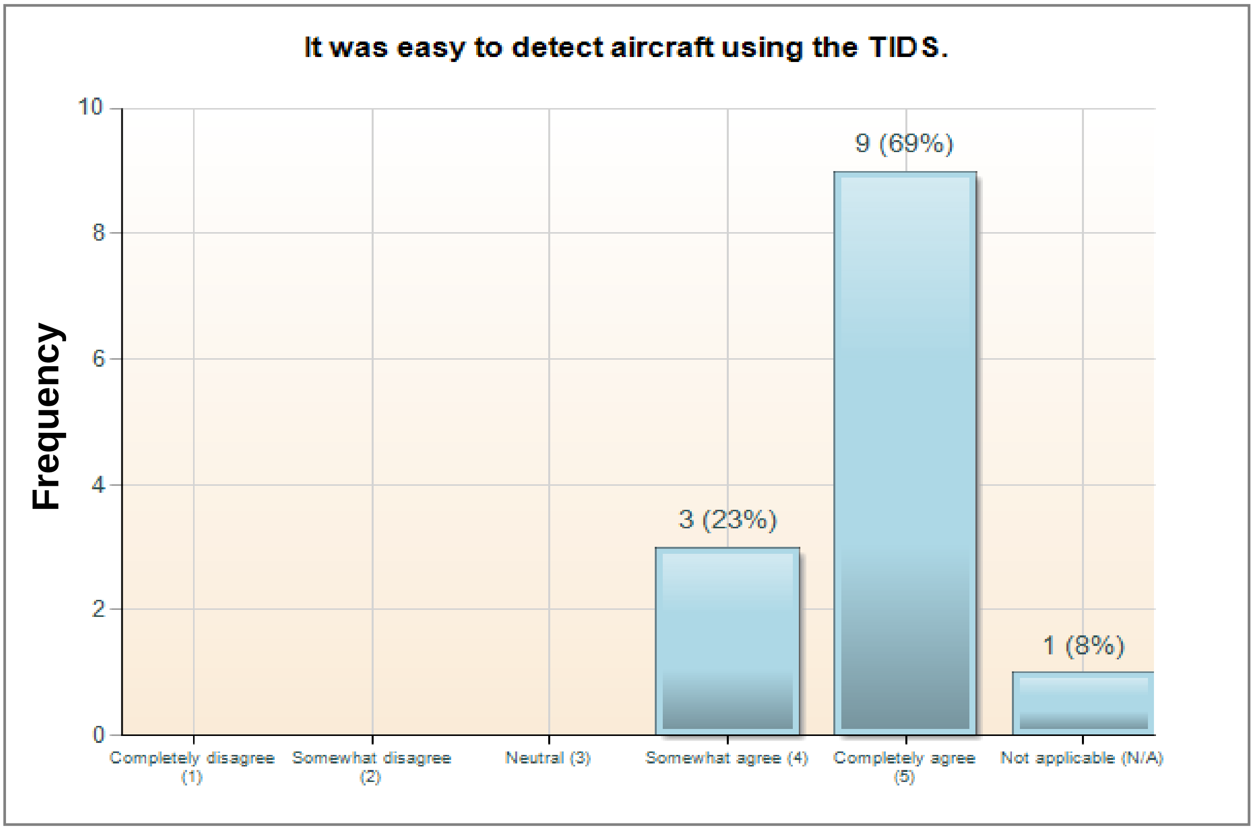

Figure D-54: Ease of detecting aircraft using the TIDS

As shown in Figure D-54, there was a significant difference between observed ratings and expected ratings for perceived ease to detect aircraft using the TIDS, χ^2 (4, N = 12[§]) = 25.50, p < .05. More participants than expected completely agreed that it was easy to detect aircraft using the TIDS.

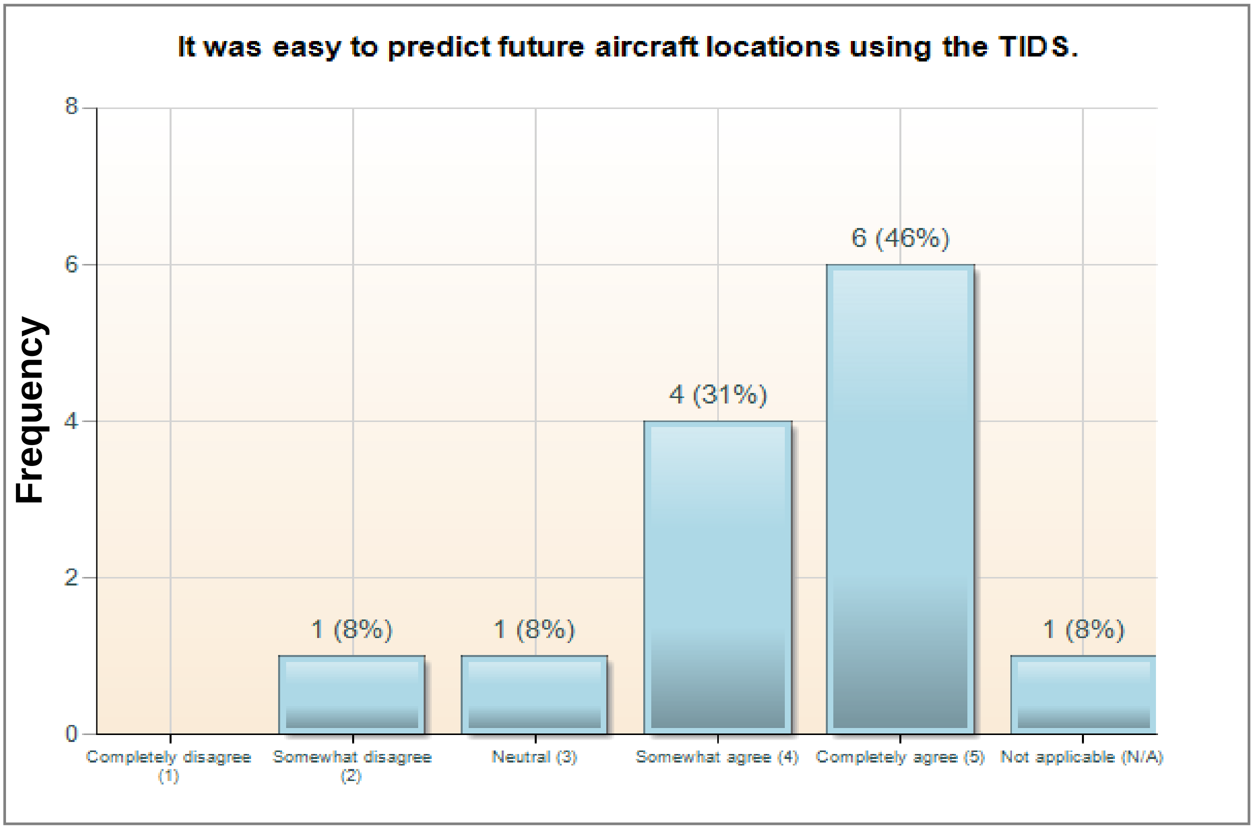

Figure D-55: Ease of predicting aircraft location using the TIDS

As shown in Figure D-55, there was a significant difference between observed ratings and expected ratings for perceived ease of predicting future aircraft locations using the TIDS, χ^2 (4, N = 12[§]) = 10.50, $p < .05$. More participants than expected completely agreed or somewhat agreed that it was easy to predict future aircraft locations using the TIDS.

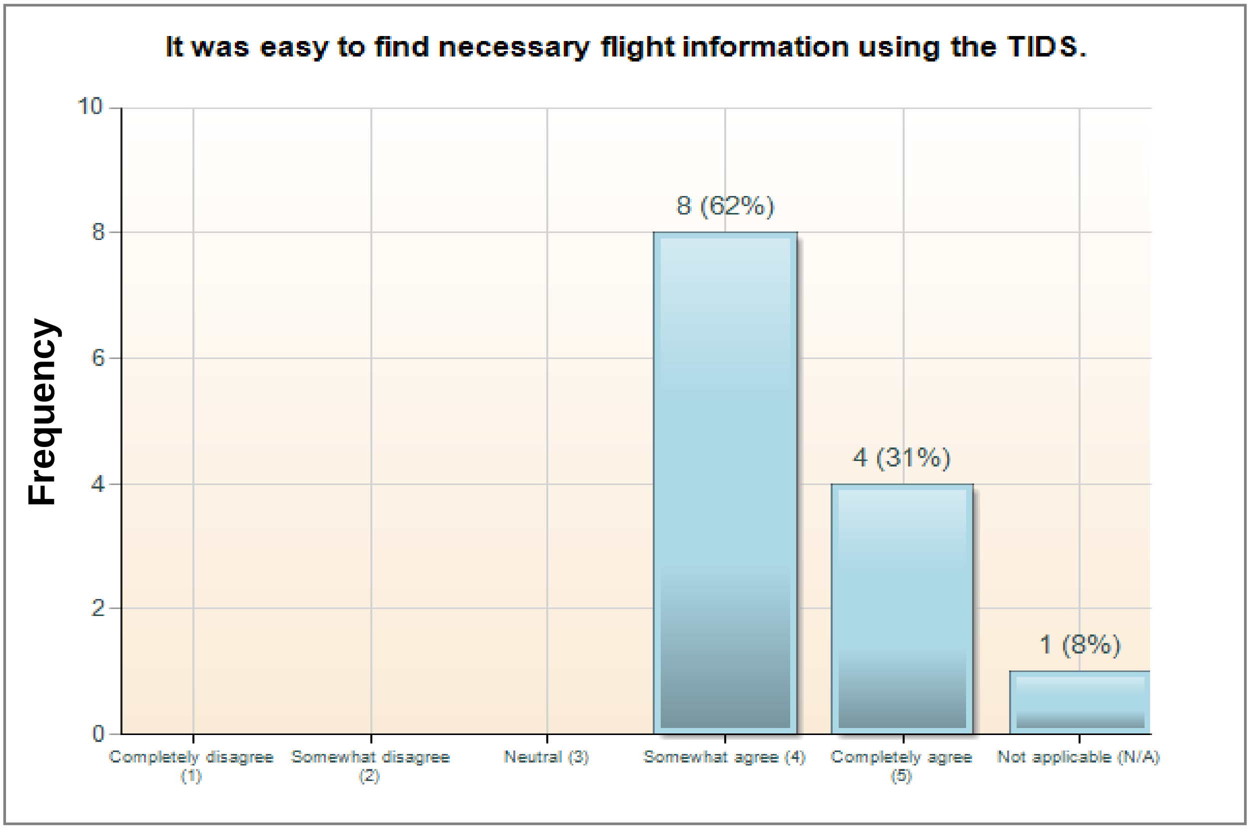

Figure D-56: Ease of finding necessary information using the TIDS

As shown in Figure D-56, there was a significant difference between observed ratings and expected ratings for perceived ease of finding necessary flight information using the TIDS, χ^2 (4, N = 12[§]) = 21.33, p < .05. More participants than expected somewhat agreed that it was easy to find necessary flight information using the TIDS.

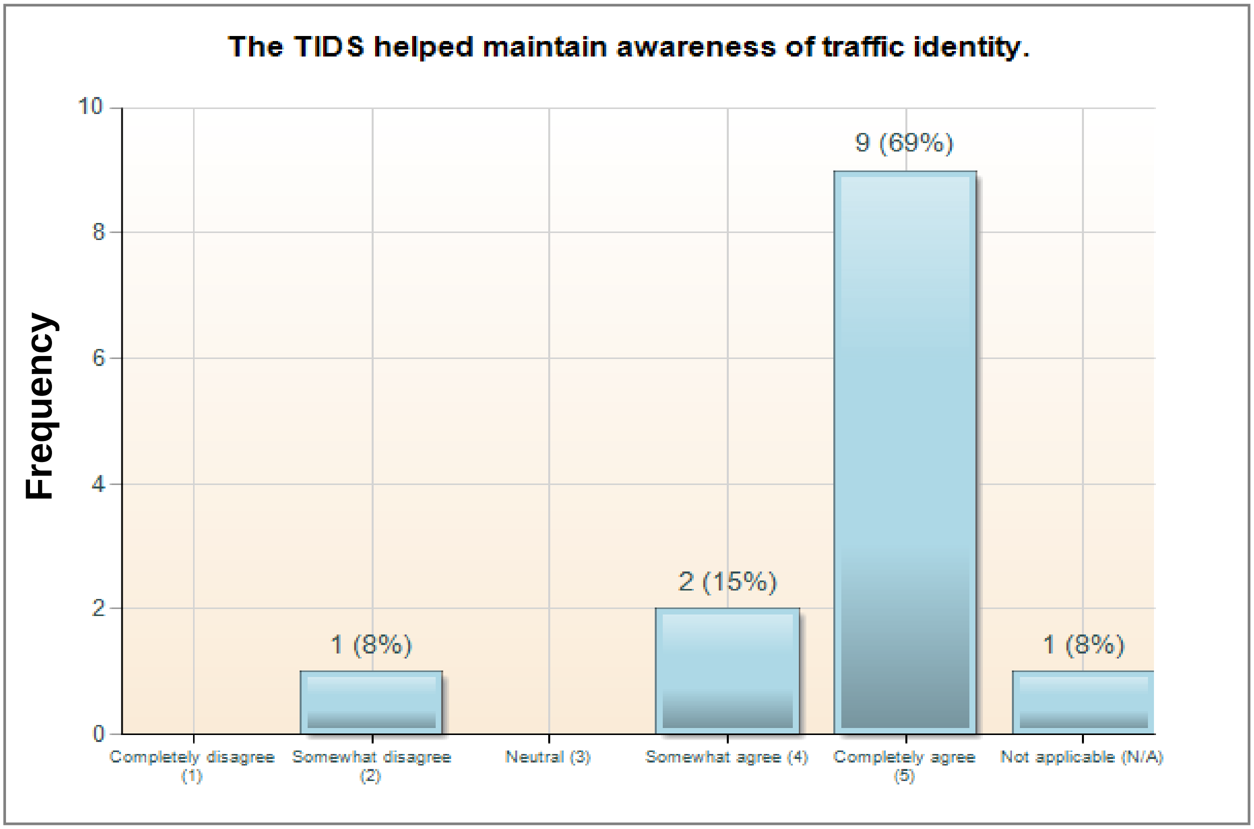

Figure D-57: Ease of maintaining traffic identity awareness

As shown in Figure D-57, there was a significant difference between observed ratings and expected ratings for perceived TIDS helpfulness in maintaining awareness of traffic identity, χ^2 (4, N = 12[§]) = 23.83, p < .05. More participants than expected completely agreed that the TIDS helped maintain awareness of traffic identity.

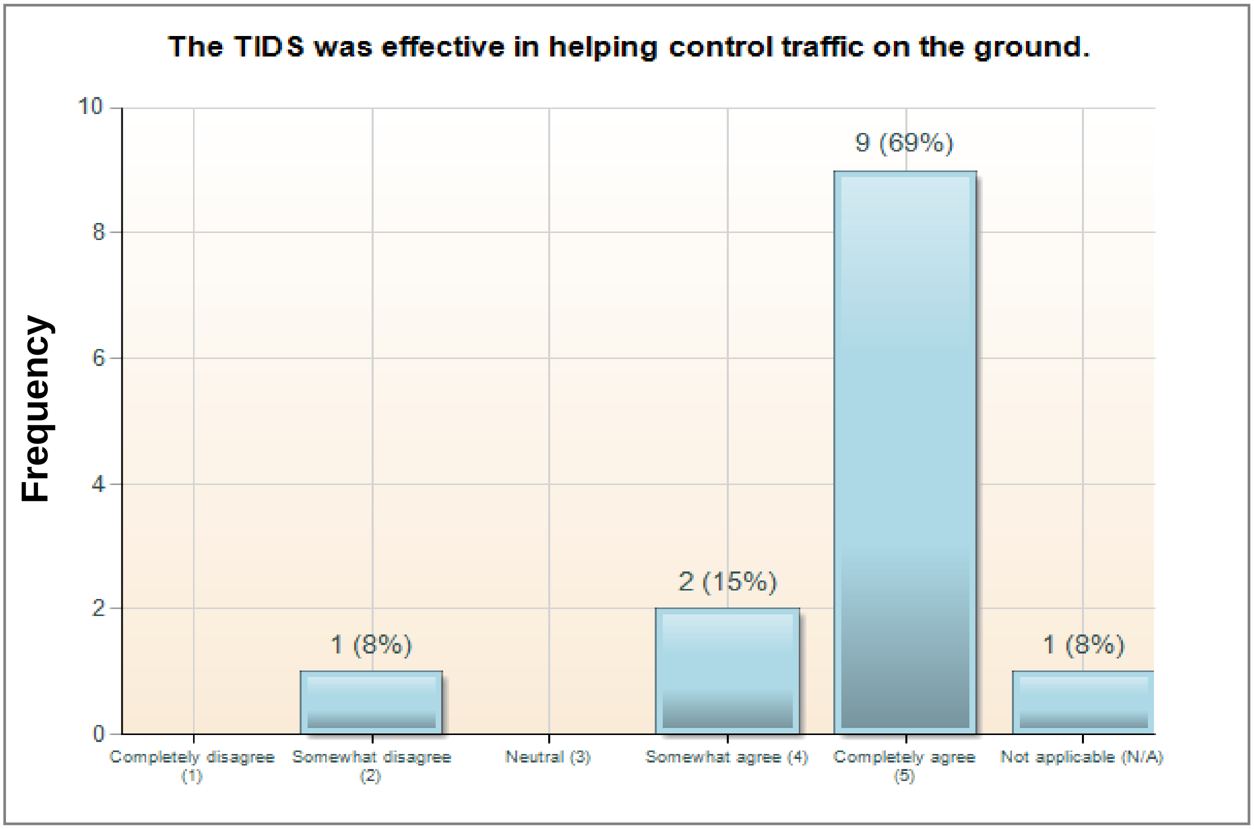

Figure D-58: TIDS helpfulness in helping control traffic on the ground

As shown in Figure D-58, there was a significant difference between observed ratings and expected ratings for perceived TIDS effectiveness in helping control traffic on the ground, χ^2 (4, N = 12[§]) = 23.83, $p < .05$. More participants than expected completely agreed that the TIDS was effective in helping control traffic on the ground.

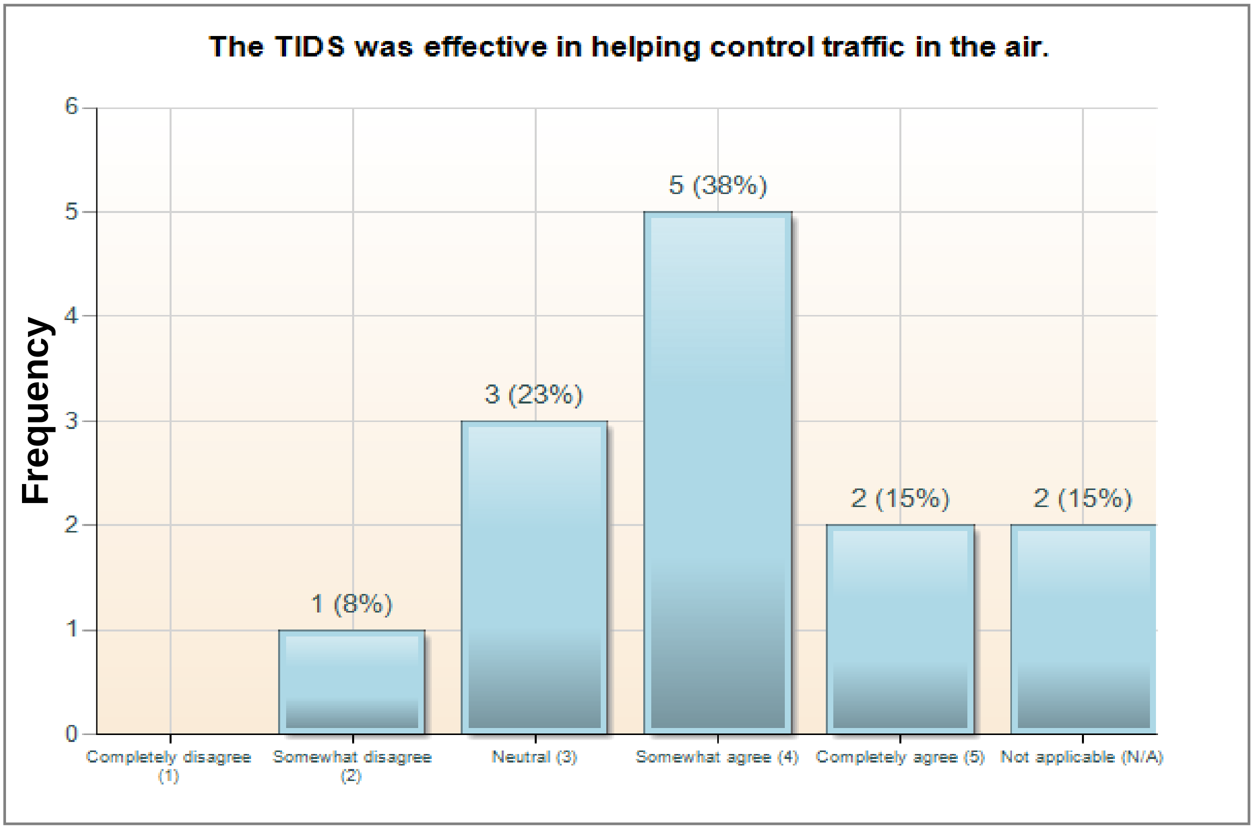

Figure D-59: TIDS effectiveness in helping control traffic in the air

As shown in Figure D-59, there was no significant difference between observed ratings and expected ratings for perceived TIDS effectiveness in helping control traffic in the air, χ^2 (4, N = 11[§]) = 6.72, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or somewhat disagree with perceived TIDS effectiveness in helping control traffic in the air.

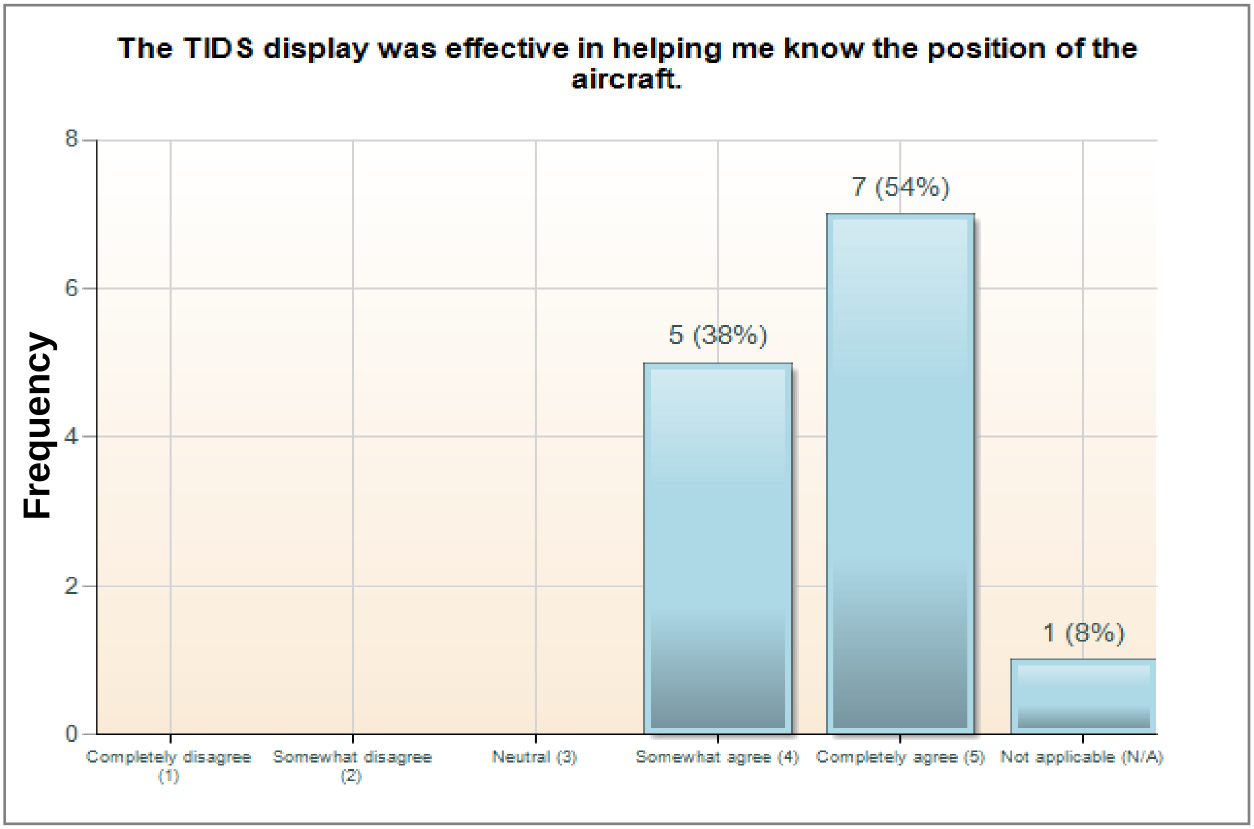

Figure D-60: TIDS effectiveness in helping controllers know position

As shown in Figure D-60, there was a significant difference between observed ratings and expected ratings for perceived TIDS display effectiveness in helping controllers know the position of the aircraft, χ^2 (4, N = 12[§]) = 18.83, $p < .05$. More participants than expected completely agreed or somewhat agreed that the TIDS display was effective in helping them know the position of the aircraft.

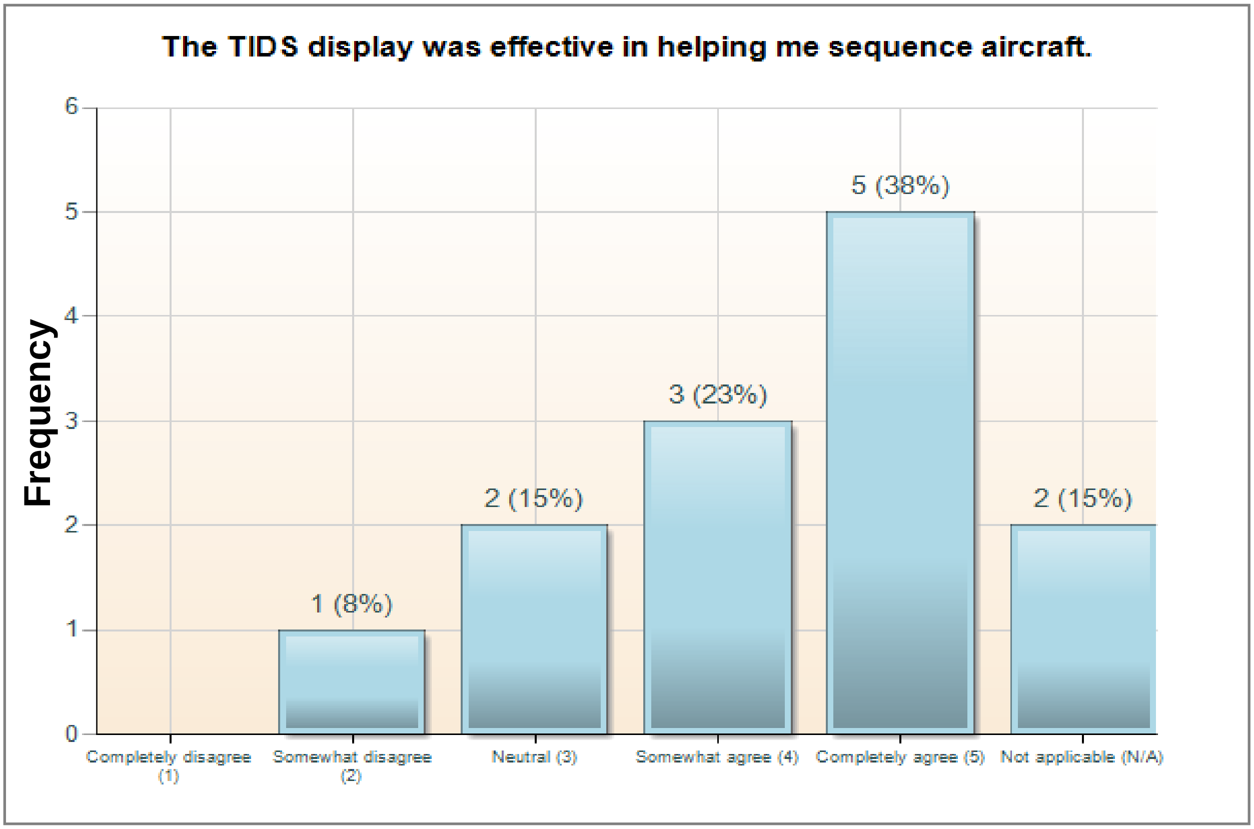

Figure D-61: TIDS display effectiveness in helping controllers sequence aircraft

As shown in Figure D-61, there was no significant difference between observed ratings and expected ratings for perceived TIDS display effectiveness in helping controllers sequence aircraft, χ^2 (4, N = 11[§]) = 6.72, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or somewhat disagree with perceived TIDS effectiveness in helping them sequence aircraft.

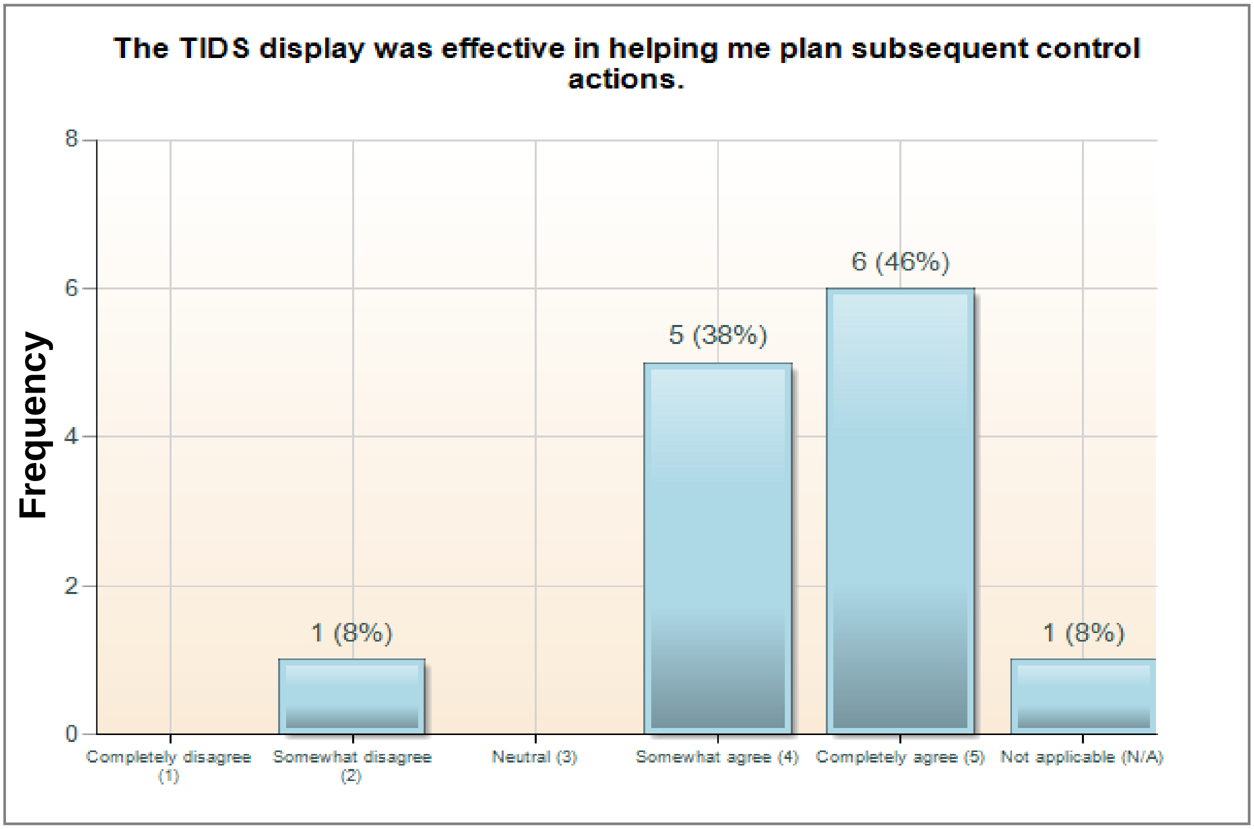

Figure D-62: TIDS display effectiveness in helping controllers plan

As shown in Figure D-62, there was a significant difference between observed ratings and expected ratings for perceived TIDS display effectiveness in helping controllers plan subsequent control actions, χ^2 (4, N = 12[§]) = 13.83, p < .05. More participants than expected completely agreed or somewhat agreed that the TIDS display was effective in helping them plan subsequent control actions.

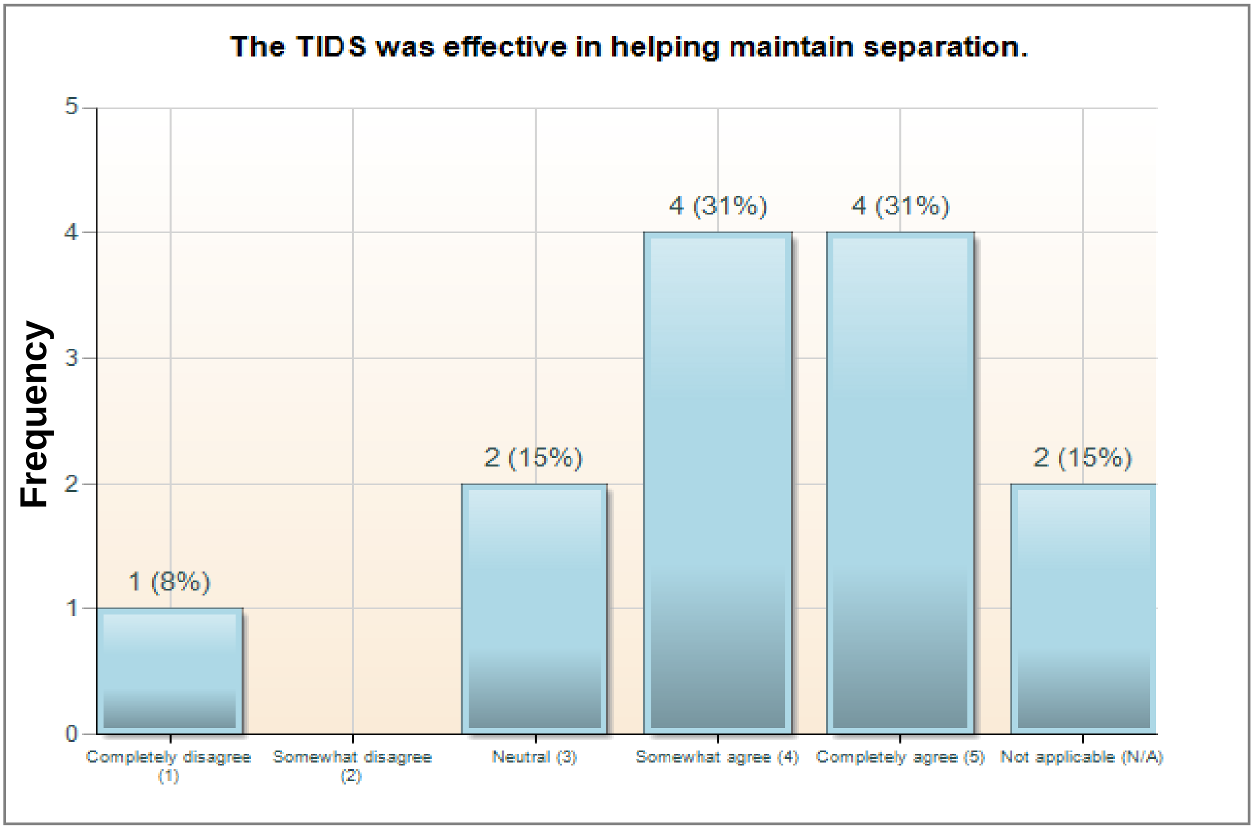

Figure D-63: TIDS effectiveness in helping maintain separation

As shown in Figure D-63, there was no significant difference between observed ratings and expected ratings for perceived TIDS effectiveness in helping maintain separation, χ^2 (4, N = 11[§]) = 5.81, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or completely disagree with perceived TIDS effectiveness in helping maintain separation.

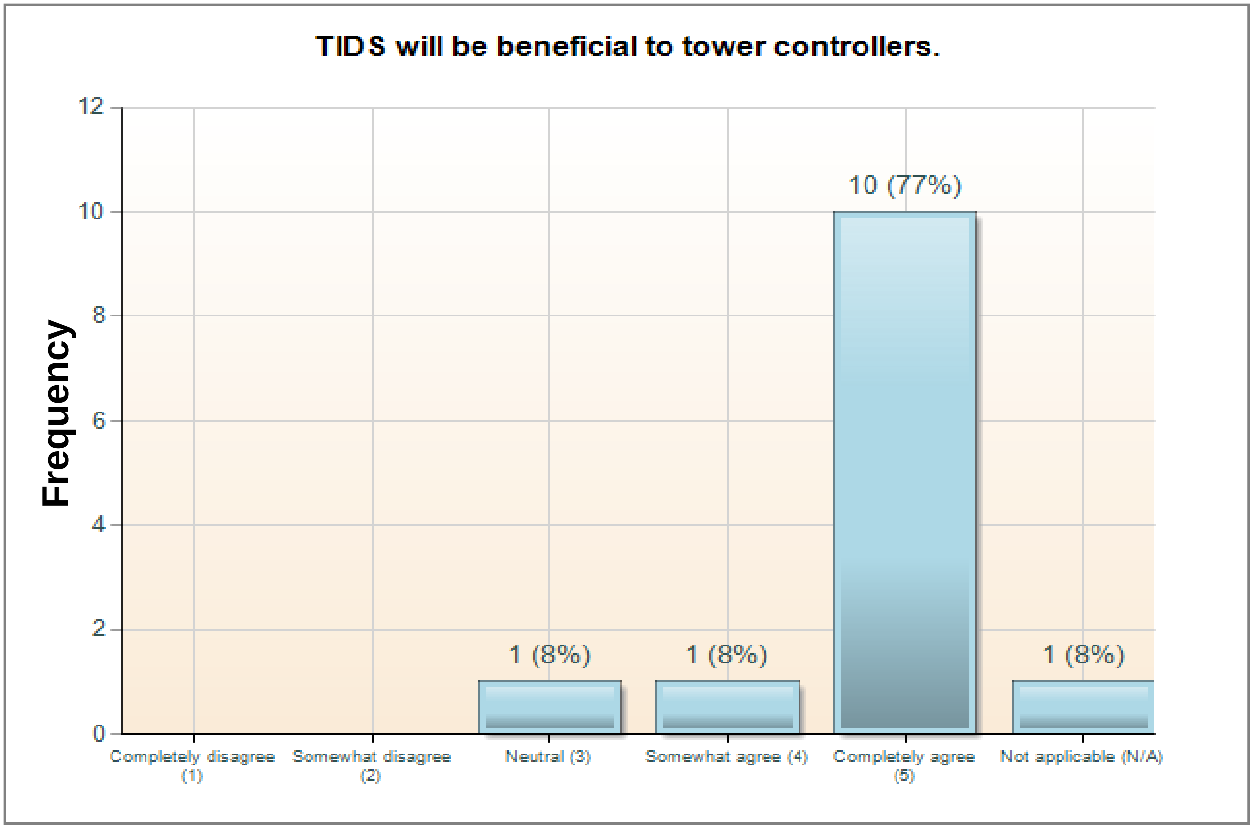

Figure D-64: TIDS benefit to tower controllers

As shown in Figure D-64, there was a significant difference between observed ratings and expected ratings for perceived TIDS benefit to tower controllers, χ^2 (4, N = 12[§]) = 30.50, p < .05. More participants than expected completely agreed that TIDS will be beneficial.

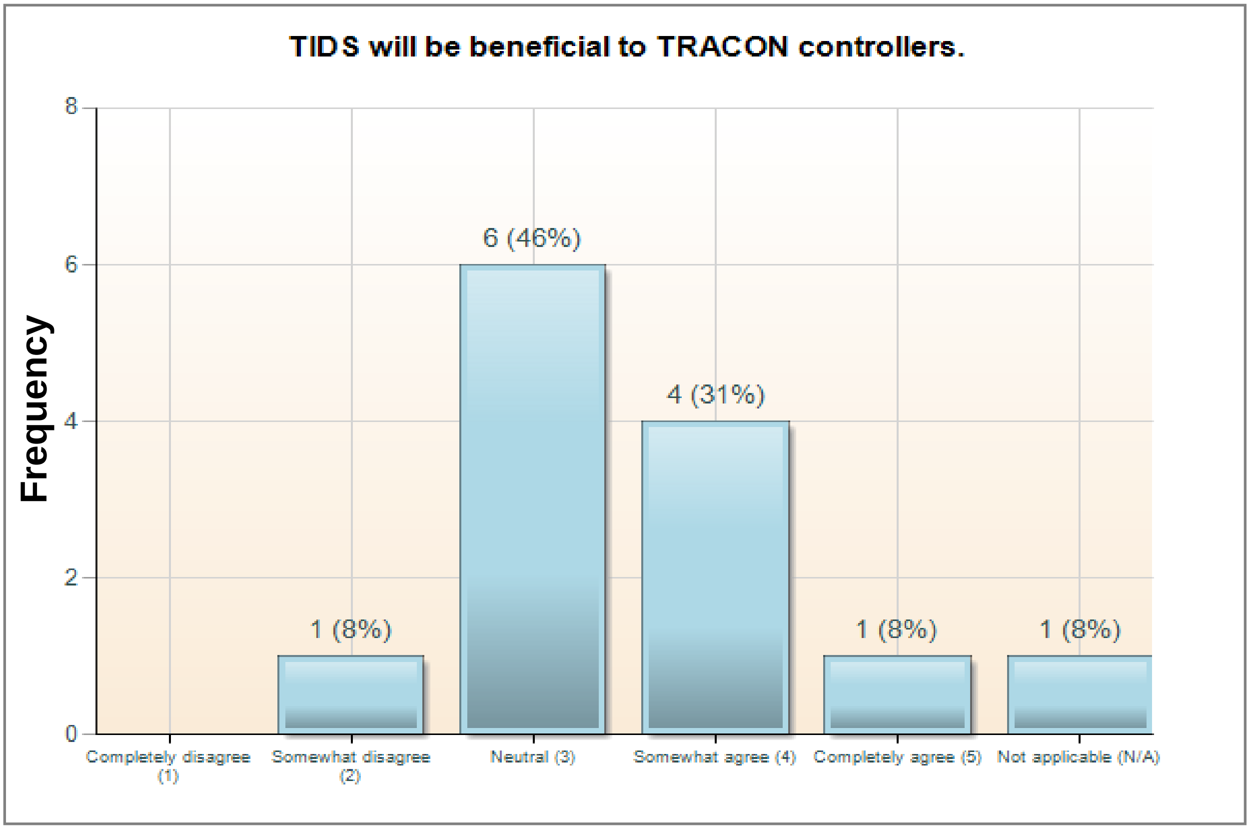

Figure D-65: TIDS benefit to TRACON controllers

As shown in Figure D-65, there was a significant difference between observed ratings and expected ratings for perceived TIDS benefit to TRACON controllers, χ^2 (4, N = 12[§]) = 10.50, p < .05. More participants than expected were neutral or somewhat agreed that TIDS will be beneficial to TRACON controllers.

The Chi Square values, means, and standard deviations for the TIDS results are presented in Table D-1.

Table D-1: General summary for TIDS results[4]

		Chi Square	Mean	SD
Target Information				
Question 1	Target position was accurate	31.33 *(p=.001)*	4.83	.389
Question 2	Target's indicated altitude was accurate	8.14 *(p=.086)*	4.07	.995
Question 3	State color presentation on the data block was accurate	9.57 *(p=.048)*	4.07	1.07
Question 4	Target heading was accurate	46.71 *(p=.001)*	4.92	.267
Question 5	Displayed target type was appropriate for all targets	38.14 *(p=.001)*	4.78	.579
Question 6	Number of target types were appropriate to represent the traffic	25.28 *(p=.001)*	4.57	.852
Question 7	No frozen icons or indications of stale data on TIDS	23.83 *(p=.001)*	4.50	1.16
Question 8	No false targets or tracks on the TIDS	27.38 *(p=.001)*	4.61	.870
Question 9	No jumping targets on TIDS	17.16 *(p=.002)*	4.41	.996
Information Accuracy and Availability				
Question 11	TIDS provided appropriate information to ground controllers	25.28 *(p=.001)*	4.64	.633
Question 12	TIDS provided appropriate information to local controllers	25.28 *(p=.001)*	4.64	.633
Question 13	Data block was accurate	32.42 *(p=.001)*	4.79	.426

[4] Question 54 was omitted because it deviated from the Likert scale convention of agreement since it asked about relative salience of the closed runway indication that was offered as four different display indicator options.

		Chi Square	Mean	SD
Question 14	Timesharing of the departure fix and assigned runway in the data block was useful	24.57 *(p=.001)*	4.57	.756
Question 15	Data block's aircraft state indications were accurate	19.57 *(p=.001)*	4.50	.760
Question 16	Airport configuration information was accurate	22.00 *(p=.001)*	4.62	.650
Question 17	Taxiway status information was accurate	30.50 *(p=.001)*	4.75	.622
Question 18	Information provided on TIDS accurately reflected the operational environment	24.57 *(p=.001)*	4.57	.756
User Interface				
Question 20	TIDS user interface was easy to use	21.71 *(p=.001)*	4.43	.514
Question 21	TIDS target icon color coding was useful	31.00 *(p=.001)*	4.71	.611
Question 22	Data block color coding was useful	16.00 *(p=.003)*	4.43	.756
Question 23	TIDS hot keys were useful	9.45 *(p=.051)*	4.27	.786
Question 24	Target selection/highlighting on the TIDS was eye catching	16.71 *(p=.002)*	4.36	.842
Question 25	It was easy to access the TIDS menu functions	10.50 *(p=.033)*	4.08	.900
Question 26	User preference sets were useful	15.84 *(p=.003)*	4.46	.660
Question 27	It was easy to create and access TIDS user preference sets	4.00 *(p=.406)*	3.82	1.16
Picture-in-Picture Windows				
Question 29	Picture-in-picture windows are useful	8.83 *(p=.065)*	4.17	1.03
Question 30	Camera picture-in-picture window was useful	3.09 *(p=.543)*	3.64	1.43
Question 31	Picture-in-picture windows were easy to configure	4.90 *(p=.297)*	3.82	.982

		Chi Square	Mean	SD
Question 32	Number of camera picture-in-picture windows were sufficient	6.00 *(p=.199)*	3.10	1.10
Wind Information				
Question 34	Wind display window was useful	7.16 *(p=.127)*	4.00	.953
Question 35	Using the wind display window did not distract them from other information on the TIDS	23.83 *(p=.001)*	4.58	.793
Question 36	Wind information provided was sufficient for ATC purposes	18.00 *(p=.001)*	4.50	.798
Question 37	Wind information was updated in a timely manner	11.00 *(p=.027)*	4.10	.994
Question 38	Wind information presentation was acceptable	13.00 *(p=.011)*	4.17	1.11
Display Features				
Question 40	Wake turbulence timer was useful	6.72 *(p=.151)*	3.91	.944
Question 41	Countdown time provided by the wake turbulence timer was appropriate	5.81 *(p=.213)*	4.00	1.00
Question 42	Aircraft types for which the wake turbulence timer was shown were sufficient	8.83 *(p=.065)*	3.92	1.24
Question 43	Optional runway pattern overlaid on the runway when the wake turbulence timer was active was useful	6.57 *(p=.160)*	3.14	1.21
Question 44	Approach bars were useful	6.72 *(p=.151)*	4.09	1.09
Question 45	Approach bar depiction was appropriate	9.66 *(p=.046)*	4.17	.937
Question 46	Restricted areas were useful	4.00 *(p=.406)*	3.33	1.03
Question 47	Creating a restricted area was simple	20.00 *(p=.001)*	3.00	.000
Question 48	Runway hold bars were useful	13.83 *(p=.008)*	4.42	.793
Question 49	Runway hold bars appeared at an appropriate time	31.33 *(p=.001)*	4.83	.152

		Chi Square	Mean	SD
Question 50	Threshold hold bars were useful	22.18 *(p=001)*	4.73	.467
Question 51	Threshold hold bars appeared at an appropriate time	25.50 *(p=.001)*	4.75	.452
Question 52	Closed runway indication was useful	30.50 *(p=.001)*	4.75	.622
Question 53	Closed runway indication was eye catching	18.00 *(p=.001)*	4.50	.522
Question 55	Overflight and traffic filters were useful	8.00 *(p=.092)*	3.60	.843
Question 56	Overflight and traffic filters appropriately filtered out traffic controllers were not interested in	3.00 *(p=.558)*	3.30	1.41
Question 57	Overflight filters were simple to set up	24.00 *(p=.001)*	3.00	.000
Question 58	Traffic filters were simple to set up	28.00 *(p=.001)*	3.00	.000
Display Usefulness				
Question 60	Easy to detect aircraft using the TIDS	25.50 *(p=.001)*	4.75	.452
Question 61	Easy to predict future aircraft locations using the TIDS	10.50 *(p=.033)*	4.25	.965
Question 62	Easy to find necessary flight information using the TIDS	21.33 *(p=.001)*	4.33	.492
Question 63	TIDS helped maintain awareness of traffic identity	23.83 *(p=.001)*	4.58	.900
Question 64	TIDS was effective in helping control traffic on the ground	23.83 *(p=.001)*	4.58	.900
Question 65	TIDS was effective in helping control traffic in the air	6.72 *(p=.151)*	3.73	.905
Question 66	TIDS display was effective in helping controllers know the position of the aircraft	18.83 *(p=.001)*	4.58	.515
Question 67	TIDS display was effective in helping controllers sequence aircraft	6.72 *(p=.151)*	4.09	1.04
Question 68	TIDS display was effective in helping controllers plan subsequent control	13.83 *(p=.008)*	4.33	.888

		Chi Square	Mean	SD
Question 69	TIDS was effective in helping maintain separation	5.81 *(p=.213)*	3.91	1.22
Question 70	TIDS will be beneficial to tower controllers	30.50 *(p=.001)*	4.75	.622
Question 71	TIDS will be beneficial to TRACON controllers	10.50 *(p=.033)*	3.42	.793

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APPENDIX E
SUMMARY OF CHI SQUARE RESULTS

The following is a summary of the TIDS results for items that passed the success criteria of ≥ 4 out of 5 on a five-point Likert scale, as presented in Appendix D.1 .

E.1 Tower Information Display System

Target information. When asked about the TIDS target information, most participants completely agreed that the target position was accurate (Figure D-1), target heading was accurate (Figure D-4), displayed target type was appropriate for all targets (Figure D-5), number of target types were appropriate to represent the traffic (Figure D-6), there were no frozen icons or indications of stale data on the TIDS (Figure D-7), there were no false targets or tracks on the TIDS (Figure D-8), and that there were no jumping targets seen on the TIDS (Figure D-9). Also, most participants completely agreed or somewhat agreed that the state color presentation on the data block was accurate (Figure D-2).

Information accuracy and availability. When asked about the TIDS information accuracy and availability, most participants completely agreed that the TIDS provided appropriate information to ground controllers (Figure D-10), TIDS provided appropriate information to local controllers (Figure D-11), data block was accurate (Figure D-12), timesharing of the departure fix and assigned runway in the data block was useful (Figure D-13), data block's aircraft state indications were accurate (Figure D-14), airport configuration information was accurate (Figure D-15), taxiway status information was accurate (Figure D-16), and that the information provided on TIDS accurately reflected the operational environment (Figure D-17).

User Interface. When asked about the TIDS user interface, most participants completely agreed that the TIDS target icon color coding was useful (Figure D-19), and that the data block color coding was useful (Figure D-20). Also, most participants completely agreed or somewhat agreed that the target selection/ highlighting on the TIDS was eye catching (Figure D-22) and that the user preference sets were useful (Figure D-24). In addition, most participants somewhat agreed or completely agreed that the TIDS user interface was easy to use (Figure D-18), and that it was easy to access the TIDS menu functions (Figure D-23).

Picture-in-picture windows. There were no significant findings in participants ratings on the picture-in-picture.

Wind information. When asked about the wind information, most participants completely agreed that using the wind display window did not distract them from other information on the TIDS (Figure D-31), the wind information provided was sufficient for ATC purposes (Figure D-32), and that the wind information presentation was acceptable (Figure D-34). In addition, most participants completely agreed or were neutral when asked if the wind information was updated in a timely manner (Figure D-33).

Display features. When asked about the display features, most participants completely agreed that the runway hold bars were useful (Figure D-43), hold bars appeared at an appropriate time (Figure D-44), threshold hold bars were useful (Figure D-45), threshold hold bars appeared at an appropriate time (Figure D-46), and that the closed runway indication was useful (Figure D-47). Also, most participants completely agreed or somewhat agreed that the approach bar depiction was appropriate (Figure D-40) and that the closed runway indication was eye catching (Figure D-48). In addition, most participants preferred to show the closed runway indications as a thick white X or a thick red X (Figure D-49). Finally, most participants were neutral when asked if creating a restricted area was simple (Figure D-42), if the overflight filters were simple to set up (Figure D-52), or if the traffic filters were simple to set up (Figure D-53).

Display usefulness. When asked about the display usefulness, most participants completely agreed that it was easy to detect aircraft using the TIDS (Figure D-54), the TIDS helped maintain awareness of traffic identity (Figure D-56), the TIDS was effective in helping control traffic on the ground (Figure D-57), and the TIDS would be beneficial to tower controllers (Figure D-63). Also, most participants completely agreed or somewhat agreed that it was easy to predict future aircraft locations using the TIDS (Figure D-54), the TIDS display was effective in helping them know the position of the aircraft (Figure D-59), and that the TIDS display was effective in helping them plan subsequent control actions (Figure D-61). Moreover, most participants somewhat agreed that it was easy to find necessary flight information using the TIDS (Figure D-55). Finally, most participants were neutral or somewhat agreed when asked if the TIDS will be beneficial to TRACON controllers (Figure D-64).

APPENDIX F
SUGGESTED TFDM DISPLAY MODIFICATIONS

This section expands on the issues and requested modifications described in Section 3.3.

Affected Display	Capability/Issue	Requested Modification
System	VFR/IFR information needs	• Separate profiles for VFR/IFR weather
System	Improved workstation	• Adjustable workstation for seated/standing
TIDS	Additional information needed on TIDS	• Add altimeter, RVR, hat status • Add windshear data when available
TIDS	Provide indication of flight status	• Datablock color coding (green=cleared for takeoff, yellow=restricted, red=stopped)
TIDS	Provide information as to when a flight can safely take off	• Provide takeoff countdown timer or color coding
TIDS	Provide CFR/EDCT info on TIDS	• CFR/EDCT in scratchpad/datablock
TIDS	Ability to close runways	• Runway closure capability on GC/LC TIDS
TIDS	Wake turbulence timer modifications	• Ability to set timer duration • Ability to toggle wake turbulence timer display • Timer should start when intersection departure is airborne
TIDS	Improved hold short bars during LAHSO	• Inhibit hold bars past LAHSO points during LAHSO operations
TIDS	Font sizes inadequate	• Add more font size options
TIDS	Provide more information for sequencing during config change	• Highlight last arrival and departure aircraft in configuration
TIDS	Allow for different preferences in separation	• Provide ability to use miles and time for full-length departures
TIDS	Profile changes should be linked to configuration changes	• Automatically change profile when configuration is changed
TIDS	Ability to hide datablocks	• Hide datablocks when clicked
TIDS	Improved separation monitoring	• Add configurable distance-based “bats”
FDM	Configurable FDM layouts	• FDM layout should be configurable and linked to user preference sets
FDM	Improved visibility into other	• Shadow editing capability on FDEs • Ability to change sequence on GC/LC

	controllers' bays	
FDM	Information (e.g., spots) desired for arrivals	• Add/enable arrival table • 35L arrival table needed to handle mixed runway usage • Add LAHSO column to arrival table • Manual spot entry in arrival table
FDM	Additional information needed on FDM	• Add altimeter, hat status • Add beacon code, CID to minimized FDE • Provide access to ATIS text • Add local remarks field • 3-character hold short point field • Add ILS status information to prompts
FDM	Automatic sequencing updates	• Automatic departure sequence correction by surveillance information
FDM	Coordination/alerting with other facilities, controllers	• Flashing or other identification of need for coordination with other facilities • Identification of completed coordination • Flashing or other identification that other controller needs a strip
FDM	Visibility of west side flights on GC queue	• Bridge action button or bay for GC
FDM	Visibility into hat status change	• Hat status displayed on FDM
FDM	Improved identification of data changes or upcoming events	• Brief flashing when data changes, then solid highlighted field • More salient runway closure prompts • Highlight p-time field if p-time close to expiration
FDM	EDCTs should be more visible	• Automatic EDCT highlighting with bold red text • Indication that a flight is within/not within its EDCT window
FDM	Nonstandard assignments should be more visible	• Show nonstandard runway assignments in red • Show altitude in red for jets below 16000'
FDM	Integrated voice recognition	• Ability to say a command and have associated FDE move to correct bay
FDM	Prompts and hot keys are inconvenient to access	• Put prompts and hot keys in the middle of the FDM • Provide left/right-hand options for FDM
FDM	Greater CFR visibility	• Add CFR information to facility-specific area in FDE
FDM	Improved surface surveillance	• Add surveillance to spots 1-4 to trigger automatic FDE movement • Prevent flights from immediately moving into Ready to Taxi upon pushback
FDM	Improved Severe Weather Avoidance Plan (SWAP) capability	• Provide different status icon for SWAPped flights • Provide ability to amend SWAP request before

		FDE transfer • Ability for automatic rerouting due to weather • Ability to graphically combine SWAP routes
FDM	Improved camera tracking	• Right-click on FDE to track target with camera
FDM	Improved runway closure information	• Provide notification to GC/LC five minutes prior to runway closure • Provide electronic version of runway incursion device blank strip for closed runways
FDM	Improved separation monitoring	• Provide real-time tracking of MIT conformance • Add ability to set dynamic constraints between flights • Provide ability to note use of vectoring • Cleared for Takeoff queue flashes when previous departure tags on RACD • Display Xes on Cleared for Takeoff, LUAW bays when arrival is inbound
FDM	Improved flight plan validity monitoring	• Provide ability to prevent flight plan timeout • Clear indication of FDE timeout
FDM	Improved undo capability	• Add history for undo button • Allow selective implementation of undo action
FDM	Remove unneeded queues	• Ability to remove queues/bays not currently in use
FDM	Improved prompts window	• Ability to remove specific prompts from info window • Categories for prompts
FDM	Improved user interface	• Easier to use highlighting/text color change capability • Single tap to select FDE • Double tap to expand FDE • Larger text for departure fix • Multiselect acknowledgement
Supervisor	Improved user interface	• Add Y/N confirmation dialog for resource scheduling • Closure prompts shown in red • Restriction prompts shown in yellow
Supervisor	Ability to combine routes and fixes	• Add ability to combine routes, fixes
Supervisor	Ability to SWAP routes	• Add ability for SWAP
Supervisor	Additional information needed on Supervisor display	• Add ability to enter GS, GDP, AFP • Show EDCT status
Supervisor	Improved TMI information	• Add ability to add TMIs to combinations of airports, routes, FCAs • Display number of flights subject to each TMI • Calculate and display release time for following aircraft in order to meet constraint

Supervisor	Improved visibility for CFR valid times	• Add ability to set CFR valid/expiration times on relevant FDEs
Supervisor	Need information on number of flights affected by fix changes	• Provide count of affected flights over 30-60 min period by runway and fix
Supervisor	Improved off-hat assignments	• Off-hat assignments should automatically be highlighted red in FDEs • Add ability to manually suggest off-hat departures • Add automatic off-hat runway assignment capability based on spot location
Supervisor	Improved visibility of airport fix map	• Display airport fix map under mapping control area
Supervisor	Improved configuration changes	• Checklists populated automatically with relevant info for current configuration • Add ability to dynamically identify last flight out in old configuration • Add ability to dynamically identify first flight out in new configuration • Add ability to create ad hoc configurations
Supervisor	Information organization	• Separate RVR information by flow direction and east/west side • Add ability to reorder and filter NOTAMs • Provide improved, more graphical checklist • Provide text box on checklist for off-nominal status reporting
Supervisor	Improved timelines	• Improve timeline reliability • Improve wheels on/off time accuracy • Show departure/arrival fix information on timelines • Provide plan view option for timelines • Change ACIDs to red when AAR is exceeded • Show closed fixes in red on timeline, datablock
Supervisor	Too many departure fixes shown in departure routes	• Restrict routes to 16 departure fixes, not downstream routes
Supervisor	Improved departure re-routing	• Add automation ability to re-route flights • Add ability to notify controllers to plan a re-route
Supervisor	Increased information on flights	• Add wheels-off times to active flight list • Show E-times when appropriate in active flight list • Add columns for departure fix, TMIs to active flight list • Show canceled flights • Provide overall weather display
Supervisor	Improved information display for active flight list	• Add ability to search active flight list by multiple criteria • Allow users to select columns shown

		• Allow users to set display time period • Show flight ownership information • Show full flight route and FDE representation • Allow users to change runway assignment from flight list
Supervisor	Improved information display (misc)	• Add summary screen similar to IDS • Automatically populated TRACON info • Highlight flights that have nearly timed out and notify controllers • More consistent color coding • Add color coding by priority, function
Supervisor	Improved logic for closures, config changes	• Improve runway assignment logic to account for runway closures and config changes
Supervisor	Ability to access delay statistics	• Track and display delay statistics
Supervisor	Ability to close fixes, set arrival rates, and schedule TMIs/MINITs is unrealistic for DFW	• Remove abilities to close fixes, set arrival rates, schedule TMI/MINIT

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APPENDIX G
CONTROLLER COMMENTS FROM TIDS QUESTIONNAIRES

G.1 TIDS Accuracy

10. Please provide any additional comments about the target information displayed on TIDS.

Response
None
n/a
At times saw some “caterpillaring” One example was ASA670 who was told to change his code.
I use the TIDS for organizing traffic that is on the ground. The only time I would use the TIDS for airborne traffic is to find out if the plane has crossed the landing threshold and if it has crossed a certain taxiway on its take off roll.
The jumping targets were only on the ramp as the aircraft was sitting still.

19. Please provide any additional comments about the accuracy of the information shown on TIDS.

Response
None
n/a
I actually never saw the taxi status depicted anywhere nor the HAT status?
Didn’t get a chance to see the way a closed taxiway would display on TIDS. Also would like to see more TIDS coverage/surveillance in the EL alleyway as ground control east all movement west of K on EL Ramp.
Time-share of alt and speed needs to have an additional space for clarification.
The information on the TIDS is good information. There is still information I can get from looking out the window better. Thus I think of the TIDS as more of an organizational piece of equipment.
Thought the display was great. Wish we could be using it now!

G.2 TIDS Information

39. Please provide any additional comments about the wind information displayed on TIDS.

Response
None
It was in a good location. It did not take away or distract from traffic.
Either I forgot from the initial training lesson where the wind information window WAS, or it just wasn't eye-catching enough to notice...but regardless, I didn't notice it and didn't use it; instead, I referred to the standard wind indicator.
I actually didn't even notice it being there for the first session. I didn't glance at the wind near as often as I would for each arrival in a normal work environment.
Winds weren't updating today for whatever reason. But the concept is great.
Need a filter to only see sector winds unless of a wind shear/microburst alert
Wind information was not available to me.
38: I found the font size to small for me. I guess I could have changed it, but did not.

74. Are there any additional information or features that should be considered on the TIDS?

Response
A better placement of ground stop, call for release, and swap routes that would catch the controllers eyes.
n/a
In addition to above, it would be nice to see LAHSO operations incorporated into TIDS. The actual entries would be made on FDM at Local. But based on LAHSO status for each landing aircraft, hold bars (and RWSL Lights) would be dictated on this.
Adding a separation bubble or headlight for ac on final. heads up for potential conflicts such as an ac in position and an ac on final to the same runway
No

75. Are there any existing features that should be removed from the TIDS?

Response
Being able to look so far out on final, tower controllers only need to look out no more than 10 miles.
No
n/a
No

G.3 TIDS User Interface

28. Please provide any additional comments about the TIDS user interface.

Response
None
n/a
None really
Didn't get a chance to use the menus or pref sets
User prefs were not used much, but what was done took a while, maybe because of familiarity only
As I work with the TIDS and the other pieces of equipment using the mouse I find myself wasting time looking for the curser. It would be helpful if the curser could flash red or yellow a few times at first when you grab the mouse. That would help finding it so you could move on with the task.
When searching for an a/c by selecting the strip on the FDM it would be helpful if the a/c and associated data block would flash instead of the outline appearing around the data block. As is it isn't much faster than just scanning the display.
I believe that once I was use to using the TIDS the user interface would be very easy.

33. Please provide any additional comments about the TIDS picture-in-picture windows.

Response
Too distorted of a view, need the whole airport environment to get a better view instead of looking out the windows.
Because of the visual multi-tasking which must be accomplished in a high density traffic environment, either a.) A greater scan capability, or b.) Multiple cameras would be very helpful.
I really liked the panoramic picture on the last session, it gave me an easy place to look for when an aircraft was airborne to clear the next for takeoff or even start crossing!
Would be nice to re-size the PIP Camera windows
Delay in the ability to zoom was cumbersome and would make me not waste to use this function
The camera technology needs improvement and a clearer picture. It's going to be hard to beat the amount of information I can get by looking out the window at a plane. Much, much clearer camera pictures are needed for this to work. Even at that, I can turn my head and look at a plane anywhere on the airport much faster that I can get the camera to go to that plane. Being able to look out the window in of extreme importance to me.
The available technology for the cameras is not sufficient to replace the windows even in a contingency situation at this time. I believe this is going to be the hardest task to accomplish, since nothing manmade can duplicate the human eye.
I found it of no use to have the window view in a PIP. Just look out the window that always tells the story

G.4 TIDS Usefulness

72. Please provide any additional comments about the usefulness of the TIDS.

Response
It would help ground control when using the bridge to keep those a/c in their sequence until they turn on the bridge
I like the TIDS with the exception of monitoring traffic on the final. I like our current display for arrivals better. The current splat P entry (baseball bat) that we have should be included in whatever technology is used to monitor the finals.
The TIDS needs to be implemented ASAP as a replacement for the ASDE-X. The presentation, user interface and appearance are far above those of the ASDE-X display. As a note, the keyboard/mouse combination needs to be in a fixed position directly below the display. Controllers tend to not be as gentle while moving things, as they should. The display should be mounted on an axis recessed into the counter so as not to obstruct the controllers view out the window.
I feel it is a 100% step forward from the ASDE-.X

G.5 TIDS Miscellaneous

59. Please provide any additional comments about the TIDS display features.

Response
Be able to send a flight strip back to ground control, have an easier way to sequence the aircraft that are at the end, have a place to put a check mark for a/c that require a release.
n/a
Had several departures in North Flow off of DAL that appeared over my TIDS display, as they turned southbound in their climb out. Closed Runway Outline is slightly similar to Hold Bars. The Bold White OR Red X should be sufficient in identifying a closed runway ALONG with a Red Bar in the Bay on FDM – Currently we use a Red "RID" in our bay to denote a closed runway and White X's on the ASDE-X
There needs to a way to set hold bars for 3 min wake turbulence for a small departing an intersection behind a large aircraft
The wake turbulence timer is ineffective when counting down the time an aircraft begins takeoff roll. Almost all controllers use distance vice minutes since it is more efficient. However, the mandatory 3 minutes at an intersection is a different story. The 3 min should be calculated from rotation to provide a controller with the non-waverable time required for departure from the intersection.
I think it was just right. Did not find anything that I would have needed that was not already on there.

73. Is there anything that would improve the TIDS for controllers' use?

Response
Besides what I already wrote, none that I can think of yet
Put a list of last arrivals on the display.
n/a
The timing of when the aircraft turns to cyan color once airborne. it doesn't appear to be accurate with the aircrafts true state.
The ability to add scratch pad data. Example adding "No Load" in the time-share to denote an aircraft that is waiting for numbers. This will allow Ground to see why traffic isn't moving in the departure pad. Also having EDCT or CFR times flash in timeshare would be beneficial to help Ground maintain awareness of taxiway availability for aircraft awaiting departure times once the strip has been passed to Local.
Example: 757 or heavy is departing. MD80 is departing and needs wake turbulence separation. It would be nice if the box in the left corner of the strip (holding in position) were red until you had the appropriate wake turbulence spacing. The idea is that the red would alert the controller to a lack of spacing and when the appropriate spacing was there then the box would turn green.
Being able to drag aircraft from TIDS to your FDM if you sent them to local and needed them back for a modification.
Not sure, but there was enough information presented to me that I would not need anything else added

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APPENDIX H
DFW-2 DISCUSSION RESULTS FOR TIDS

- Target location, go-arounds impt to be shown on TIDS
- King Air, Cessna missing flight plans
- Both controllers agreed UI is responsive
- TIDS added some workload but didn't hurt
- Controller thinks arrival list would be useful if ARTS is lost. Would prefer arrivals on TIDS so don't have to look down to FDM (such as on ARTS P-list). Would like to see 5-6 a/c.
- Controller keeps pad on busy/bad wx days. Depends on flow, wx, etc.
- Just uses a/c, clear, holding—simple, not time consuming. Can get confusing near Y, Z.
- Accuracy of TIDS is compelling compared to camera; easier to watch than camera.
- Would like MIT timers
- WT timers on departure are "revolutionary"—nice to have something to be expeditious, most people err on overcautious side so more precise measure would increase efficiency
- Controller liked WT timer—didn't use it much, but nice. Other controller used miles.
    - Might use timer more but that might be slower than miles.
- TIDS much better than ASDE-X, esp colors
    - Controller used to be NATCA ASDE-X rep and prefers TIDS
- Want hat status, altimeter, toggleable RVR on TIDS
- RACD used for checking a/c call-ins
- Controller thinks TIDS is improvement over ASDE-X, which is good tool
- Also loves TIDS
    - Allows him to clear to cross as departure passes—efficiency improvements
    - Organizational benefits
    - Easier to organize and have clean operation
- Likes TIDS size, spacebar declutter
- Likes TIDS PiP but no use for camera PiP
- Controller wants TIDS in and ASDE-X out—easier on eyes
    - Could see all rwys on east and west parallels when zoomed out, and still had space for more info
- Controller thinks more info is currently available on TIDS than before—wants in tower tomorrow
- Directional pointer to indicate if a/c turning on dep/final is good
    - Could use for go-around/break out
- Approach bars are good; space bar separation is good
- Controller: displays are helpful, esp TIDS. Aircraft rotation can't be told w/surveillance but can get a feel for where it happens.

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APPENDIX I
GENERAL DISCUSSION COMMENTS

- Controller likes added stuff from last time: route closures, delay info/highlights
- Controller says system is easy to use once he got used to it.
- Camera didn't allow for accustomed degree of multitasking but TIDS/TFDM helped a lot
- Controller loves TIDS, likes how FDM is progressing. Can use in supplemental tower, better than anything available now.
- Seem to have thought of everything wrt info on TFDM.
- Want to use TFDM operationally—put it in!
- Very few airports w/bridges—not needed as a rule
- TFDM gives clear picture and is easy to work with
- Great for traffic management
- TFDM could simplify procedures—off-hat simplification, automated coordination, reduced phone calls.
- Workload decreases, balanced airport, fuel savings, reduced taxi distances
- Controller pleased to see ideas taken into consideration for latest display
- Controller preferred mouse to touchscreen
- Need inbound data
- LAHSO tracking
- Don't want to have to manually enter any info available from other systems (all interfaced)
- Incorporate checklists, RVR, alarms from IDS5
- Tailorable profiles for VFR, IFR
- Would like single button access to all sorts of info—phone numbers, etc, then easy access back to main page (home button?)
- Access to laser lights, TSA info
- Controller can see benefits of getting rid of towers but realizes it's a ways away
- Voice recognition for go-arounds would help w/paperwork, voice activation for call signs
- Newer controllers more likely to enter info on scratch pad.
- Controller says you need hard mounted keyboard to keep equip from getting worn out too fast
- More info on single display without clutter
- Concerns about losing SA—too much lack of thinking.
- Controller liked everything—TIDS he'd take tomorrow, could learn to love FDM. Cameras nice but not helpful.
- Likes interface btwn sup/LC/GC.
- Concern is safety—are we clean?
- Nothing really lacking; 100% better than current systems

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APPENDIX J
FDM QUESTIONNAIRE RESULTS

J.1 FDE Information

The FDE information question results are presented in Table J-1 and Figure J-1.

Table J-1: Questionnaire summary for FDE information

FDE information		Mean	SD
Question 1	FDE accuracy	4.58	0.669
Question 2	FDE appropriate for GC	4.75	0.622
Question 3	FDE appropriate for LC	4.83	0.389

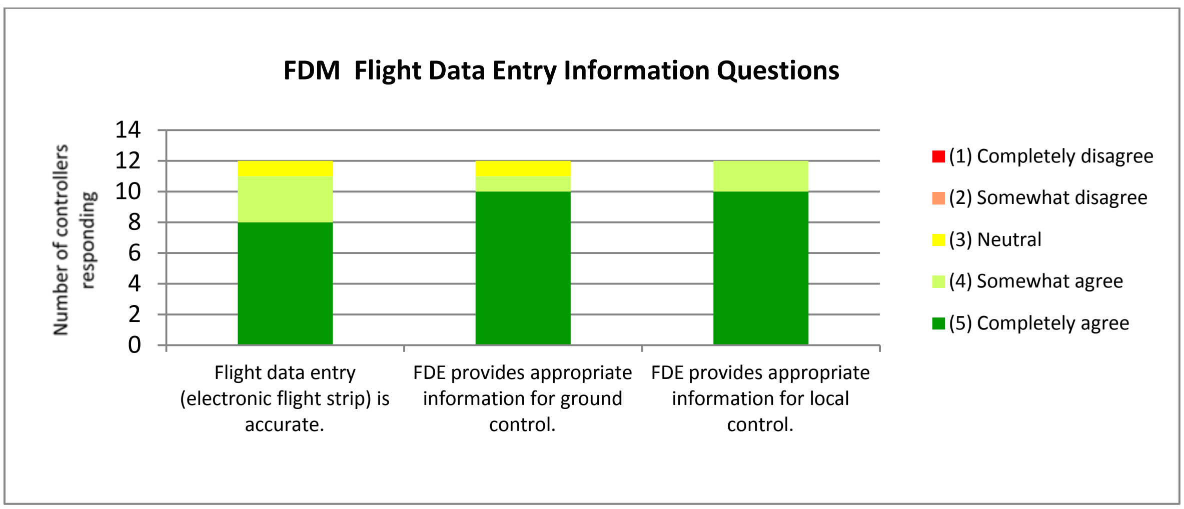

Figure J-1: Controller responses to FDM information questionnaire

All of the controllers with the exception of two responses were positive about the content of the FDEs for both ground and local control. As requested during DFW-1, the beacon code was added to the expanded FDE in DFW-2. One controller wrote in that he or she would prefer to see the Computer Identification (CID) on the FDE, particularly in convective weather during the Severe Weather Avoidance Plan (SWAP) periods. In another question, all of the controllers were asked if there were additional fields that should be present on the FDE. Sixty-two percent (5 controllers) responded that they would like to see the CID on the FDE. Thirty-eight percent (3 controllers) responded that they would like to see the beacon code on the minimized FDE.

J.2 FDM Basic User Interface

The basic user interface questions are presented in Table J-2 and Figure J-2.

Table J-2: Questionnaire summary for FDM UI

Basic User Interface		Mean	SD
Question 4	FDM not cluttered	4.00	0.603
Question 5	FDM easy to use	4.08	0.900
Question 6	Use of color appropriate	4.33	0.900
Question 7	New FDE easy to create	3.67	1.12
Question 8	FDE amendment easy	4.00	0.603
Question 9	FDE transfer easy	4.67	0.492

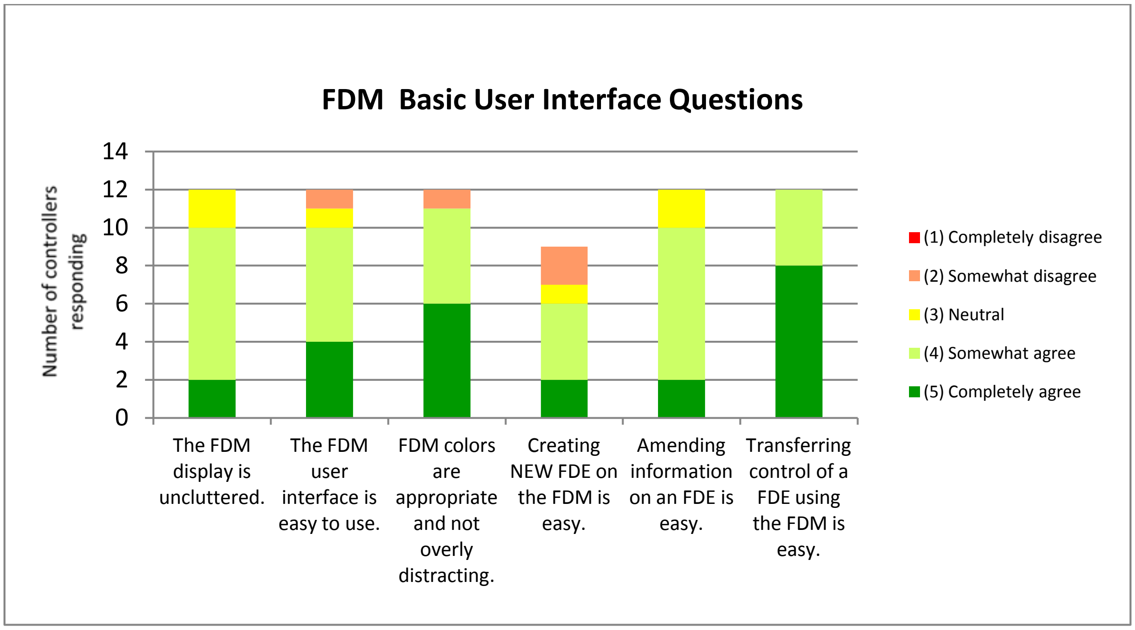

Figure J-2: Controller responses to FDM UI questionnaire

In assessing the basic user interface of the FDM, the majority of the controllers were overall positive about the usability. Since DFW-1, the ability to call attention to aspects of the FDEs (e.g., red text, field highlighting) were added. Some issues were reported in creating a new FDE for a flight by two controllers.

J.3 FDM Features

The results of the FDM features questions are presented in Table J-3 and Figure J-3.

Table J-3: Questionnaire summary for FDM features

FDM Features		Mean	SD
Question 10	FDM sorting utility	4.20	0.919
Question 11	Highlighting utility	4.75	0.452
Question 12	Process of highlighting easy	4.00	1.348
Question 13	Red text utility	4.83	0.389
Question 14	Process of red text easy	3.92	1.443
Question 15	Flagging an FDE utility	4.27	1.009
Question 16	Process of flagging easy	4.20	0.919
Question 17	Surveillance-based FDE movement utility	4.50	0.905
Question 18	Surveillance-based FDE movement accurate	4.67	0.492

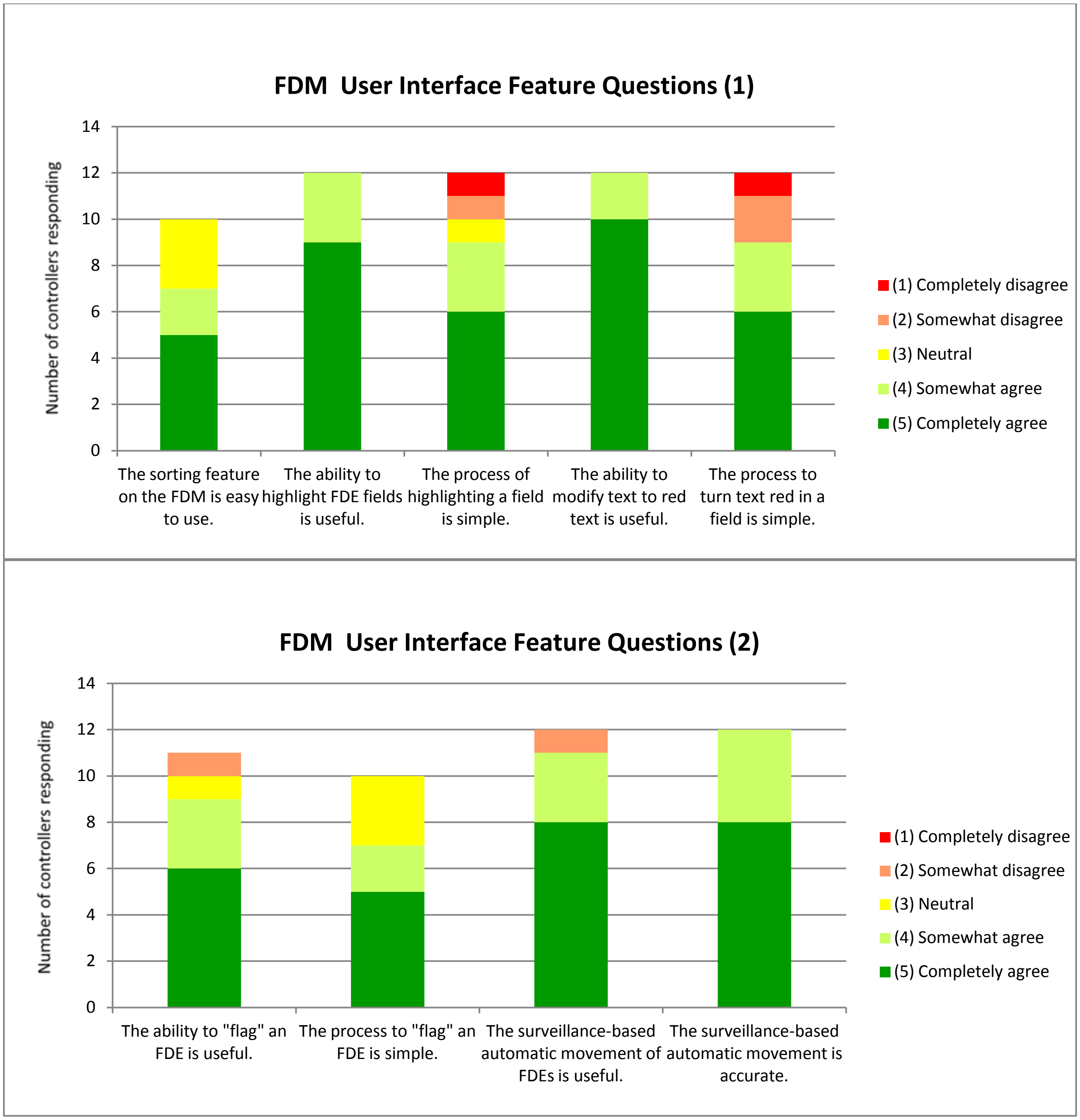

Figure J-3: Controller response to FDM feature questionnaire

In general, the FDM features received positive overall reviews, i.e., a majority of the controllers "agreed" or "somewhat agreed." Several controllers were not satisfied with the process to highlight and red text individual FDE fields and flagging individual FDEs.

J.4 FDM Notifications

For DFW-2, TMI and EDCT prompts were introduced and evaluated. The results of the FDM notifications questions are presented in Table J-4 and Figure J-4.

Table J-4: Questionnaire summary for FDM notifications

Notifications		Mean	SD
Question 21	Appropriate information	4.00	0.669
Question 22	Displayed appropriate amount of time	4.08	1.128
Question 23	Displayed in appropriate location	4.33	1.267
Question 24	Lacking needed notification	3.67	1.252
Question 25	EDCT prompt usefulness	4.00	1.044
Question 26	TMI prompts usefulness	4.67	1.293

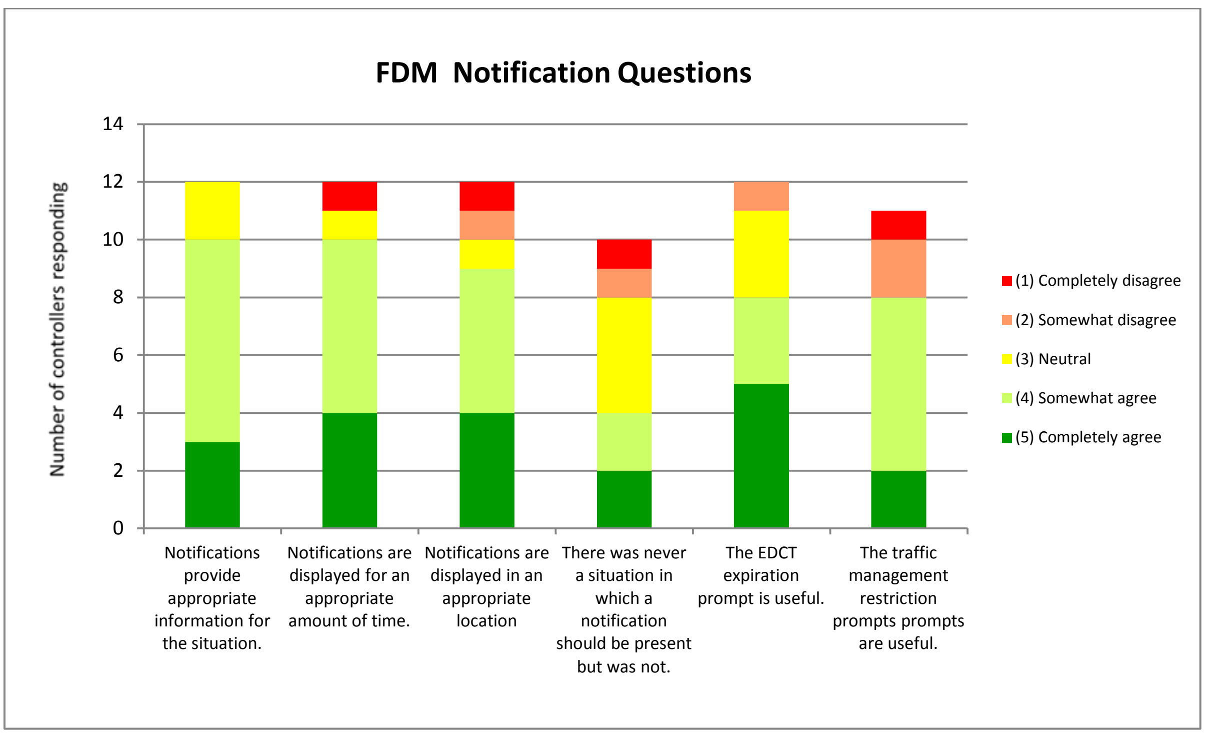

Figure J-4: Controller responses to FDM notification questionnaire

The controllers were somewhat positive about the notifications displayed on the FDM.

J.5 DSTs on the FDM

The results of the questions about DSTs on the FDM are presented in Table J-5 and Figure J-5.

Table J-5: Questionnaire summary for DSTs on FDM

DSTs on FDM		Mean	SD
Question 28	Runway assignments useful	4.08	0.793
Question 29	Runway assignments logical	4.25	0.622
Question 30	Runway assignments easy to modify	4.67	0.888
Question 31	Metering easy to integrate into GC ops	2.75	0.707
Question 32	Metering recommendation easy to interpret	2.75	0.707
Question 33	Metering in appropriate location	3.33	0.707

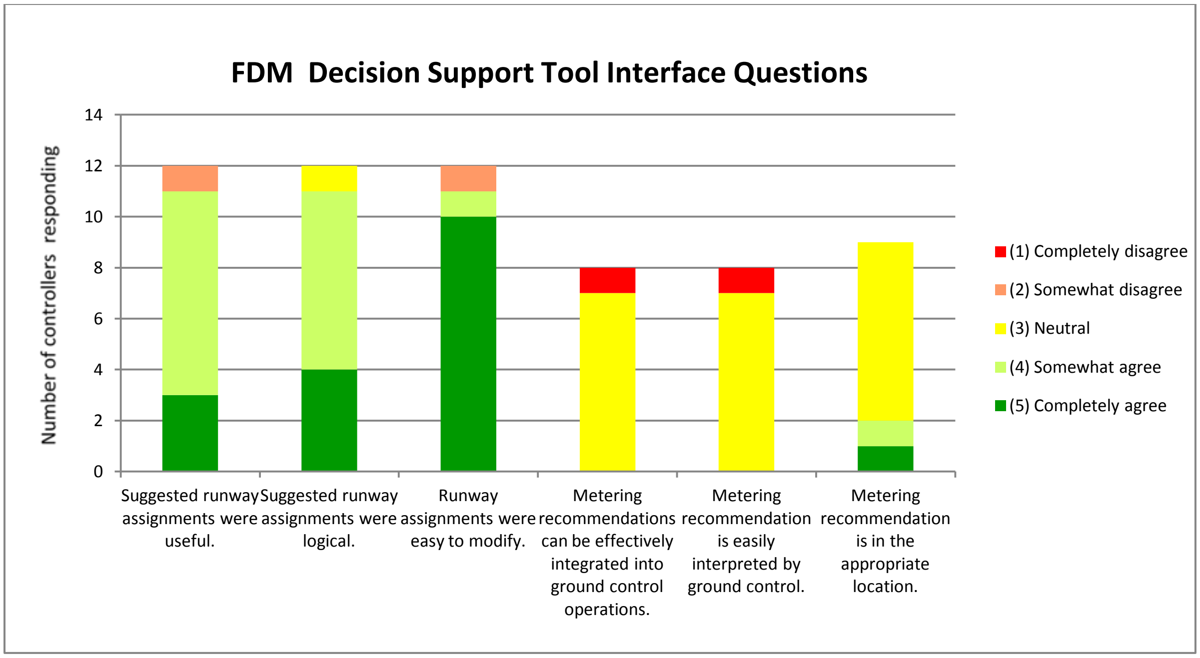

Figure J-5: Controller responses to FDM DST interface questionnaire

The controllers were positive about the runway assignment suggestions displayed on the FDM (i.e., a majority "completely agreed" or "somewhat agreed"); however, they were neutral or negative with regard to the departure metering recommendations. In the open-ended question asking the controllers' feedback on the DSTs presented on the FDM, several controllers mentioned that they did not use the departure metering recommendation. Two controllers responded that they did not think that metering was appropriate for DFW. One controller further commented that American Airlines ramp areas would back up quickly with metering and would not want the flights waiting for load numbers at the end of the runway counted in the metering algorithm.

J.6 FDM Summary

The results of the FDM summary questions are presented in Table J-6 and Figure J-6.

Table J-6: Questionnaire summary for FDM

FDM Summary		Mean	SD
Question 35	FDM help sequence aircraft	3.50	0.905
Question 36	FDM help plan control actions	3.67	1.155
Question 37	FDM beneficial to towers	4.42	1.138

Question 38	FDE found as easily as finding a FPS in the bay	3.25	1.138
Question 39	FDE modified as easily as modifying FPS	3.25	1.215

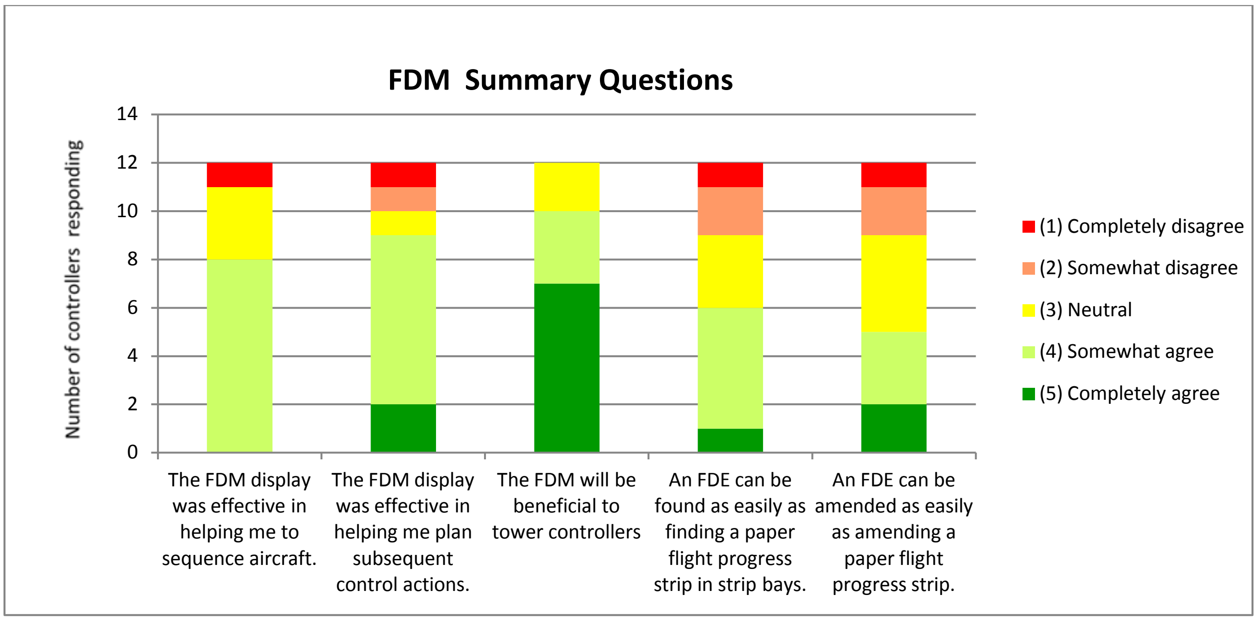

Figure J-6: Controller responses to FDM summary questionnaire

Controllers responded positively (i.e., all controllers responded “completely agree,” “somewhat agree” or “neutral”) about the FDM being beneficial to tower controllers. All controllers except three or four responded that the FDM was helpful in sequencing and planning control actions. Half of the controllers responded that FDEs could be found as easily as paper flight strips, and five controllers felt that FDEs could be amended as easily.

Controllers did not have any suggestions about features that should be removed from the FDM.

APPENDIX K
FDM FIELD OBSERVATIONS

The field observations were collected by the staff stationed with each controller and FLM/TMC throughout the length of the demonstration. The categories of observation included FDM problems, FDM functionality liked, FDM functionality suggestions, and FDM benefits observed. Only the observations listed for more than one controller are listed. The number of controllers for which the issue was observed is listed in the left column.

K.1 FDM Interface Problems

#	Comment
5	Would like beacon code on minimized FDE
4	Did not notice prompts, would EDCT prompts to flash for a few seconds
3	Want EDCT in red font (and bold- RW)
3	Needs attention drawn more to new TMIs, resource changes, but no prompts needed for weather blockage, only closures & SWAPs
3	Need 3-character hold short point (for M/E)
3	Want prompts for runway closure to appear in red
2	Want room for 1 more FDE in clear for takeoff queue
2	Expanding an FDE in Line up & wait and Clr for takeoff queues problematic
2	Metering recommendation not noticed. Move metering under information window or under Ready to Taxi queue (at the point when metering information is needed)
2	Need ability to remove singular prompts (RW wants to keep TMI prompts
2	May be good to have CID in SWAP
2	Extensive blue on multiple FDE runway assignments confusing/not helpful

K.2 FDM Functionality Liked

#	Comment
4	Liked that MIT highlighted destination field
4	Liked that inputting CFR for individual flights would propagate to FDEs
2	Liked location of MIT prompts
2	Liked flip with ACID
2	Primarily used touch-screen on LC, initially mouse on GC but then switched to touch-screen.
2	Liked automatic strip movement when aircraft at gate or coming over bridge.

K.3 FDM Functionality Suggestions

#	Comment
5	Would want ability to indicate off-hat in runway to fix mapping (and turn dep fix to red text on FDEs) Black runway assignments should be consistent with HAT status, off-hats should always be in red (text or field), want red background, red text not salient enough, automatically show DP in red text for “off hat,” flights departing on nominal arrival runways with red runway (until coordination is finished?).
5	Would want a shadow-editing capability at FD/Sup/TMC positions, keeping FDE in GC or LC queues
4	Want ability to amend from GC & LC
3	Want ability to notify of coordination requirement on West side and when coord completed
3	Want ability to see HAT status change on GC/LC FDM
3	Want action button to show “Bridge” for flights with runway assignments to west side in Active GC queue
3	Want automatic surveillance correction when flight is in the departure queue
3	Would like altimeter, HAT status, & RVR (to toggle)
2	All jets below 16000 should show altitude in red
2	Non-standard runway assignments should be in red (i.e., for an arrival runway)
2	Interested in TFDM auto-sequencing FDEs when passing to LC
2	Want a brief salient notification of HAT status change and TMIs
2	Voice recognition: I should say a spot and FDE should pop into Ready to Taxi
2	Suggestion of using red outline to FDEs with EDCT which are outside of +/- 5 mins window, then red outline goes away when in EDCT interval
2	Have option for sequence of FDEs to be in operational not enter-chronological order. Logic dictates that aircraft behind others in a sub-queue are unlikely to take off before aircraft ahead of them, so use that fact to re-order strips. automatically put all EF, EG and EH departures together in bay.
2	Prompts on info panel should be color-coded to distinguish between different classes/priorities of prompts.
2	Want ability to view and modify LC’s departure sequence. e.g., sequence for split RNAV flights
2	Want ability to put FDE with no numbers in the “hold short” queue, but out of the sequence completely (so another aircraft does not appear to be first in queue)

K.4 FDM Benefit Observed

#	Comment
2	Could simplify procedures & coordination

APPENDIX L
POST-DEMONSTRATION VIDEO/AUDIO PLAYBACK ANALYSIS OF COGNITIVE WORKLOAD AND VISUAL ATTENTION

Post-demonstration analyses were conducted to quantitatively investigate human performance issues using the TFDM system in a shadow operation. The analyses described below include a verbal control commands analysis that provides an indication of cognitive workload and a visual gaze analysis that provides initial information about where controller visual attention was directed.

Video and audio recordings of test participants in shadow operation sessions were used to gather data. Video was chosen as the most non-invasive and inconspicuous option for the field demonstration. The video camera for LC was placed under the RACD monitor, pointed towards the controller. The video camera for GC was placed over the ASDE-X monitor, pointed towards the controller. In addition, participant controllers wore a small, light microphone around their neck to capture their commands to pilots. Audio recordings of East Tower controllers (referred to as *live controllers*) and pilot communication frequencies were also provided to MIT/LL by DFW Tower upon request. The TIDS, FDM, Supervisor Display, and Cohu display screens were also captured using an Epiphan screen recorder, so that exactly what the participants were looking at could be replayed.

All of these data were gathered throughout the entire field demonstration for GC, LC and FLM/TMC participants. For analysis, all data were gathered into and synched with Adobe Premiere to create a video playback complete with Center Tower, East Tower and pilot audio. A clock displaying the UTC time of the demonstration was added to the center of the playback for timing purposes. A screenshot of this video playback system is shown in Figure L-1.

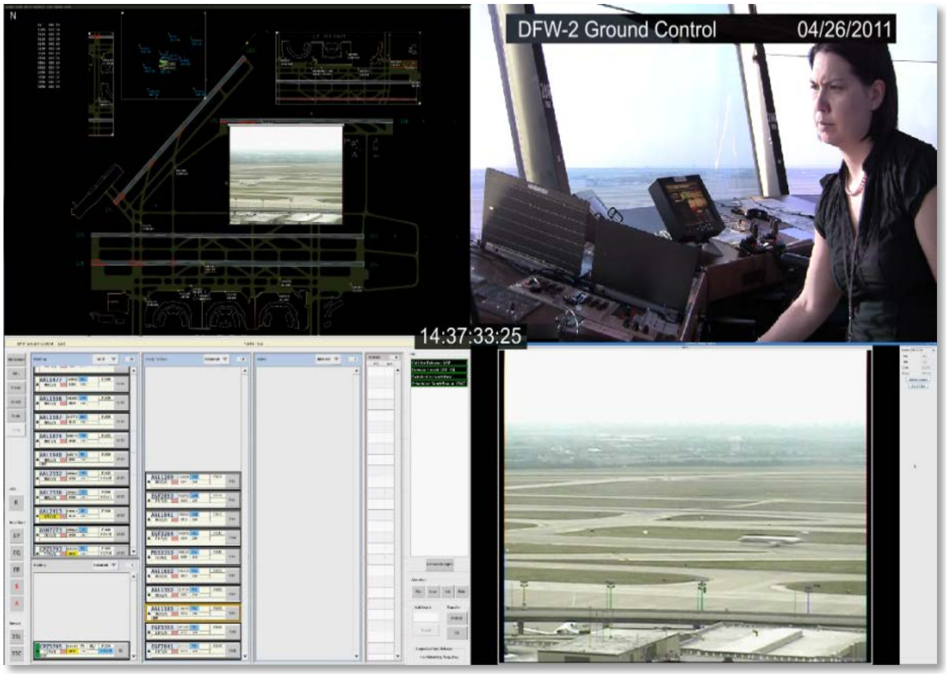

Figure L-1: Video playback system used for analyses

L.1 Verbal Control Commands Analysis

During the DFW-1 demonstration, MITLL staff observed that many participant controllers issued instructions for the same flights before live controllers. On occasions in which participant controllers later issued control commands, it was generally due to a problem understanding the user interface or another workload-inducing situation. It was thus hypothesized that the order in which participant and live controllers issued verbal commands could indicate their cognitive workload. Comparing the times at which similar instructions were issued between participant and live controllers aided in measuring the extent of cognitive workload, since a longer response time on behalf of the participant controllers could mean a larger cognitive workload for them as well (Ayaz, et al., 2010; Embrey, Blackett, Marsden, & Peachey, 2006). For example, if live controllers issued instructions before participant controllers, this implied greater cognitive workload for participant controllers since they completed the same task more slowly.

Verbal control command analysis is, however, a novel approach to cognitive workload estimation. As such, we note that results are subject to error as the technique has yet to be validated elsewhere. While our results are indicative of trends, they are not to be taken as truth due to noise and various potential error effects in data. Sources of error discussed later in this paper can be used to apply verbal command analysis in a more robust fashion in future efforts to quantify ATC cognitive workload.

L.1.1 Sampling Strategy

For all participants, shadow operations sessions were variable in length, usually ranging from 30 to 60 minutes, and 5-minute data samples were selected based on which had the least controller/observer interaction. When participants operated as LCs, one 5-minute sample of verbal command data was collected from the end of the first LC shadow operations procedure, to allow the controller to adjust to the TFDM environment. Two more 5-minute data samples were collected from the beginning and end of the second LC shadow operations session. A graphical depiction of the LC data sampling plan is seen in Figure L-2. Contrastingly, due to a need for increased GC data points, GC data was sampled throughout both shadow operations sessions per participant.

By comparing data points across these three sample times for each individual controller, it was hypothesized that controllers would exhibit reduced cognitive workload as they became more accustomed to the TFDM environment.

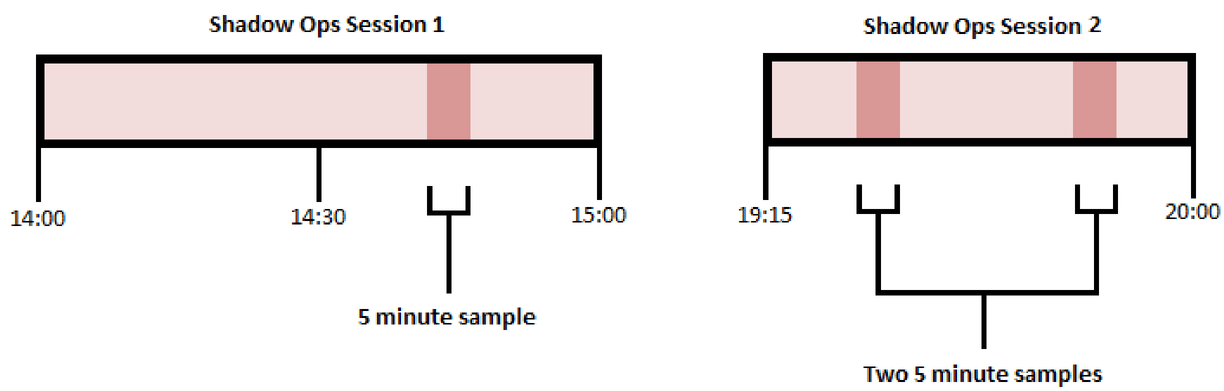

Figure L-2: Data sampling plan for cognitive workload analysis.

Sources of error most pertinent to the data collection methods were due to controller/observer interaction and live controller influence upon participant controller actions. At random points during test sessions, participant controllers spoke to their observers to provide TFDM design suggestions and ask questions about operating the system. As a result, controllers ended up shifting their attention towards the discussion and away from their operations. In order to minimize the presence of this noise in the analyses, each five-minute video sample was chosen at a period in time during which there was little to no controller/observer interaction. If controller/observer interactions distracted participant controllers during any point in data recording, affected data points were not considered in the analyses. If distractions were too prevalent, then that participant controller's data was not included in our analyses. Two local controller data sets and one ground controller data set were removed for this reason.

Participant controllers were also visibly affected by their ability to hear live controller instructions and communications with pilots. An audio connection between participants and live controllers was established to allow participants to follow live controller plans of operations and to maintain present conditions and changes to FDEs and flight sequences. Some participant controllers, however, aimed to issue pilot instructions before live controllers. While a competitive nature may have caused participants to issue commands quickly, data observations revealed that commands were almost always the same as those issued by live controllers. For instances in which commands to the same pilot were different, these data were considered unavoidable noise and that were noted and observed, but did not significantly impact results. Additionally, due to a competitive nature or due to participant realization that their actions did not propagate outside the tower, participant controllers may have preferred not to issue instructions second to live controllers. Such instances were recorded in the data but not factored into the current analyses.

As mentioned earlier, our results are preliminary at best and must be analyzed with the knowledge that verbal command analysis is a novel technique and can be improved in the future. Despite sources of error and noise, results are indicative of trends that may be supplemented in the future with more robust data recording and environmental control.

L.1.2 Data Recording

To quantitatively analyze cognitive workload, the order in which participant and live controllers issued commands for the same flights was recorded. These data points were evaluated to get the controller *response rate*, i.e., the percentage of time participants issued a command first, second, and at the same time (neutral to) their corresponding live controller. The issuance time for each command was recorded in "hours: minutes: seconds (hh:mm:ss)" with use of the onscreen clock timer. The difference in command issuance time between participant and live controllers was also calculated in "hh:mm:ss" and termed the *gap time*. Response rates and average gap times were used to demonstrate the level of cognitive workload each participant controller experienced.

While data recording of this nature was subject to human error and decreased precision, the data were treated as a rough estimate. DFW2 data analyses emphasized differences in gap times over two seconds, and since the exact points at which instructions were issued were only used to calculate gap times, consistency in recording time points was more important than precision. To promote consistency, data were coded by a single MIT/LL human factors staff member. Also, while the screen timer had a precision of up to $1/100^{th}$ of a second, gap times were rounded to the nearest second to account for lower levels of precision inherent to this recording method.

In specific cases, the data recording strategy was slightly adjusted to account for special circumstances. For example, if the participant controller issued instructions while ETC did not, these instructions were not recorded since there would be no basis of comparison to evaluate participant controller workload. Such a situation arose due to individual differences in managing traffic, where an instruction issued by the participant controller was not deemed necessary by ETC. Conversely, situations also arose in which ETC issued directions and the participant controller did not. This situation occurred in different circumstances, such as when the participant controller was too busy interacting with the observer and also when participant controllers simply did not issue instructions due to the knowledge that their instructions were transferred to neither the live controller nor the pilot of the flight in question. Due to the presence of external noise in the first instance and unknown sources of noise in the second instance, these data points were not factored into our quantitative analyses.

A sample section of raw data is presented in Table L-1.

Table L-1: Sample of participant controller gap time and instruction issuance position

Time	Participant Controller	ETC	Gap Time	Notes/Observations
13:35 Z	2	1	0:01:35	No pilot prompt
13:40 Z	2	1	0:00:02	
	n/a	1	n/a	Participant controller speaking to observer
	2	1	0:00:57	
	1	2	0:00:06	
Avg Gap Time	**31.3 sec**	**6 sec**		

The time at which data were recorded is noted in the first column, and, for each set of instructions issued, the order in which each command is issued is recorded ("1" for first, "2" for second, and "n/a" for not at all) in the second and third columns, respectively. The gap time is then presented in the fourth column, and any additional notes that may be relevant to the cognitive workload analyses are included in the final column. In this case, the first row of data captures an issuance in which the live controller provided instructions one minute and 35 seconds prior to the participant controller. The observation in this column, "No pilot prompt," relays the fact that each controller issued his instruction independently of any pilot requests or call-ins.

At the end of each sampling session, controller average gap time was calculated. The average gap time measure for each participant or live controller provided a measure for the data points in which the controller issued instructions second (i.e., were given a "2"). The gap times for which the controller issued a command second were averaged to get an average gap time for that sampling session. An example is seen in the last row in Table L-1. Cases where the participant controller was given an "N/A" in place of a "1" or "2" were not factored into the average gap time calculations. The average gap time for each controller across all three sampling sessions was also calculated and termed the "overall average gap time."

L.1.3 Data Analysis Plan

For data analysis, the response rate and gap times were quantitatively and qualitatively analyzed and represented in graphical form. Response rates for the amount of times a participant controller was first, second, and neutral (instructions issued within the same temporal second as ETC) were calculated and compared across controllers. Response rates were used as a quantitative measure to demonstrate the level of cognitive workload each participant controller experienced across all three sampling sessions. Average gap time was also compared across each individual participant controller's three sampling sessions and an overall gap time was calculated to compare across all controllers, including live controllers. Gap time trends, such as a decrease in gap time for a single participant controller over his three sampling sessions, revealed the presence of a learning curve for some participant controllers. Gap times and response rates were also plotted together for each individual controller.

L.2 Verbal Control Command Pattern Results

For the DFW2 video analysis, controller cognitive workload was observed and participant controller instruction patterns were quantified to understand potential ways to improve process efficiency and TFDM interface usability.

L.2.1 Response Rate

Both GC and LC participants were successful at issuing the majority of their verbal commands before or at the same time as live controllers. Figure L-3 indicates that, for 77% of their control commands, GC participants were able to operate at optimum level compared to live controller counterparts and that cognitive workload imposed by the TFDM system did not appear to hinder their ability to sequence and taxi flights.

LC participants issued a 69% of instructions before or at the same time. While both controller types demonstrated successful operation of daily activities, Figure L-3 shows that local controllers were significantly more successful at issuing verbal commands first (t = –3.25, $p < 0.05$). A weak trend was also seen in which local controllers issued less verbal commands second to their corresponding live controller (t = 1.94, $p < 0.10$). Further video analyses were conducted to understand causes of participant controllers issuing commands second. The results for these analyses are presented at the end of this section, in Table L-4.

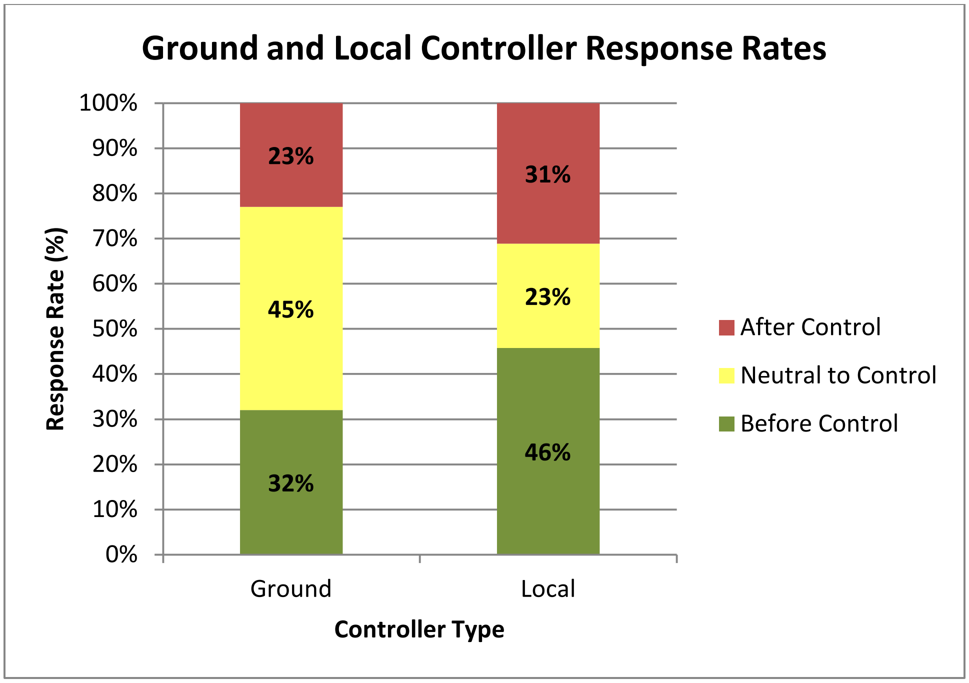

Figure L-3: Ground and local controller response rates

Table L-2 provides response rate information for all GC participants. The first column displays an assigned participant number given by the MIT/LL data analyzer. The second column displays the number of control commands used as data points for the data analysis of that specific controller. The third, fourth, and fifth column present the percentage of time the participant controller issued instructions first, second, or at the same time (neutral) as the live controllers. In the sixth column, the total percentage of time a participant controller issued instructions first or neutral to their corresponding live controller is shown. This sixth column provides insight into a total measure of cognitive workload for each ground participant controller.

Table L-2: Ground controller response rates

Controller Number	# Control Commands	First (%)	Second (%)	Neutral (%)	First + Neutral (%)
1	27	0.37	0.04	0.59	0.96
2	36	0.31	0.19	0.50	0.81
3	30	0.37	0.00	0.63	1.00
5	29	0.28	0.24	0.48	0.76
6	32	0.16	0.50	0.34	0.50

8	24	0.08	0.21	0.71	0.79
9	33	0.42	0.24	0.33	0.76
10	22	0.27	0.27	0.45	0.73
11	29	0.45	0.41	0.14	0.59
12	31	0.45	0.23	0.32	0.77
Overall	29.30	0.32	0.23	0.45	0.77
Std. dev	4.16	0.12	0.15	0.17	0.15

Table L-3 provides response rate information for all LC participants, with the format of this table being similar to Table L-2.

Table L-3: Local controller response rates

Controller Number	# Instructions	First (%)	Second (%)	Neutral (%)	First + Neutral (%)
1	31	0.48	0.26	0.26	0.74
2	23	0.70	0.17	0.13	0.83
3	34	0.56	0.24	0.21	0.76
5	26	0.54	0.12	0.35	0.88
6	26	0.35	0.54	0.12	0.46
8	23	0.22	0.26	0.52	0.74
9	26	0.38	0.38	0.23	0.62
10	27	0.26	0.37	0.33	0.59
11	25	0.44	0.56	0.00	0.44
12	27	0.63	0.19	0.19	0.81
Overall	26.80	0.46	0.31	0.23	0.69
Std. dev	3.22	0.15	0.14	0.14	0.15

Response rates for both GC and LC participants demonstrated that, even with minimal experience in TFDM system operation, participant controllers verbally conducted daily air traffic activities as well as, and sometimes better than their corresponding ETC in the air traffic control environment. High standard deviation between individual controllers is another avenue that may be further analyzed. While there were three local controllers who demonstrated difficulty in adjusting to the system, five controllers issued first and neutral responses over 75% of the time. Similarly, while two ground controllers had a first and neutral response rate of 50% and 59%, a large majority of others demonstrated a successful rate of above 75%. Further analyses presented in this section utilized video data to compare the operational strategy and environmental factors affecting individual participant controllers according to skill level. Understanding sources of error and processes that required a high cognitive workload will also lead to more favorable and universally accepted TFDM design improvements.

L.2.2 Gap Time Trends

Average gap time measurements were an investigation into the 23% of verbal commands issued second by GCs and the 31% by LCs. LC participants had a lower average gap time than live controllers, though no difference was seen between GC participant and live controllers ($t = 3.12$, d.f. = 15.35, $p < 0.01$) (Figure L-4). Though GC and LC participant controllers did not exhibit any disparity in gap time, LC live controllers also had a high average gap time of 7.50 seconds, which was significantly longer than GC live controllers ($t = 3.52$, d.f. = 17.99, $p < 0.01$). LC participant controllers had an average 5.1 second gap time, while corresponding ETCs had a 9.9 second gap time. A lower gap time for local controllers suggests a smaller difference in cognitive workload. It could also suggest that ground controller gap times may have a higher cognitive workload when utilizing the TFDM system than local controllers.

Gap time trends demonstrated that LC live controllers, the control group, had the highest average gap time among LC participant controllers and GC live controllers. However, it must also be noted that many data points are not present because they were either thrown out due to excessive controller/observer interaction or they were not existent at all (i.e., no cases existed for that sampling session in which the participant controller issued instructions second to their live controller counterpart). Lack of data points may have added noise to the results, though the data still prevalently shows that LC participant controllers almost always had a lower gap time than their live controller counterparts.

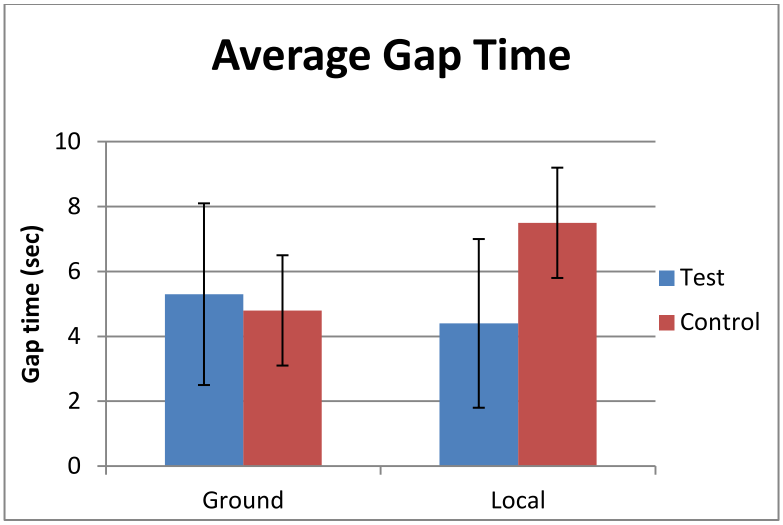

Figure L-4: Average gap time (sec) between initial and secondary control command issuance.

When comparing gap time trends within individual participant controllers and across sampling sessions, participant controllers exhibited too much variability to suggest any trends. However, an interesting phenomenon that arose from comparing gap times and response rates was the idea that participant controllers were affected by hearing their live controller counterparts and were actively aiming to "beat" the live controller when making an instruction. While this competitive attitude was apparent in some controllers, others did not seem willing to issue verbal instructions at all due to pilot inability to hear them. Due to the subjective nature of these inferences, controller data was not thrown out. Despite these sources of noise, our preliminary results indicate that small participant controller gap times and successful response rates point towards low to moderate levels of cognitive workload when utilizing the TFDM system.

L.2.3 Gap Time Plots

Gap time data was also plotted to present a visual method of understanding participant controller experiences. For each participant controller graph, the time an instruction was issued is given on the x-axis, while the gap time for this instruction is provided on the y-axis. When the participant controller is first, the bar is green and gap time represents how far ahead the participant controller issued instructions before the live controller. When the participant is second, the bar is red and gap time represents how long it took the participant controller to issue instructions after the live controller. When the participant gap time was neutral, the difference in gap time was 0 seconds and thus neutral data points are always plotted directly on the x-axis.

Figure L-5 shows the response types (first, second, or neutral) of GC participant #6 plotted against the gap time for each response. A perfectly acclimated participant is hypothesized to have mostly green bars with a high gap time across the samples. Likewise, a participant that is completely overwhelmed with the system would show mostly red bars with high gap times. This graph demonstrates GC participant #6 who exhibited signs of high workload while issuing verbal control commands within the shadow TFDM environment. GC participant #6 was able to issue instructions before the corresponding live controller towards the end of the sampling sessions, demonstrating a significant cognitive workload to which he or she began a slight acclimation towards the end. When revisiting the video playback over the 15:26 and 15:29 time periods, it was discovered that just prior to the live controller issuing a control command, the GC participant was busy highlighting a field and changing the text to red on an FDE on the FDM (for approximately 7 sec). In the next moment, at 15:26:30, the live controller began issuing an instruction to another flight. This same lag effect occurred for a third time at 15:26:39. There was a serial lag affect because the test controller was distracted with completing the highlight function on the FDM, leading to the participant falling behind on the verbal control command task.

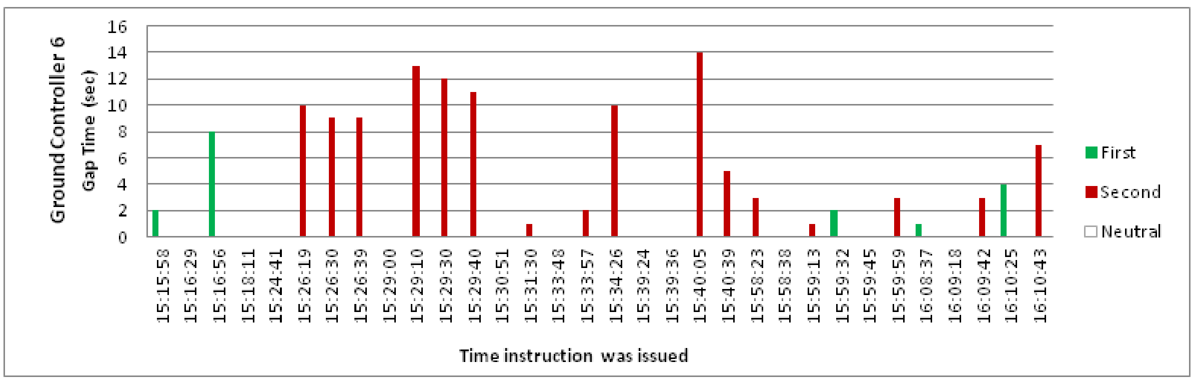

Figure L-5: GC participant #6 gap time trends

Comparatively, LC participant #2, shown in Figure L-6, demonstrated a quick acclimation to the TFDM environment and most often issued directions before the corresponding live controller. Future data analyses could focus on individual controller trends, comparing them with controller actions to reveal correlations and causes of gap time delays and response rate timing.

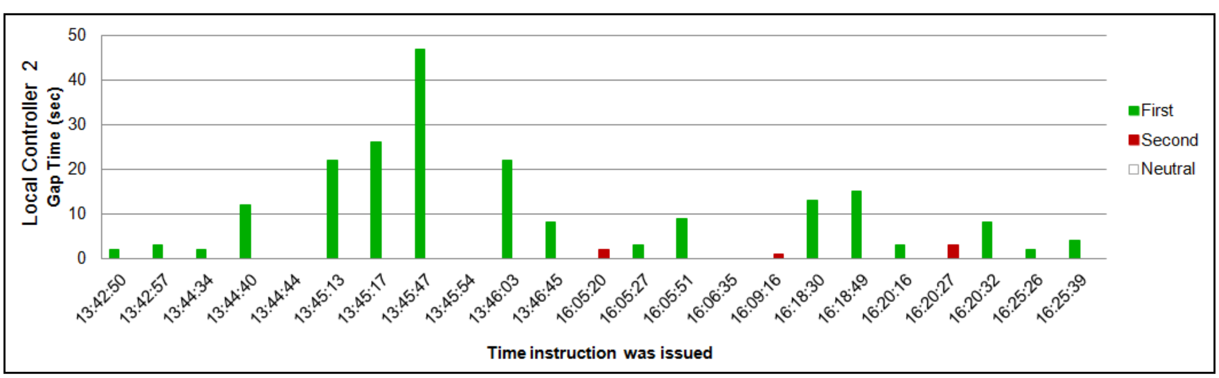

Figure L-6: LC participant #2 gap time trends

L.2.4 Design Recommendations

Understanding the context of participant actions when their gap times were highest also revealed potential avenues of display design improvement. Video data during highest participant gap times were investigated to find the results shown in Table L-4. In many cases, GC and LC participants issued verbal commands after hearing the live controller issue a command, thus indicating that while the participants were aware of the flights, they only issued a command upon being prompted by hearing their live counterparts. However, it also became apparent that FDE operations were also causing participants to lag behind live controllers. GC participants in particular exhibited high gap times due to performing FDE operations. The most time-consuming operations were manually searching for an FDE on the FDM and moving one or multiple FDEs. Future design efforts are suggested to build upon these recommendations to reduce cognitive workload of participant controllers.

Table L-4: Causes of highest gap times

	Ground Control (# of instances)	**Local Control (# of instances)**
Prompted to issue command upon hearing ETC	7	12
Interacting with FDEs	10 Looking for FDE 7 Moving FDE 4 Editing FDE 2 Using *Search* function	2 Looking for FDE 2 Moving FDE 1 Editing FDE
Looked at RACD	0	3
FDE not sent in time by GC	N/A	3
Tracking flight on TIDS	1	2
TOTAL (all gap times over 3 sec)	54	37

L.2.5 Verbal Control Commands Analysis Summary

From this analysis, it appears that GC participants struggled more than LC participants in performing shadow operations with TFDM such that they could effectively keep up or anticipate verbal control commands issued by the East Tower. This was supported both by the percentage of time in which GC fell behind the live controller in verbal control commands and also by the amount of time by which they fell behind as compared to live controller gap times. FDM user interface issue in highlighting a field in the FDE accounted for many of the instances in which the GC participants fell behind. This observation correlates with the request from the controllers to revise the method by which FDE fields are highlighted in the FDM to reduce workload and heads down time. In addition, it appeared that gap time provided an indication that LC participants using TFDM in shadow operations exhibited lower workload (lower gap times) than their live controller counterparts. This could be because shadow operations naturally require less cognitive capacity than actually ensuring separation. However, there could also be a contribution of TFDM actually reducing LC participant's workload over the systems used by their live controller counterparts. Further research is required to establish this.

L.3 Visual Gaze Analysis

Scanning data was gathered in order to quantify head up and head down time and evaluate attentional demands of the TFDM test environment. For each participant controller, five one-minute samples of video data from each shadow ops sessions were analyzed to capture eye scanning behavior (Figure L-7). The first 10 minutes of each shadow ops session was omitted from analysis in order to reduce noise caused by controller unfamiliarity with the TFDM system or by controller re-adjustment to the system after a break.

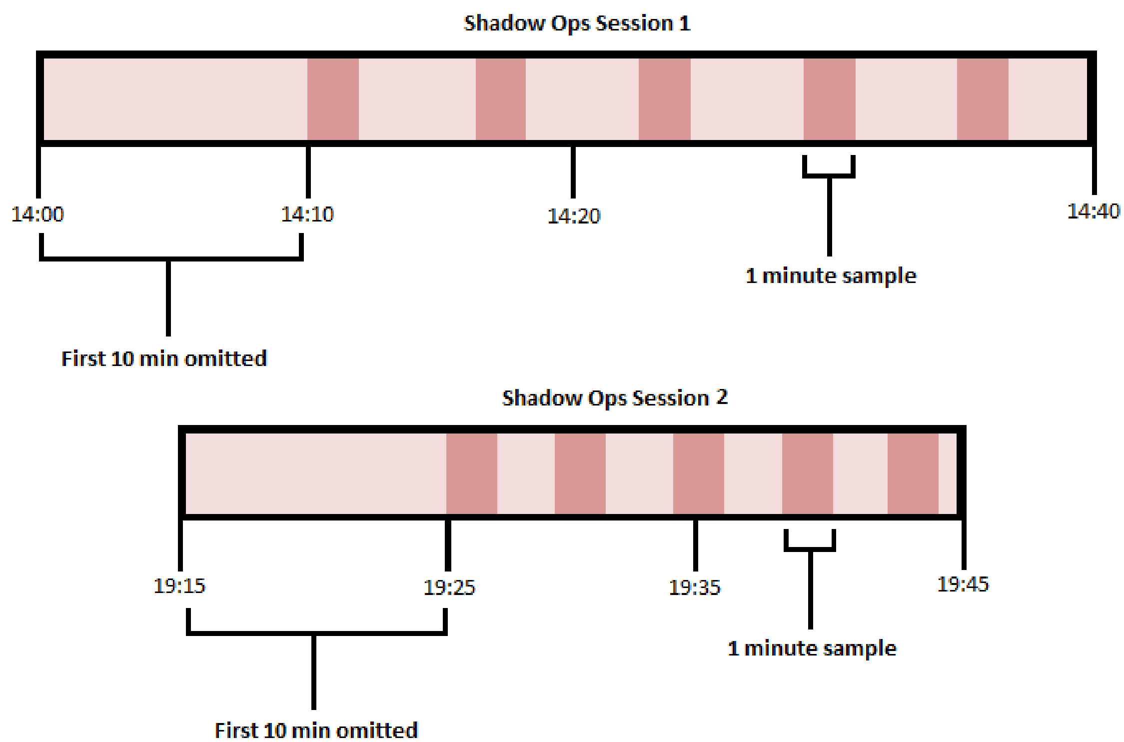

Figure L-7: Data sampling plan for scanning analysis

Scanning data was gathered in order to quantify head up and head down time and evaluate attentional demands of the TFDM test environment. For each participant controller, five one-minute samples of video data from each shadow ops sessions were analyzed to capture eye scanning behavior. The first 10 minutes of each shadow ops session was omitted from analysis in order to reduce noise caused by controller unfamiliarity with the TFDM system or by controller re-adjustment to the system after a break. Additionally, times during which participant controllers were interacting too heavily with observers were not recorded and instead the next minute during which there was little interference was analyzed. As a result, sample minutes were not all spaced evenly apart in time.

To quantify participant controller eye movements, each potential dwell area was assigned a numerical code, called a dwell code (i.e., 1 = FDM, 2 = TIDS). Head up dwells were divided into three codes (3, 4, and 5), though they were subsequently merged and analyzed as one code to gather an overall view of head-up trends. Dwell codes are presented below:

Dwell Codes:

1 = FDM	**2** = TIDS	**3 – 5** = Up
6 = COHU (Camera Display)	**7** = RACD (Remote ARTS Color Display)	**8** = ASDE-X (***Airport Surface Detection Equipment***, Model X)
9 = IDS (Integrated Display System)	**10** = Observer (OBS)	**11** = Miscellaneous (drinking coffee, etc.)

For a given sampled minute, each of the controller's individual gazes was recorded as a dwell code along with their duration. Recording participant controller gaze resulted in numerical sequences that were analyzed for total dwell time per 1 minute sampling session, average single dwell length per code, and dwell frequency. Resultant data were used to gain insight into head up/head down time (i.e., time looking out the window versus time looking at the various head down displays).

L.3.1 Gaze Duration Timing

Due to the fact that the video analysis method was manual, the smallest unit of time measured was in seconds. Each point at which the participant controller changed his focus, video playback was paused and the time at which the gaze began was recorded through use of the onscreen clock timer referred to previously, as seen in Figure L-1. Each time data point was recorded in "h:mm:ss" and the difference between beginning and end time for this fixation was calculated in "h:mm:ss" and termed the "gaze duration." Gazes less than 1 second long were rounded up to 1 second. While the screen timer included precision up to 1/100th of a second, gap times were rounded to the nearest second to account for lower levels of precision inherent to the manual recording method. Similar to cognitive workload measurement methods, gaze duration data points were treated as rough estimates that sufficed for the purposes of our study.

L.3.2 Accuracy of Estimating Gaze Position

While manual observation of visual gaze is not as accurate as eye movement data collected by an eye tracker, there is evidence to support the fact that our selected method is appropriate for DFW-2 informational needs. Previous studies have found that the human eye is accurate in distinguishing gaze direction, and leads us to believe that precision error is acceptable when placed in the context of the large ATC environment (Schieber, Harms, Berkhout, & Spangler, 1997).

In (Schieber et al., 1997) participants assessed the accuracy and precision of participants judging the gaze locations of a vehicle driver looking between the instrument panel of a car and outside of his windshield. Participant precision reflected how consistently they assigned a specific gaze to one area of the panel, and participant accuracy reflected whether their assignment of a gaze to one area was indeed correct. Researchers found that the average accuracy of estimated location was within 8.45 cm while precision was within 12.2 cm.

These measures are sufficient for DFW-2 testing since dwell recordings supported a more gross level of observation and dwell code areas were at least several inches apart from each other. A more fine-grained analysis of determining where participant controllers were looking on a single display would be much better supported by eye tracking software. In DFW-2, participant eye movements and head position, along with concurrent mouse movements displayed in Epiphan data, provided an accurate indication of controller gaze. In cases where displays were placed right next to each other, the position of the video camera supported more precise estimations of where the controller was looking, since gaze direction could be determined from the positioning of the eye in relation to the video camera (Figure L-8).

Figure L-8: Diagram of Ground (North Flow) and Local Control (South Flow) environment shows each display location.

Mouse movements seen during video analysis also helped to provide an indication of where participant controllers were looking. When it was difficult to determine gaze between the FDM and TIDS displays, mouse movement observations were utilized. If an FDE was seen being edited or moved on the FDM, it was determined that the participant controller was viewing the FDM. When a mouse was placed over a moving plane on the TIDS, it was determined that the participant controller was viewing the TIDS and tracking a plane on it.

It was most difficult to determine gaze position in South Flow Local Control, where the Cohu, RACD, and ASDE-X displays were all immediately next to each other. Strategic placement of the camera, however, enabled analysts to recognize which of the three screens a controller was viewing according to gaze with relation to the camera. The camera was placed in front of the RACD screen, which was positioned in between the Cohu and ASDE-X. Thus, if the participant controller was looking above the camera, he was clearly viewing the RACD and if the controller was looking to the left or right of the camera, the controller was viewing the Cohu or the ASDE-X screens, respectively.

L.4 Scanning Analysis

Analysis of the scanning data was performed to quantify head up and head down time and evaluate attentional demands of the TFDM participant environment. To record visual gaze patterns, analysts sampled a one minute span of time for every five minutes' worth of video data during each participant controller's first and third shadow operation sessions. As discussed previously, each potential dwell point (e.g., TIDS, FDM) was given a numeric code and, for each minute sampled, the sequence of the controller's visual gaze and the duration of each gaze were recorded. These data resulted in numerical sequences of dwell codes used to quantify and visualize head up vs. head down times and examine display usage.

L.4.1 Head Down vs. Head Up

Controllers spent the large majority of their time, approximately 50 seconds per sample minute, looking head down, and less than 10 seconds per sample minute looking head up outside the tower (t = –17.34, $p < 0.05$) (Figure L-9). An "Other" category was also used to measure the percentage of dwells that could not be determined or were miscellaneous (e.g., the participant controller looking at his coffee mug). Participant controllers spent approximately 1% of their time looking at areas defined within this category.

While participant controllers spent a significant amount of time head down, results are comparable to previous studies also examining head up vs. head down time in air traffic control (SensoMotoric Instruments, 2011). In an eye tracking study performed by The German Air Traffic Control and Human Factors Consult, air traffic controllers were found to conduct out the window (head up) views less than 30% of the time when their airports had sufficient radar capabilities. At German airport Dortmund (DTM), participant controllers spent only 26.2% of their time viewing head up information and about 60.3% head down viewing displays and flight strips. At Niederrhein (NRN), participant controllers viewed head up information 28.0% of the time and 53.5% head down. While each of these tower environments differs from the DFW-2 testing environment, this real world study demonstrates the reliance of air traffic controllers upon technical displays over head up information. DFW-2 head up results demonstrate a trend of reliance upon displays that is not necessarily caused by the TFDM system. However, a comparatively higher head down dwell rate for DFW-2 may also reflect participant controller adjustment to the new system and the request by the researchers to spend time considering the system's functionality during the demonstration. The novelty of the TFDM system may have required exaggerated controller attention due to their inexperience with it and due to instructions given to exercise the tools being tested.

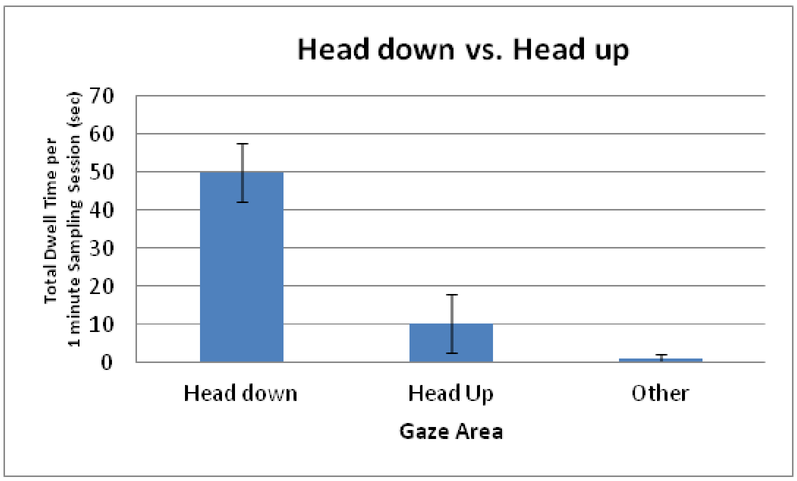

Figure L-9: Head down versus head up total dwell time

Figure L-10 displays the amount of time it took participant controllers to gather information from a source during each gaze, known as the mean dwell duration. In addition to spending almost 50 seconds per each sampling minute viewing head-down information, test controllers also spent longer individual dwells viewing and gathering information from head-down displays ($t = 10.61$, $p < 0.001$). A high amount of attention was clearly directed towards displays and information within the tower as opposed to outside of it or to miscellaneous non-informational areas. DFW-2 visual attention results may be caused by various factors that are further examined in this section.

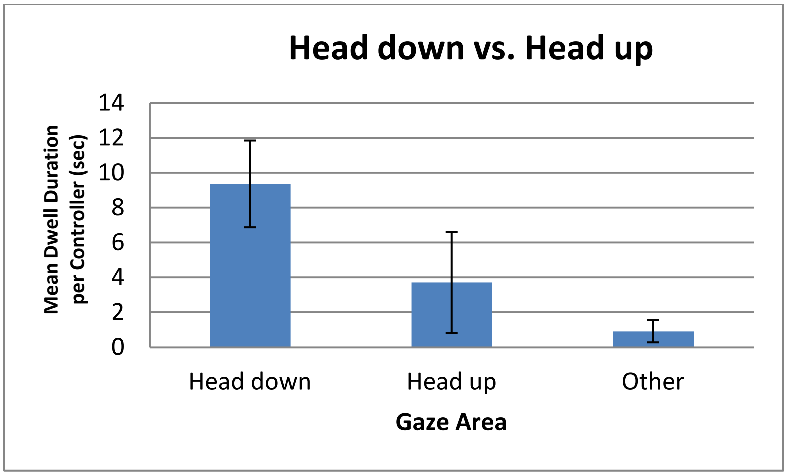

Figure L-10: Head down versus head up mean dwell duration

Figure L-11 demonstrates that, when comparing across shadow operation sessions, a marginally significant trend was seen in head down time. As participant controller experience with TFDM over the day increased, head down time decreased (t = 2.00, p = 0.06). Comparatively, Figure L-12 displays an increase in head up time across shadow operation sessions (t = –1.71, p = 0.10) for total dwell length, albeit this relationship is not yet at the point of statistical significance.

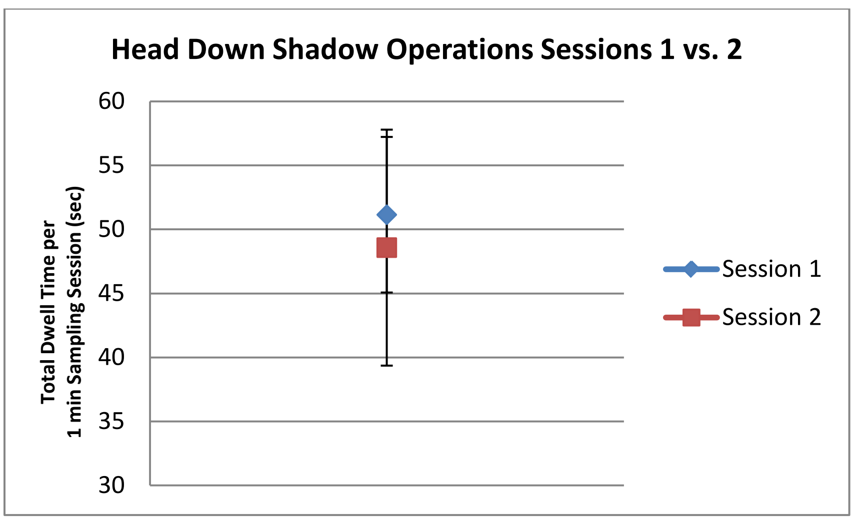

Figure L-11: Head down time across shadow operations

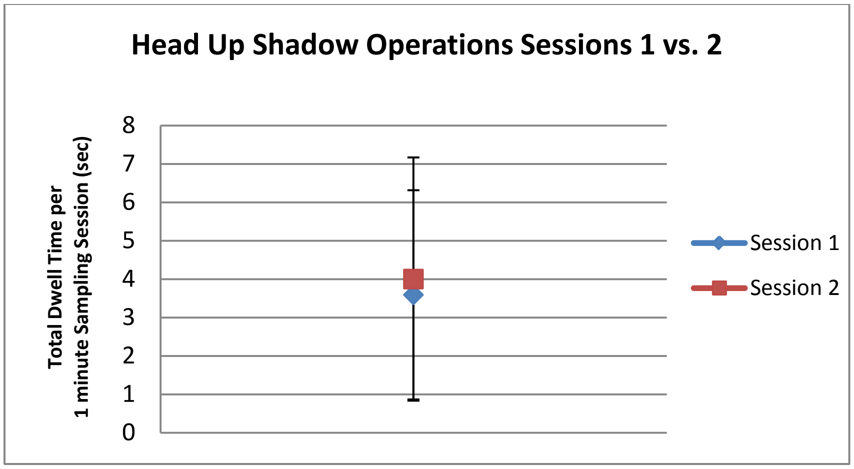

Figure L-12: Head up time between shadow operations

L.4.2 Display Usage

Dwell code display usage was also analyzed to examine the difference between GC and LC participant habits. While the German Air Traffic Control and Human Factors Consult study did not compare between GCs and LCs, DFW-2 results indicate that there was no significant difference between the two groups for head up and head down total dwell time. However, both GC and LC participants did use the TIDS and FDM to a significantly greater extent than looking at head up information (Ground controller TIDS vs. head up: ($t = 6.12$, $p < 0.05$); Ground controller FDM vs. head up ($t = 5.10$, $p < 0.05$); Local controller TIDS vs. head up ($t = 4.45$, $p < 0.05$); Local controller FDM vs. head up ($t = –1.99$, $p < 0.06$).

Total dwell time comparisons between GC and LC participants revealed a statistically significant difference between usage of the FDM ($t = 5.01$, $p < 0.05$) and of the RACD ($t = –10.39$, $p < 0.05$) (Figure L-13). GC participants spent an average of 22.46 seconds per minute interacting with the FDM compared to an average of 14.87 seconds for local controllers. This difference may reflect individual controller function as ground controllers must sequence planes and continuously evaluate flight sequences on the FDM. Similarly, the difference between GC and LC usage of the RACD more certainly reflects controller function. LC participants spent an average of 7.03 seconds per sample minute viewing the RACD while GC participants spent 0.21 seconds per sampling minute. This disparity is appropriate because RACD information is more pertinent to local controller needs, who must view it to monitor the progress of arrivals in the air. While the TIDS display also included the option of zooming out to view arriving flights, no GC or LC participants were seen utilizing this function or demonstrating that they were aware of it ($t = 8.36$, $p < 0.05$) (Figure L-14).

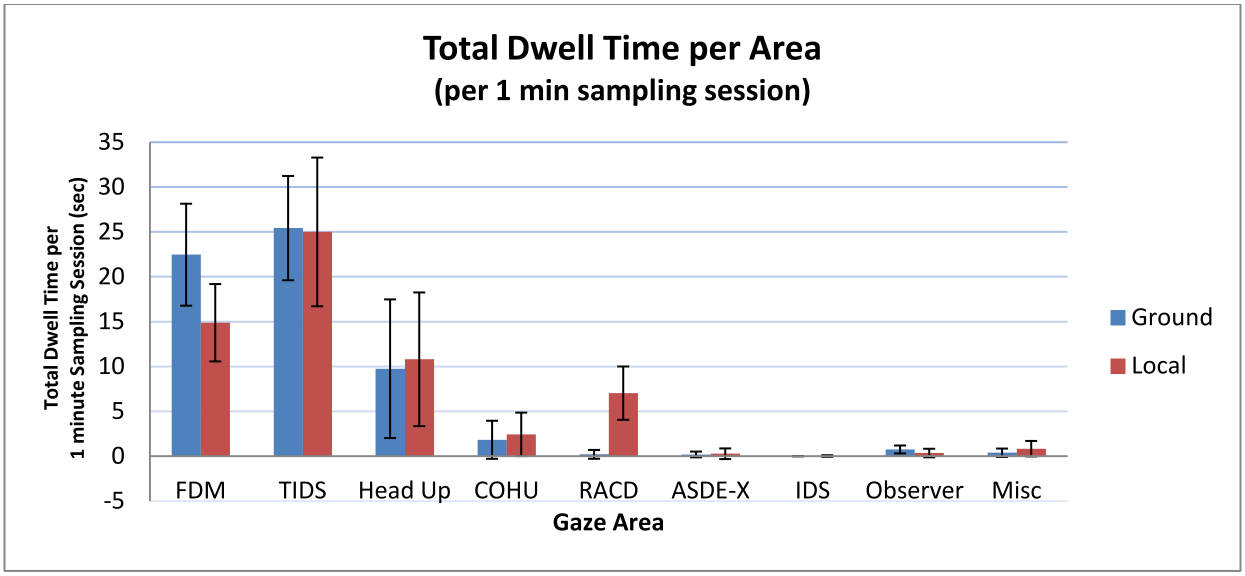

Figure L-13: Total dwell times across displays

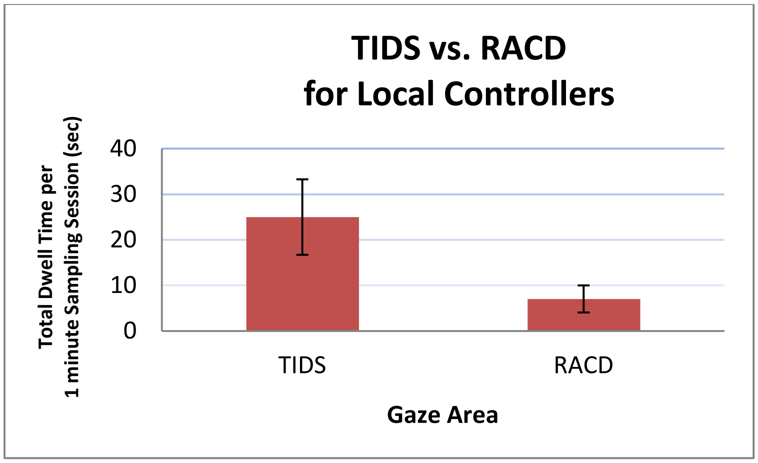

Figure L-14: Total dwell time comparing TIDS and RACD

Though the TIDS, FDM, RACD and Cohu were the most heavily utilized displays, there was no difference in usage across controller type (ground or local) or across shadow operation sessions. Additionally, while both local and ground controllers heavily utilized the TIDS, they were rarely seen gathering information from the ASDE-X. While controllers were intentionally instructed to utilize TFDM displays, the ASDE-X displays were still available to them as a traffic control tool. These results, in addition to highly positive survey results for the TIDS display, suggest that the TIDS is a successful replacement for the ASDE-X that both ground and local controllers readily accepted as accurate and relevant to their needs.

L.4.3 Design Recommendations

To elicit design recommendations from visual gaze data, dwell durations were correlated with dwell codes and playback videos were referenced to find controller actions causing high dwell durations (defined as over 10 seconds). Numerical results demonstrated that both GC and LC participants viewed the TIDS and FDM displays for the majority of times in which their dwells lasted 10 or more seconds (Tables L-5 and L-6). Each dwell over 15 seconds was also individually analyzed in video to examine the actions and conditions that caused these dwells (Table L-7). (Analysis of several dwells between 10 and 15 sec showed no new information added, thus only dwells over 15 sec were further analyzed.) When viewing the FDM for over 15 sec, participant controllers were found to be often spending time editing an FDE and finding one in the Pending bay, or using the "Search" function on the FDM. When viewing the TIDS, participants were found to be often monitoring a plane through the PiP camera window, or viewing or monitoring plane movement and runway surface information. Future design efforts are suggested to build upon these recommendations to reduce cognitive workload of participant controllers.

Table L-5: Ground controllers

Code Frequency	#	%
FDM	104	52
TIDS	81	40.5
Up	12	6
COHU	3	1.5
Total	**200**	

Table L-6: Local controllers

Code Frequency	#	%
FDM	28	26.17
TIDS	56	52.34
Up	8	7.48
COHU	5	4.67
RACD	8	7.48
Misc	2	1.87
Total	**107**	

Table L-7: Breakdown of longest dwells (> 15 sec)

Display	Action	Notes
FDM – (28x) Ground – (6x) Local	**Viewing/Monitoring** – (8x) Ground – (3x) Local	**Ground** – (3x) Forgetting to update an FDE – (3x) Looking for FDEs in Pending Bay
	Editing FDE – (13x) Ground – (2x) Local	**Ground** – (1x) Wanting to enter text while adding highlighting/text to red **Local** – (1x) Slow when using touch keyboard
	Other – (7x) Ground – (1x) Local	**Ground** – (2x) Using Search function to find FDEs/looking for FDEs on the FDM – (1x) Adding text as joke to say hi to **Local** – (1x) Confused by hearing live controller – (1x) Speaking to observer – (1x) FDE found when it should have been sent to Bridge
TIDS – (25x) Ground – (16x) Local	**Viewing/Monitoring** – (11x) Ground – (8x) Local	
	Using PiP camera – (11x) Ground – (7x) Local	
	Other – (3x) Ground – (1x) Local	**Ground** – (1x) Looking at TIDS adjusting PiP zooming view, no planes visible though so it did not seem purposeful **Local** – (1x) GC found feature he liked, was observing it more

L.4.4 Video Analysis Summary

DFW-2 scanning analyses indicated a high level of head down display usage. Despite this trend, however, voice communications analyses established that participant controllers were able to adapt to the TFDM environment and issue flight instructions at the same time or more efficiently than the ETC over 60% of the time. It was determined that LC participants continued to rely on the RACD as a means to ascertain arrival information. The FDM also appears to be a significant visual sink for the GC participants due to the requirement to sequence departures. There appears to be a learning curve on TFDM throughout the demonstration day for controllers, since head up time was demonstrated to marginally increase over the course of the day.

Design recommendations resulting from video analyses revolve around FDE operations, mainly for ground controllers who utilize the FDM to a greater extent than local controllers. When analyzing gaze times, it was found that ground controllers spent a high amount of time viewing the FDM when performing FDE operations, specifically searching for FDEs and moving FDEs around to their appropriate bays. Visual dwell analyses indicated the same. Future design efforts may concentrate on making these processes both easier and less time consuming. When analyzing dwell times, both ground and local controllers were found to spend a large amount of time also viewing the TIDS. Much time was spent by all controllers viewing and monitoring planes on the TIDS and using the PiP camera. However, a high dwell time is not necessarily negative and may simply indicate the usefulness of TFDM systems.

Future work could continue to explore voice communications and scanning analysis data to identify causes of instances where cognitive workload was increased. Scanning data could also be used to discern dwelling sequence patterns that may prevail across participant controllers when performing more difficult tasks. Understanding what tasks cause a higher cognitive workload would enable researchers to direct TFDM interface and workflow improvement.

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APPENDIX M
DSTS & SUPERVISOR DISPLAY QUESTIONNAIRE RESULTS

M.1 Supervisor Display Questionnaire Results

Similar to the TIDS and FDM questionnaires, the Supervisor Display/DST questionnaires were distributed to FLMs/TMCs/controllers at the end of the shadow operations sessions. The questions presented were grouped in terms of general supervisor display assessment, airport configuration, runway assignment, sequencing & scheduling, taxi routing, departure routing, and summary questions. The DST sections were already addressed in section 5.2.8, and the general assessment and summary question results are presented in Table M-1 and Figure M-1.

Table M-1: Questionnaire summary for supervisor display

Sup Display Assessment		Mean	SD
Question 1	Supervisor display functionality useful	3.56	1.20
Question 2	Supervisor display user interface easy to use	3.56	1.24

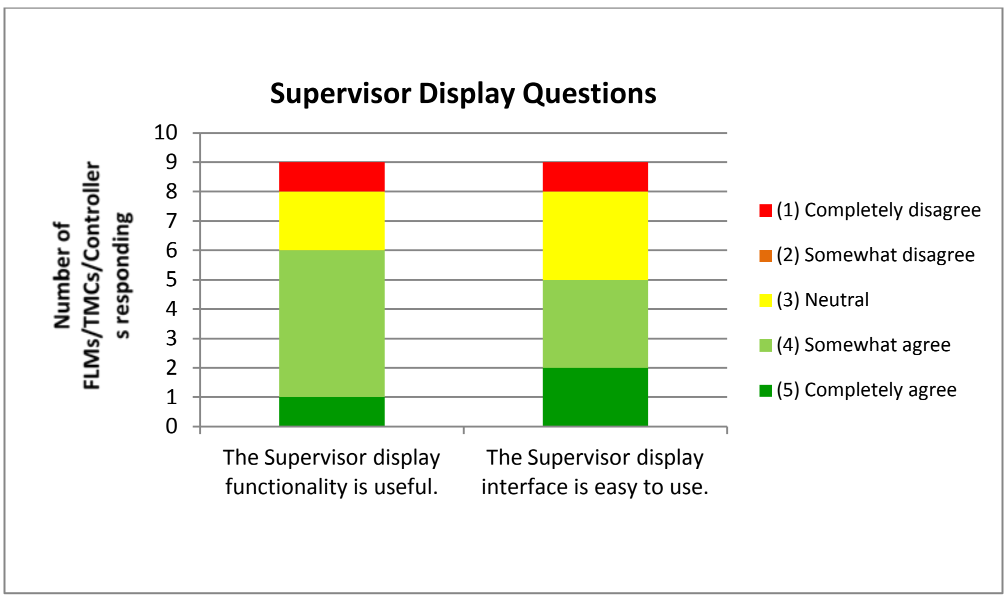


Figure M-1: Controller responses to supervisor display questionnaire

A majority of the participants agreed that the Supervisor Display functionality is useful and is easy to use. One participant disagreed on both questions. In open-ended questions at the end of the written questionnaire, participants were asked about suggested improvements to the Supervisor Display. One participant suggested adding capabilities to track delays and combine routes. Another also suggested route combination and automatic updates to traffic management restrictions. When asked about additional features that should be considered, one participant suggested adding the full route to the active flights list. Another participant suggested integrating the Integrated Display System (IDS) into TFDM and combining routes. When asked if any features should be removed from the Supervisor Display, one participant suggested removing the scheduling functions.

M.1.1 Verbal Ratings of Supervisor Display Functionality

After the entirety of the Supervisor Display functionality had been walked through with the FLMs/TMCs, the FLMs/TMCs were asked to rate both the Supervisor Display DFW-2 prototype and the overall concept of the Supervisor Display. As shown in Figure M-2, the Supervisor Display concept, which is the fully integrated display with user interface issues fixed and appropriate feeds from other facilities and the Tower Flight Management System (TFMS), was rated highly at an average of 4.75 out of 5 with a 0.61 standard deviation. The DFW-2 prototype was rated an average of 3.21 out of 5 with a 0.33 standard deviation.

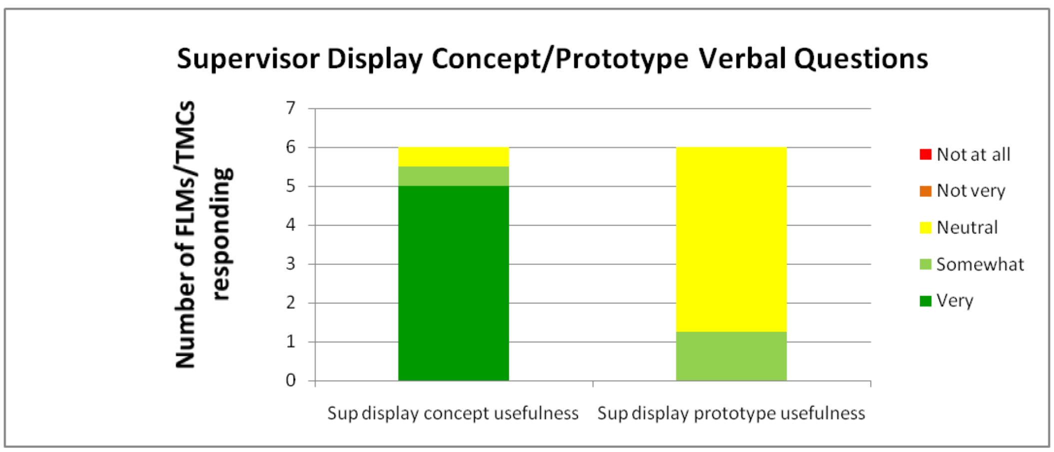


Figure M-2: FLM/TMC responses to supervisor display concept verbal questions

Additional Supervisor Display functionality, aside from the DSTs that were reported above, was also verbally rated and is shown in Figure M-3.

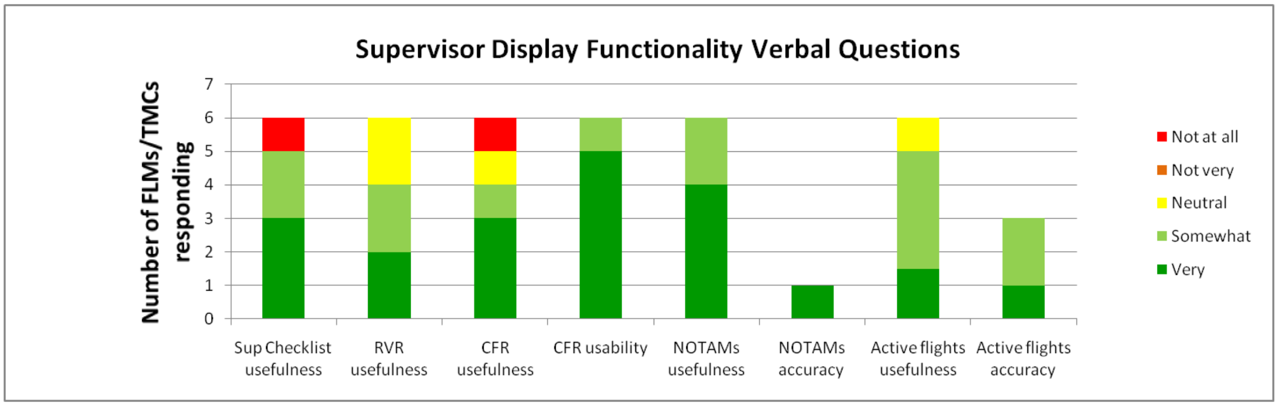


Figure M-3: FLM/TMC responses to supervisor display functionality verbal questions

FLMs/TMCs responded positively to the RVR, NOTAMs, and Active flights functionality. A majority were also positive towards the usability of the Call for Release capability and the accuracy of the NOTAMs and Active flights tabs. One FLM/TMC rated the CFR functionality and the Supervisor Checklist as not useful at all. All of the participants rated accuracy for NOTAMs and Active flights tab as positive.

Comments and suggestions were also collected from the FLMs/TMCs throughout the demonstration and during the post-demo discussions. These Supervisor Display interface problems, functionality liked, functionality suggestions, DST concerns, and DST benefits are itemized in Appendix N.

M.2 Airport Configuration

During the demonstration, the FLM/TMC participant was asked to demonstrate various DST and Supervisor Display functionalities. The participant was then verbally asked to rate the usefulness, accuracy, and usability of the different functionalities. The results from the verbal questions about the usefulness and usability of the airport configuration components are reported in Figure M-4.

A majority of the participant FLMs/TMCs were very positive about the overall usability of the components. They were also positive about the runway open/closure capability and airport configuration change usefulness. Because DFW does not often open or close departure fixes, but rather combines departure routes during convective weather, they rated the usefulness of the departure fix open/close functionality lower overall.

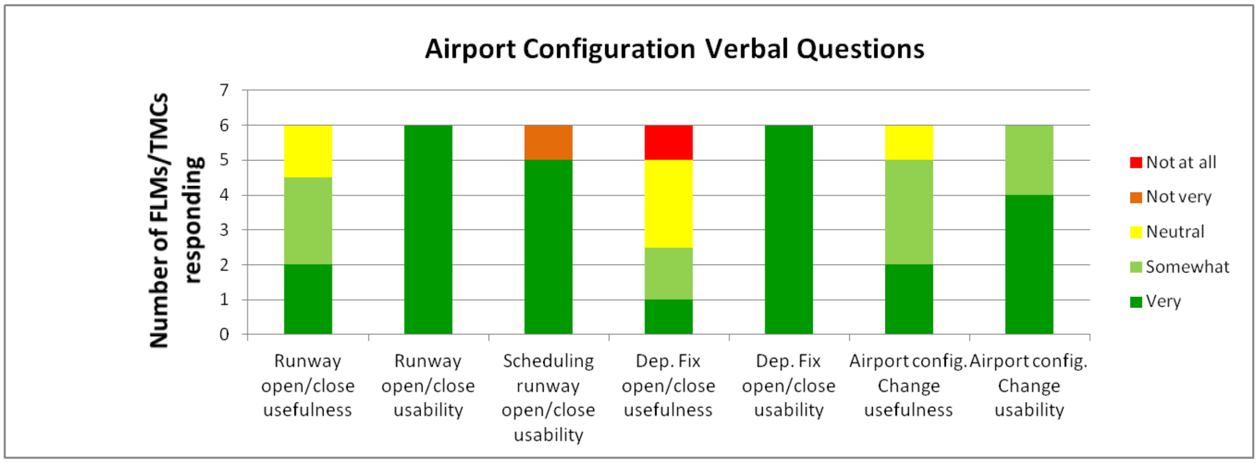
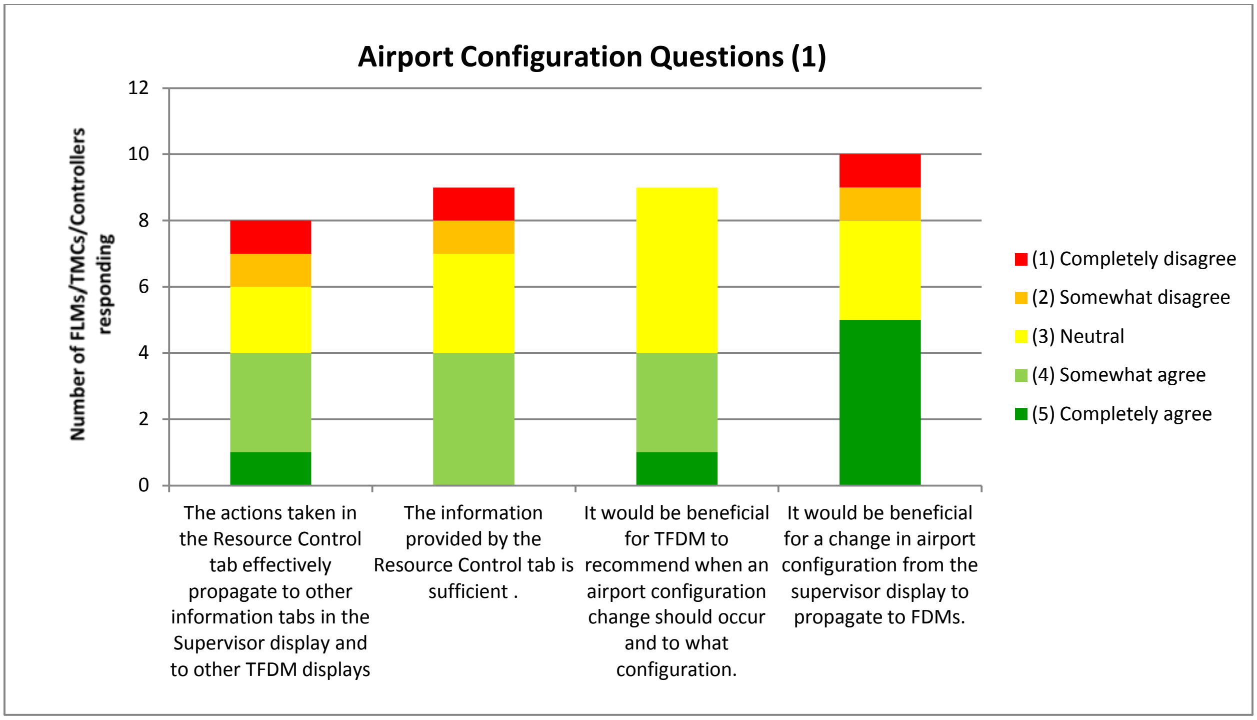


Figure M-4: FLM/TMC responses to airport configuration verbal questions

At the end of the demonstration day, questionnaires were also issued to all participants regarding the DSTs and Supervisor Display. While the verbal questions during the demonstration related to the current functionality available in the prototype, the post-demo questionnaire focused on the integration of the DST with the rest of TFDM and the possible future design improvements to that DST or the Supervisor Display. The results of the questionnaires (on a scale of 1 to 5, with 1 being the lowest amount of agreement to 5 being the highest) regarding the airport configuration components are reported in Table M-2 and Figure M-5.

Table M-2: Questionnaire summary for airport configuration DST

Airport Configuration		Mean	SD
Question 3	Effective DST propagation to TIDS/FDM	3.25	1.28
Question 4	Information sufficient to recommend a/p config changes	3.11	1.05
Question 5	Beneficial for TFDM to recommend a/p configuration and timing	3.56	0.73
Question 6	Enable a/p config change from sup display to GC & LC FDMs	3.70	1.49
Question 7	Beneficial to view a/p config change effect on future demand & delay	3.80	0.79
Question 8	Beneficial to graphically view historical airport delay & throughput	3.50	1.18
Question 9	Beneficial to graphically view predicted airport delay & throughput	3.75	1.36



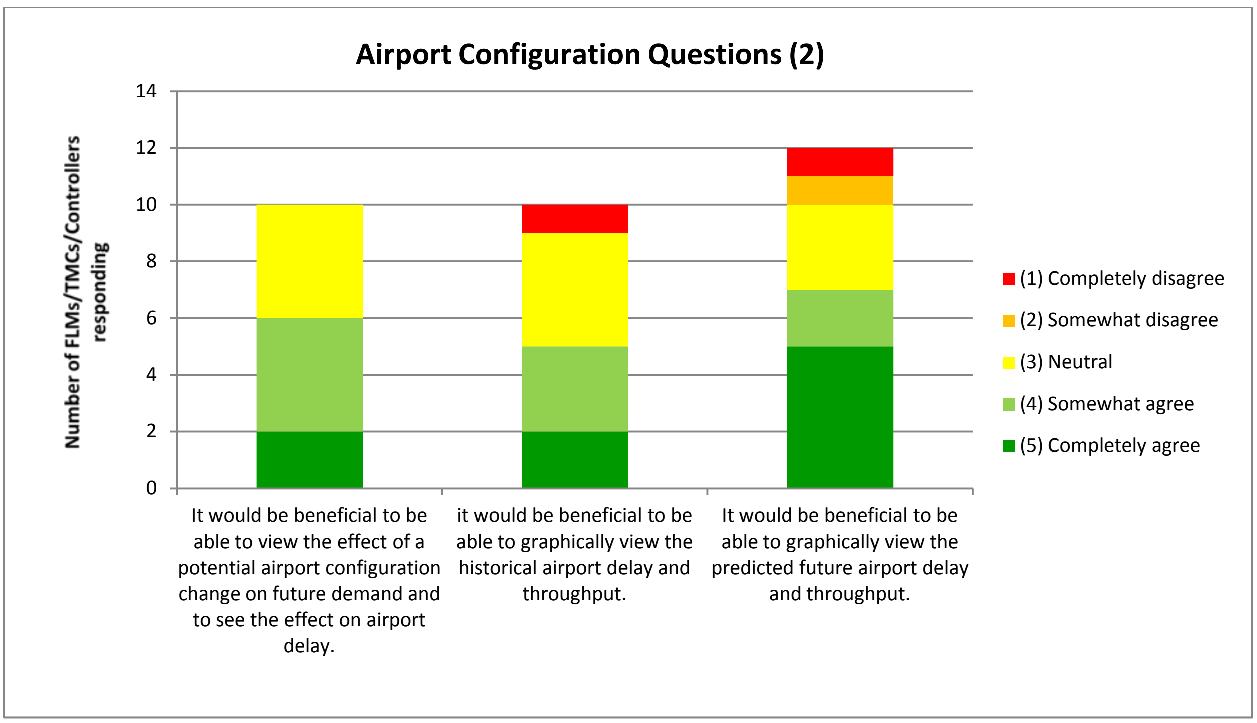


Figure M-5: Controller responses to airport configuration questionnaire

The participants were mixed in their responses about whether the information effectively propagated from the Supervisor Display to TIDS/FDM and whether the information was sufficient to recommend configuration changes. Half of the participants wanted to see the configuration changes propagate from the Supervisor display to the FDMs. More than half of the controllers wanted to see airport configuration extended to view the effect of potential airport configuration changes on future traffic demand and delay. Participants were all positive or neutral towards the concept of TFDM recommending a configuration change and its timing. In an open-ended question requesting input on how to improve the airport configuration DST, one participant responded that he or she would "prefer to see results of information (and) not have to input information twice." He or she was likely referring to the prototype requirement to manually input whether departure fixes were open/closed, rather than receiving this information automatically from external sources, such as the Traffic Flow Management System.

M.3 Runway Assignment

During the demonstration, the FLM/TMC participant was asked to demonstrate various DST and Supervisor Display functionalities. The participant was then verbally asked to rate the usefulness, accuracy, and usability of the different functionalities. The results from the verbal questions about the usefulness and usability of the runway assignment components are reported in Figure M-6.

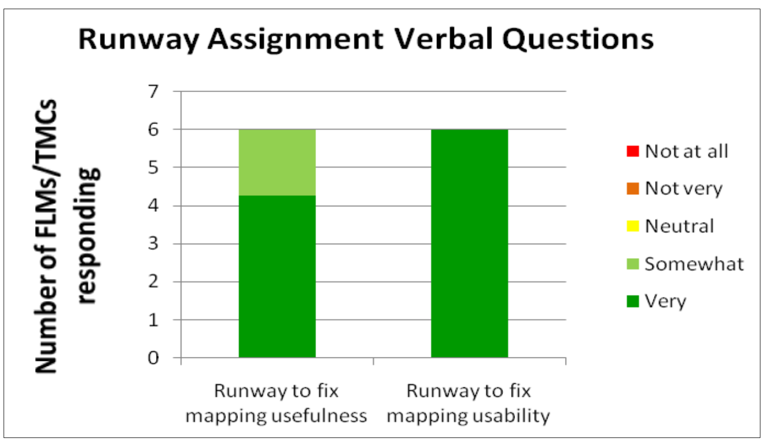


Figure M-6: FLM/TMC responses to runway assignment verbal questions

The participant FLMs/TMCs were very positive about the overall usefulness and usability of the runway-to-fix mapping component. DFW often changes runway to fix mapping to balance the traffic demand between East and West Towers.

At the end of the demonstration day, questionnaires were also issued to all participants regarding the DSTs and Supervisor Display. While the verbal questions during the demonstration related to the current functionality available in the prototype, the post-demo questionnaire focused on the rules used by the DST and the possible future design improvements to that DST or the Supervisor Display. The results of the questionnaires regarding the runway assignment components are reported in Table M-3 and Figure M-7.

Table M-3: Questionnaire summary for runway assignment DST

Runway Assignment		Mean	SD
Question 11	TFDM runway assignments logical for jet departures	3.67	1.15
Question 12	TFDM runway assignments logical for prop departures	3.83	1.19
Question 13	TFDM runway assignments logical for jet arrivals	3.10	1.20
Question 14	TFDM runway assignments logical for prop arrivals	3.67	0.92
Question 15	Runway to fix mapping sufficient	3.14	1.46
Question 16	Beneficial to recommend optimal runway assignments	4.00	0.82

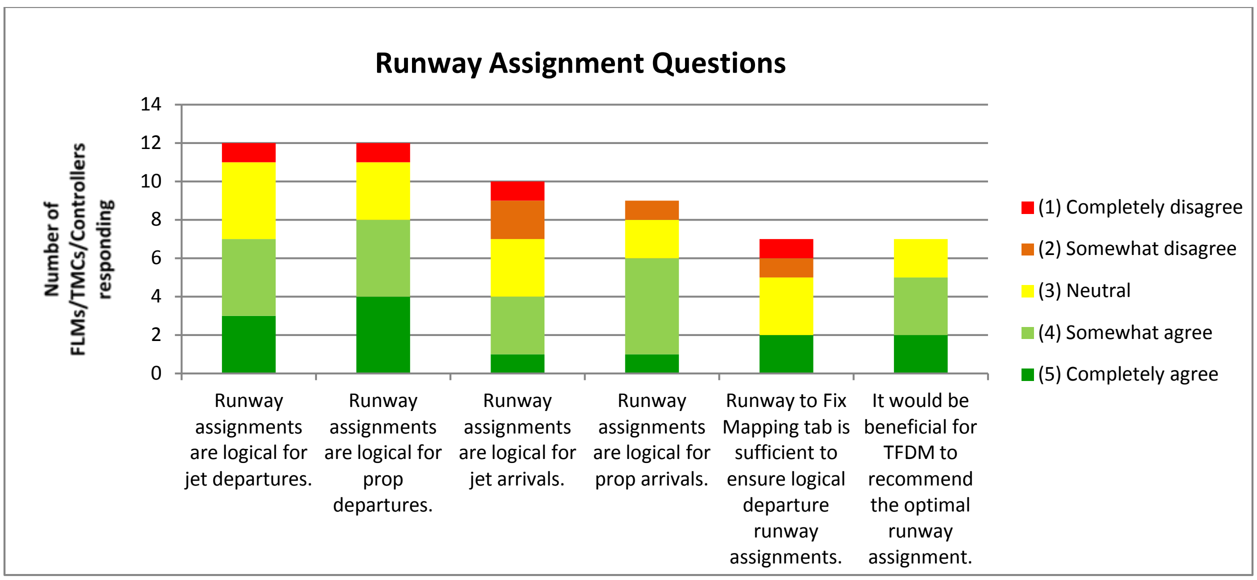


Figure M-7: Controller responses to runway assignment questionnaire

The participants were mixed in their responses on the logic of the runway assignment in this DST questionnaire; however, if one refers back to the FDM questionnaire (in which runway assignment logic was evaluated by the controllers), the controllers had overall positive responses to the logic used. There was slightly more negative feedback about jet arrivals in this questionnaire over the other runway assignment logic. This may be due to the requirement of the prototype to use decision tree logic to assume arrival runways rather than the use of scratchpad runway assignment, which would be preferable to the operation. In addition, the default runway assignment for west side arrivals is 18R. In a south flow configuration, 20% of the flights from the west land on 13R, which makes the arrival rule somewhat faulty as well. A majority of participants responded positively towards the possibility of TFDM recommending an optimal runway assignment based upon demand balancing, minimizing delay, and minimizing fuel burn/emissions.

M.4 Taxi Routing

At the end of the demonstration day, questionnaires were also issued to controllers/FLMs/TMCs regarding the DSTs and Supervisor Display. The results of the questionnaires regarding the taxi routing components are reported in Table M-4 and Figure M-8.

Table M-4: Questionnaire summary for taxi routing DST

Taxi Routing		Mean	SD
Question 26	Inputting taxi route easy	4.27	0.79
Question 27	Taxi non-conformance prompts improve safety	3.70	0.99
Question 28	Beneficial for taxi non-conformance to use standard taxi routes	3.90	1.20

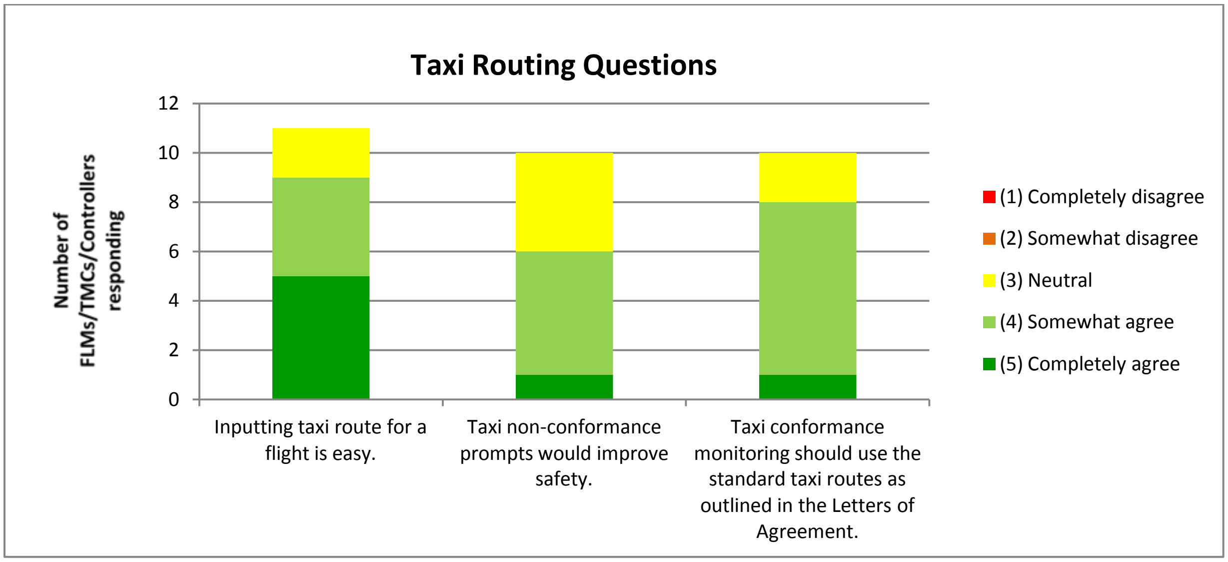


Figure M-8: Controller responses to taxi routing questionnaire

A majority of participants responded positively to the taxi routing capabilities provided in the DFW-2 prototype. There were no negative responses to the capability that currently exists nor towards the possible taxi non-conformance concepts presented for the future. An open-ended question asking FLMs/TMCs/controllers for their feedback on the taxi routing DST resulted in one participant responding, “Please keep in mind that the least number of data entries will enhance the overall effectiveness of the system. Having information appear where it is best used without user input is ideal. The routing entries should be automated and displayed quickly.”

M.5 Sequencing & Scheduling

During the demonstration, the FLM/TMC participant was asked to demonstrate various DST and Supervisor Display functionalities. The participant was then verbally asked to rate the usefulness, accuracy, and usability of the different functionalities. The results from the verbal questions about the usefulness and usability of the sequencing & scheduling components are reported in Figure M-9.

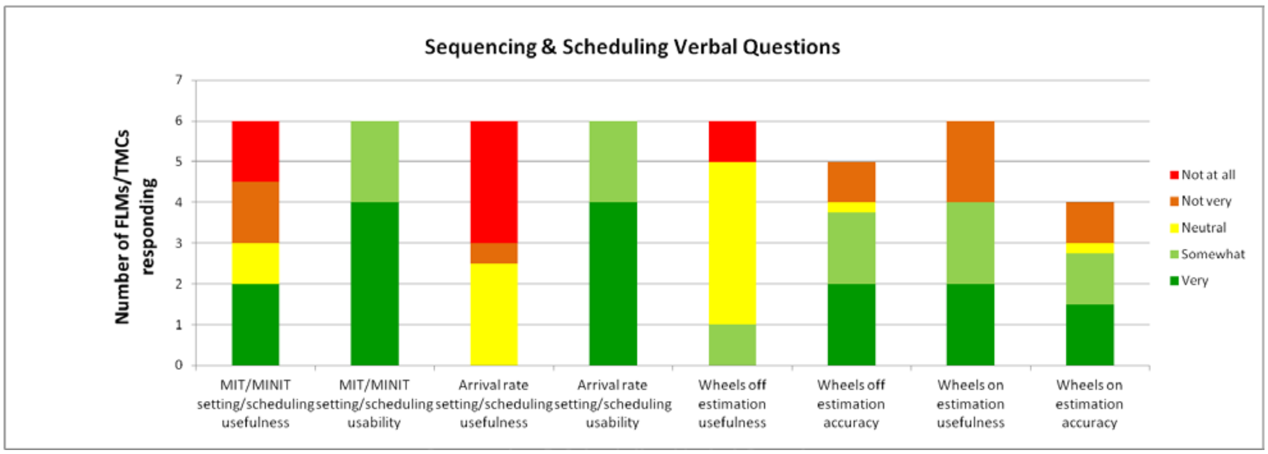


Figure M-9: FLM/TMC responses to sequencing and scheduling verbal questions

A majority of participant FLMs/TMCs were positive about the overall usability of the MIT/MINIT and arrival rate setting and scheduling capabilities. The MIT/MINIT functionality received mixed responses from the participants, likely because some reacted negatively to the MINIT capability (which DFW does not use very often). A majority were negative about the usefulness of the arrival rate setting and scheduling capability, because the participants stated that TRACON, not the Tower, sets the arrival rate.

A majority were also neutral to negative when responding to the usefulness of the wheels off estimations on the timelines. While Traffic Management Advisor (TMA) is a familiar tool at DFW and the interface is similar for TFDM departures as it is for TMA arrivals, the participants struggled with the concept of operations for the flight-specific information for departures during the demonstration. It is likely that more direct links between tasks that the FLMs/TMCs do today for departures (e.g., evaluating departure fix separation, ensuring departure TMIs are met) need to be more explicitly supported by the timeline interface. Despite the technical data report that the wheels on/off accuracies were less than adequate for the operation, over half of the participants rated the accuracies positively. This may be due to the lack of use of the timelines due to the issues with the concept of operations for them.

At the end of the demonstration day, questionnaires were also issued to all participants regarding the DSTs and Supervisor Display. While the verbal questions during the demonstration related to the current functionality available in the prototype, the post-demo questionnaire focused on the integration of the DST with the rest of TFDM and the possible future design improvements to that DST or the Supervisor Display. The results of the questionnaires regarding the sequencing and scheduling components are reported in Table M-5 and Figure M-10.

Table M-5: Questionnaire summary for sequencing & scheduling DST

Sequencing & Scheduling		Mean	SD
Question 18	Timelines easy to understand	3.86	0.69
Question 19	Timeline information sufficient for understanding expected arrival/departure demand	3.71	0.76
Question 20	Seq & sched timeline information enable reduced delay	2.43	0.98
Question 21	Seq & sched timeline information improves ability to schedule airport config. changes to maximize operational efficiency	3.57	0.53

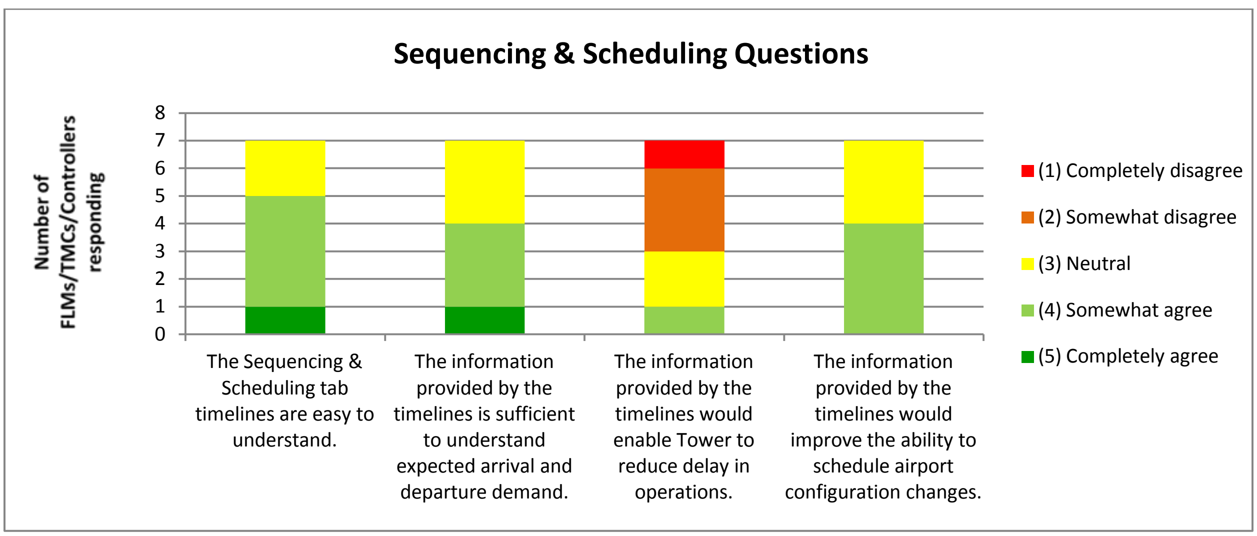


Figure M-10: Controller responses to sequencing & scheduling questionnaire

A majority of participants responded positively to the information sufficiency and ease of understanding of the sequencing and scheduling timelines, which was slightly contrary to the previous verbal responses. The participants' responses reflected the possibility that the timeline information could potentially aid in improving airport configuration change scheduling and implementation. Over half of the participants responding responded negatively to the possibility of the timeline information enabling a reduction of delay, which is consistent with the previously discussed issue of understanding the concept of operations of flight-specific departure wheels off information. In an open-ended question asking for sequencing and scheduling DST improvement suggestions, one participant recommended, "System needs to determine whether combined routes, SWAPs, impact the departure queue."

Table M-6 and Figure M-11 provide the responses to the questions focusing specifically on the metering capability.

Table M-6: Questionnaire summary for metering DST

Metering		Mean	SD
Question 22	Metering effective means of maintaining optimal departure queue	2.57	0.79
Question 23	Adequate metering information provided	2.88	0.99
Question 24	Beneficial for TFDM to recommend optimal departure sequences and spot release times	3.22	1.20

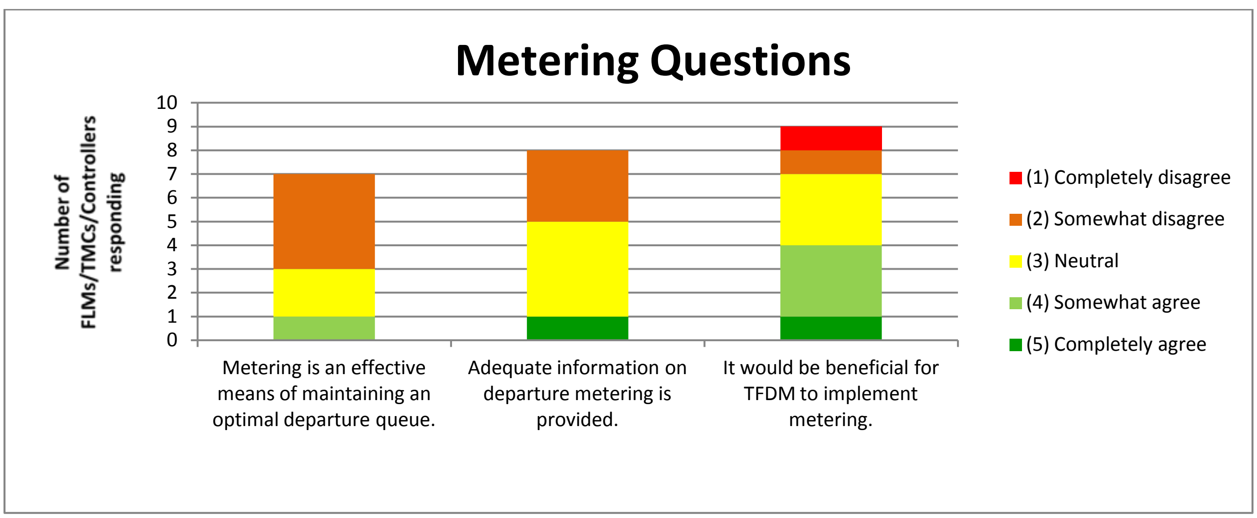


Figure M-11: Controller responses to metering questionnaire

Less than half of the participants responded that metering was an effective means of maintaining an optimal departure queue. In the post-demonstration discussions, participants relayed experiences about unsuccessful metering in which barring some flights from pushing back prevented the ability to create an efficient departure sequence. Other participants mentioned that the metering responsibility should lie with the ramp tower at DFW. A mixed response resulted from the question posed about TFDM recommending optimal departure sequences and spot release times to maximize efficiency and minimize fuel burn and emissions. In the discussions there appeared to be skepticism about whether the automation could do as well as or better than a good controller in sequencing departures.

M.6 Departure Routing

During the demonstration, the FLM/TMC participant was asked to demonstrate various DST and Supervisor Display functionalities. The participant was then verbally asked to rate the usefulness, accuracy, and usability of the different functionalities. The results from the verbal questions about the usefulness and accuracy of the departure routing components are reported in Figure M-12.

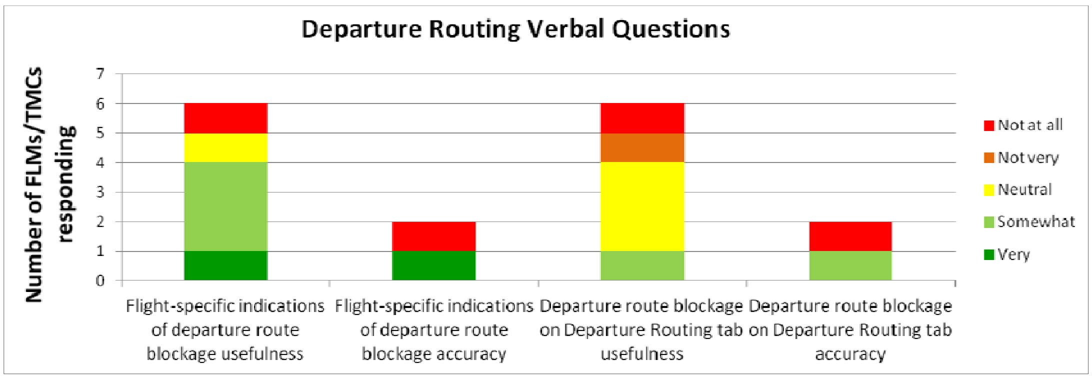


Figure M-12: FLM/TMC responses to departure routing verbal questions

A majority of participant FLMs/TMCs were positive about the usefulness of the flight-specific indications of weather blockage on the sequencing and scheduling timelines. There was a mixed participant response to the usefulness of the departure routing tab. Similar to the sequencing and scheduling timeline, the concept of operations for this tab will likely need further thought. It is possible that future functionality including bulk Flight Data Input/Output (FDIO) write capabilities may clarify the departure routing tab's role in the Supervisor Display. It is unclear why one particular FLM/TMC assessed the departure routing information as inaccurate. However, staff and the DFW FLM point of contact during the demonstration all found the departure routing information to be operationally accurate. DFW only has access to ITWS, but not Corridor Integrated Weather System (CIWS) or RAPT, the tool upon which the departure routing module is based. Thus, there may have been a misunderstanding about the meaning of the weather blockage due to limited training time. Only two FLMs/TMCs felt that they could adequately assess the accuracy of the departure routing capability due to lack of convective weather affecting DFW during the demonstration.

At the end of the demonstration day, questionnaires were also issued to all participants regarding the DSTs and Supervisor Display. While the verbal questions during the demonstration related to the current functionality available in the prototype, the post-demo questionnaire focused on the integration of the DST with the rest of TFDM and the possible future design improvements to that DST or the Supervisor Display. The results of the questionnaires regarding the departure routing components are reported in Table M-7 and Figure M-13.

Table M-7: Questionnaire summary for departure routing DST

Departure Routing		Mean	SD
Question 30	Departure routing tab information sufficient to identify weather impacts on surface	3.25	0.71
Question 31	Departure routing info would improve efficiency of surface operations in convective weather	3.11	0.93
Question 32	Beneficial to have means to view which departure routes closed by ZFW in departure routing tab	3.89	0.93
Question 33	Desirable to have means to view and allocate available departure slots based on existing traffic management constraints to individual departures	3.50	0.76

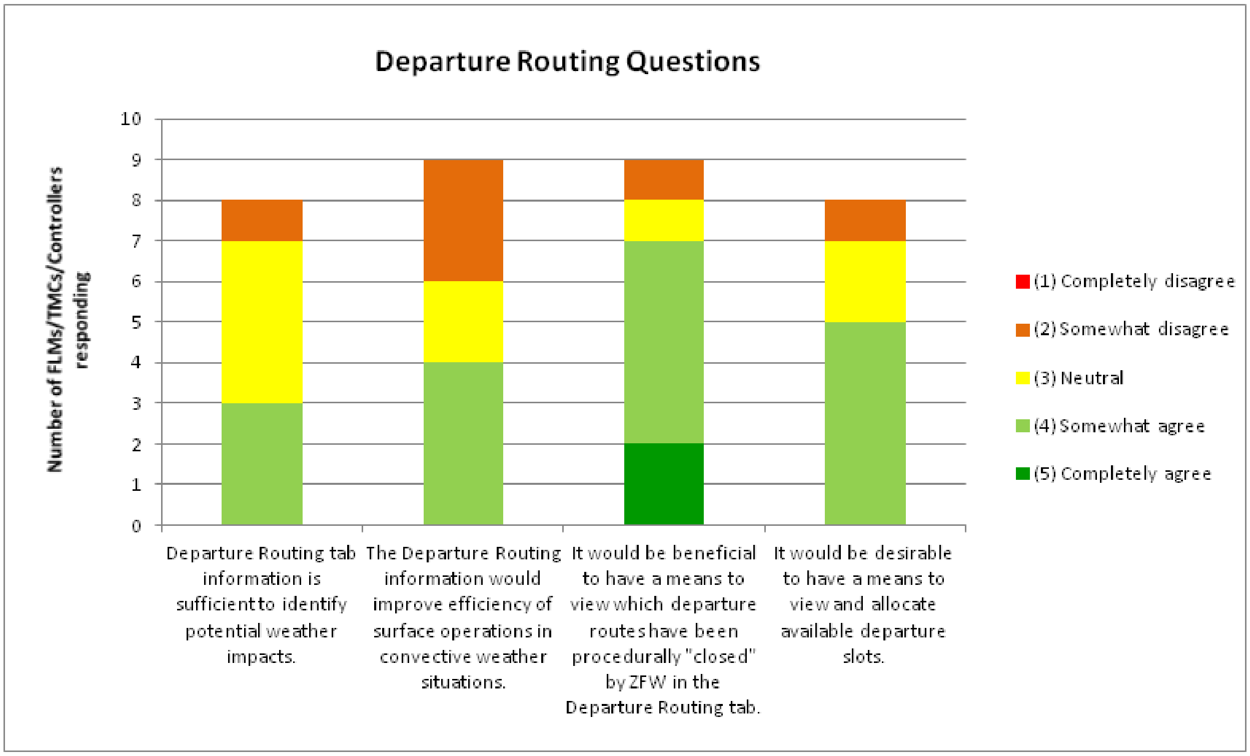


Figure M-13: Controller responses to departure routing questionnaire

Half of the participants were neutral towards the sufficiency of the departure routing information provided. Less than half of the participants agreed that the information provided would improve efficiency during convective weather. Most of the participants were optimistic towards the possibilities of enhancing the information provided through including procedural departure route closures and providing an ability to allocate departure slots to individual flights. In an open-ended question about how to improve the departure routing capability, one participant commented, "It appears that the system is set on telling the controller what cannot be done instead of how to change routes and taxi to depart aircraft in convective situations." This possibly expresses a need for proactive recommendations on changing flights' departure routes and taxi recommendations in conjunction with the latest weather information knowledge.

APPENDIX N
CONTROLLER COMMENTS ON SUPERVISOR DISPLAY AND DSTS

The Supervisor Display Interface Problems, Functionality liked, Functionality Suggestions, DST concerns, and DST benefits are included below. Only the items having two or more FLMs/TMCs commenting on the issue were listed here. The number of FLMs/TMCs mentioning the issue is included in the column to the left.

N.1 Supervisor Display Interface Problems

# Respondents	Comments
2	Would not use arrival rate—TRACON determines this. Would want timelines to reflect whatever demand TRACON sending, thought (restricted or not).
2	Would remove scheduling MIT/MINIT restrictions (don't schedule, only implement)
2	Want more pictorial display of prompts

N.2 Supervisor Display Functionality Liked

# Respondents	Comments
5	Supervisor display is good, "you focus on one area" and there is a "centralization of information." Liked concept of centralization of info as long as supervisor was not "tied to the system," e.g., using confirmation prompts rather than automatic state change on scheduled events, especially for ones that have the potential to impact alarm/alert states.
4	Liked that inputting CFR (and other TMIs) for individual flights would propagate to FDEs
4	Liked runway to fix mapping capability to set hat status.
3	Liked active search list.

N.3 Supervisor Display Functionality Suggestions

# Respondents	Feature	Comments
3	Active flights search	Would like FDE to show in Active Flights tab
2	A/p resources: fix closure	Want the ability to close/open N, S, E, W routes
2	A/p resources: fix closure	Want ability to combine departure routes (in same cardinal direction)
4	A/p resources: fix closure	Want ability to SWAP routes to another cardinal direction

# Respondents	Feature	Comments
3	A/p resources: MIT/MINIT	Want ability to restrict SWAPped flights only
4	A/p resources: rwy close, config	Want ability to identify last flight for runway closures and airport configuration changes
2	A/p resources: MIT/MINIT	Want ability to create groupings (airports, routes, fixes, FCAs) to place TMIs upon
2	Misc	Want ability to track taxi delay from departure queue entry
2	A/p resources: runway	Want ability to open/close a runway early or late
2	NOTAMs	Need ability to reorder/filter NOTAMs, e.g., main ones of relevance (e.g., accountability="DFW") should at least be on top of list.
2	Misc	IDS should be integrated into Sup display
3	TMIs	Want ability to enter GDPs, AFPs into Sup Display (or even better, automatically acquire them from FDIO)
4	A/p resources	On **scheduled** runway/airport/fix etc. config, would not want system to automatically close/open runway due to lack of robustness to system uncertainties and resulting potential for alarms/alerts/safety-related incidents, etc while Supervisor is dealing with other business in the tower. Would be much better to have a "Confirm runway close/open now?" prompt which would need to be confirmed within a certain time for the change to take effect, otherwise change not initiated.
3	A/p resources	Instead of fix closure (which is not useful), need to give ability to combine fixes into smaller number of routes, e.g., all east fixes into "East OTG (out the gate)." ZFW->D10 dictate which routes get combined and where the combinations ultimately go. In order of increasing severity: MIT over single fix; combine two fixes; MIT over two combined fixes; combine three fixes; MIT over three combined fixes; OTG/combine four routes; MIT OTG; SWAP; SWAP + MIT (re-route). All except SWAP do not need flight plan re-route. In last case, some MITs may be route-dependent, e.g., apply MITs on SWAPPed routes to New York, but not others on same departure route. WE: Also need to know how many flights are affected by route combination
2	A/p resources/ Seq & Scheduling	Would like ability for Supervisor to manually tag "last out/in on old, first out/in on new."
3	Checklist	Automatic population of relevant info of checklist would be useful. could you also actually conduct tests of alarms etc. from Sup Display?
2	RVR/FDM	Need PiP option of RVR info at LC/GC
2	RVR	RVR info needs to reformat to filter by north/south/northwest flow and by east/west side of airport.

# Respondents	Feature	Comments
3	TMIs	Need ability to set CFR valid/expiry time once coordinated with TRACON. CFRs typically coordinated with nearby facilities (not national level like EDCTs), key ones for DFW are for IAH, ATL, ORD, MEM, DAL (think about putting them at top of airport drop-down list). Set CFR now is good, scheduling CFR is not relevant given they are tactical TMIs that either affect flights now or do not. WE: Today, when a flight starts taxiing to CFR airport, GC tells Sup who then calls ZFW for CFR time and expiration. Goes to strip and writes “13V15” for release time of 13 mins past hour, expiration at 15 mins past hour. Need similar feature in TFDM, e.g., temporary control over FDE of affect flight to write CFR time on it, then return control to GC. FDE greys out on GC bay while Sup has control?
2	TMIs	Need to see how many flights in each bay on GC and LC are affected by CFRs.
3	TMIs	Scheduling CFRs, MITs, MINITs not operationally useful: they are active or not (MINITs not used at DFW unless pilot requests time separation for wake vortex separation reasons.)
2	TMIs	MITs need to be able to specified for combined routes and groups of airports, e.g., all New York airports, Washington airports, NYC + BOS, etc. (MIT to airport can be fix-specific, so need control over that too)
4	Rwy-fix mapping	Runway-to-fix mapping: would like to know how many flights impacted by changing a given fix/runway mapping at +30 and +60 mins, and resulting aggregate impact on each runway from changed mappings at +15 and +30 mins. Consider adding two columns and row to mapping GUI to include this info? Also desire cue on GC/LC displays of HAT status and changes to it. Turn RA red on FDEs kept on flights contrary to runway/fix mapping? (WE: But would numbers be based on proposed or actual times?)
2	Departure routing	Departure routing: Filter routes by 16 dep fixes only, not downstream routes.
3	Active flight search	Active flight search: add departure route, ACTUAL dep/arr time, EDCT time, cancelled flights, FCA, lose departure airport (if only DFW deps!); search by multiple DPs, destinations, arrivals too?
2	Misc	Prompts on info panel should be color-coded to distinguish between different classes/priorities of prompts.

N.4 DST Benefits

# Respondents	Comments
4	Departure metering concept is definitely beneficial. JFa: if managed by ramp.
3	Want DSTs to let LC know when able to clear for takeoff (EDCTs, MIT, fix sequencing)

N.5 DST Concerns

# Respondents	Comments
2	Function easy to use, but moving flights from a closed runway to a single alternate runway is much too simple to properly mimic actual operations. Actual operations would reallocate aircraft to alternate runways depending on their arrival fix, wake category, fleet mix in same flow, arrival gate, weather conditions, eqpt status, etc. Some of this info is known to controllers and could be factored into decision. Some scheduled flights might not even land at the airport. Ditto for airport config.
2	Logic for Northwest flow OK for VMC but incorrect for IMC: no IMC arrivals to 31L because no ILS. All departures on 31L, arrivals on 31R in IMC northflow.
2	Arrival rate function not useful at DFW: this is a TRACON-controller function (WE: unless it sends a message to TRACON replacing phone call to say what MITs needed to given runway)
2	Timelines are only valuable if they are accurate, which they currently are not.

APPENDIX O
CONTROLLER COMMENTS ON SCENARIOS AND WORKLOAD

O.1 Controller Workload

5. Were there any points during the day where your effort, performance, frustration, or demand was higher than average while maintaining your situational awareness? If so, what occurred to increase the levels, and how high were they?

Controller #	Response
1	When I had to edit several things within a flight plan like rwy, ATIS code etc., it took time for me to locate the buttons, toggle the flight pal and get the change made, and I was falling behind on the ATC duties.
2	Initially I was fighting the system to select text to make red or highlight on FDM. This was counter-intuitive and caused me to spend more time than necessary. Once I figured the process out, no biggie...
3	The only thing I experienced was the normal learning curve type stuff. The equipment seems fairly easy to learn and seems to be more user friendly than much of the equipment we have now.
4	Head down in monitors a little too much but with time spent with the equipment more time looking out windows should improve.
5	Only when we were talking about what was going on and I had to catch back up to the game.

19. Were there any points during the day where your effort, performance, frustration, or demand was higher than average while monitoring traffic and compliance? If so, what occurred to increase the levels, and how high were they?

Controller #	Response
1	The time spent on the lc-1 position was excessive and I found myself struggling to address the tasks at hand.
2	I only felt behind the curve because I was not use to using the equipment and I had to guess what the east controller was going to do.

14. Please provide any additional comments on your workload and the effect of TFDM/SNT systems on it during this evaluation.

Controller #	Response
1	The only thing that added to any workload was the flight strip display I am not a fan.

O.2 Flight Test Scenarios

6. What display features provided the most useful information for detecting the flight test scenarios (aircraft tracking, flyby, flight plan change, incorrect beacon code, taxi route deviation)? Why?

Controller #	Response
1	I liked the TIDS and the FDM the most. I think they both provided a good bit of info on this.
2	TIDS, I was looking at this piece of equipment the most.
3	TIDS, because its presentation most closely aligns with the ASDE-X monitor which I'm familiar with using.
4	The TIDS was the best or most useful for gathering information for monitoring.
5	The tracking feature
6	I preferred to use the TIDS for scanning my arrivals on final. I couldn't see aircraft really well that were on a base leg to final due to the setup. I didn't trust the TIDS for crossing aircraft at multiple intersections once the aircraft was airborne and turned cyan in color. Some planes climb really slow or tend to hold a very low altitude over the runway, which would normally force me to wait another few seconds to cross the aircraft that were still within the intersection of the departing aircraft.
7	Inbound information was great from TIDS; however, it is not very intuitive to watch for a change in color to tell whether the aircraft is airborne or on the ground in VFR conditions. Out the window and with improved camera technology would be the best way to determine airborne status in VFR conditions.
8	The TIDS gave the best info for quickly finding the aircraft and tracking said ac on the ground. The displays are sharp and clean and easily maneuvered to each individuals liking.
9	As far as activity at the airport, departures and arrivals that occupy a runway, the TIDS is a good piece of equipment. I didn't like using the TIDS to track arrivals that were on final from the threshold out.
10	For arriving aircraft it would be best to be looking out the windows for departing the TIDS is probably better.
11	Data blocks as usual were the most beneficial.

12	I would have to say it would be out the window. (But I am I am old school.) The TIDS is really a step up from the ASDE-X, really like the information displayed.
13	TIDS
14	The TIDS since it is a representation of the outside window view.

75. What information could be provided on the displays to improve detection of flight test scenarios (aircraft tracking, flyby, flight plan change, incorrect beacon code, taxi route deviation)?

Controller #	Response
1	Not much
2	None
3	Greater ease in scanning the camera left and right to view several intersections and aircraft airborne points.
4	Maybe a change of color when they change from arrival to touchdown or from rolling to airborne
5	Have a fixed camera set on the arrivals and departures depending on what flow the airport is in. The tower has to ensure that the aircraft “auto acquires” prior to switching an aircraft to departure. The TIDS display would change color of the aircraft climbing out that became airborne, but has no indication that the aircraft has acquired on the radar.
6	Scratchpad entries on the TIDS would be helpful in passing short bits of information between users. Examples: No Load, Visual Separation, Spot Assignment, etc. A key piece of information that is not displayed on the TIDS or FDM is departure release (HAT) status.
7	Regarding arrivals on final. I much prefer the display we currently use. It shows a much larger area than the display used for the final on the TIDS. Regarding departures. I didn’t use anything other than looking out the window to verify the status of a departure, which I think is a very important event. When an aircraft gets airborne and before I send them to the departure controller I look at it to make sure everything is ok, gear up and normal flight. I’m not comfortable leaving this step (looking out the window at the departure while I can still talk to it) out.
8	Getting used to the equipment will allow a controller to still have time to look out the windows better.
9	Can’t think of anything to add.
10	Departures: Different departure SIDS could be different colors as well as different colors for arrivals on different runways.
11	Maybe arrivals to different runways could be in different colors. Also different departure routes might be two colors.

11. What display component provided the most useful information for helping to recognize the flight test scenarios (aircraft tracking, flyby, flight plan change, incorrect beacon code, taxi route deviation)? Why?

Controller #	Response
1	TIDS, it was easy to tell when the aircraft was airborne
2	The scanning camera, mostly because of the high resolution.
3	The TIDS as wells the FDM provided useful information. I liked the way the FDM highlighted things that were happening at different airports like EDCT's or MIT separation.
4	The camera because you were able to zoom right in on the aircraft
5	TIDS
6	In this instance, the tracking camera provided me with the most information. Looking out the window, I did not see N83 in the location I expected short final. Shifting my view to the camera, I noticed he was too high for the approach, and that his gear was down. I didn't notice this until he was over the threshold though. There would not have been enough contrast out the window to see the gear wasn't down. TIDS would have indicated the aircraft was airborne over the runway, but I was aware of the situation prior to expecting to see a white/cyan target. Again, in VFR conditions the camera and windows are the best tools.
7	The camera is a very helpful tool in this situation, but the definition was poor. A better high definition camera, that is easier to manipulate (faster), would enhance this situation.
8	I find the TIDS good for organizing traffic on the ground. I don't find it useful for airborne traffic. I can get more information by observing the aircraft out the window in an airborne situation. I can tell if an aircraft is going to go around or is having airborne issues looking out the window better.
9	Looking out the window would have been the best in this particular situation.
10	Not much use unless having to call traffic that may be a factor.
11	FDM color coding, TIDS fix info.
12	Did not see the flyby

O.3 Displays Information

12. What information could be provided on the TIDS or FDM to improve the ability to recognize the flight test scenarios (aircraft tracking, flyby, flight plan change, incorrect beacon code, taxi route deviation)?

Controller #	Response
1	None
2	Undecided.
3	Maybe have the distressed aircraft a red color or something.
4	Within the FDM< When we kept an “off-hat” aircraft I would highlight the route in red text and in Yellow for the background. I would also like TIDS to indicate the new routing (i.e., AUP) in the data block. This was for King Air N83 changing flight plans today.
5	Perhaps for an aircraft that is MUCH higher on approach that is expect on glideslope, the altitude could change color or draw some extra attention. Waiting to see that an aircraft turns from Cyan to White at the touchdown zone is not effective unless we are IFR.
6	When an aircraft is expected to be on the ground or in a descending attitude, it would be nice to have a flashing of the call sign or an aural alarm to attract the attention of the controller. The delay in the changing of color on the TIDS for departing/arriving ac needs to be improved to allow more effective use of the runways.
7	I don’t know that it’s possible to communicate things like that slight nose up attitude at the begging of a go around through a computer. There have been times when a go around has taken place and for whatever reason I saw it out the window before the pilot had a chance to tell me he was going around. Being about to see what is going on outside is very valuable.
8	I don’t know what could be put on those to alert a controller to this situation until the pilot actually states he is missed approach.
9	None that I can think of.
10	Blinking information that will draw attention that a change has been made to flight plan, new restrictions and fix blinking capability on the TIDS.

O.4 Displays Usefulness

6. What display features provided the most useful information for monitoring arriving and departing aircraft? Why?

Controller #	Response
1	I liked the TIDS and the FDM the most. I think they both provided a good bit of info on this.
2	TIDS, I was looking at this piece of equipment the most.
3	TIDS, because its presentation most closely aligns with the ASDE-X monitor which I'm familiar with using.
4	The TIDS was the best or most useful for gathering information for monitoring.
5	the tracking feature
6	I preferred to use the TIDS for scanning my arrivals on final. I couldn't see aircraft really well that were on a base leg to final duet the setup. I didn't trust the TIDS for crossing aircraft at multiple intersections once the aircraft was airborne and turned cyan in color. Some planes climb really slow or tend to hold a very low altitude over the runway, which would normally force me to wait another few seconds to cross the aircraft that were still within the intersection of the departing aircraft.
7	Inbound information was great from TIDS; however, it is not very intuitive to watch for a change in color to tell whether the aircraft is airborne or on the ground in VFR conditions. Out the window, and with improved camera technology, would be the best way to determine airborne status in VFR conditions.
8	The TIDS gave the best info for quickly finding the aircraft and tracking said ac on the ground. The displays are sharp and clean and easily maneuvered to each individuals liking.
9	As far as activity at the airport, departures and arrivals that occupy a runway, the TIDS is a good piece of equipment. I didn't like using the TIDS to track arrivals that were on final from the threshold out.
10	fir arriving aircraft it would be best to be looking out the windows for departing the TIDS is probably better.
11	Data blocks as usual were the most beneficial.
12	I would have to say it would be out the window. (But I am I am old school.) The TIDS is really a step up from the ASDX (really like the information displayed.
13	TIDS
14	the TIDS since it is a representation of the outside window view

7. What information could be provided on the displays to improve arrival and departure monitoring?

Controller #	Response
1	not much
2	none
3	Greater ease in scanning the camera left and right to view several intersections and aircraft airborne points.
4	maybe a change of color when they change from arrival to touchdown or from rolling to airborne
5	Have a fixed camera set on the arrivals and departures depending on what flow the airport is in. The tower has to ensure that the aircraft "auto acquires" prior to switching an aircraft to departure. The TIDS display would change color of the aircraft climbing out that became airborne, but has no indication that the aircraft has acquired on the radar.
6	Scratchpad entries on the TIDS would be helpful in passing short bits of information between users. Examples: No Load, Visual Separation, Spot Assignment, etc. A key piece of information that is not displayed on the TIDS or FDM is departure release (HAT) status.
7	Regarding arrivals on final. I much prefer the display we currently use. It shows a much larger area than the display used for the final on the TIDS. Regarding departures. I didn't use anything other than looking out the window to verify the status of a departure which I think is a very important event. When an aircraft gets airborne and before I send them to the departure controller I look at it to make sure everything is ok, gear up and normal flight. I'm not comfortable leaving this step (looking out the window at the departure while I can still talk to it) out.
8	Getting used to the equipment will allow a controller to still have time to look out the windows better.
9	Can't think of anything to add.
10	Departures: Different departure SIDS could be different colors as well as different colors for arrivals on different runways.
11	Maybe arrivals to different runways could be in different colors. Also different departure routes might be two colors.

11. What display component provided the most useful information for helping to recognize the flyby? Why?

Controller #	Response
1	TIDS, it was easy to tell when the aircraft was airborne
2	The scanning camera, mostly because of the high resolution.
3	The TIDS as wells the FDM provided useful information. I liked the way the FDM highlighted things that were happening at different airports like EDCT's or MIT separation.
4	The camera because you were able to zoom right in on the aircraft
5	TIDS
6	In this instance, the tracking camera provided me with the most information. Looking out the window, I did not see N83 in the location I expected short final. Shifting my view to the camera, I noticed he was too high for the approach, and that his gear was down. I didn't notice this until he was over the threshold though. There would not have been enough contrast out the window to see the gear wasn't down. TIDS would have indicated the aircraft was airborne over the runway, but I was aware of the situation prior to expecting to see a white/cyan target. Again, in VFR conditions the camera and windows are the best tools.
7	The camera is a very helpful tool in this situation, but the definition was poor. A better high definition camera, that is easier to manipulate (faster), would enhance this situation.
8	I find the TIDS good for organizing traffic on the ground. I don't find it useful for airborne traffic. I can get more information by observing the aircraft out the window in an airborne situation. I can tell if an aircraft is going to go around or is having airborne issues looking out the window better.
9	Looking out the window would have been the best in this particular situation.
10	Not much use unless having to call traffic that may be a factor.
11	FDM color coding, TIDS fix info

12. What information could be provided on the TIDS or FDM to improve the ability to recognize the flyby?

Controller #	Response
1	none
2	Undecided.
3	maybe have the distressed aircraft a red color or something
4	Within the FDM< When we kept an "off-hat" aircraft I would highlight the route in red text and in Yellow for the background. I would also like TIDS to indicate

Controller #	Response
	the new routing (i.e., AUP) in the data block. This was for KingAir N83 changing flight plans today.
5	Perhaps for a aircraft that is MUCH higher on approach that is expect on glideslope, the altitude could change color or draw some extra attention. Waiting to see that a aircraft turns from Cyan to White at the touchdown zone is not effective unless we are IFR.
6	When an aircraft is expected to be on the ground or in a descending attitude, it would be nice to have a flashing of the call sign or an aural alarm to attract the attention of the controller. The delay in the changing of color on the TIDS for departing/arriving ac needs to be improved to allow more effective use of the runways.
7	I don't know that it's possible to communicate things like that slight nose up attitude at the begging of a go around through a computer. There have been times when a go around has taken place and for whatever reason I saw it out the window before the pilot had a chance to tell me he was going around. Being about to see what is going on outside is very valuable.
8	I don't know what could be put on those to alert a controller to this situation until the pilot actually states he is missed approach.
9	None that I can think of.
10	Blinking information that will draw attention that a change has been made to flight plan, new restrictions and fix blinking capability on the TIDS

17. What display component provided the **most** useful information for helping to recognize the flight plan change? Why?

Controller #	Response
1	The FDM provided the best info. Everything was readily available. Once you become better adept at the system, I think it will be a breeze.
2	TIDS, I was using it the most.
3	The FDM because of the detailed flight plan information.
4	The FDM was great in recognizing that flight plans had changed.
5	The color of the strip markings the color of the box
6	TIDS......I noticed the data block changed on N83. I think that if it changes that it should turn to a different color until acknowledged to draw more attention since it is a small detail to notice.
7	The only way I noticed an issue with N83, was the fact that I saw him squawking 1234 between EK and EL, and then tagging as N83 south of taxiway EL. I didn't have a flight plan in FDM for this aircraft until it was at taxiway L & EM and it was for a N083 going to ORD versus DAL. This

Controller #	Response
	information didn't match any of the conversation on LE frequency.
8	The colors enhancement feature on the FDM was the most useful for me. It drew my attention and was easily determined that the info needed to be looked at.
9	It was an odd aircraft to be operating out of DFW so looked at it closely.
10	FDM ......spelled it out.
11	FDM. I noticed the Keene was highlighted in blue. Then went to expanded flight strip to review.
12	When a change has been made it seems that everyone would be able to recognize it with more familiarization, i.e., look for blue
13	The FDM showed the wrong fix in blue this was very helpful in noticing the change.

18. What display component provided the **least** useful information for helping to recognize the flight plan change? Why?

Controller #	Response
1	The TIDS. I just didn't use it as much for this purpose.
2	FDM, did not use it
3	The scanning camera, because an airplane looks like an airplane regardless of where it's going.
4	The display on the side
5	Kind of weird, but the TIDS again my fall into this category because if you aren't scanning the data blocks, you wouldn't notice. Once an aircraft has been given taxi instructions, strips marked and the aircraft has no more turns to make.......I pass the strip to Local.....if it changes after I have completed all my tasks I would more than likely not catch the changes.
6	FDM. Never did I have strip on N83 going DFW-DAL. This information never popped up when issued a VFR clearance by CDE. I only had a strip on N083 which was a invalid clearance to ORD. Additionally, on taxi out N83 showed DFW as the destination, and changed to 31R when it started to depart 35L at A.
7	The full flight plan view.
8	Cameras.
9	Cam. Shows no flight information.
10	TIDS and FDM provided the information consistently when the change was made. FDM more so than TIDS.
11	The cams.

19. What information could be provided on the displays to improve the ability to recognize the flight plan change?

Controller #	Response
1	The ability to change colors on certain blocks and being able to highlight those.
2	Make it easier to highlight fields in red, and to have EDCTs and off hat gates already in red.
3	Perhaps some highlighting device which displays a disparity between HAT status and flight plan route.
4	Flashing bar on the side.
5	Flashing changes or highlighted different.
6	In this case, we were dealing with a N83 and N083, which I cannot expect automation to catch. There could have really been those two call signs. Again, as Local Control in this instance, I am relying on Flight Data and Ground Control to rectify flight plan issues prior to passing an aircraft/strip to Local control. I never did get correct flight plan data on N83.
7	Components on the FDM to alert the controllers that flight plans were about to time out. Maybe a toggle that would allow a certain time frame for notification (15-30 min. before timing out).
8	As soon as an aircraft is taxied to a runway that traditionally does not depart it should give an alert.
9	Maybe red instead of blue for something that needs to be acknowledged.
10	Flashing if Sid does not match predetermined runway configurations.
11	Blinking or even a time-share with the original and the change.
12	Maybe a flashing fix that would be setup for the flow the airport is in. If it is different from a pre determined runway configuration it would flash until an acknowledge is hit.

23. What display component provided the **most** useful information for helping to recognize the taxi route deviation? Why?

Controller #	Response
1	TIDS, used it the most
2	The scanning camera, because it provided more real-time information about aircraft movement on the taxiways.
3	The color change.
4	TIDS, I was scanning the airfield when I notice N83 turned one intersection too early than the assigned intersection.
5	As local control, I wouldn't have been aware of his taxi deviation.
6	I noticed the ac ask for taxi to the SW hold pad and I assumed they were mistaken since we were in a north flow and the proper place would have been the ne or nw pad for that type of request. I saw on the TIDS the aircraft actually using the nw pad.
7	TIDS was where I noticed it first. Then I looked out the window to verify.
8	N/a
9	TIDS since you could see where he is going.
10	To recognize the situation none of the displays, camera or window would have helped if the controller did not recognize the a/c taxing on the wrong route. Plenty of resources available.
11	The TIDS since I could see that he was turning a different way than I thought he should be going.

24. What information could be provided on the displays to improve the ability to recognize the taxi route deviation?

Controller #	Response
1	None
2	A visual cue--such as flashing data blocks when the aircraft is not on the FDM-indicated taxiway.
3	Flashing lights on the side bar.
4	I'm really not sure.
5	N/a
6	? No idea other than mentioned above.
7	See above.
8	Blinking taxi route on the FDM and blinking call sign on the TIDS.
9	Not sure.

28. What display component provided the **most** useful information for helping to recognize the incorrect beacon code? Why?

Controller #	Response
1	TIDS, it made the aircraft caterpillar.
2	The TIDS because of disparities between the beacon code and the data block assigned to the traffic.
3	TIDS was the only resource I had to identify this situation. Even though I was working local control, during my scan I noticed someone squeaking 1234 on taxiway Kilo. This caused me to look out the window and notice a King Air and keep some attention to the aircraft. I initiated camera tracking.
4	The FDM gave the most obvious display since the flight showed one thing and the TIDS was indicating something else.
5	TIDS. The display clearly showed the aircraft was not on the correct code, which is good. Better catch it on the ground than have to scramble in the air.
6	TIDS was an obvious choice since the problem was right in front of you.
7	TIDS since I could see a no tag.
8	TIDS.
9	TIDS since I could see there was no data tag with the aircraft.

29. What information could be provided on the displays to improve the ability to recognize the incorrect beacon code?

Controller #	Response
1	Have the target flash at the operator.
2	Undecided.
3	Similar to ASDE-X, when an aircraft is squawking the same code as another aircraft, I will get a DUP ID msg above the aircraft. Also, in this case, 1234 was showing to indicate he was squawking 1234. This might change to a bigger font to draw attention to the matter.
4	Maybe a flashing beacon code if it does not match with a filed fp.
5	On FDM maybe a flashing beacon code.
6	A flashing beacon code.

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GLOSSARY

ACID	Aircraft ID
ADS-B	Automatic Dependent Surveillance—Broadcast
AGL	Above Ground Level
ASDE-X	Airport Surface Detection Equipment, Model X
ASDI	Aircraft Situation Display to Industry
ASR	Airport Surveillance Radar
ASTERIX	All Purpose Structured Eurocontrol Surveillance Information Exchange
ATC	Air Traffic Control
ATCT	Air Traffic Control Tower
ATIS	Automatic Terminal Information Service
BPF	Berkeley Packet Filter
CD	Common Digitizer or Controller Display
CFR	Call for Release
CONOPS	Concept of Operations
CPC	Certificated Professional Controller
D-ATIS	Digital Automatic Terminal Information Service
DBRITE	Digital Bright Radar Indicator Tower Equipment
DFW	Dallas/Fort Worth International Airport
DFW-1	Dallas/Fort Worth Field Demonstration #1
DFW-2	Dallas/Fort Worth Field Demonstration #2
DST	Decision Support Tool
EDCT	Estimated Departure Clearance Time
ERAM	En Route Automation Modernization
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FAA	Federal Aviation Administration
FCA	Flow Control Area
FD	Flight Director
FDE	Flight Data Entry
FDIO	Flight Data Input/Output

FDM	Flight Data Manager
FLM	Front Line Manage
FTI	FAA Telecommunications Infrastructure
FPS	Fixed Position System
GC	Ground Control
HITL	Human-in-the-Loop
IDS	Integrated Display System
IFR	Instrument Flight Rules
ITWS	Integrated Tower Weather System
LAHSO	Land and Hold Short Operations
LC	Local Control
LLWAS	Low Level Windshear Alert System
MINIT	Minutes-In-Trail
MIT	Miles-In-Trail
MLAT	Multilateration
NAS	National Airspace System
NATCA	National Air Traffic Controllers Association
OTW	Out-the-Window
PDT	Predicted Departure Time
PiP	Picture in Picture
PTFZ	Pan, Tilt, Focus, Zoom
RACD	Remote Control ARTS Display
RAPT	Route Analysis and Planning Tool
RID	Runway Identifier
RVR	Runway Visual Range
RWSL	Runway Status Lights
SDSS	Surface Decision Support System
SMR	Surface Movement Radar
SNT	Staffed NextGen Tower
SWAP	Severe Weather Avoidance Plan
TDAC	TFDM Direct ASDE-X Connect
TDWR	Terminal Doppler Weather Radar
TFDM	Tower Flight Data Manager

TFMS	Tower Flight Management System
TIB	TFDM Information Bus
TIDS	Tower Information Display System
TMC	Traffic Management Coordinator
TOO	Targets of Opportunity
TRACON	Terminal Radar Approach Control
VFR	Visual Flight Rules
ViPS	Visual Processing Subsystem

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