Project Report
ATC-389

U.S. Department of Transportation Federal Aviation Administration Field Demonstration #2: Final Report for Staffed NextGen Tower (SNT)

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1 March 2012

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Prepared for the Federal Aviation Administration,
Washington, D.C. 20591

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Springfield, Virginia 22161

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
ATC-389		

4. Title and Subtitle	5. Report Date
U.S. Department of Transportation Federal Aviation Administration Field Demonstration #2: Final Report for Staffed NextGen Tower (SNT)	1 March 2012
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
M.P. Kuffner, S.K. Yenson, Group 42; D.K. Johnson, Group 43	ATC-389
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
MIT Lincoln Laboratory 244 Wood Street Lexington, MA 02420-9108	11. Contract or Grant No. FA8721-05-C-0002
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Department of Transportation Federal Aviation Administration 800 Independence Ave., S.W. Washington, DC 20591	Project Report
	14. Sponsoring Agency Code

15. Supplementary Notes

This report is based on studies performed at Lincoln Laboratory, a federally funded research and development center operated by Massachusetts Institute of Technology, under Air Force Contract FA8721-05-C-0002.

16. Abstract

Staffed NextGen Towers (SNT), a research concept being developed and validated by the Federal Aviation Administration (FAA), is a paradigm shift to providing air traffic control services primarily via surface surveillance approved for operational use by controllers instead of the existing out-the-window (OTW) view at high-density airports. SNT was exercised as a prototype installed at the Dallas–Fort Worth International Airport (DFW) during a two-week demonstration in the spring of 2011. MIT Lincoln Laboratory conducted this demonstration for the FAA in coordination with DFW air traffic control (ATC) and the DFW airport authority. This proof-of-concept demonstration used live traffic and was conducted 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 SNT field demonstration was to validate the supplemental SNT concept, to assess the operational suitability of the Tower Information Display System (TIDS) display for surface surveillance, and to evaluate the first iteration of prototype cameras in providing visual augmentation. TIDS provided surface surveillance information using an updated user interface that was integrated with electronic flight data. The cameras provided both fixed and scanning views of traffic to augment the OTW view. These objectives were met during the two-week field demonstration.

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 "worked" the traffic according to their own techniques, using new hardware and software that included high resolution displays of surveillance data augmented by camera views. This equipment was designed to provide enhanced situational awareness to allow controllers to manage increased traffic volume during poor visibility conditions, leading to increased throughput. Results indicated that the likelihood of user acceptance and operational suitability is high for TIDS as a primary means for control, given surface surveillance that is approved for operational use. Human factors data indicated that TIDS could be beneficial. However, major technical issues included two display freezes, some incorrectly depicted targets, and display inconsistencies on TIDS. The cameras experienced numerous technical limitations that negatively influenced the human factors assessment of them. This report includes the percentages of human factors and technical success criteria that passed at DFW-2.

17. Key Words	18. Distribution Statement
	This document is available to the public through the National Technical Information Service, Springfield, VA 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	268	

FORM DOT F 1700.7 (8-72) Reproduction of completed page authorized

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ACKNOWLEDGMENTS

The authors of this field demonstration final report gratefully acknowledge the excellent sponsorship provided by Michele Triantos, FAA Program Manager of SNT, the outstanding expert advice provided by all the subject matter experts, including members of our User Group, the superior management, air traffic controllers, and staff at DFW, and the highly capable FAA flight inspection pilots. We very much appreciate all the hard working members of the SNT project team, including manager Gregg Shoults, technical lead Steve Campbell, and developers and analysts Ed Campbell, Chris Edwards, James Keefe, Mark Kozar, Ted Londner, Mark McDonough, Sam Provencher, Kevin Roll, and Bruce Taylor, with special thanks to human factors expert for TFDM, Hayley Reynolds.

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1. EXECUTIVE SUMMARY

Staffed NextGen Towers (SNT), a research concept being developed and validated by the Federal Aviation Administration (FAA), is a paradigm shift to providing air traffic control services primarily via surface surveillance approved for operational use by controllers instead of the existing out-the-window (OTW) view at high-density airports. SNT was exercised as a prototype installed at the Dallas–Fort Worth International Airport (DFW) during a two-week demonstration in the spring of 2011. MIT Lincoln Laboratory conducted this demonstration for the FAA in coordination with DFW air traffic control (ATC) and the DFW airport authority.

This proof-of-concept demonstration used live traffic and was conducted 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 SNT field demonstration was to validate the supplemental SNT concept, to assess the operational suitability of the Tower Information Display System (TIDS) display for surface surveillance, and to evaluate the first iteration of prototype cameras in providing visual augmentation. TIDS provided surface surveillance information using an updated user interface that was integrated with electronic flight data. The cameras provided both fixed and scanning views of traffic to augment the OTW view. These objectives were met during the two-week field demonstration.

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Results indicated that the likelihood of user acceptance and operational suitability is high for TIDS as a primary means for control, given surface surveillance that is approved for operational use. Human factors data indicated that TIDS could be beneficial. However, major technical issues included two display freezes, some incorrectly depicted targets, and display inconsistencies on TIDS. The cameras experienced numerous technical limitations that negatively influenced the human factors assessment of them. The following table shows the percentages of human factors and technical success criteria that *passed* at DFW-2.

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

	Human Factors	Technical
TIDS	72% (39/54 average responses)	68% (41/60 criteria met)
Cameras	6% (6/99 average responses)	30% (13/41 criteria met)

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2. OVERVIEW

2.1 PURPOSE

This document provides an evaluation of the second field demonstration for the Staffed NextGen Tower (SNT) program. The purpose of this field demonstration, known as DFW-2, was to collect human factors and technical performance data for engineering prototypes for SNT and the Tower Information Display System (TIDS). TIDS provides an electronic presentation of surveillance information on a 30" display, and the SNT prototype provides visual information presented by two long-range cameras in a picture-in-picture (PiP) window on the TIDS, as well as on an external display monitor. A panoramic view of the airport, provided by an array of fixed-range camera images stitched together, was also presented on the external display. These images were intended to augment the controllers' out-the-window (OTW) view of traffic.

Electronic flight data was displayed on a prototype Flight Data Manager (FDM) display as part of the Tower Flight Data Manger (TFDM) program that was tested simultaneously with SNT; these results are reported separately in the *Field Demonstration #2 Final Report for Tower Flight Data Manager (TFDM).* TFDM also included a set of decision support tools (DSTs) that provided decision-making guidance to controllers. A limited set of DSTs provided information, such as runway assignment, on the TIDS.

DFW-2 was conducted from 26 through 28 April and 2 through 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.

2.2 BACKGROUND

The TIDS is a component of the Tower Flight Data Manager (TFDM), which is an integrated display suite designed to provide surveillance and flight information data to controllers. It assists controllers and supervisors in making informed decisions by providing surface surveillance information and decision support tools as part of the display suite. TFDM is a potential enabler of the SNT concept.

The SNT program leverages the TFDM prototype by supplementing existing air traffic control towers with operationally approved surface surveillance displays and optional cameras and displays. The concept also may be extended to controlling traffic from remotely located facilities on a contingency basis. The demonstration of SNT in DFW-2 focused on integrating SNT capabilities into existing control towers to supplement the current equipment and OTW view, though controllers were asked their opinions on both supplemental and contingency operations.

An external camera display and a PiP camera window inset into the TIDS were provided as part of the prototype SNT display. A fixed-range camera array provided a stitched panoramic image of the airfield, and two long-range cameras allowed users to focus on selected targets.

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 consisted of a non-touchscreen FDM. A test team member who was not an air traffic controller but was cognizant of procedures at DFW staffed this support position.

2.3 OBJECTIVES

The goal of this evaluation was to provide proof of concept for the supplemental SNT concept, using TIDS augmented with the first iteration of prototype cameras, by means of shadow operations evaluations with live traffic. During shadow operations, controllers verbalize but do not transmit clearances and commands to real-time targets of opportunity (TOO), and 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]*).

SNT Objectives

1. Collect user feedback on feasibility, usability, and usefulness of the supplemental SNT concept.
2. Demonstrate initial camera capabilities, including display, tracking, control, and data processing, for scanning and fixed cameras.
3. 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.
4. Reaffirm the operational suitability of the controller surface surveillance display known as the TIDS.

TIDS TFDM Objectives

1. Demonstrate the ability to provide accurate real-time situational awareness information, including integrated surveillance, weather, and electronic flight data information.
2. Evaluate presentation and user interface on TIDS.

2.4 METHOD

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 B.

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.

Participants listened to East side radio communications and were asked to respond as if they were controlling traffic, using TIDS and the camera displays 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.

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.

After participating in the shadow operations, the controllers were asked to rate their level of agreement to a number of statements pertaining to the SNT TIDS and camera displays. They provided feedback by using iPads to input their responses to online surveys that included questions about the TIDS, supplemental SNT camera use, flexible/contingency SNT camera use, 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.

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 on TIDS using a five-point Likert scale. Ratings ranged from negative (1) to positive (5). For the camera ratings, participants responded to questions in the context of supplemental SNT and (separately) in the context of flexible/contingency SNT. Some of the camera questions used a seven-point Likert scale with 7 being most positive[1]. 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 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[2].

At the close of each evaluation day, participant controllers 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 the comments are provided in Section 4.3, Section 5.3, and Appendix F.

2.5 MATERIALS

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 2-1). 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

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[1] This was done to be consistent with the same questions asked during related simulations so that future analysis can be conducted.

[2] 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)

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. For further details on the TFDM FDM and Supervisor displays, see the TFDM DFW-2 Final Report.

An external camera display and a PiP camera window inset into the TIDS were provided as part of the prototype SNT display. A fixed-range camera array provided a stitched panoramic image of the airfield as well as a view focused on the active runway threshold, and two long-range cameras allowed each user to focus on selected targets.

Figure 2-1: DFW-2 controller workstation

2.6 REPORT ORGANIZATION

This report discusses the results of the DFW-2 field demonstration for SNT. Controller demographics are summarized in Section 3. Sections 1 and 5 discuss the technical and human factors performance of the TIDS and cameras, respectively. A summary of controllers' comments and suggestions for future improvements regarding the TIDS and cameras is also provided in these sections.

Section 6 provides important feedback on the SNT concept, which was the goal of this demonstration. Section 7 discusses the scenarios and awareness probes as they pertain to the TIDS and the camera displays.

A summary of DFW-2 results is provided in Section 8, and the collected data, questionnaires, and detailed results are provided in the appendices.

3. CONTROLLER DEMOGRAPHICS

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

Table 3-1 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 3-1: 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 3-2 summarizes the participants' previous experience with demonstration or simulation activities related to SNT. Controllers who had not had previous experience with SNT were given additional time to familiarize themselves with the displays and were also given reminders and pointers during the evaluation as needed.

Table 3-2: Participation in SNT 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

The typical daily schedule for the test participants is provided in Table 3-3.

Table 3-3: Typical controller schedule

Time	Activity
7:00	Training
7:15	
7:30	Familiarization
7:45	
8:00	Shadow ops (long-range camera)
8:15	
8:30	
8:45	
9:00	Shadow ops (long-range camera)
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 (long-range camera)
12:15	
12:30	
12:45	Shadow ops (all cameras)
13:00	
13:15	
13:30	Questionnaires
13:45	
14:00	
14:15	Discussion
14:30	
14:45	

4. 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, and 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.

4.1 TIDS TECHNICAL RESULTS

The TIDS performed adequately against its technical success criteria. Sixty-eight 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, 15% of the criteria were not tested. The remaining 17% 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 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”).

Table 4-1 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 4-1: 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 observed for each target. • Content of each data block matches the information received from ASDE-X, FDIO, and TFDM for each target.	• All icons on TIDS have a data block that can be selected for display.
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.	

Category	Passed	Did Not Pass
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 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.	• ASDE-X detects 1 or fewer false tracks per 2400h of collected data.
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	• No discrepancies are found between recorded ASDE-X data and the ASDE-X data stored on the TIB. • ASTERIX Cat 10 and 11 data

Category	Passed	Did Not Pass
	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.	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)

4.1.1 Surveillance Object

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)

4.1.2 Data Blocks

4.1.2.1 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)

4.1.2.2 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)

4.1.3 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)

4.1.4 User Interaction

4.1.4.1 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)

4.1.5 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 through the Terminal Doppler Weather Radar (TDWR). 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)

4.1.6 Airport Configuration and Runway/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 and 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)

4.1.7 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)

4.1.8 Wake Turbulence Timers and Surface Monitor

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)

4.1.9 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)

4.1.10 Surveillance Processor

4.1.10.1 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)

4.1.10.2 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 B. For detailed results, see the *DFW-1 Field Demonstration Final Report for Tower Flight Data Manager (TFDM) and Staffed NextGen Tower (SNT).* [3]

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[3] *U.S. Department of Transportation Federal Aviation Administration, Field Demonstration #1 Final Report for Tower Flight Data Manager (TFDM) and Staffed NextGen Tower (SNT), Rev. 1,* MIT Lincoln Laboratory, Lexington, MA, 15 November 2010.

4.1.11 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.

4.1.12 ASDE-X

4.1.12.1 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)

4.1.12.2 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 B.

4.1.13 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 not available for DFW-2 and were not shown on the TIDS PiP window that replicates data from the ribbon display. (Success criteria 4.4.1, 4.4.2, 4.4.3)

Aside from the ITWS outage on 27 April (described in Section 4.1.5**),** 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.

4.1.14 TIDS Performance Issues

4.1.14.1 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 SurfaceMonitor 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.

4.1.14.2 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.

4.1.14.3 Data Tags

<u>Lost Data Tags</u>

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.

<u>Multiple Data Tags</u>

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.

4.1.14.4 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 during this outage, but it came back after a short time. It could have been caused by events including preventive maintenance, software upgrade, or hardware issues. This failure 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.

4.1.14.5 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.

4.1.14.6 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 were 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 one. 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 nonreliable 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.

4.2 TIDS HUMAN FACTORS RESULTS: RATINGS

Overall, 72% of the TIDS human factors success criteria passed according to the criteria determined a priori and documented in the DFW-2 Test Plan. 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 and they expressed appreciation for the tools and features provided on the TIDS. However, some controllers found it difficult to set up some features or questioned their usefulness. Some were distracted by display anomalies including 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.

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 4-2 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 J.1. For a TIDS Chi Square results summary, see Appendix K.1.

4.2.1 DFW-2 Human Factors Survey Results for TIDS

Table 4-2 presents the TIDS items 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 Table J-1.

Table 4-2: 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 • 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	• It was easy to create and access TIDS user preference sets
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	

Category	Passed	Did Not Pass
	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
Display Usefulness	• Easy to detect aircraft using the TIDS • TIDS helped maintain 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	• TIDS was effective in helping control traffic in the air • TIDS was effective in helping maintain separation

Category	Passed	Did Not Pass
	• Easy to find necessary flight information using the TIDS • TIDS display was effective in helping controllers sequence aircraft	

4.3 CONTROLLER COMMENTS AND REQUESTED MODIFICATIONS FOR TIDS

4.3.1 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 4-3: 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 4-4: 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 4-5: 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 4-6: 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 4-7: Controller comments on TIDS usefulness[4]

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

4.3.2 Requested Modifications for TIDS

Table 4-8 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. Responses from the questionnaires are provided in Appendix D, and the discussion results are contained in Appendix G.

[4] For the comments regarding display and keyboard suggestions, note that the placement of these items was limited due to constraints of working within the existing tower and therefore the ergonomics were not optimal.

Table 4-8: 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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5. CAMERA PERFORMANCE ANALYSIS

The supplemental SNT concept, where cameras are used to augment information provided to controllers through the OTW view and the TFDM displays, was tested at DFW-2. Test controllers interacted with long-range cameras provided by Cohu Electronics; this image was displayed on a dedicated external camera display and could optionally be shown on a PiP window on the TIDS. In the afternoon sessions, controllers were also provided with a stitched panoramic image created from an array of fixed-range cameras. This image was shown on the external display as a split-screen image with the long-range camera image.

Figure 5-1: Panoramic (top), fixed threshold (bottom left), long-range (bottom right)

5.1 CAMERA TECHNICAL RESULTS

Camera technical performance was problematic. Only 30% of the camera success criteria passed, 54% did not pass, and 16% of the criteria were unable to be evaluated, mainly due to a lack of sufficient logging capabilities. Most problems experienced with the camera technical performance revolved around lack of camera control, a somewhat unresponsive interface, and poor resolution, resulting in an inability to adequately track and distinguish targets in the control area, especially during windy conditions.

Controllers did see the potential for the use of cameras in supplemental tower operations, though, provided that the problems experienced are resolved prior to operational camera usage. The participants provided a number of suggestions for improving camera performance and use, and were cautiously interested in further exploration in this area.

Table 5-1 summarizes the camera technical success criteria that passed or did not pass during DFW-2. For a criterion to have passed, no contrary indications were observed during DFW-2 and/or during post hoc analysis. If any contrary indications were seen or uncovered during analysis, the criterion did not pass.

Table 5-1: Camera technical success criteria results

Category	Passed	Did Not Pass
PiP Display	• Long-range camera image is shown on TIDS camera PiP.	
Long-range Camera Capabilities	• The tracked target is displayed in the TIDS camera window until the user deselects it. • The tracked target is displayed in the external camera display until the user deselects it.	• Aircraft can be selected and tracked out to 5nm by clicking on target in PiP. • Tracking initiation coincides with time of target selection in PiP. • Aircraft can be selected and tracked out to 5 nm by clicking on target in external display. • Tracking initiation coincides with time of target selection in external display.
Long-range Camera Control Interface		• Users can pan the long-range camera by interacting with the camera PiP. • Users can tilt the long-range camera by interacting with the camera PiP. • Users can zoom the long-range camera by interacting with the camera PiP. • Users can focus the long-range camera by interacting with the camera PiP. • Users can focus the long-range camera by interacting with the camera PiP.

Category	Passed	Did Not Pass
		• Users can slew the long-range camera by interacting with the camera PiP. • Users can pan the long-range camera by interacting with the long-range camera image on the external display. • Users can tilt the long-range camera by interacting with the long-range camera image on the external display. • Users can zoom the long-range camera by interacting with the long-range camera image on the external display. • Users can focus the long-range camera by interacting with the long-range camera image on the external display. • Users can focus the long-range camera by interacting with the long-range camera image on the external display. • Users can slew the long-range camera by interacting with the long-range camera image on the external display.
Usability	• Video, observational data collected and analyzed to determine controller tool usage. • Controller feedback on tool, OTW, display usage collected.	
External Display for Long-range Camera	• Long-range camera image is shown on external camera display.	
Long-range Camera Control		• Long-range camera can be panned, tilted, zoomed, focused, slewed, and image can be tracked. • The time elapsed between ViPS sending a control message to the long-range camera and the

Category	Passed	Did Not Pass
		desired position being achieved is less than 0.5 s.
Long-range Camera Tracking Capabilities	• The long-range camera follows the selected target until the user deselects it. • No discrepancies exist between the tracked image shown on the PiP and the external long-range camera display.	
Long-range Camera Independence		• LC control inputs (PTZ, track, slew) are reflected on LC long-range camera PiP and external displays only. • GC control inputs (PTZ, track, slew) are reflected on GC long-range camera PiP and external displays only.
External Display for Fixed Array Cameras	• Fixed camera array main fused image is shown on the external camera display. • Fixed camera array north threshold is shown on the external camera display. • Fixed camera array south threshold is shown on the external camera display.	
Taxiways	• Targets can be seen using long-range camera image on farthest perimeter taxiways.	• Targets can be seen using fixed-array camera image on farthest perimeter taxiways.
Runways	• Targets can be seen using long-range camera image on all runways.	• Targets can be seen using fixed-array camera image on all runways.
Arrival/ Departure		• Targets can be seen using long-range camera image on approach and departure out to 5 nm.

Some success criteria for camera technical performance were unable to be tested during DFW-2 due to the inability to play back raw recorded camera video for comparison against recorded camera data shown on the camera displays. Images shown on the TIDS camera PiP, the external camera, and images shown on external camera display (both long-range and fixed-array) were unable to be compared against raw recorded camera data. Similarly, since the raw data could not be played back, timestamp data was unavailable and a comparison between raw and recorded data timestamps was unable to be made. (Success criteria 5.1.1.2, 5.1.2.2, 5.1.3.3, 5.1.3.4, 5.1.3.7, 5.1.3.8, 5.2.1.4)

5.1.1 Long-range Cameras

5.1.1.1 Long-range Camera External and PiP Display

The long-range cameras allowed users to select areas of the airfield on which to focus their attention by panning and zooming the camera display to a desired location. The resulting images were displayed on an external monitor, and, if desired, on a PiP window on the TIDS. Users were able to see the long-range camera images on the external display and on the PiP when it was selected for display on the TIDS. This requirement was visually verified during DFW-2. Most controllers indicated that the camera images matched the OTW view, but two controllers commented that the displays did seem to lag the real world events, though observers did not verify these reports during the evaluation. Additionally, the raw data feed from the long-range cameras was unable to be viewed and could not be compared to the recorded video data; thus this criterion failed. (Success criteria 5.1.1.1, 5.1.1.2, 5.1.2.1, 5.1.2.2)

5.1.1.2 Long-range Camera Control and Control Interface

Users were able to interact with the long-range camera by clicking on the camera images to pan, tilt, zoom (PTZ), and slew the camera. Although they had the ability to interact with the camera, controllers had numerous problems with the interactions. The zoom performance was inconsistent and required significant attention to feedback, and at least one controller reported problems with getting the camera to focus on the desired location. The cameras were self-focusing and did not require controller interaction to focus on objects, but the cameras needed a second or so to focus on the desired object. Controllers commented that the zooming and scanning capabilities were “cumbersome” and indicated that they could see the benefits of cameras if the resolution and response times were improved.

The problems that were discovered severely hampered camera performance and acceptance, and these criteria are judged to have failed. (Success criteria 5.1.1.6, 5.1.1.7, 5.1.1.8, 5.1.1.9, 5.1.1.10, 5.1.2.6, 5.1.2.7, 5.1.2.8, 5.1.2.9, 5.1.2.10, 5.1.3.1)

5.1.1.3 Long-range Camera Capabilities

Controllers were also able to track a target with the long-range camera by clicking on its image in either display and could release the tracking by clicking on the target a second time. The tracking capability worked the majority of the time, though some controllers reported specific instances where they were unable to get the camera to track the desired target. Additionally, the tracking performance was not smooth and the image was often not centered in the display. Finally, on 4 May 2011, the south camera stopped tracking. To fix this, the sensor and video nodes were recycled while the controllers were at lunch. The cause of the problem is unknown and the issue was not seen again during the DFW-2 test. Because of these problems, these criteria failed. (Success criteria 5.1.1.5, 5.1.2.5, 5.1.3.5)

If a user selected a target in the long-range camera external or PiP displays, the target was tracked until the user deselected the target, selected another target, or the system was no longer receiving surveillance that allowed the camera to track the target. When supplied with surveillance, targets could be tracked by the camera out to 12 nm; however, the targets were only visually discernable on the camera display out to approximately one to two nm. Camera specifications stated that the long-range camera was supposed to achieve a 35× optical zoom; however, during DFW-2, the best zoom performance was limited to 20× due to a firmware bug. This problem was unable to be fixed for DFW-2, but a firmware update was installed after DFW-2 that improved zoom performance to 30×. These limitations resulted in reduced camera capabilities during DFW-2. (Success criteria 5.1.1.3, 5.1.2.3, 5.1.3.5)

5.1.1.4 Long-range Camera Independence

The local controller and the ground controller each had control of a single camera. The images displayed on the long-range camera external display and the scanning PiP were consistent for each position and no discrepancies between images at a single position were reported by controllers or observers; additionally, the video on both displays was provided by the multicasted video from the video node. Therefore, the requirement for a consistent image between the external display and the PiP was met. Camera control inputs made by the north-most workstation affected only that position’s camera. However, the Supervisor TIDS shared camera control with the local control workstation, which caused some confusion for at least one controller until test staff realized what was occurring. The requirement for independently operating cameras was not met. (Success criteria 5.1.3.6, 5.1.4.1, 5.1.4.2)

5.1.1.5 Long-range Camera Latency

Controllers reported significant difficulties with camera control, stating that the time elapsed between a control input on the camera display and the camera’s reaching the desired position was too long. Multiple clicks on the camera display were sometimes required to initiate target tracking; although the final click may have initiated the tracking, the number of clicks required to capture the target was excessive. Controllers indicated that this would be unacceptable in a real-time air traffic control operation where time may be critical. Controllers also experienced lags on the order of one second when zooming or panning the camera, which was also deemed unacceptable. These lags were determined through observation throughout the evaluation period. Thus, success criteria stating that the time elapsed between a control message being sent and the camera reaching the desired position should be less than 0.5 s, and that tracking initiation coincides with the time of target selection in the external display, both failed. (Success criteria 5.1.1.4, 5.1.2.4, 5.1.3.2)

The latency between the timestamp on the long-range camera image and the successful display of the image on the external or PiP displays appears to be low. During DFW-2, two controllers reported that they found that the long-range camera image lagged reality by approximately three seconds; however, observers did not confirm these reports. Recorded camera data was unable to be played back and therefore was not able to be compared to the recorded video data. (Success criteria 5.1.1.3, 5.1.3.3, 5.1.3.4, 5.1.3.7, 5.1.3.8)

5.1.2 Fixed Camera Array

5.1.2.1 External Display

Four fixed-zoom cameras provided a fused panoramic image of approximately 180 degrees of the east side of DFW as seen from the Center Tower by stitching the individual images into a single picture. When it was available, this image was displayed on the external camera monitor along with the long-range camera data. The fused image was only available to users during the final session of each test day, and provided a stitched panoramic view of the majority of the East side of the airport, as well as a fixed view of the departure thresholds of the main parallels.

5.1.2.2 Fixed Camera Array Latency

Most controllers stated that the fused image provided an accurate depiction of the OTW situation; however, two controllers stated that it looked as if the fused image had lagged reality by approximately three seconds. Again, these comments have not been confirmed. These observations may have been due to the fact that the fused image did not include the departure threshold, so that while observing an aircraft along the full length of the runway, it appeared as if the target were not shown by the fixed camera array. Further investigation is needed to determine if this is the case.

Again, due to an inability to view recorded camera data, the fixed camera data could not be compared to recorded video data and the requirement that the images shown on the fixed image display match those received from the camera was unable to be met. (Success criteria 5.2.1.1, 5.2.1.2, 5.2.1.3, 5.2.1.4)

5.1.3 Camera Coverage

Due to constraints in the selection of installation location for the cameras, the coverage and resolution measures suffered since (although a memorandum of agreement was in progress to locate the cameras closer to the vantage points of interest) the physical mounting of the cameras was on top of the DFW center tower.

Figure 5-2: Aircraft on east side main parallels (long-range camera external display)

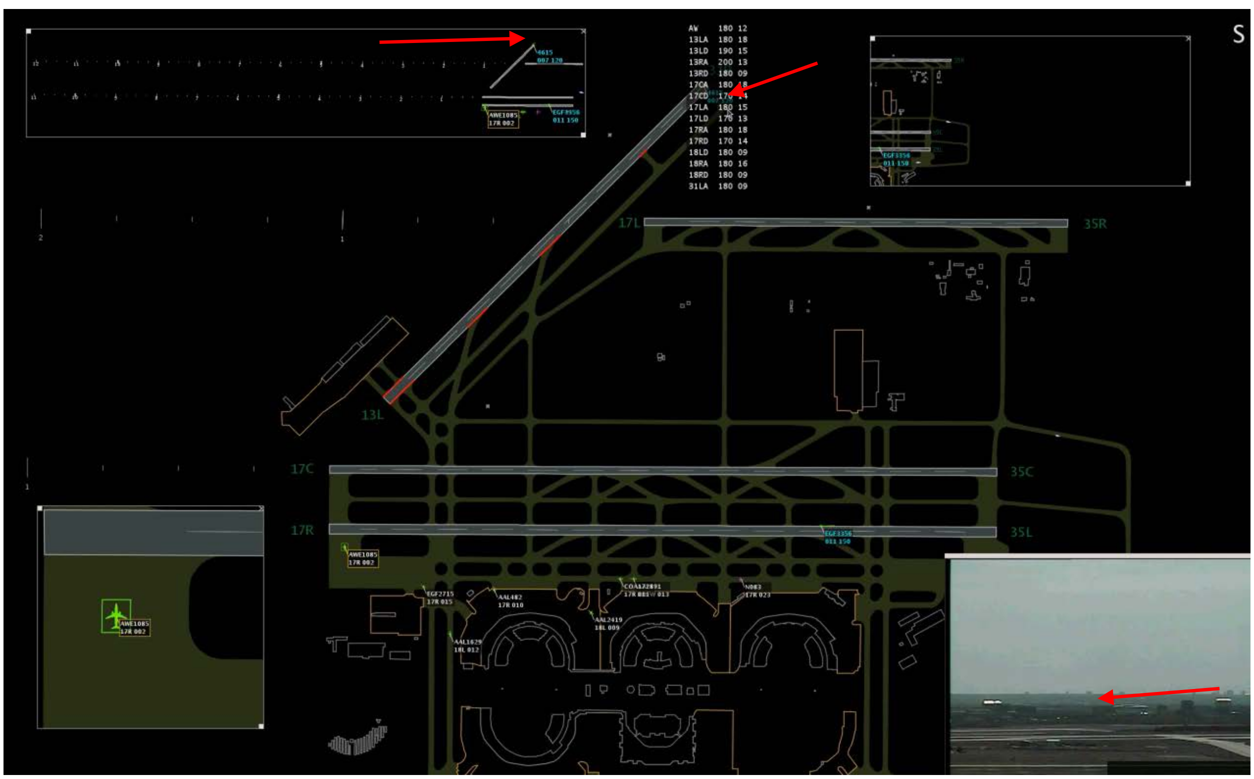

Figure 5-3: Aircraft landing east diagonal (indicated by red arrows on TIDS and PiP)

5.1.3.1 Runways

Targets were easily seen on the main parallel runways on the east side of DFW with the fixed camera, particularly at high zoom levels, as seen in Figure 5-2. Targets were also easily able to be seen on the outboard runways at higher zoom levels, but were not as easily seen at longer ranges, as seen in Figure 5-3. This image uses red arrows, not depicted on the TIDS, to point out the location of an aircraft arriving on the east side diagonal on the TIDS, the arrival corridor PiP, and the camera PiP.

The panoramic display allowed users to see the majority of the main east side parallel runways; however, the threshold ends were not visible in the main image, as seen in Figure 5-1. The threshold for the runway in use was displayed on a separate display, but controllers did not have a view of the opposite threshold as part of the panoramic display. This also meant that the perimeter taxiways north and south of the airport were not visible, so success criterion 5.3.1 did not pass.

Targets were difficult to see on the secondary parallel and diagonal runways due to the size of the display. Figure 5-4 shows a target on the far parallel runway—this target is highlighted here with a red circle to increase its visibility, but this circle is not present on the display. Targets on perimeter taxiways and the secondary runways were visible on the panoramic display, but its small display size made it difficult for users to discern targets on the display. Some controllers indicated that the scanning display would be more usable if its larger display area had the resolution and crispness of the panoramic display. (Success criterion 5.3.3)

Figure 5-4: Aircraft on 17L, fixed camera display. Red circle added to identify aircraft.

5.1.3.2 Arrival and Departure

Since targets were difficult to be seen on the runway thresholds, it was also difficult to see targets on approach and departure, so success criterion 5.3.5 did not pass.

5.1.3.3 Taxiways

Similarly, targets also were readily visible on the innermost taxiways and on outermost taxiways at high zoom levels, but not as easily seen at longer ranges. Controllers were still able to discern the targets, especially in conjunction with the TIDS, but the suboptimal resolution led them to request higher-resolution displays. Controllers also expressed significant difficulty seeing and tracking small targets on the farther runways and taxiways. (Success criterion 5.3.2, 5.3.4)

5.2 CAMERA HUMAN FACTORS RESULTS: RATINGS

5.2.1 Results of Camera for Supplemental SNT Operations Survey

Camera human factors assessment was also problematic. The camera technical problems were reflected in the camera human factors results, where only six percent met the criteria for success. Participants used the Likert scale ratings to respond to questions rating agreement, difficulty, adequacy, and necessity of camera capabilities for supplemental SNT. Table 5-2 presents the camera items that passed or did not pass the success criteria in the context of supplemental SNT operations. Items that passed were rated, on average, as ≥4 on a scale of 1 to 5, or ≥5 on a scale of 1 to 7, with 5 and 7 being best or complete agreement, respectively. For detailed camera Chi Square analyses in the context of supplemental SNT operations, see Appendix J. For a summary of the supplemental SNT camera Chi Square results, see Appendix K.2.

Table 5-2: Camera human factors success criteria results for supplemental SNT

Likert Scale	Passed	Did Not Pass
Camera display usefulness for Supplemental SNT		• External display • Picture-in-picture
Camera image size optimal		• External display
Camera image layout sufficient		• External display
Camera image size optimal		• Picture-in-picture
Camera display useful for ATC		• External display • Picture-in-picture
Camera controls easy to use		• External display • Picture-in-picture
Camera update rate sufficient for ATC		• External display • Picture-in-picture
Camera control rate sufficient for ATC		• External display • Picture-in-picture
Camera PTZ behavior and response sufficient for Supplemental SNT		• External display • Picture-in-picture
Camera coverage area sufficient for ATC		• Long-range camera
Camera image resolution sufficient		• External display • Picture-in-picture
Camera's tracking capability useful		• External display • Picture-in-picture
Camera's tracking capability smooth		• External display • Picture-in-picture
Camera's tracking capability quick		• External display • Picture-in-picture
Camera performance was equivalent to or better than binoculars		• External display • Picture-in-picture
Camera will help controlling traffic		• External display • Picture-in-picture
Camera view will help maintain awareness of aircraft		• External display • Picture-in-picture

Likert Scale	Passed	Did Not Pass
identify		
Camera view will help maintain awareness of traffic location		• External display • Picture-in-picture
Camera view will help maintain efficient operations		• External display • Picture-in-picture
Camera was easy to zoom	• Picture-in-picture	• External display
Camera was easy to pan	• Picture-in-picture	• External display
Camera was easy to tilt		• External display • Picture-in-picture
Determining aircraft location was easy		• External display • Picture-in-picture
Determining aircraft type/ company was easy		• External display • Picture-in-picture
Camera viewing area was easy to select	• Picture-in-picture	• External display
Camera viewing area was easy to resize		• External display • Picture-in-picture
Selecting a target was easy	• External display • Picture-in-picture	
Tracking a target was easy	• External display	• Picture-in-picture
Display presentation was adequate		• External display • Picture-in-picture
Display functionality was adequate		• External display • Picture-in-picture
Text was legible		• External display • Picture-in-picture display
Locating a target was easy		• External display • Picture-in-picture display
Overall tracking functionality was adequate		• External display • Picture-in-picture

Likert Scale	Passed	Did Not Pass
Determining nonconformance was easy		• External display • Picture-in-picture
Assisted in maintaining situational awareness		• External display • Picture-in-picture
Camera view necessary for supplemental SNT operations		• External display • Picture-in-picture

5.2.2 Results of Camera for Contingency/Flexible SNT Operations Survey

Participants used the Likert scale ratings to respond to questions rating agreement, difficulty, adequacy, and necessity of camera capabilities for contingency and flexible SNT. Items that passed were rated, on average, as ≥4 on a scale of 1 to 5, or ≥5 on a scale of 1 to 7, with 5 and 7 being best or complete agreement, respectively. Table 5-3 presents the camera items that passed or did not pass the success criteria in the context of contingency/flexible SNT operations. For detailed Chi Square analyses for contingency and flexible SNT operations, see Appendix J.3. For a contingency/flexible SNT camera Chi Square results summary, see Appendix K.3.

Table 5-3: Camera human factors success criteria results for contingency/flexible SNT

Likert Scale	Passed	Did Not Pass
Camera display usefulness		• External display • Picture-in-picture
Camera display useful for ATC		• External display • Picture-in-picture • Panoramic • Threshold
Camera update rate sufficient for ATC		• External display • Picture-in-picture • Panoramic
Camera control rate sufficient for ATC		• External display • Picture-in-picture
Camera coverage area sufficient for ATC		• External display • Panoramic
Camera image size optimal		• External display
Camera image size sufficient		• External display • Picture-in-picture • Panoramic • Threshold
Camera image resolution sufficient		• External display • Picture-in-picture • Panoramic • Threshold
Camera's tracking capability useful		• External display • Picture-in-picture
Camera performance was equivalent to or better than binoculars		• External display • Picture-in-picture
Camera will help controlling traffic		• External display • Picture-in-picture • Panoramic
Camera view will help maintain awareness of aircraft identity		• External display • Picture-in-picture • Panoramic

Likert Scale	Passed	Did Not Pass
Camera view will help maintain awareness of traffic location		• External display • Picture-in-picture • Panoramic
Camera view necessary for full SNT operations		• External display • Picture-in-picture

5.2.3 DFW-2 Human Factors Survey Discussion for Cameras

DFW-2 was the first occasion where the initial prototype cameras were deployed for use during shadow operations. Both long-range cameras (one for GC and one for LC) and the fixed panoramic view from stationary cameras (the same view was provided to GC and LC) were assessed through controller feedback. Participant controllers and FLMs/TMCs were asked to imagine the utility and assess the operational suitability of using different types of cameras and camera views for both the supplemental SNT concept, where the OTW view is still available, and the flexible/contingency SNT concept, where the OTW view is absent or otherwise degraded. The ratings showed some positive response to the user interface camera use metrics when considered in the context of supplemental SNT.

For supplemental SNT, the user interface functions with respect to working with the cameras that were rated positively, as measured by controller questionnaire responses, included panning the long-range camera image by using the mouse placed inside the PiP on TIDS, zooming inside the PiP by using the middle control scroll wheel, right-clicking to selecting an area to view with the camera PiP, right-clicking the mouse on a target to track it from both the PiP and external display, and determining the location of an aircraft using the both the PiP and external display camera and the ease of tracking a target on the external camera display. The controllers did not indicate that the cameras were necessary for air traffic control for supplemental SNT, at least in this initial demonstration. There were no positive responses by controllers when queried about the use of cameras for flexible/contingency SNT.

5.2.3.1 Panoramic Cameras

Controller feedback was mixed on the use of the panoramic view. Controllers noted potential benefits that included the use of fixed camera data to view blocked, ramp, or “hot spot” areas, verifying a departure’s rotation point, matching an aircraft with flight data, and foreign object debris detection. Other potential uses that were cited were to verify gear and thrust reverser status. During post-test interviews, some controllers stated that they thought that if the OTW view were removed, the camera views would become necessary for successful ATC, with the panoramic camera perceived as more useful than the long-range camera.

The controllers expressed some concerns about the panoramic camera view; one such misgiving was that the rate of climb was perceived differently as seen on the camera versus as seen OTW. This was caused by technical limitations that resulted in a distorted panoramic view since the stitching of the individual images was not perfectly aligned.

Most controllers concluded, based on this first iteration of the prototype, that the cameras are not yet ready for operational use, even for supplemental SNT. One FLM stated that more work needs to be done to improve the cameras and their displays before he would feel confident in using them to verify that a departure has satisfied the criteria required to launch the next aircraft. Finally, many controllers stated that identifying necessary information using the cameras was not as quick or intuitive as looking OTW (Contingency SNT).

5.2.3.2 Long-range Camera

The long-range camera was shown on the external camera monitor and, optionally, in its own PiP on the TIDS. Some controllers stated that this long-range camera data could be useful at small or medium airports. With improved quality, this capability could be used to view physical issues with aircraft, including bird strikes or flat tires, allowing controllers to assist airport operators in determining a need for runway closures. At DFW-2, this capability was demonstrated when some controllers first identified a gear-up go-around flight test scenario by noticing it on the long-range camera view.

Some controllers thought the camera PiP was useful for identifying the number one aircraft waiting to take the runway from the queue in the hold pad. Others thought the camera PiP was clutter and the size and quality of the image in the PiP was a concern; some controllers commented that they felt there was a loss of situational awareness when using the long-range camera since they were unable to focus on more than one aircraft at a time.

5.2.4 Camera Technical Limitations

Both the scanning and fixed cameras, in this first iteration of the prototypes, experienced some technical limitations. For the long-range camera view, technical limitations included an inadequate zooming capability, unreliable focus, and instability of the camera view when the equipment was buffeted by wind. Some controllers expressed frustration with the technical difficulties encountered and said it was easier to pick up the binoculars to view an aircraft on final approach to the runway. Many controllers expressed a concern about the long-range camera view being distracting. At least in part due to these numerous technical limitations, the ratings show mixed results with many individual differences, and the findings were mostly not statistically significant on the agreement scale for the long-range camera view.

The DFW-2 evaluation provided some indications that cameras are potentially beneficial to controllers. It is important to note that these initial results are the reactions of a highly experienced group of subject matter experts to a first experience with a potentially controversial concept that was met with skepticism. Further field deployment and evaluation using improved camera technology and site locations would benefit the examination of camera use for SNT. It is recommended that these human factors and technical data be collected again in any future demonstrations.

5.3 CONTROLLER COMMENTS AND REQUESTED MODIFICATIONS FOR CAMERAS

5.3.1 Controller Comments on Camera for SNT Operations

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

Table 5-4: Controller comments on camera PiP for supplemental SNT

Negative	Neutral or Suggestion
• Too distorted of a view, need the whole airport environment to get a better view instead of looking out the windows. • Delay in the ability to zoom was cumbersome and would make me not waste (time) to use this function	• Would be nice to re-size the PIP Camera windows

Table 5-5: Controller comments on camera external display for supplemental SNT

Positive	Negative	Neutral or Suggestion
• 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!	• camera technology needs improvement and clearer picture… hard to beat the amount of information I can get by looking out the window, much clearer camera pictures are needed … 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 is of extreme importance to me.	• 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.

Table 5-6: Controller comments on camera usability for supplemental SNT

Negative
• Refresh/Focus/Zoom/Tracking would need a LOT of refining before I would feel comfortable using these in remote operations. • I do not have confidence in using cameras for remote operations at airports. Imagine driving a car down a freeway by remote control and think of all the info the driver has to take in. Cars as well as airports should not be run by camera. • Did not use. They were of no help to me

Table 5-7: Controller comments on camera usefulness for supplemental SNT

Positive	Negative	Neutral or Suggestion
• Cameras are a great tool. I was actually able to notice the King Air whose gear was up and going around based solely on camera view. • I would use the panoramic a lot more than the scanning. I don't see any steady use for the scanning camera.	• The available technology for the cameras is not sufficient to replace the windows even in a contingency situation at this time. • The picture quality was lacking and also the amount of picture that was covered or viewable. • The jerkiness thru the refresh is very distracting on either screen. • Did not find the cameras useful… images were not clear enough, the tracking of targets jerked … (too) much time involved in operating them. Not enough detail in the picture. Using my own eyes, neck and head I can take in MUCH more information. • With camera when your field of vision is narrow you are doing a disservice to all the other operating aircraft. Could be useful but I think we were missing other things using it. • As of this time the technology just is there to make cameras a viable option for either SNT or supplemental SNT operations. We just aren't there yet. • I did not use any of the camera view to control. I found them to be distracting	• I believe this is going to be the hardest task to accomplish, since nothing manmade can duplicate the human eye. • I would like to zoom and unzoom better • The Zoom/Tracking/Focus have a lot of work yet. The refresh rate also needs to be enhanced. • Cameras located in the departure pads would provide greater detail in congested areas. • Cameras might be useful in areas that can't be seen from a TWR but not for the whole airport.

Table 5-8: Controller comments on camera user interface for supplemental SNT

Negative	Neutral or Suggestion
• Size of any PiP is of concern as well as quality of image therefor I am not a fan. • Did not use. Would turn them off if I had to use them • Did not use them • I did not like them at all	• Simply the resolution factor. • PIP resizing would be nice. • Better quality picture would help, much better. Cameras should only be used for areas that cannot be seen from the tower. • I prefer the spilt screen for my own use, to track whatever aircraft or area I want. I feel the External Camera Display would be best suited in a spilt screen operation: 1 pane could track the next aircraft inbound to the landing runway, this would constantly move to the next inbound as the first passed the touchdown zone. Pane 2 could display the departure pad for that local controller.

5.3.2 Requested Camera Modifications

Table 5-9 summarizes the controllers' suggestions and modifications to improve camera functionality and usefulness. These suggestions were compiled from the post-evaluation discussions that occurred after each session, and from the controllers' responses to the evaluation questionnaires. Results of the camera discussions are provided in Appendix E, and controller responses to the questionnaires can be found in Appendix H.

Table 5-9: Camera suggestions and requested modifications

Affected Display	Suggestion/Issue	Requested Modification
Camera	Would like ability to see strategic locations (hot spots, intersections, short final, etc.)	• Provide additional camera views • Allow controllers/sups to select areas to monitor
Camera	Would like to track arrivals and departures	• Ability to auto-track arrivals and departures
Camera	Would like to monitor activity and occurrences (foreign objects/animals)	• Observation mode
Camera	Would like camera to return to "home" position	• Single-click access to "home" camera position
Camera	View of entire airport	• Fisheye panoramic view of entire airport • Full view of movement area
Camera	Improved PTZ capabilities	• Improved PTZ update rates • Improved response to PTZ inputs
Camera	Larger PiP	• Increase PiP size and resolution
Camera	Split-screen external display	• One pane for inbound tracking, one pane for departure pad

6. SNT OPERATIONAL CONCEPT DISCUSSION

With regards to the SNT operational concept, participant controllers were asked to rate whether SNT will be beneficial to the National Airspace System (NAS) as a whole and whether it will be beneficial to tower controllers. The results were favorable[5], especially for this early stage of the prototype research and development. Eighty-three percent of controllers either somewhat or strongly agreed that supplemental SNT will be beneficial to the NAS as a whole. Similarly, 89% of controllers either somewhat agreed or strongly agreed that supplemental SNT will be beneficial to tower controllers.

The TIDS was almost unanimously accepted as an improved surface surveillance display. Many controllers expressed their professional opinion that the TIDS would increase situational awareness and have a positive effect on safety. However, the ASDE-X multilateration surveillance data shown on TIDS is not yet operationally approved for providing separation. The TIDS exhibited various artifacts, such as multiple and split targets, some of which were noted during DFW-2 (see section 4.1.14 for details).

When considering the SNT concept, some of the controllers stated that the information on the TIDS is useful, but they remain convinced that some information is still better supplied by the OTW view. However, other controllers believed that, assuming operationally approved surface surveillance was driving the displays, using the TIDS to control traffic in a flexible/contingency SNT concept (without an OTW view) is doable.

Still, controllers understood and accepted the concept of SNT, given the use of improved surveillance. The controllers were skeptical about the camera use, but this is partially a result of the technical limitations experienced during the test of a first iteration prototype. They agreed that the cameras are not yet ready for operational use in either supplemental or contingency SNT. However, based on their comments, at least some of the controllers could see some potential promise in improved technology and had multiple suggestions for potential use of cameras in both the supplemental and contingency SNT concept.

[5] These two questions were asked as part of a brief TFDM integration questionnaire which is documented in an appendix of *Field Demonstration #2 Final Report for Tower Flight Data Manager (TFDM).*

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7. 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.

7.1 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 7-1.

Table 7-1: 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 7-2 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 7-2: 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.

7.2 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 7-1.

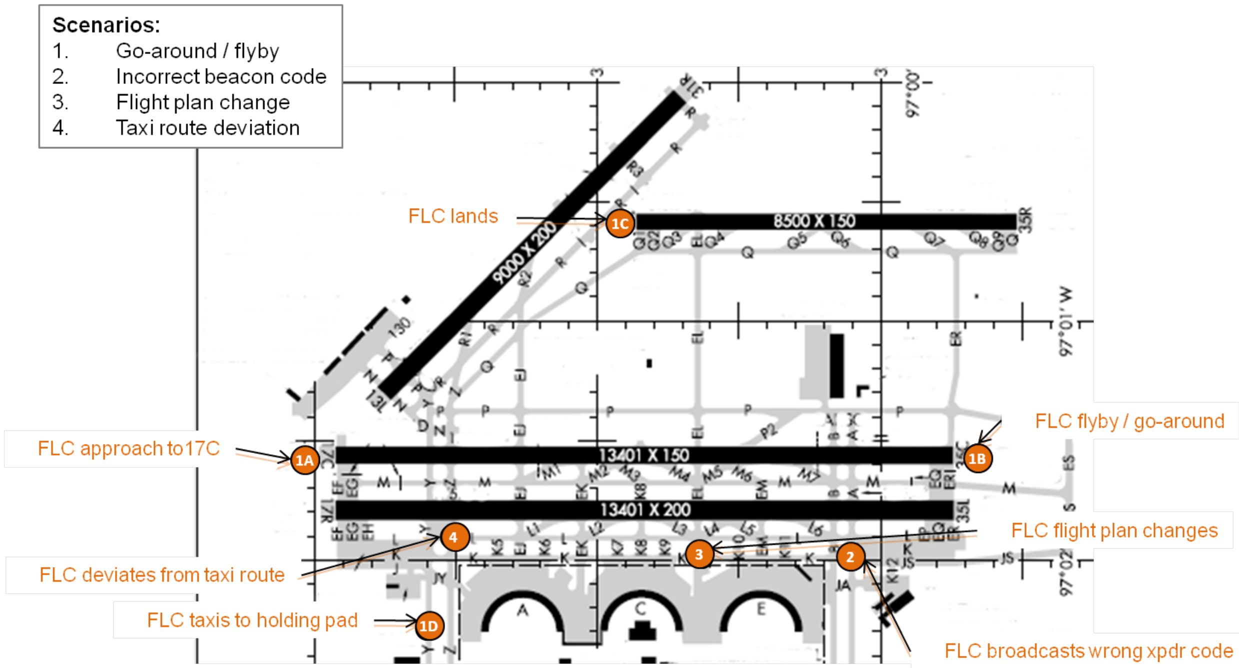

Figure 7-1: Flight test scenarios map

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 7-2 shows the distribution of controllers' ratings on the simplicity of identifying each flight test scenario.

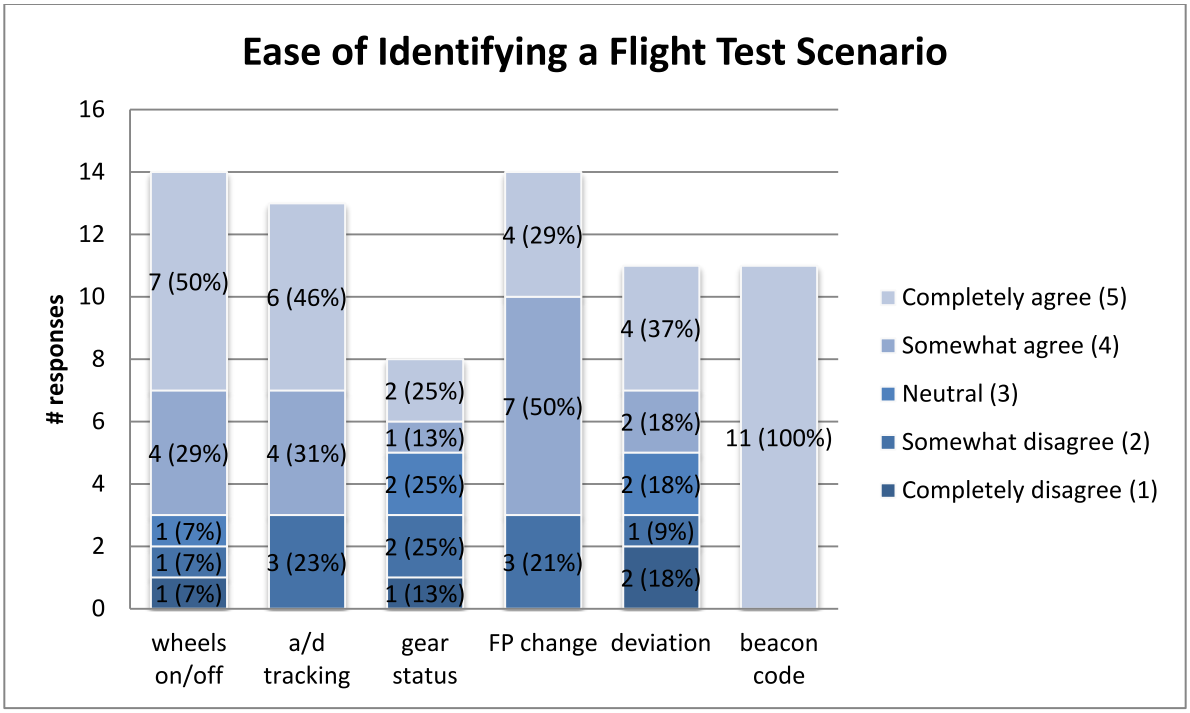

Figure 7-2: Ease of flight test scenario identification

7.2.1 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 7-3 summarizes the percentage of respondents who agreed or completely agreed that a display was useful in identifying each situation.

Table 7-3: 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

Long-range 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 7-3 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 4.1.14. 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.

7.2.2 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 7-4 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 7-4: 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
Long-range 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.

8. SUMMARY AND CONCLUSIONS

The DFW-2 NextGen field demonstration was a proof of concept for supplemental SNT. This demonstration evaluated the performance and acceptance of a prototype SNT including the TIDS component of the TFDM display system, two long-range cameras, a fixed-range camera array, and camera displays. This field demonstration involved professional air traffic controllers interactively observing live traffic on the TIDS and OTW, with augmented visual information from the camera views, during shadow operations to assess the feasibility of supplemental SNT.

The TIDS technical performance during DFW-2 was satisfactory. All categories aside from the Target Broker had passing criteria, and many of these categories had no failures. However, camera technical performance was highly unsatisfactory. Although technical limitations severely impacted controllers' impressions of the cameras, many of them did note a number of potential uses for cameras in a supplemental SNT context.

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. In contrast, controller comments about camera use were mostly negative. The human factors data indicated that the cameras need much work.

Validation of the SNT operational concept was supported by a thorough analysis of data collected during the DFW-2 demonstration. An assessment of the supplemental SNT feasibility was undertaken with some promising results, especially for use of TIDS in the control tower. Many performance issues were identified, for both the TIDS software and the camera technology, leading to refinement in the functional and performance requirements for SNT. Technical, operational, and cultural challenges all must be addressed and resolved before SNT, especially contingency SNT with no OTW view, is realized for the provision of next generation tower air traffic control services. Although a statistically significant increase in controller situational awareness with SNT was not found, anecdotal evidence uncovered a trend in that direction and potential usefulness of both the TIDS and cameras.

In conclusion, DFW-2 has indicated that controllers are receptive to the use of next generation tools, especially TIDS, to supplement the OTW view for tower operations. User feedback obtained on the TIDS prototype will be reflected in written requirements for a production level system. Acceptability of the cameras, including the concept and use of them, is low at this time due to the technical limitations apparent in this first iteration of the prototype. This demonstration has highlighted many issues, both technical and human factors, which need to be addressed prior to providing supplemental SNT equipment in operational towers. As these issues are addressed and the technology improves, further development and evaluation of the SNT concept is recommended.

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APPENDIX A
ACRONYMS

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
BPF	Berkeley Packet Filter
CFR	Call for Release
CPC	Certificated Professional Controller
DBRITE	Digital Bright Radar Indicator Tower Equipment
DST	Decision Support Tool
DFW	Dallas–Fort Worth International Airport
DFW-1	Dallas–Fort Worth Field Demonstration #1
DFW-2	Dallas–Fort Worth Field Demonstration #2
EDCT	Estimated Departure Clearance Time
FAA	Federal Aviation Administration
FCA	Flow Control Area
FDE	Flight Data Entry
FDIO	Flight Data Input/Output
FDM	Flight Data Manager
FLM	Front Line Manager
FTI	FAA Telecommunications Infrastructure
GC	Ground Control
HITL	Human-in-the-Loop
IFR	Instrument Flight Rules
ITWS	Integrated Tower Weather System
LAHSO	Land and Hold Short Operations
LC	Local Control
LLWAS	Low Level Windshear Alert System
MLAT	Multilateration
NAS	National Airspace System
OTW	Out-the-Window
PiP	Picture in Picture
PTZ	Pan, Tilt, Zoom
RACD	Remote Control ARTS Display
RVR	Runway Visual Range
SMR	Surface Movement Radar

SNT	Staffed NextGen Tower
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
ViPS	Visual Processing Subsystem
VFR	Visual Flight Rules

APPENDIX B
SNT SUCCESS CRITERIA

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	1.1.4	Runway status shown on displays reflects current status of runways.	Pass: Runway statuses on the TFDM displays accurately reflected the runways in 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.
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.	Pass: Verified with post hoc video review
					2.1.4	All targets provided by ASDE-X have icons on TIDS.	Pass: Verified with post hoc video review
	Data blocks	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 data block that can be selected for display.**	**Fail: intermittent data block losses on one day at DFW-2**
					2.1.6	Content of each data block matches the OTW information observed for each target.	Pass: Verified at DFW-2
					2.1.7	Content of each data block matches the information received from ASDE-X, FDIO, and TFDM for each target.	Pass: Verified at DFW-2 when data blocks 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*

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
					2.1.10	*Taxiway segments can be closed independently of adjacent segments.*	*N/A: Not tested at DFW-2*
		User settings	TPS 6284, 6287, 6011, 6012, 6016	Users are able to create and save personalized preference sets	2.1.11	Users can select a customized preference set.	Pass: Verified at DFW-2
					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 Xs on ends	2.1.18	Closed runways are outlined in red.	Pass: Verified at DFW-2
					2.1.19	Closed runways have a white X displayed on each threshold.	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
	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**
				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
	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.
			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
	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)*

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
	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)*
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,	Pass: Verified in post hoc analysis

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
						SMR, ASR data.	
			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 5 nm	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
		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**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
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**	Flight and track data reconciliation	pPRD 3.2.2	All targets are associated with accurate flight data	**3.3.4**	**Flight data stored by TFDM/TIB matches flight data received from ASDE-X, FDIO, and other data sources.**	**Fail: ASDE-X data not stored on TIB** *Inconclusive: ITWS data not evaluated*
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

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
			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.**	**Fail: ASDE-X data not stored on TIB**
				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.**	**Fail: ASTERIX data not recorded on TIB—recorded on external drives**
					4.1.6	**ASTERIX Cat 10 and 11 data are displayed in TFDM format when it's retrieved from the TIB.**	**Fail: ASTERIX data not recorded on TIB—recorded on external drives**
			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 <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	Pass: Verified at DFW-1

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
						aircraft.	
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
			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*
4.5	**External Data**	Flight-specific impact assessment and indication of weather or traffic flow constraints for filed departure route	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 s.*	*Inconclusive: Unable to retrieve diagnostic log files*
					4.5.7	*No discrepancies are found between recorded winds data and the winds data stored on the TIB.*	*Inconclusive: Unable to retrieve data*
					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*

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
5	**Cameras**						
5.1	**Long-range Cameras**						
5.1.1	**TIDS Picture-in-Picture**	PiP display of long-range camera 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*
5.1.2	**External Long-range Camera Display**	Long-range camera 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 target**
					5.1.1.5	The tracked target is displayed in the TIDS camera window until the user deselects it.	Pass: Verified at DFW-2
		Long-range camera control interface	TPS 9539	Users can pan, tilt, zoom,, slew long-range camera through camera PiP window on TIDS	**5.1.1.6**	**Users can pan the long-range camera by interacting with the camera PiP.**	**Fail: Users experienced significant problems with camera controls**
					5.1.1.7	**Users can tilt the long-range camera by interacting with the camera PiP.**	**Fail: Users experienced significant problems with camera controls**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
					5.1.1.8	**Users can zoom the long-range camera by interacting with the camera PiP.**	**Fail: Users experienced significant problems with camera controls**
					5.1.1.9	**Users can focus the long-range camera by interacting with the camera PiP.**	**Fail: Users experienced significant problems with camera controls**
					5.1.1.10	**Users can slew the long-range camera by interacting with the camera PiP.**	**Fail: Users experienced significant problems with camera controls**
		Acceptability	MIT/LL	User feedback for PTZ 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 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 long-range camera external display and PiP.**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
		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 long-range camera external display, and 2/5 *(p =.033)* for PiP**
		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
		External display for long-range camera	TPS 6165	Image shown on TIDS, external display	5.1.2.1	Long-range camera image is shown on external	Pass: Verified at DFW-2

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
						camera display.	
				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*
		Long-range camera 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 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 the user deselects it.	Pass: Verified at DFW-2
		Long-range camera control interface	TPS 9539	Users can control long-range camera through external camera display	**5.1.2.6**	**Users can pan the long-range camera by interacting with the long-range camera image on the external display.**	**Fail: Users experienced significant problems with camera controls**
					5.1.2.7	**Users can tilt the long-range camera by interacting with the long-range camera image on the external display.**	**Fail: Users experienced significant problems with camera controls**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
					5.1.2.8	**Users can zoom the long-range camera by interacting with the long-range camera image on the external display.**	**Fail: Users experienced significant problems with camera controls**
					5.1.2.9	**Users can focus the long-range camera by interacting with the long-range camera image on the external display.**	**Fail: Users experienced significant problems with camera controls**
					5.1.2.10	**Users can slew the long-range camera by interacting with the long-range camera image on the external display.**	**Fail: Users experienced significant problems with camera controls**
		Acceptability	MIT/LL	User feedback for PTZ rated 4 or higher on 5-point scale	**5.1.2.11**	**Collected user feedback on PTZ capabilities for long-range camera 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**

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	**5.1.2.15**	**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 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	**Long-range Camera Visual Processing Subsystem (VIPs)**	Long-range camera control	TPS 9539	PTZ, camera control capabilities demonstrated	**5.1.3.1**	**Long-range 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 long-range camera 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 long-range camera's timestamp of an image and the time the image is shown on the long-range camera external display is*	*Inconclusive: Unable to retrieve camera timestamps*

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
						less than 1 s.	
					5.1.3.4	*The time elapsed between the long-range camera's timestamp of an image and the time the image is shown on the long-range camera PiP is less than 1 s.*	*Inconclusive: Unable to retrieve camera timestamps*
		Long-range camera tracking capabilities	TPS 9539	Tracking capabilities demonstrated	5.1.3.5	The long-range camera follows the selected target until the user deselects the target.	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 long-range camera display.	Pass: Verified at DFW-2
			MIL-STD 1472f 5.4.6.4	<1 s tracking latency	*5.1.3.7*	*The time elapsed between the long-range camera's timestamp of a tracked target image and the time the tracked target image is shown on the long-range camera PiP is less than 1s.*	*Inconclusive: Unable to retrieve camera timestamps*
					5.1.3.8	*The time elapsed between the long-range camera's timestamp of a tracked target image and the time the tracked target image is shown on the long-range*	*Inconclusive: Unable to retrieve camera timestamps*

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
						camera external display is less than 1s.	
5.1.4	**Long-range Camera Independence**	Local Control long-range camera display	User group	LC long-range camera operates independently of GC long-range camera	**5.1.4.1**	**LC control inputs (PTZ, track, slew) are reflected on LC long-range camera PiP and external displays only**	**Fail: LC/GC cameras are independent but Supervisor position sometimes fights for control with LC/GC**
		Ground Control long-range camera display	User group	GC long-range camera operates independently of LC long-range camera	**5.1.4.2**	**GC control inputs (PTZ, track, slew) are reflected on GC long-range camera PiP and external displays only**	**Fail: LC/GC cameras are independent but Supervisor position sometimes fights for control with LC/GC**
5.2	**Fixed Array Cameras**						
5.2.1	**External Fixed Array Camera Display**	External display of fixed array data	TPS 6165	Image shown on external display	5.2.1.1	Fixed array main fused image is shown on the external camera display.	Pass: Verified at DFW-2
					5.2.1.2	Fixed array north threshold is shown on the external camera display.	Pass: Verified at DFW-2
					5.2.1.3	Fixed array south threshold is shown on the external camera display.	Pass: Verified at DFW-2
				Camera data displayed on external display matches camera feed	*5.2.1.4*	*Images shown on external camera display match data recorded from fixed 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**

Item	Capability	Test Description	Origin	Test Objectives	Ref	Success Criteria	Pass / Fail
		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
		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 C
REPORTED SURVEILLANCE PROBLEMS

Date	Time	Problem Type	Cause	Reference	Comments
4/26/2011	13:14	Incorrect aircraft state	Surface Monitor Crash	4.1.14.1	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	4.1.14.1	COA1708 issue
4/26/2011	15:25	Flashing target	Target shows drop messages near takeoff	4.1.14.6	EGF2919 flashing on departure
4/26/2011	16:10	Incorrect aircraft state	Issue w/track merge/split logic. Fixed in latest code.	4.1.14.6	Target w/beacon code 2372 showing cyan @EK—not airborne. Also frozen in position.
4/26/2011	16:11	Caterpillar	Known Target Broker issue	4.1.14.6	Target w/beacon code 5274 caterpillaring on west side
4/26/2011	16:11	Unknown target	Lost system track	4.1.14.6	EGF2715 changed to unknown, then retagged on departure
4/26/2011	16:18	Caterpillar	Known Target Broker issue	4.1.14.6	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.	4.1.14.2	North side TIDS lost all data tags twice
4/26/2011		Surface monitor crash	Unknown—Scripts put in place to Monitor and restart	4.1.14.1	Surface monitor crash
4/27/2011	13:09	Aircraft orientation	Track number changes multiple times. System has trouble merging tracks.	4.1.14.6	AMF1320 cockeyed on runway.
4/27/2011	13:41	Frozen target	Issue w/track merge/split logic. Fixed in latest code.	4.1.14.6	Overflight target 2225 frozen over C terminals. Overflight filter possibly not turned on.
4/27/2011	14:43	Missing target	Not reproducible	4.1.1	AAL1185, AAL817 w/runway assignments for 36R on east side; not seen on TIDS

Date	Time	Problem Type	Cause	Reference	Comments
4/27/2011	15:48	Caterpillar	Known Target Broker issue	4.1.14.6	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.	4.1.14.6	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	4.1.14.6	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	4.1.14.6	5165 caterpillaring
4/28/2011	13:29	Flashing target	Multiple track drop messages sent	4.1.14.6	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	4.1.14.6	AL393 caterpillaring. Going across bridge to west side.
4/28/2011	14:45	Flashing target	Multiple track drop messages sent	4.1.14.6	DAL811 flashing during taxi; intermittent, inconsistent flashing.
4/28/2011	15:00	Jumping target	Multiple track drop messages sent	4.1.14.6	AAL1609 jumping/dancing in C gate area.
4/28/2011	15:17	Unknown target	Lost system track	4.1.14.6	Departure from 35L turned to unknown once airborne.
4/28/2011	15:40	Flashing target	Multiple track drop messages sent	4.1.14.6	AAL1209 jumping/flashing in A gate area.
4/28/2011	15:52	Caterpillar	Known Target Broker issue	4.1.14.6	FLC caterpillaring; beacon code changed to 1204.
4/28/2011	16:04	Unknown target	Target not associated with flight ID	4.1.14.6	AAL708 not tagged. No target seen when pushing back; had nose-to-nose situation w/target that missed intersection.

Date	Time	Problem Type	Cause	Reference	Comments
4/28/2011	17:26	Caterpillar	Known Target Broker issue	4.1.14.6	Unknown overflight leaving trail from east to west across E gate area.
4/28/2011	17:33	Flashing target	Multiple track drop messages sent	4.1.14.6	AAL1705 blinking in A gate area.
4/28/2011	17:33	Lost data block	May be due to machine being IO bound	4.1.14.3	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.	4.1.14.3	Data block dropped again
4/28/2011	17:45	Caterpillar	Known Target Broker issue	4.1.14.6	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	4.1.14.2	FDM freeze
5/3/2011	14:40	Display freeze	Kernel panic	4.1.14.2	Displays froze—TIDS, FDM, camera.
5/3/2011	15:17	Dual data tag	Dropped arrival track linked to active departure track	4.1.14.6	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	4.1.14.6	AAL1743 flashing in A gates, west side.
5/3/2011	15:26	Flashing target	Multiple track drop messages sent	4.1.14.6	EGF3319 flashing in B gates
5/3/2011	15:43	Dual target	Dropped arrival track is incorrectly filled in with taxiing departure track	4.1.14.6	AAL2050 has double target with AAL1629 on twy K
5/3/2011	17:31	Flashing target, caterpillar	Known Target Broker issue	4.1.14.6	EGF2863 flashing, caterpillaring on departure from 17R.
5/4/2011	12:30	Caterpillar	Known Target Broker issue	4.1.14.6	Unknown target

Date	Time	Problem Type	Cause	Reference	Comments
5/4/2011	12:52	Caterpillar	Known Target Broker issue	4.1.14.6	5320 unknown on west side
5/4/2011	13:17	Caterpillar	Known Target Broker issue	4.1.14.6	3254 caterpillaring
5/4/2011	15:23	Caterpillar	Known Target Broker issue	4.1.14.6	1200 caterpillaring
5/4/2011	15:40	Stuck camera	Cause unknown. Investigation ongoing.	5.1.1	South long-range camera stopped tracking
5/4/2011	15:55	Caterpillar	Known Target Broker issue	4.1.14.6	6550 caterpillaring
5/4/2011	16:18	Inconsistent views	Cause unknown. Investigation ongoing.	4.1.14	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	4.1.14.6	DAL1791 flashing
5/4/2011	19:31	Flashing target	Not reproducible	—	AAL1625 flashing on 9 nm arrival to 17C. Stopped blinking once established
5/5/2011	13:43	Caterpillar	Known Target Broker issue	4.1.14.6	Unknown target caterpillaring in A gates. Tagged up as AAL540.
5/5/2011	14:41	Caterpillar	Known Target Broker issue	4.1.14.6	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	4.1.14.6	EGF3318 flashing at D gates
5/5/2011	14:48	Caterpillar	Known Target Broker issue	4.1.14.6	CJC3252 incorrect beacon code (2415) resulted in caterpillar. Correcting code to 2212 removed caterpillar.
5/5/2011	15:19	Caterpillar	Known Target Broker issue	4.1.14.6	MES3087 caterpillaring as unknown on L by C and A gates. Tagged up with ACID at departure end of rwy.

APPENDIX D
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.

APPENDIX E
DFW-2 DISCUSSION RESULTS FOR CAMERAS

- Distorted view when used to looking OTW
- Panoramic cam was tough
- Camera PiP used to set up external display; controller used camera display in some cases
- Not a problem esp. on ground
- Scanning wouldn't be used for tracking but would use it to monitor another area
- Cameras are beneficial in some cases but doesn't think that any controllers would really use them
- Tendency to look OTW is due to habit. Would use cams to look at otherwise unavailable/blocked views (GA, blocked spots, EL).
- Camera view would be better if different locations were used (strategic locations)
- Short final, exit points, ramp areas
- Beneficial in center tower, at certain points in ET. Long-range camera good for coyote tracking.
- Wouldn't just use it to track a/c
- Panoramic stitching is distracting. Can't tell speeds which are impt to determine where a/c will exit rwy.
    - Camera scan flexibility—AirTran has longer roll so can't clear next RNAV split till it's 6000', airborne; using cam to monitor this but also has to see other things. Need multiple views at once to manage situation.
- Stitched view is awesome, would like larger, better quality panoramic
    - Panoramic shows 80% of what he's used to seeing
- Controller preferred panoramic to smaller window—can't get full picture
    - PiP not needed if external display is available
- 30" display of east side—want ability to zoom in, then click button to return to a "home" position/state w/standard zoom settings
- Panoramic display preferable to scanning
    - Controller thought arrivals to 31R may benefit from long-range camera use
    - No advantage on sup display but big advantage for contingency/full
- Controller liked scanning cam for taxi conformity—easier to see a/c w/camera
    - Wouldn't make scanning cam part of primary scan
- Controller is "sincerely impressed except for camera"
- Controller liked panoramic but didn't like scanning cam as much
    - Didn't use external display
    - Zoom/scan too cumbersome, couldn't zoom as much as he wanted

    - Better zoom/resolution might make things better but generally neutral on scanning cam
    - Used PiP but only for specific observation purposes
    - Kind of hard with shadow ops
- Controller liked fixed thresholds at end, but other controller didn't use them much
- Cameras are moving in right direction for supplemental but are slow, cumbersome—lots of heads down time, may need an assistant
- Controller didn't find system able to respond when he actually wanted to track a target
    - "unreliable," problems focusing, "going berserk," jerkiness is distraction
    - Likes/prefers PiP—target isolation is good, want to see what he's interested in or clicking on
    - Thought he could use camera to track inbounds to touchdown, then recycle to next arrival
    - Split screen real estate with hold pad monitoring
- Panoramic is like the simulator—fake
    - Appears to be ~3s behind on approach—see note from observations—but catches up later on; useless if tracking on threshold
    - Controller prefers camera to determine whether target is airborne; would use color change if IFR
        - Can keep head focused in one general direction
        - Panoramic good for wheels on/off on VFR day—more useful than color change
    - Controller wouldn't have seen FLC go-around/gear up w/o camera
        - Target not where expected, so looked at cam
        - Arrival tracking useful for this case
- Magnified pad view may be beneficial
- Cameras should be improved or rather not have them
- Controllers can pick up flaps up visually; hard on camera
- May be useful for small/med airports
- Controller: camera at the moment is bigger distraction than help; could be better
- Controller thinks simple color change doesn't compare to OTW; didn't notice on TIDS
    - May be function of having windows
    - Controller never saw go-around; was heads-down
- Controller thinks actual responsibility for traffic would make a difference
    - Disoriented in CT somewhat
    - Routine disrupted from ET; working w/new equip also distraction

- Controller didn't realize value of OTW till camera was pushed on him—reversers, brakes, etc.
    - Impt to judge arrival timing, departure compliance
    - Cameras narrow field of vision—big problem in ATC
    - Mouse use is too cumbersome (for zoom); eyeballs work better. Too many obstacles impact quality of operations.
- Controller likes seeing down leg, if something tagged for 17L
- Controller thinks of all the a/c he's doing disservice to by not seeing them when using cam—no one's watching other a/c
- Current cam didn't allow controller to pick up anything he can't w/eyes—binocs are easier
    - Downtime required to look at images
    - Only use cam/binocs if something detected as incorrect—something reqs higher scrutiny
- Cameras will have benefits but not in current config
- Current process w/cam is slow—needs a lot of time, controller feels this is uncomfortable
- Camera is a "toy"
- Comfort level improved throughout day but no need to use camera; still uncomfortable when not scanning
- Extreme fisheye panoramic w/entire airport, decently large screen w/touch to zoom capability would be nice
- Simulator-esque display, can't get whole picture on screen
- Would be useful to assist airport ops—birdstrike, gear, FOD, etc.
- Camera distracting on VFR day
- Controller didn't use camera at all—distracting
    - External cam too jerky
    - Quicker to use binocs than to click
    - No use for panoramic w/windows, but yes if no windows
    - Controller thinks both needed if remote ops—technology not there at the moment
    - Tracking feature is good but picture no better than 20 year old military CCTV
    - Can't be second guessing things, need to trust 100%
    - Interested in apch end, crossing pts, intersections, hot spots—selectable by sup based on flow/needs
    - When are you oversaturated? Don't want to be heads-down.
- Camera and surveillance only—efficiency takes a hit. Eyes/perception better at seeing subtle changes. Would not result in 6000' and airborne.
- No advantage to cameras at DFW on tower but useful for blocked spots

- Long way to go w/cam and full SNT concept
- Controller: cam is far from useful even in supplemental. Wants display consolidation. HUD on tower window!

APPENDIX F
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

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 GE controls 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.
I found the font size too 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. Its 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
CONTROLLER COMMENTS ON CAMERAS

H.1 CAMERA USEFULNESS

31. Please provide your comments on the overall usefulness of cameras (scanning and panoramic) in supplemental SNT operations.

Response
I would use the panoramic a lot more than the scanning. I don't see any steady use for the long-range camera.
The picture quality was lacking and also the amount of picture that was covered or viewable. I would like to zoom and unzoom better
Cameras are a great tool. I was actually able to notice the King Air whose gear was up and going around based solely on camera view. The Zoom/Tracking/Focus have a lot of work yet. The refresh rate also needs to be enhanced. The jerkiness thru the refresh is very distracting on either screen. Additionally, cameras located in the departure pads would provide greater detail in congested areas.
I did not find the cameras useful in any way. The images were not clear enough, the tracking of targets jerked too much. Too much time involved in operating them. Not enough detail in the picture. Using my own eyes, neck and head I can take in MUCH more information that I ever could with a camera. Cameras might be useful in areas that can't be seen from a TWR but not for the whole airport.
When even binoculars are used your field of vision is very narrow. You automatically are not scanning other areas of the airport and not monitoring other aircraft. Same thing with camera when your field of vision is narrow you are doing a disservice to all the other operating aircraft. Could be useful but I think we were missing other things using it.
As of this time the technology just is there to make cameras a viable option for either SNT or supplemental SNT operations. We just aren't there yet.
I did not use any of the camera view to control. I found them to be distracting

32. Please provide your comments on the use of cameras (scanning and panoramic) in remote operations.

Response
The remote operations were easy.
Refresh/Focus/Zoom/Tracking would need a LOT of refining before I would feel comfortable using these in remote operations.
I do not have confidence in using cameras for remote operations at airports. Imagine driving a car down a freeway by remote control and think of all the info the driver has to take in. Cars as well as airports should not be run by camera.
See 31.
Did not use. They were of no help to me

H.2 CAMERA TECHNOLOGY AND USER INTERFACE

33. Are there any existing features that should be removed from the external camera display? From the PiP?

Response
Size of any PiP is of concern as well as quality of image there for I am not a fan.
Did not use. Would turn them off if I had to use them

34. Is there anything that would improve the external camera display or camera PiP for controllers' use?

Response
Simply the resolution factor.
PIP resizing would be nice.
Better quality picture would help, much better. Cameras should only be used for areas that cannot be seen from the tower.
Did not use them

35. Are there any additional information or features that should be considered for the external camera display? For the PiP?

Response
I prefer the spilt screen for my own use, to track whatever aircraft or area I want. I feel the External Camera Display would be best suited in a split screen operation -- 1 pane could track the next aircraft inbound to the landing runway, this would constantly move to the next inbound as the first passed the touchdown zone. Pane 2 could display the departure pad for that local controller.
I did not like them at all

APPENDIX I
CONTROLLER COMMENTS ON SCENARIOS AND WORKLOAD

I.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?

Response
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.
Initially I was fighting he 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...
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.
Head down in monitors a little too much but with time spent with the equipment more time looking out windows should improve.
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?

Response
The time spent on the lc-1 position was excessive and I found myself struggling to address the tasks at hand.
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.

Response
The only thing that added to any workload was the flight strip display I am not a fan.

I.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?

Response
Ii liked the TIDS and the FDM the most. I think they both provided a good bit of info on this.
TIDS, I was looking at this piece of equipment the most.
TIDS, because its presentation most closely aligns with the ASDE-X monitor which I'm familiar with using.
The TIDS was the best or most useful for gathering information for monitoring.
The tracking feature
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.
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.
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.
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.
For arriving aircraft it would be best to be looking out the windows for departing the TIDS is probably better.
Data blocks as usual were the most beneficial.
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.
TIDS
The TIDS since it is a representation of the outside window view.

7. 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)?

Response
Not much
None
Greater ease in scanning the camera left and right to view several intersections and aircraft airborne points.

Maybe a change of color when they change from arrival to touchdown or from rolling to airborne
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.
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.
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.
Getting used to the equipment will allow a controller to still have time to look out the windows better.
Can't think of anything to add.
Departures: Different departure SIDS could be different colors as well as different colors for arrivals on different runways.
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?

Response
TIDS, it was easy to tell when the aircraft was airborne
The long-range camera, mostly because of the high resolution.
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.
The camera because you were able to zoom right in on the aircraft
TIDS
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.
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.
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.

Looking out the window would have been the best in this particular situation.
Not much use unless having to call traffic that may be a factor.
FDM color coding, TIDS fix info.
Did not see the fly by

I.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)?

Response
None
Undecided.
Maybe have the distressed aircraft a red color or something.
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.
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.
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.
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.
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.
None that I can think of.
Blinking information that will draw attention that a change has been made to flight plan, new restrictions and fix blinking capability on the TIDS.

I.4 DISPLAYS USEFULNESS

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

Response
I liked the TIDS and the FDM the most. I think they both provided a good bit of info on this.
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FDM color coding, TIDS fix info

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maybe have the distressed aircraft a red color or something
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 (ie. AUP) in the data block. This was for KingAir N83 changing flight plans today.
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.
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.
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.
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.
None that I can think of.
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?

Response
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.
TIDS, I was using it the most.
The FDM because of the detailed flight plan information.
The FDM was great in recognizing that flight plans had changed.
The color of the strip markings the color of the box "
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.
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 information didn’t match any of the conversation on LE frequency.

Response
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.
It was an odd aircraft to be operating out of DFW so looked at it closely.
FDM ......spelled it out.
FDM. I noticed the Keene was highlighted in blue. Then went to expanded flight strip to review.
When a change has been made it seems that everyone would be able to recognize it with more familiarization, i.e. look for blue
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?

Response
The TIDS. I just didn't use it as much for this purpose.
FDM, did not use it
The long-range camera, because an airplane looks like an airplane regardless of where it's going.
The display on the side
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.
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.
The full flight plan view.
Cameras.
Cam. Shows no flight information.
TIDS and FDM provided the information consistently when the change was made. FDM more so than TIDS.
The cams.

19. What information could be provided on the displays to improve the ability to recognize the flight plan change?

Response
The ability to change colors on certain blocks and being able to highlight those.
Make it easier to highlight fields in red, and to have EDCTs and off hat gates already in red.
Perhaps some highlighting device which displays a disparity between HAT status and flight plan route.
Flashing bar on the side.

Flashing changes or highlighted different.
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.
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).
As soon as an aircraft is taxied to a runway that traditionally does not depart it should give an alert.
Maybe red instead of blue for something that needs to be acknowledged.
Flashing if Sid does not match predetermined runway configurations.
Blinking or even a time-share with the original and the change.
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?

Response
TIDS, used it the most
The long-range camera, because it provided more real-time information about aircraft movement on the taxiways.
The color change.
TIDS, I was scanning the airfield when I notice N83 turned one intersection too early than the assigned intersection.
As local control, I wouldn't have been aware of his taxi deviation.
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.
TIDS was where I noticed it first. Then I looked out the window to verify.
N/a
TIDS since you could see where he is going.
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.
The TIDS since I could see that he was turning a different way then 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?

Response
None
A visual cue--such as flashing data blocks when the aircraft is not on the FDM-indicated taxiway.

Flashing lights on the side bar.
I'm really not sure.
N/a
? No idea other than mentioned above.
See above.
Blinking taxi route on the FDM and blinking call sign on the TIDS.
Not sure.

28. What display component provided the **most** useful information for helping to recognize the incorrect beacon code? Why?

Response
TIDS, it made the aircraft caterpillar.
The TIDS because of disparities between the beacon code and the data block assigned to the traffic.
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.
The FDM gave the most obvious display since the flight showed one thing and the TIDS was indicating something else.
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.
TIDS was an obvious choice since the problem was right in front of you.
TIDS since I could see a no tag.
TIDS.
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?

Response
Have the target flash at the operator.
Undecided.
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.
Maybe a flashing beacon code if it does not match with a filed fp.
On FDM maybe a flashing beacon code.
A flashing beacon code.

APPENDIX J
CHI SQUARE AND AVERAGES RESULTS FOR TIDS AND CAMERAS

The following is a detailed report of the chi square and averages results for TIDS, and for cameras in both supplemental and contingency/flexible SNT contexts. For all charts, the Y axis (ordinate) was configured to depict maximum observed frequencies.[6]

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 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 criterion for the agreement scale was somewhat agree or above.

J.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 J-1.

[6] 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.

J.1.1 Target Information

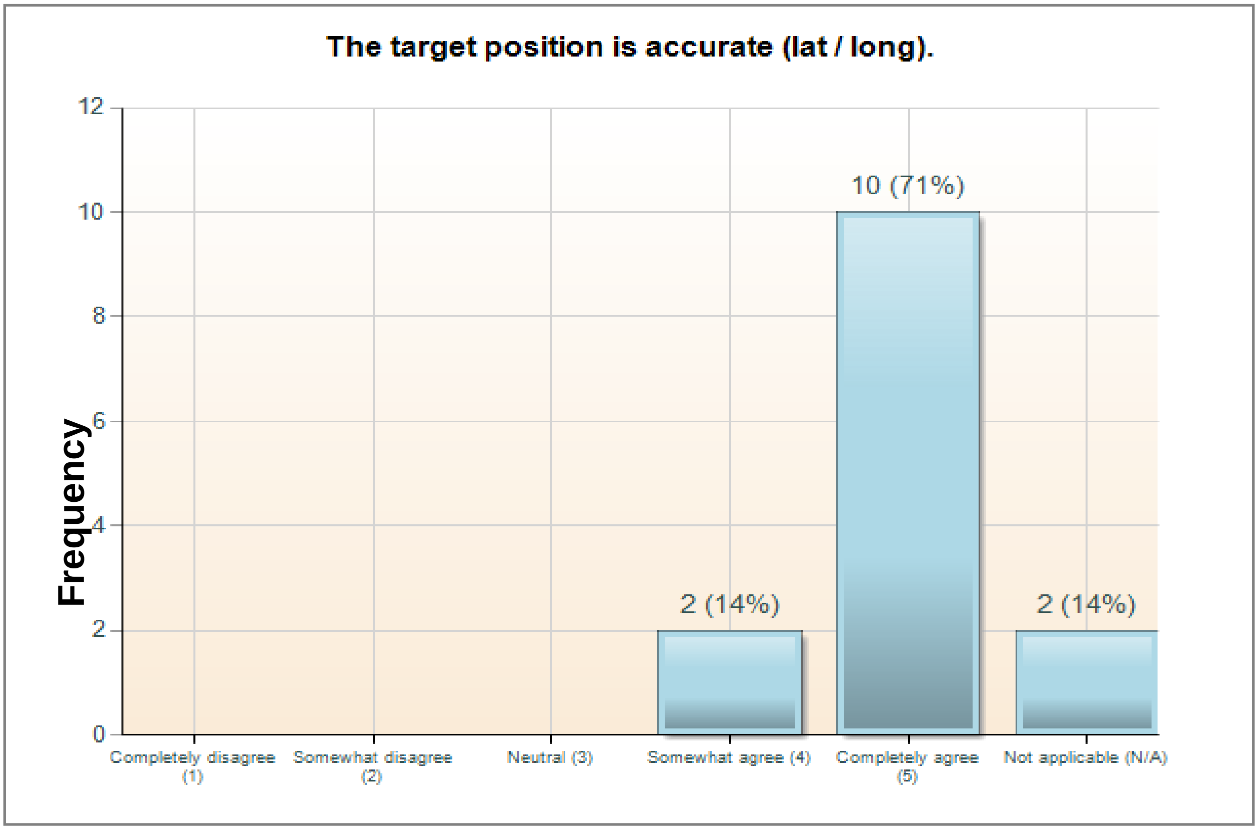

Figure J-1: Accuracy of target position

As shown in Figure J-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, $p < .05$.

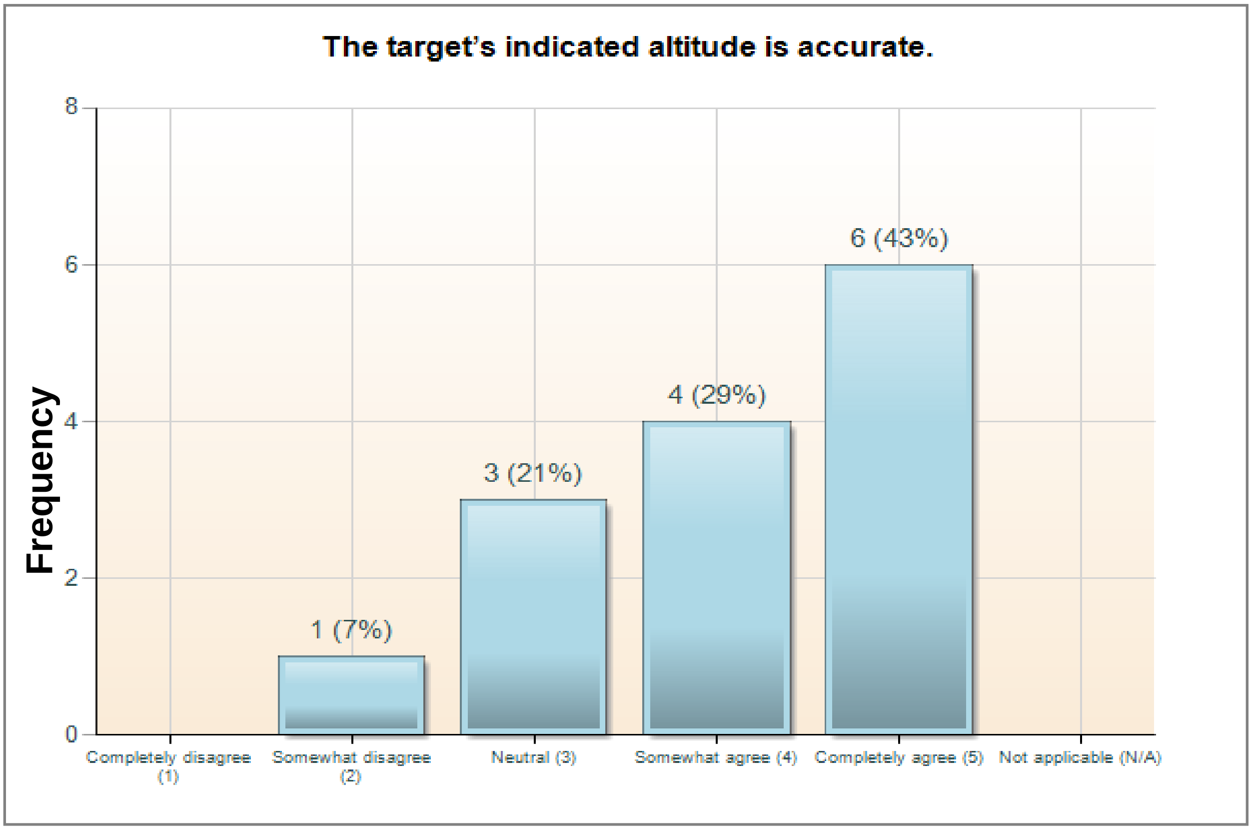

Figure J-2: Accuracy of indicated altitude

As shown in Figure J-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.

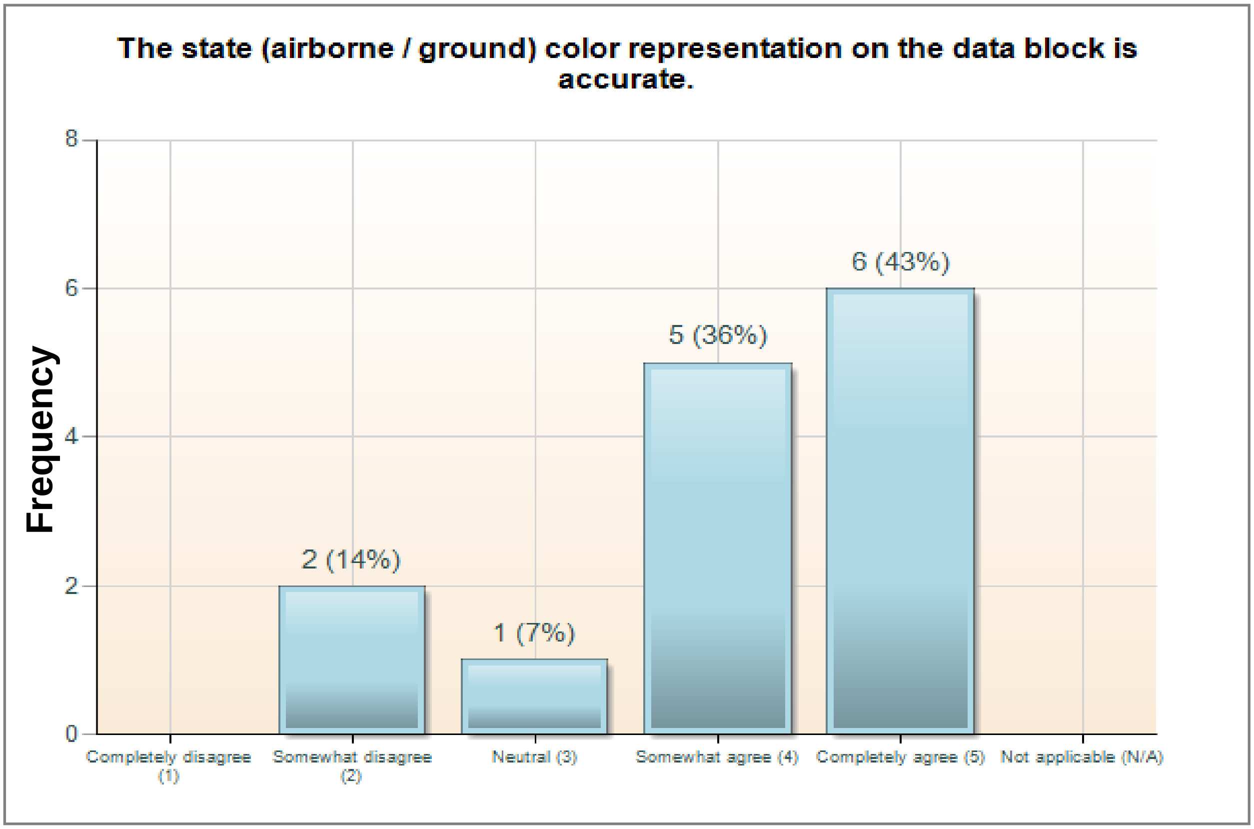

Figure J-3: Accuracy of the state color presentation on the data block

As shown in Figure J-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.

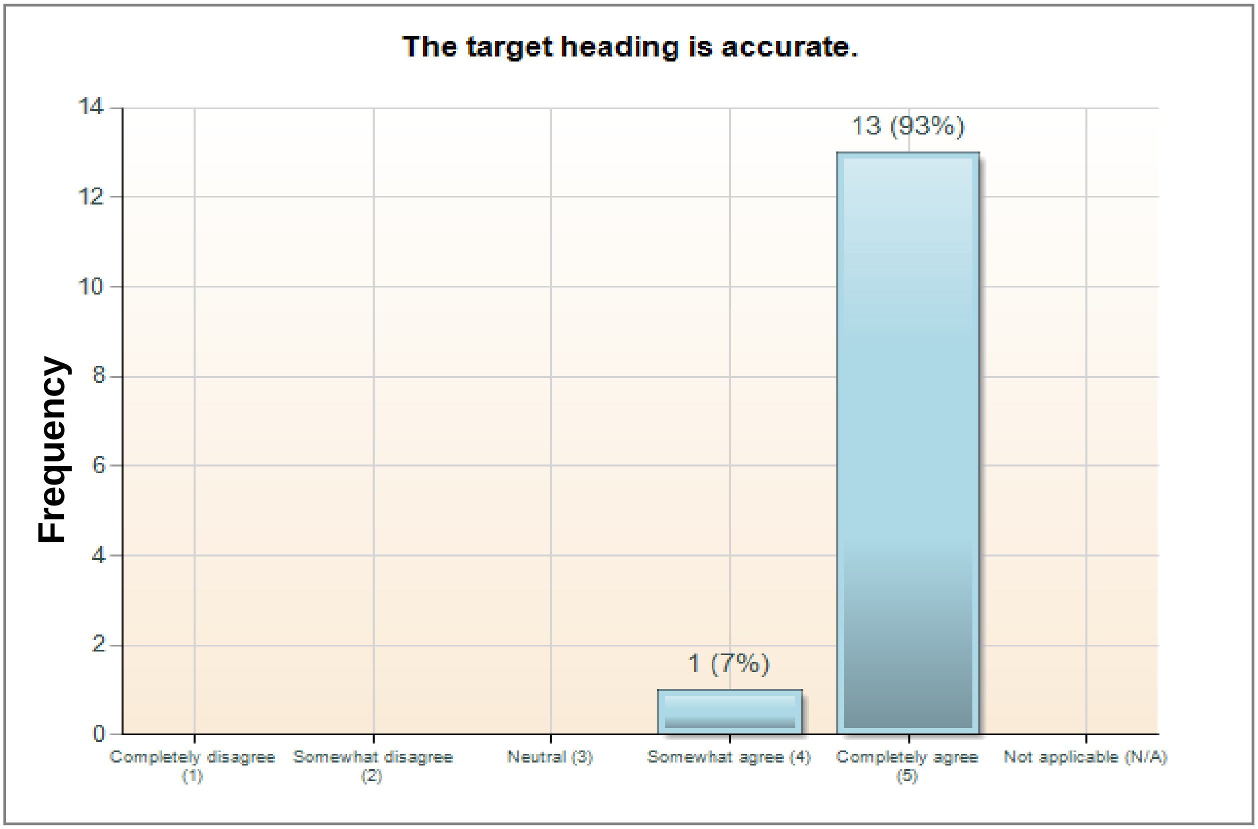

Figure J-4: Accuracy of the target heading

As shown in Figure J-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, $p < .05$.

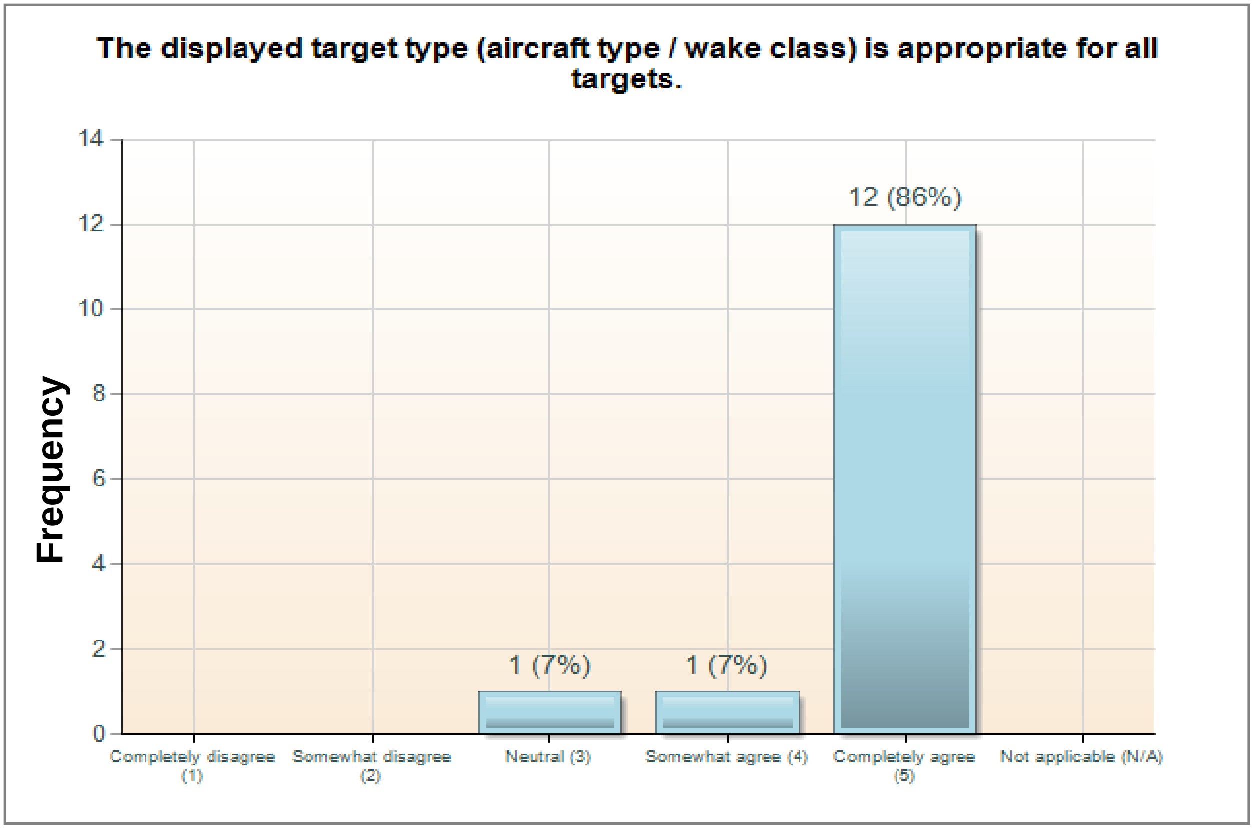

Figure J-5: Accuracy of the target type

As shown in Figure J-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.

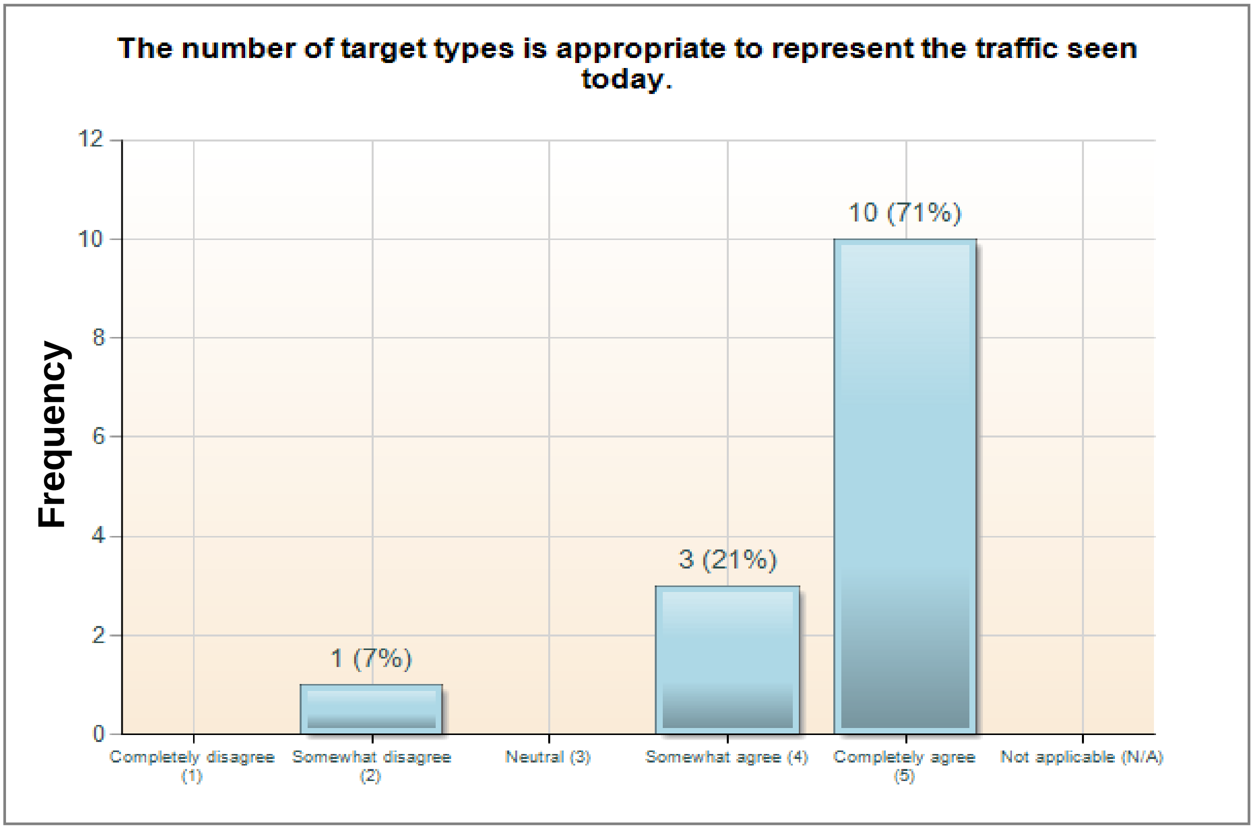

Figure J-6: Appropriateness of display target type

As shown in Figure J-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.

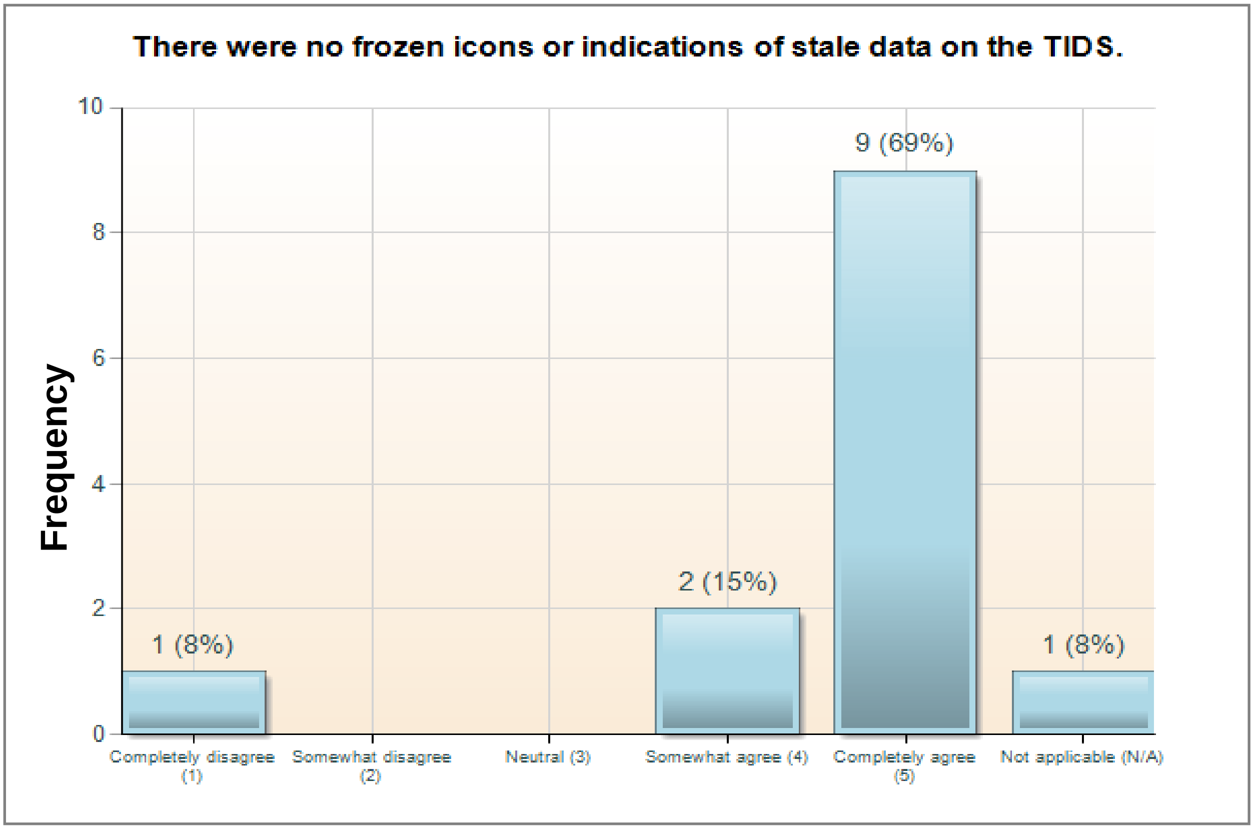

Figure J-7: Lack of number of stale data

As shown in Figure J-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.

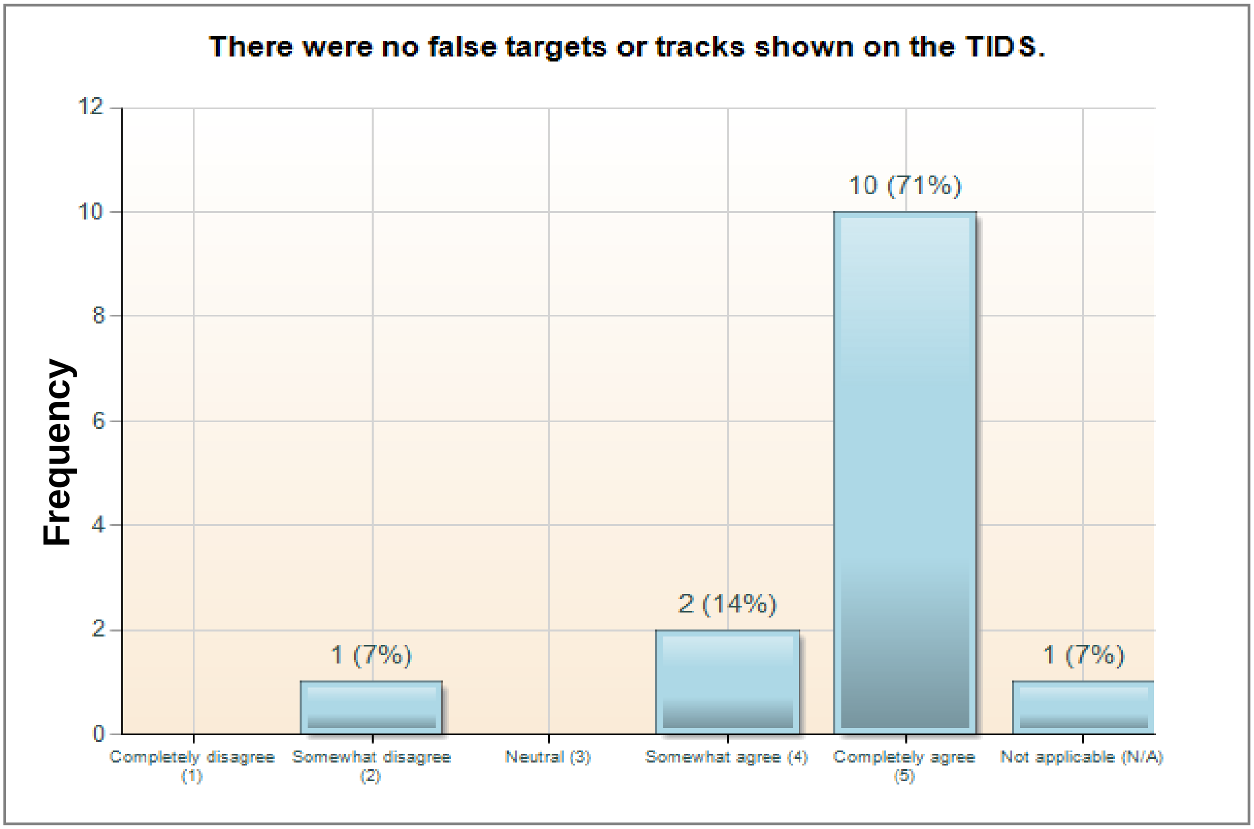

Figure J-8: Lack of false icons or tracks shown

As shown in Figure J-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, $p < .05$.

J.1.2 Information Accuracy and Availability

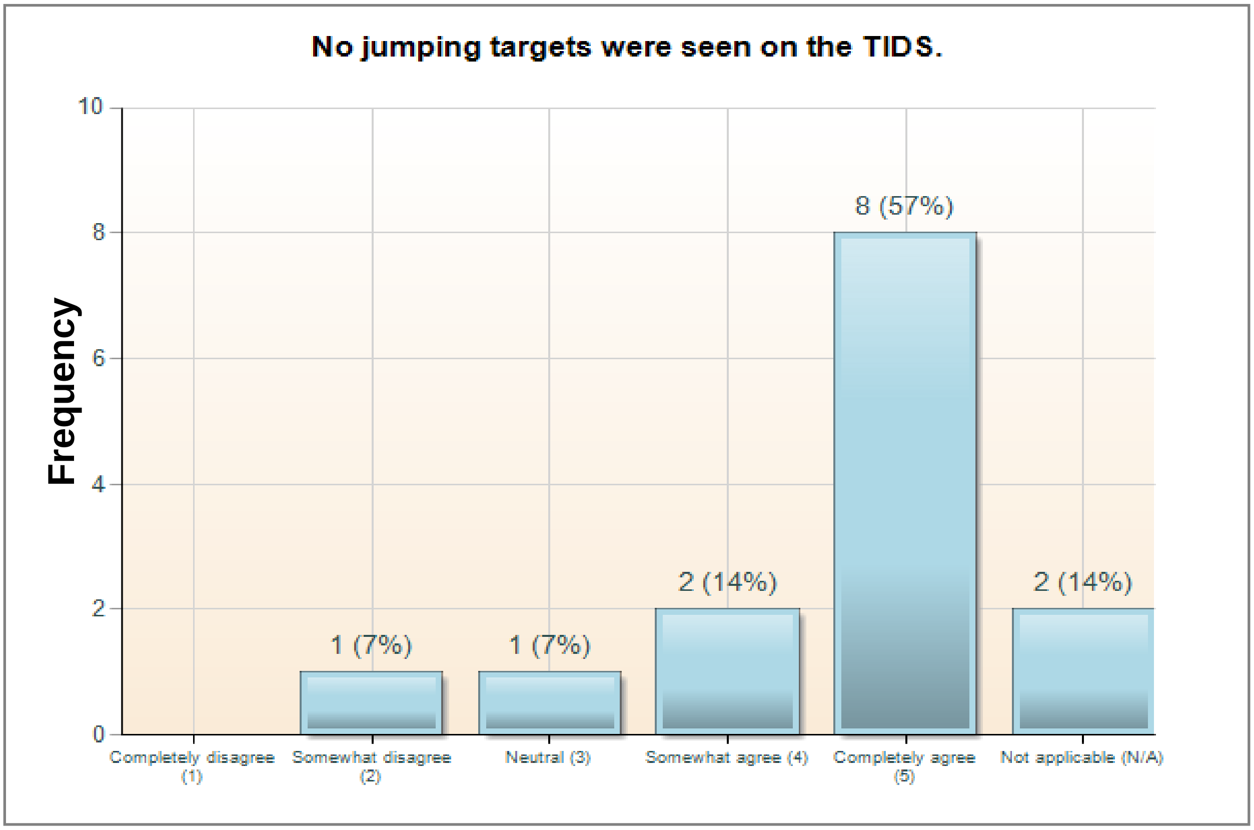

Figure J-9: Lack of jumping targets

As shown in Figure J-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.

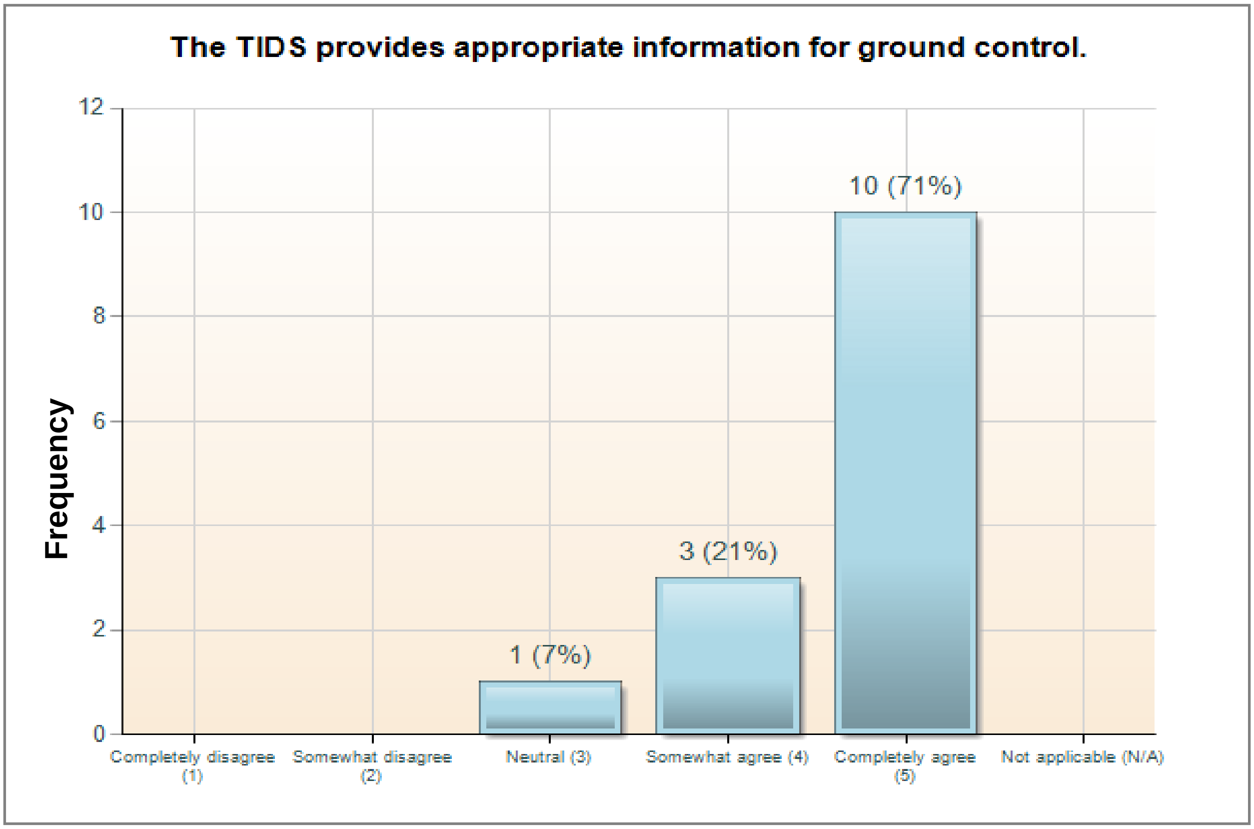

Figure J-10: Appropriateness of TIDS information to ground controllers

As shown in Figure J-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.

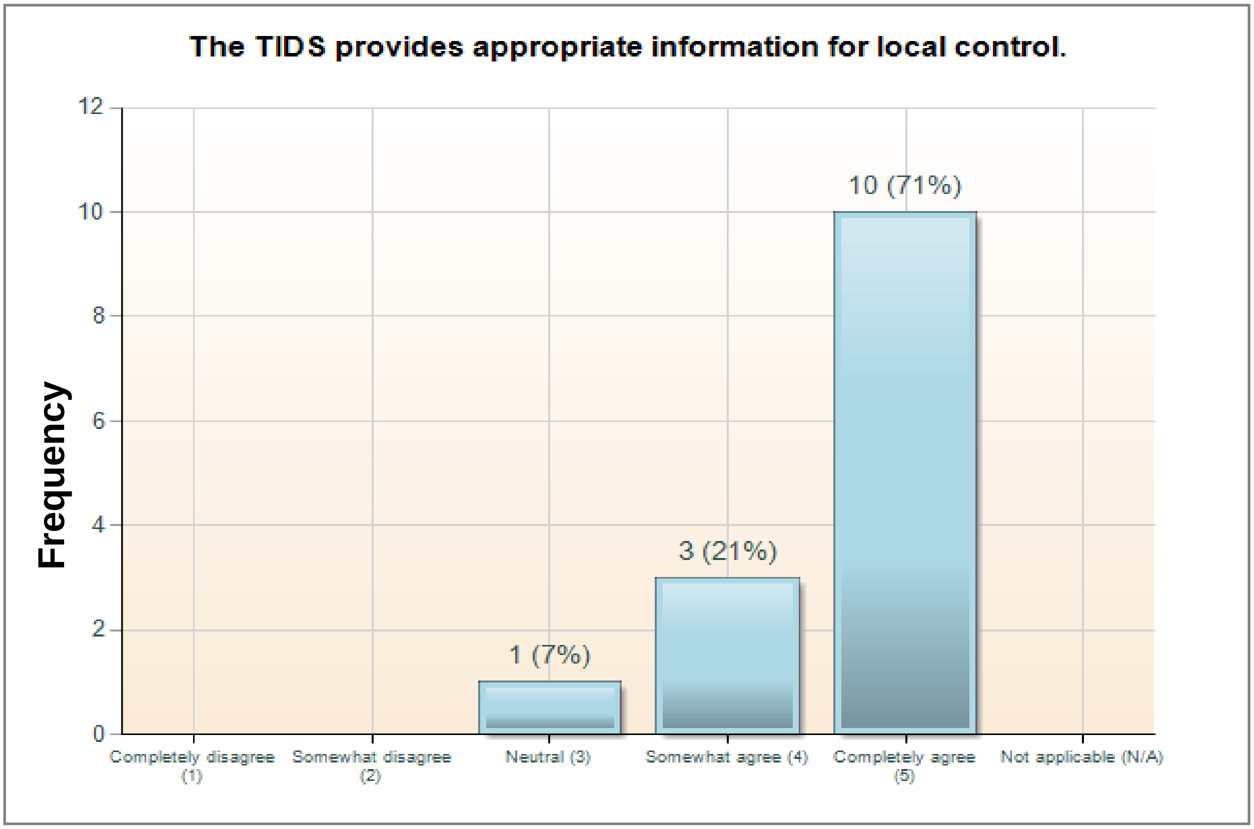

Figure J-11: Appropriateness of TIDS information to local controllers

As shown in Figure J-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.

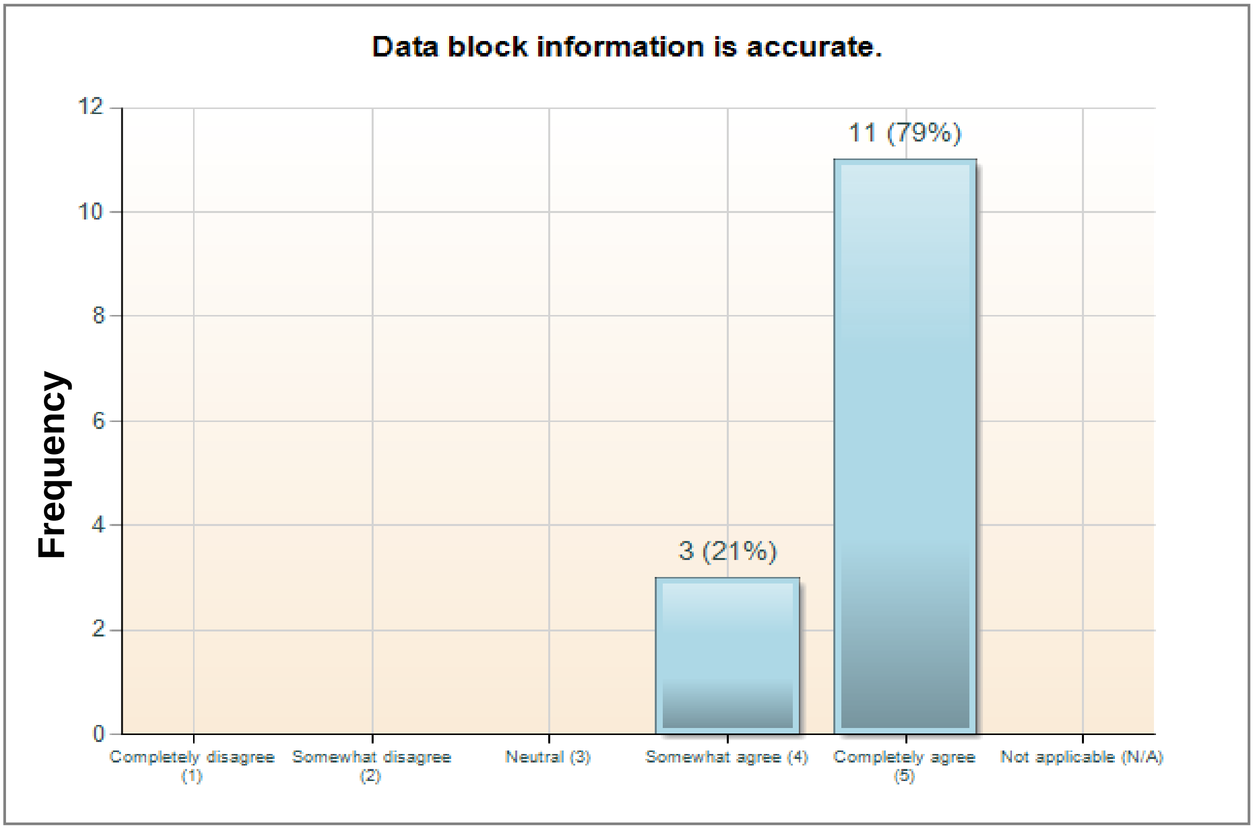

Figure J-12: Accuracy of TIDS data block information

As shown in Figure J-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.

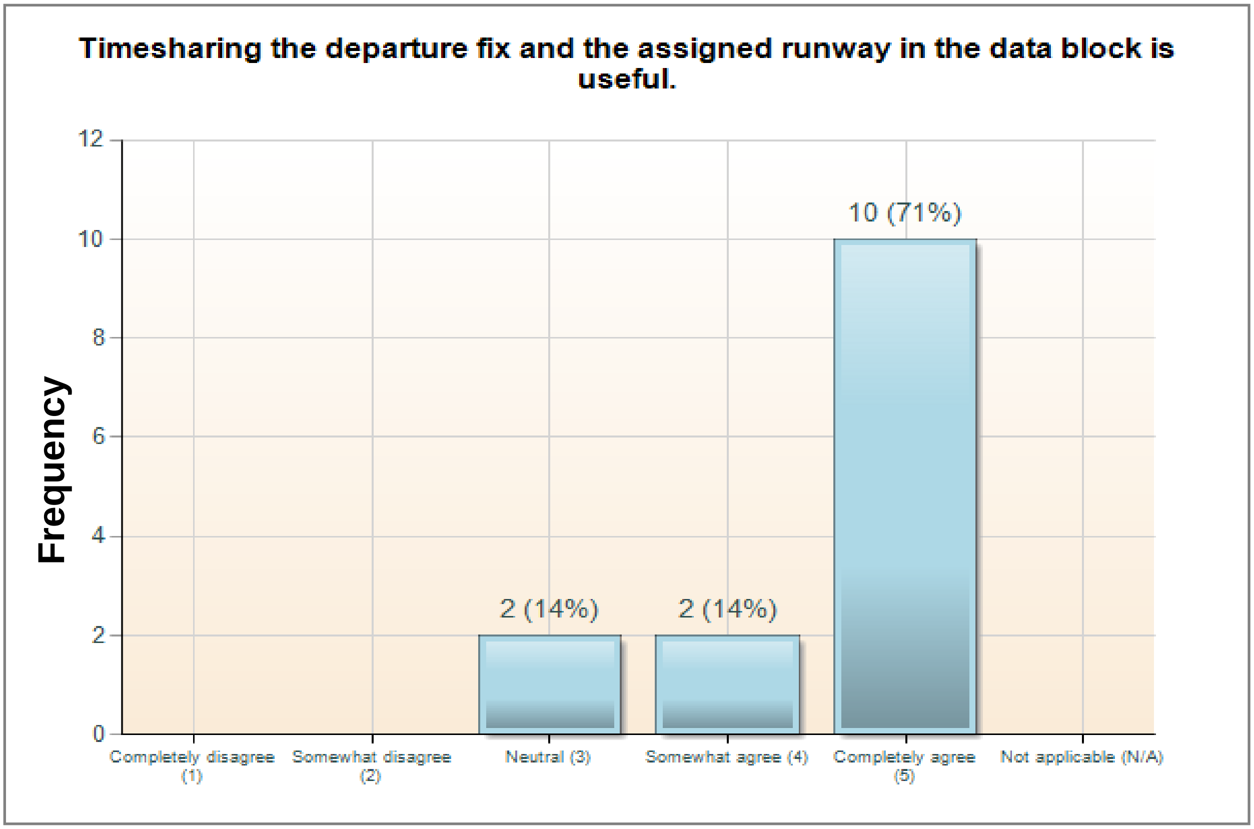

Figure J-13: Usefulness of timesharing data block

As shown in Figure J-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, χ^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.

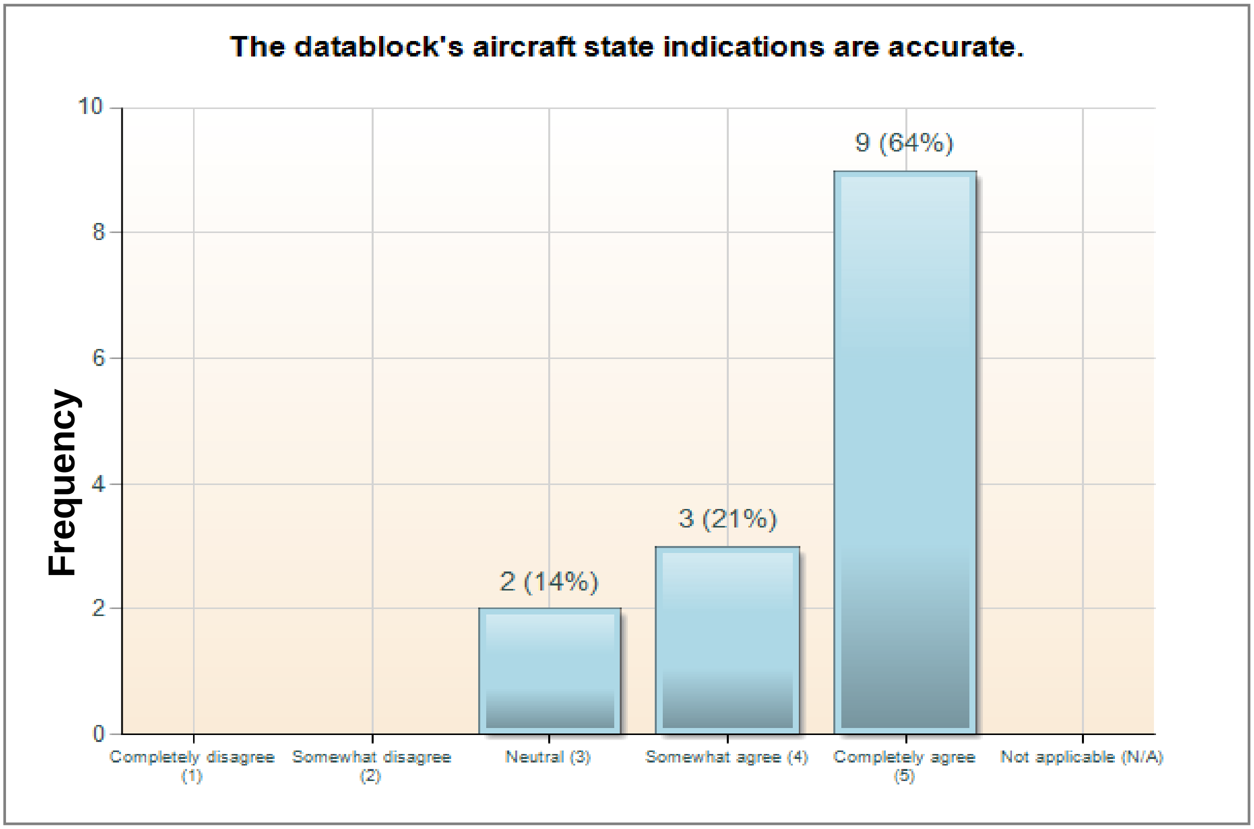

Figure J-14: Accuracy of data block state indication

As shown in Figure J-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.

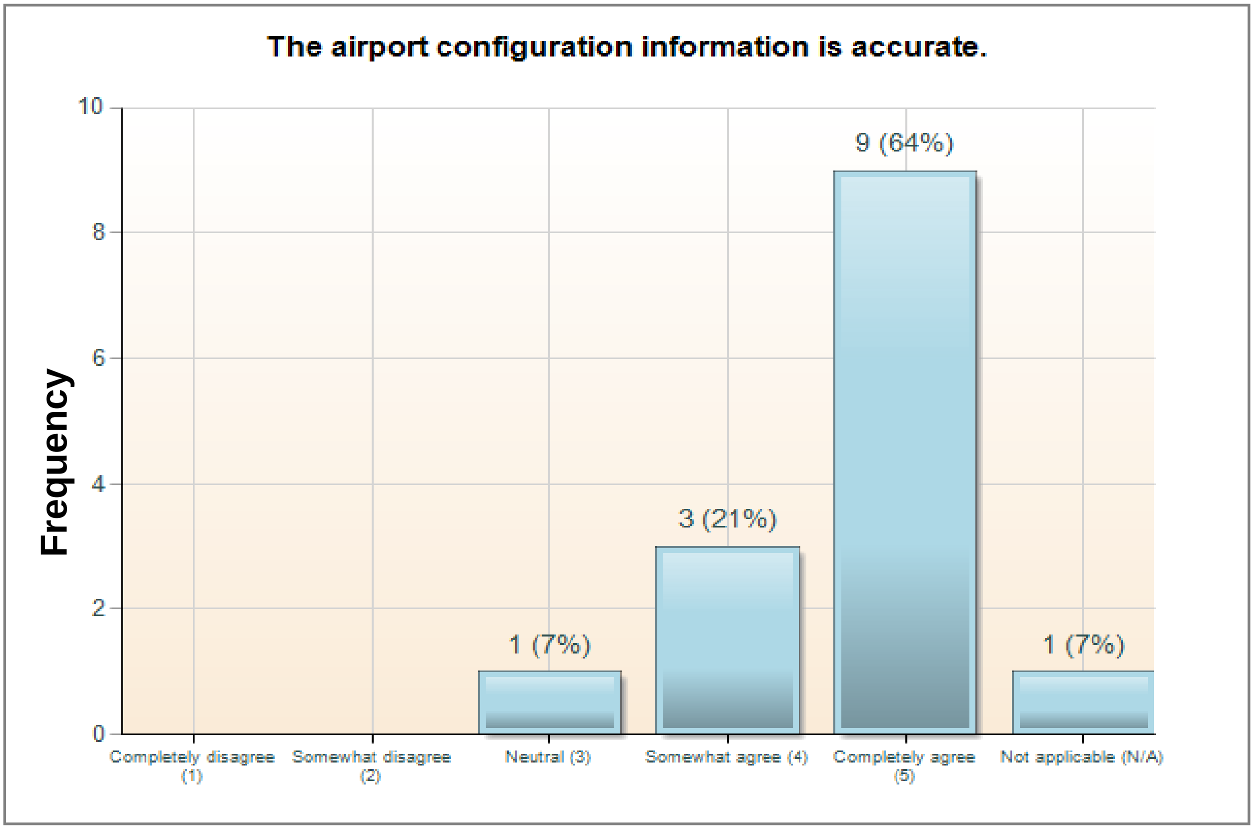

Figure J-15: Accuracy of airport configuration information

As shown in Figure J-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.

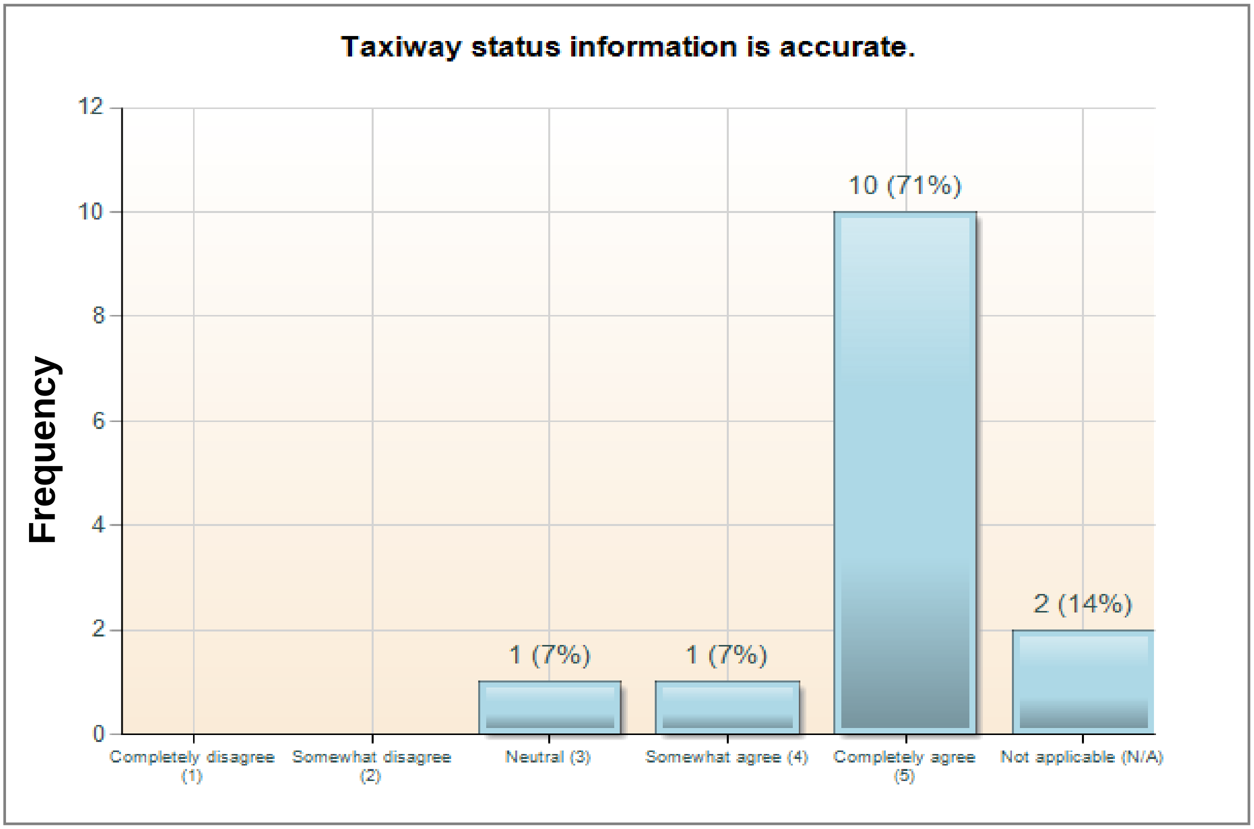

Figure J-16: Accuracy of taxiway status information

As shown in Figure J-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.

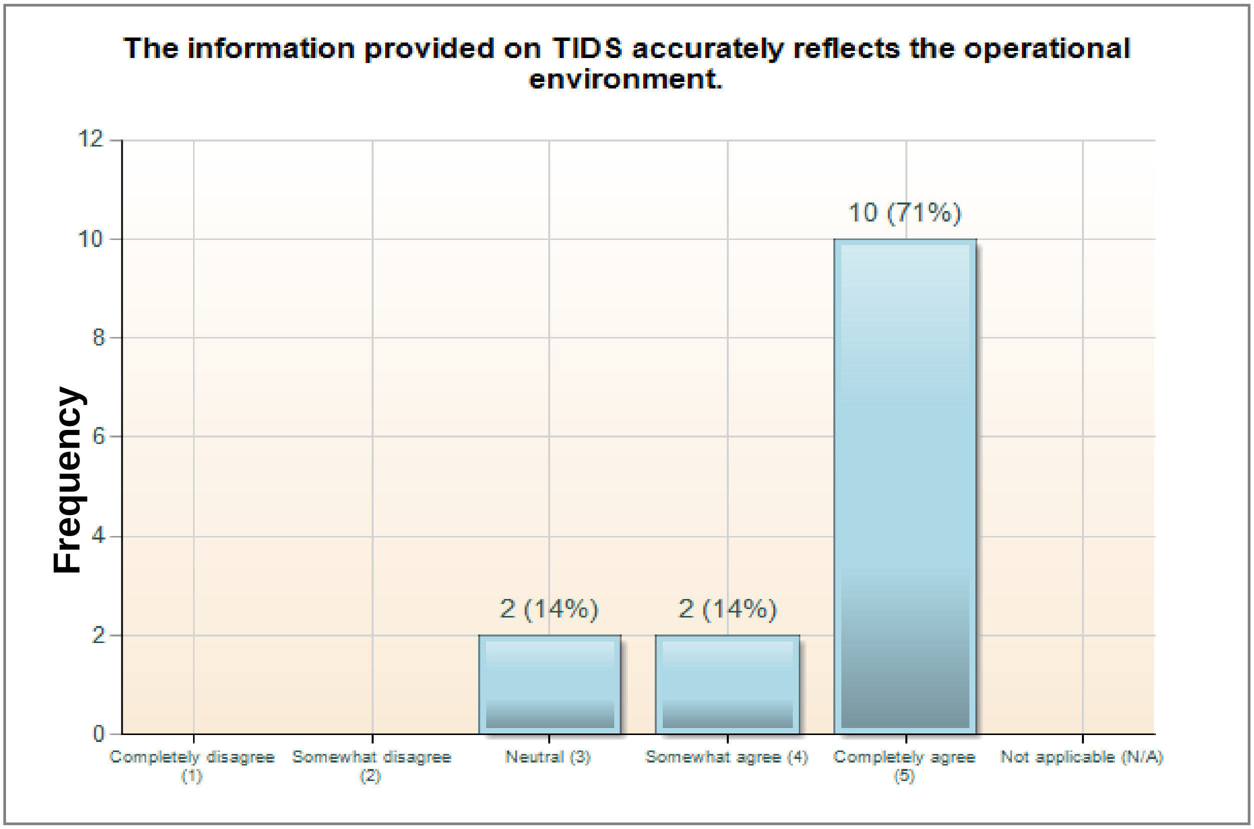

Figure J-17: Accuracy of the operational environment information

As shown in Figure J-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.

J.1.3 User Interface

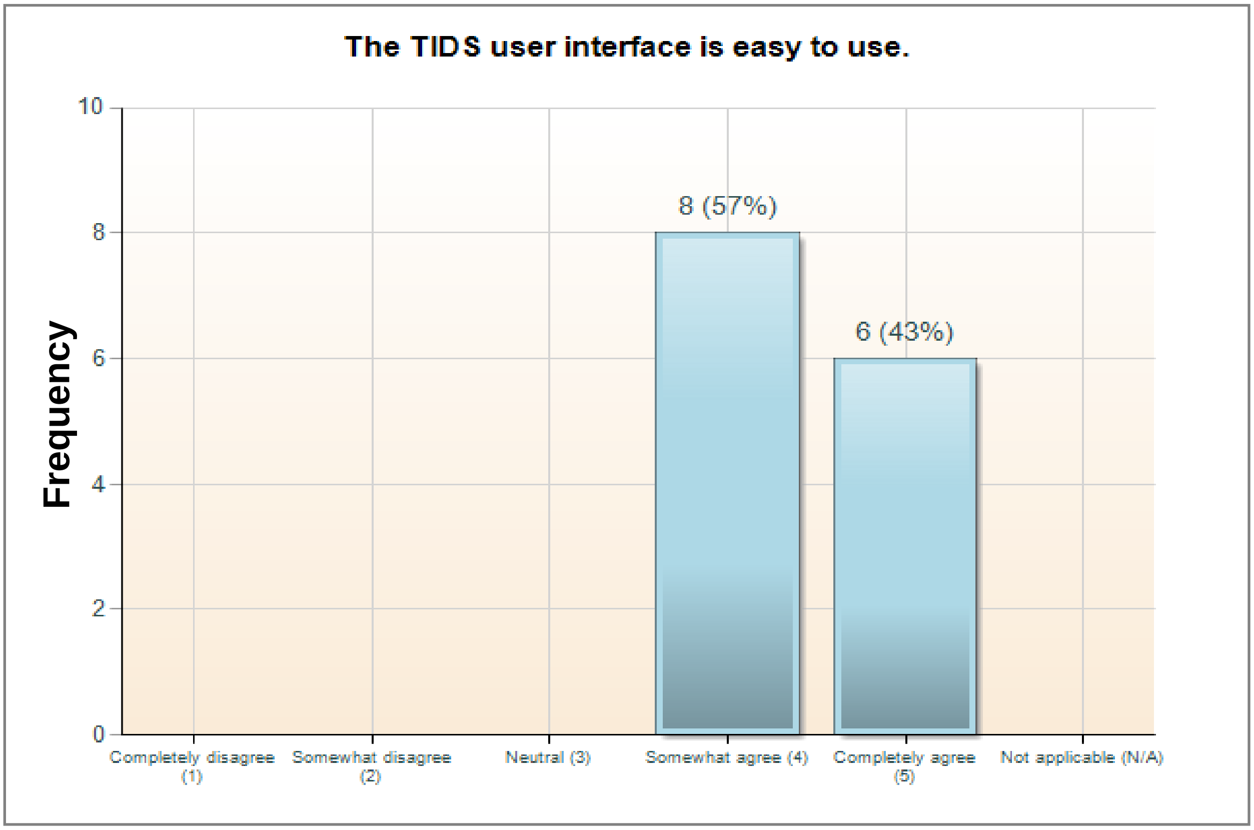

Figure J-18: Ease of use of the TIDS user interface

As shown in Figure J-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.

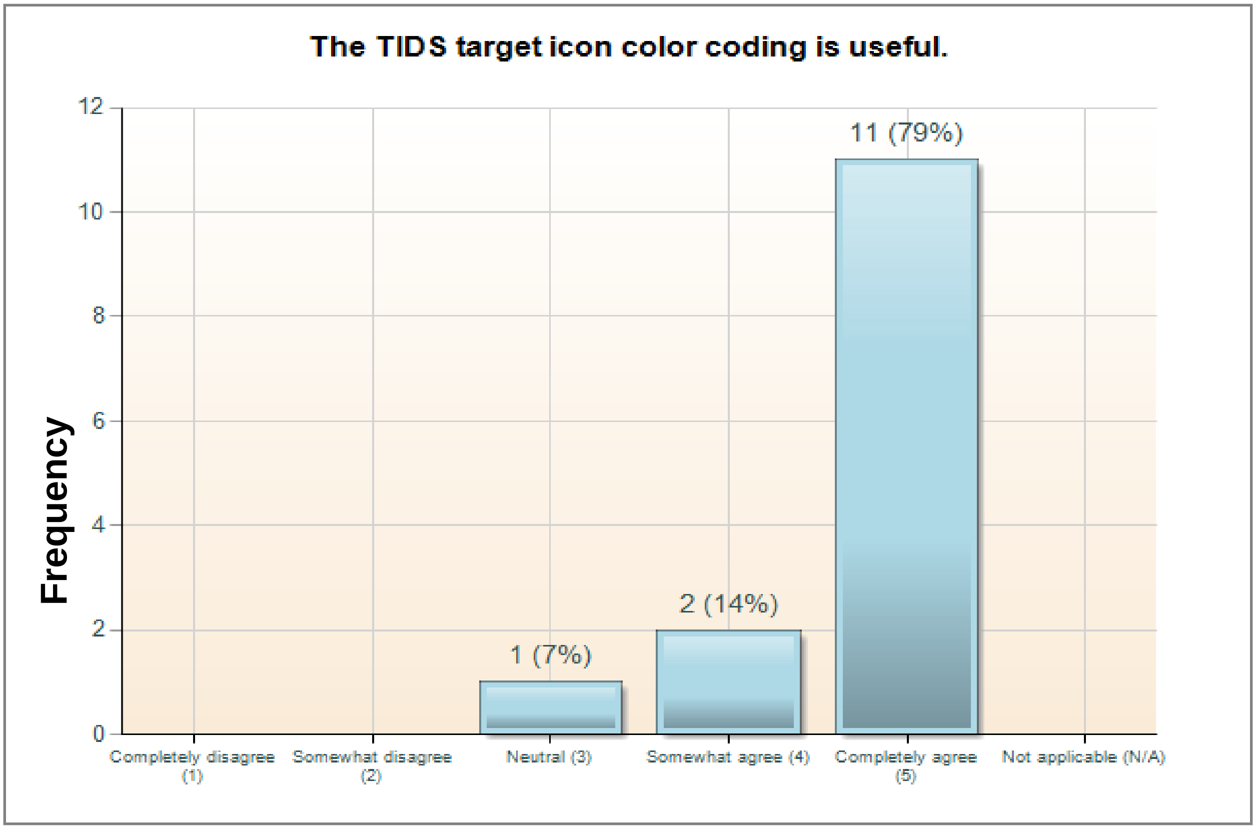

Figure J-19: Usefulness of the TIDS target icon color coding

As shown in Figure J-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.

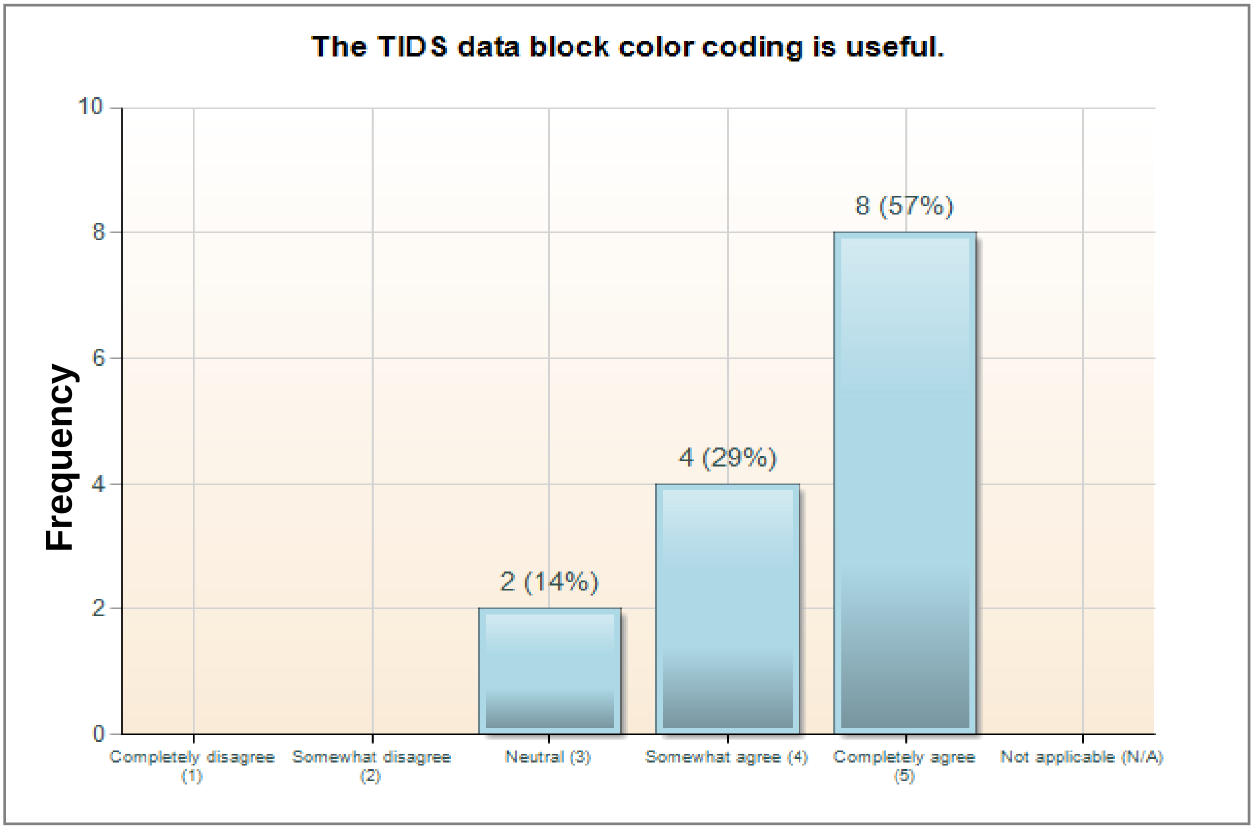

Figure J-20: Usefulness of the TIDS data block color-coding

As shown in Figure J-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.

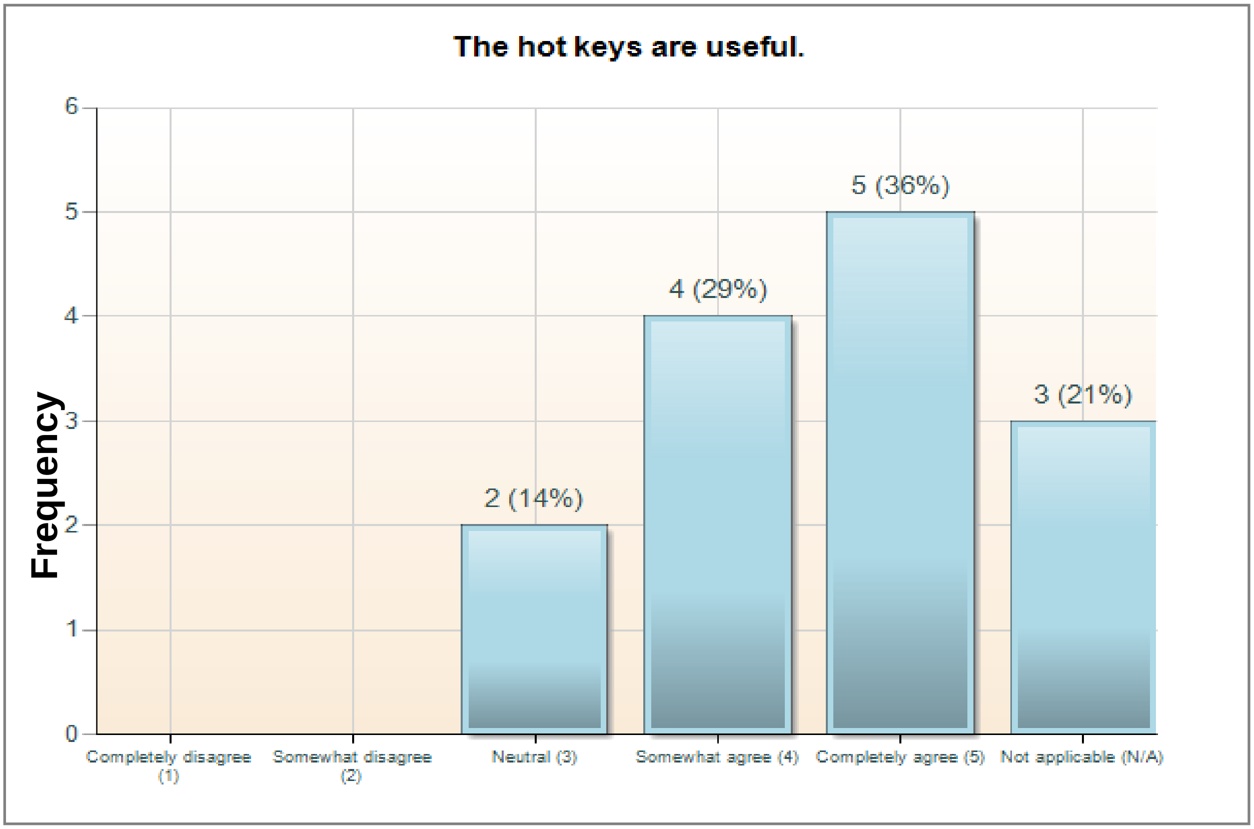

Figure J-21: Usefulness of hot keys

As shown in Figure J-21, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the hot keys, χ^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.

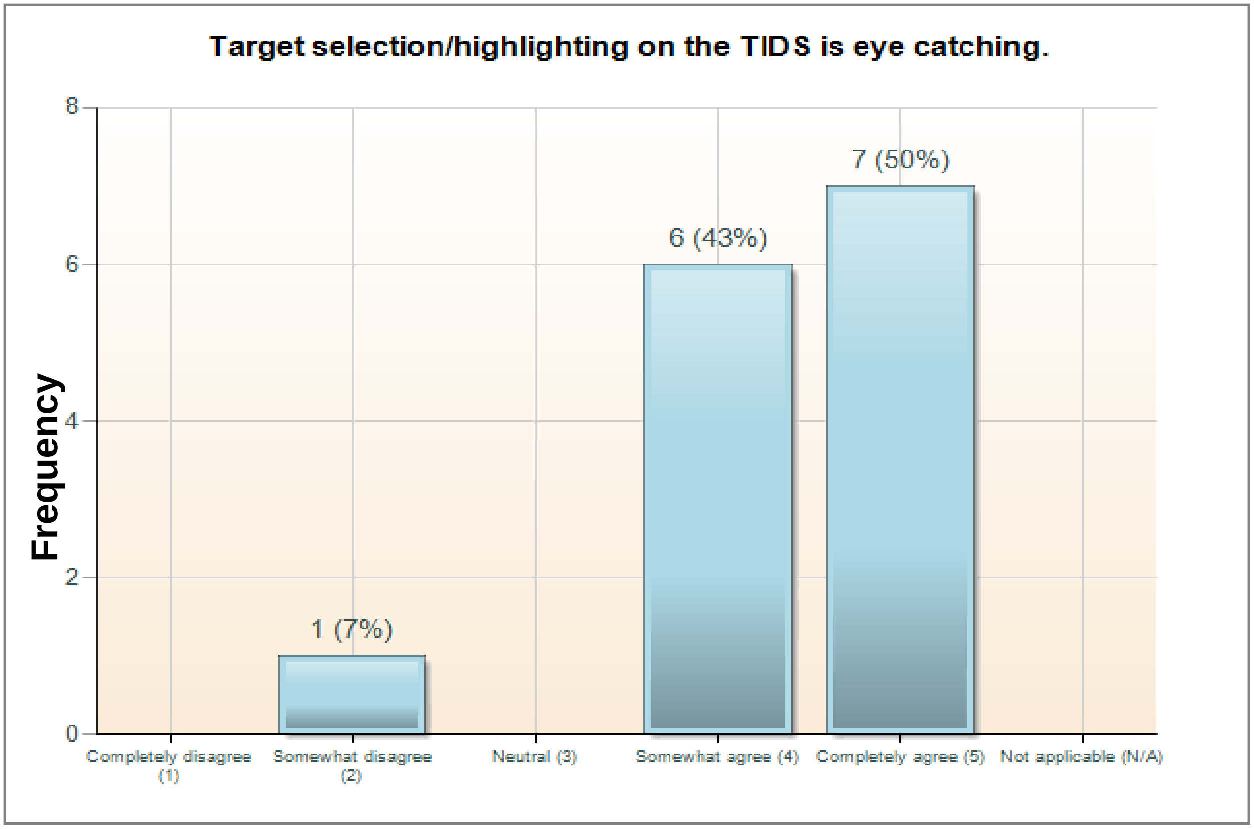

Figure J-22: Salient target selection highlighting

As shown in Figure J-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.

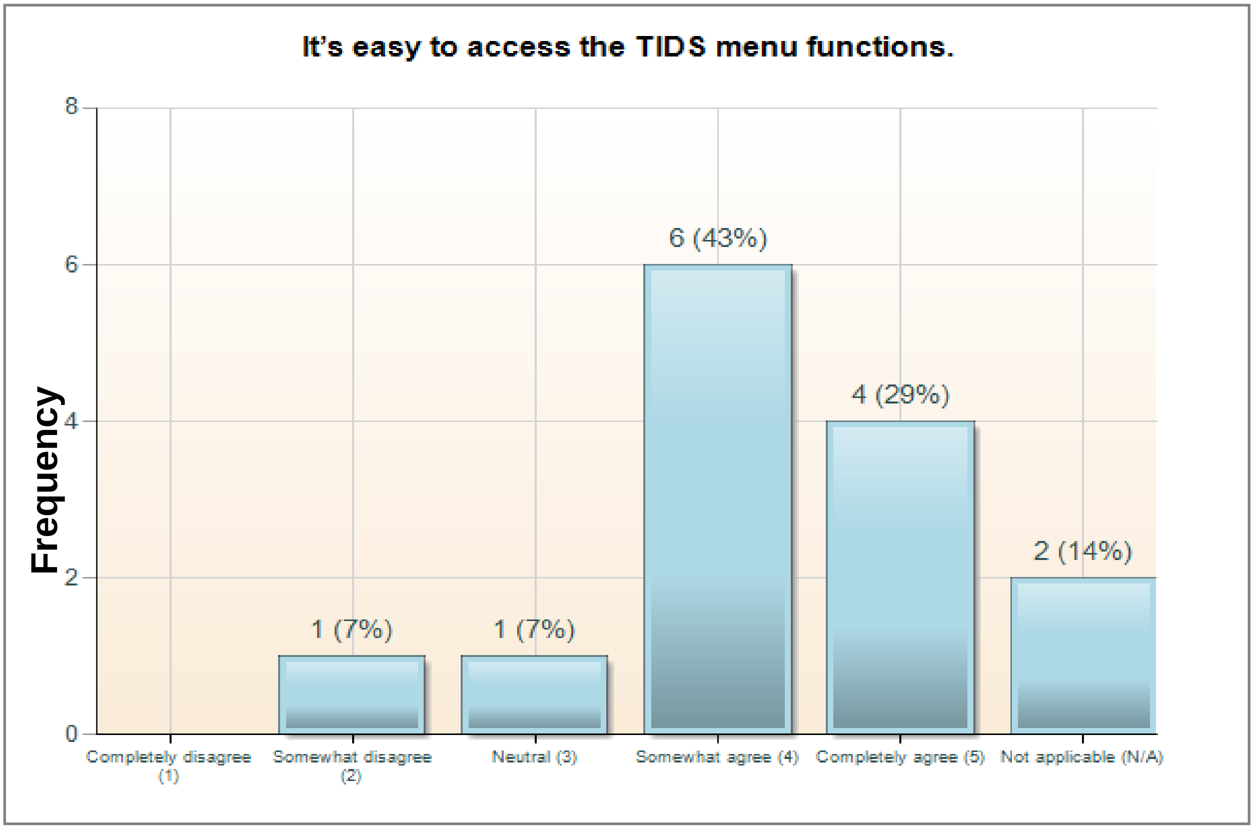

Figure J-23: Ease of accessing the TIDS menu functions

As shown in Figure J-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.

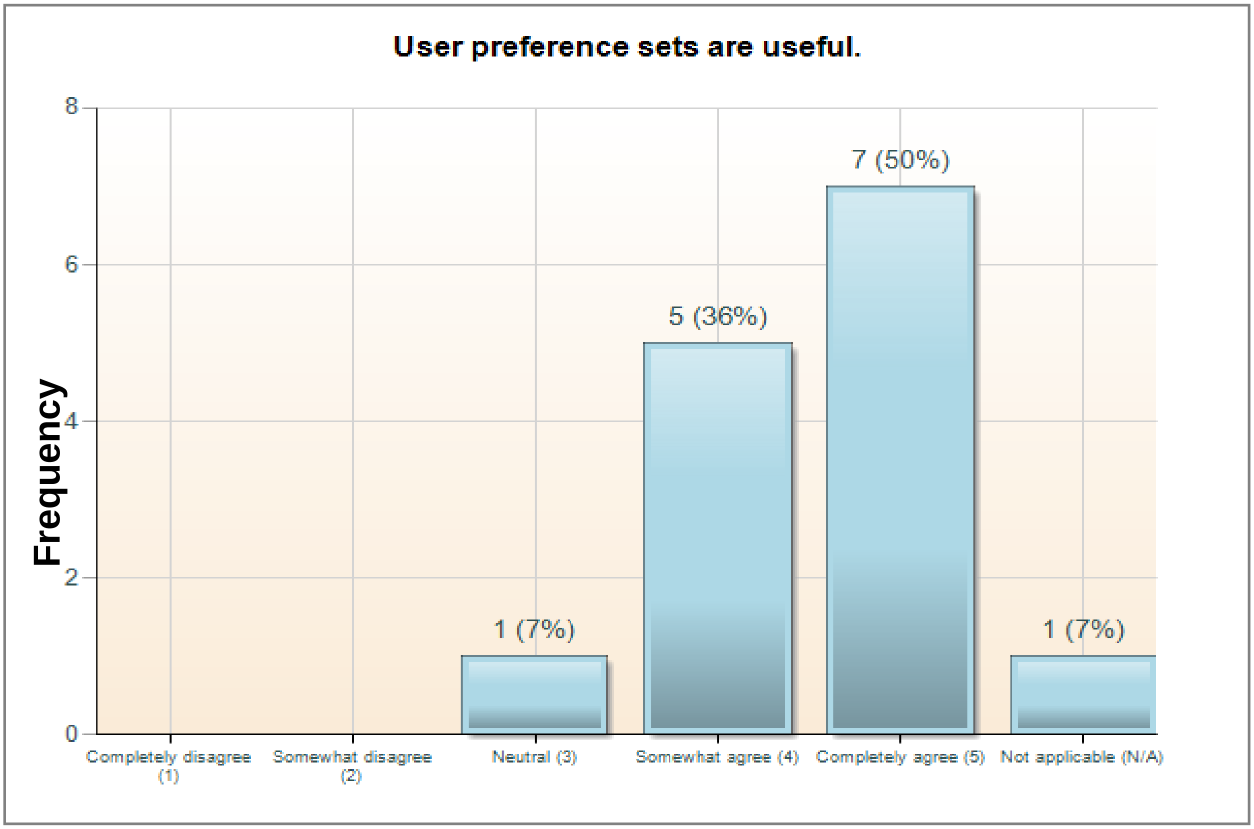

Figure J-24: Usefulness of user preferences sets

As shown in Figure J-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.

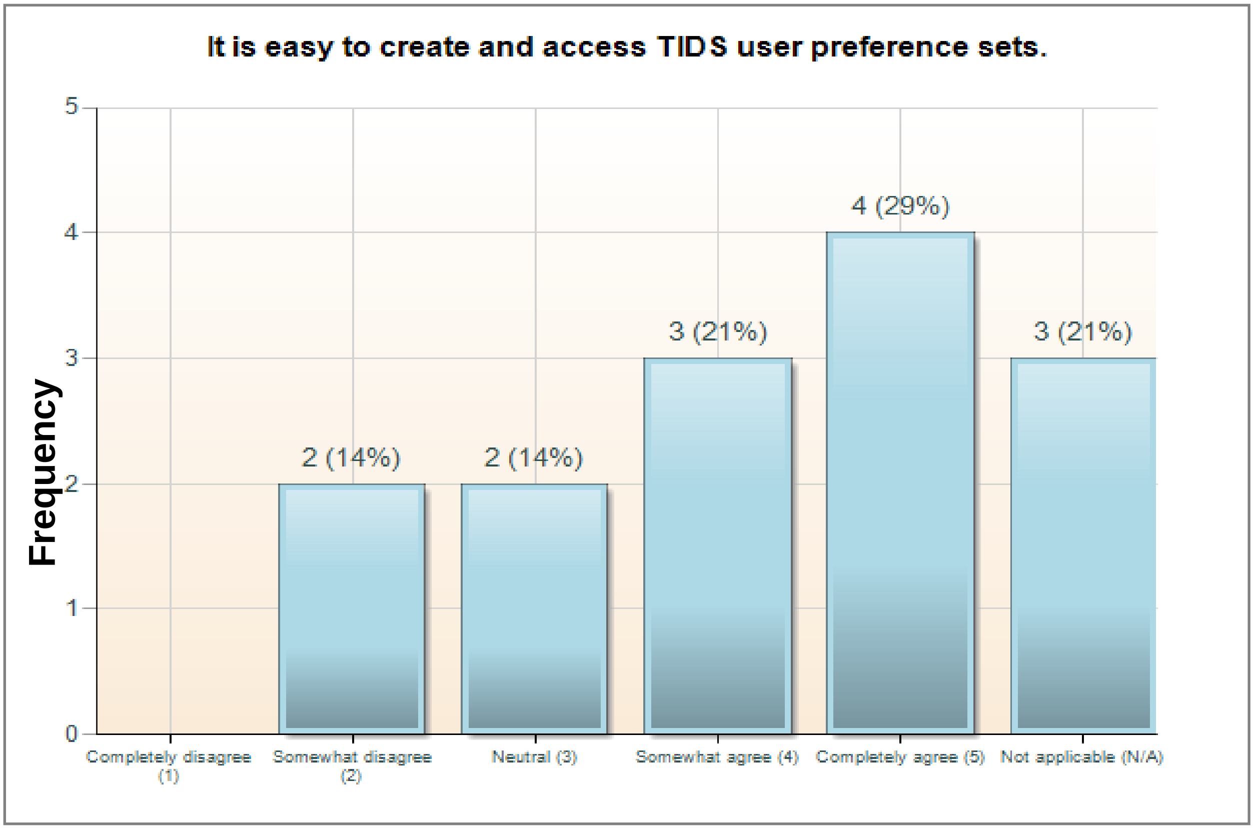

Figure J-25: Ease of creating and accessing user preference sets

As shown in Figure J-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.

J.1.4 Picture-in-Picture Windows

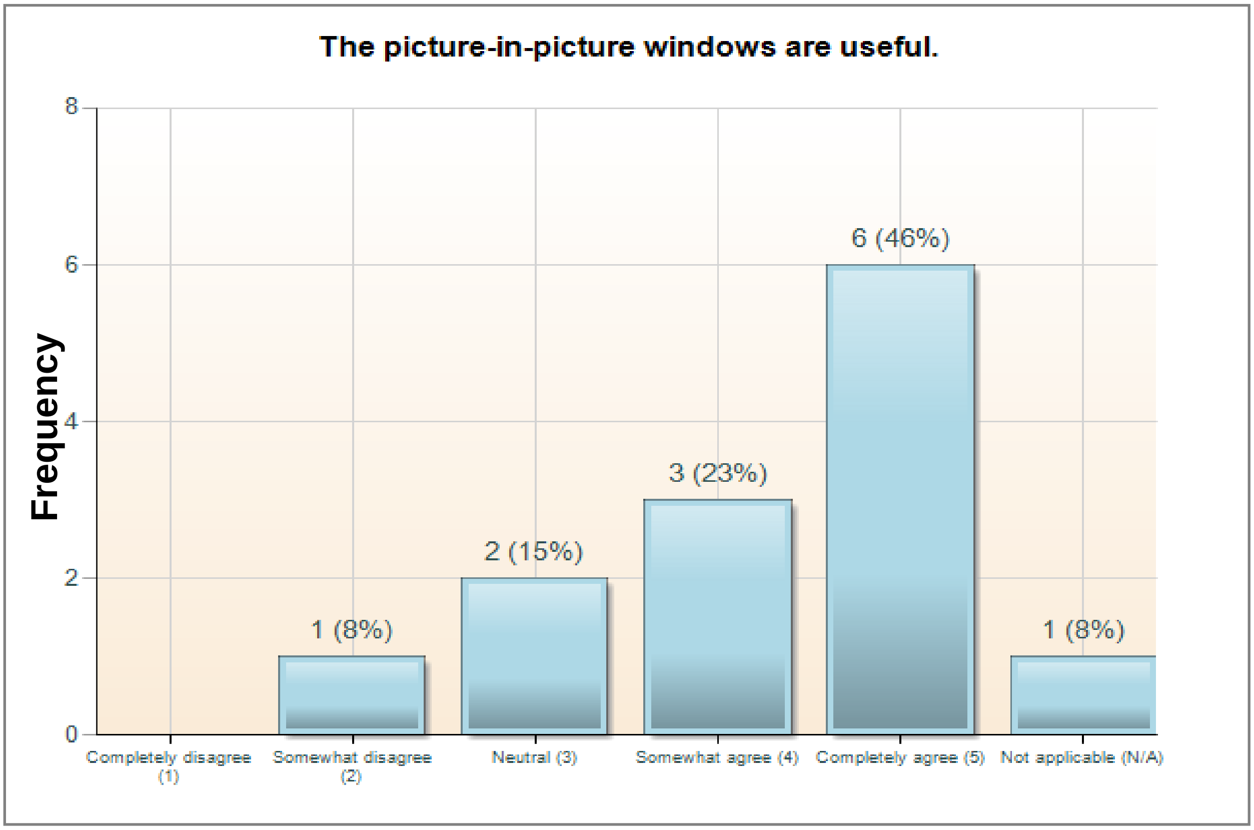

Figure J-26: Usefulness of TIDS picture-in-picture windows

As shown in Figure J-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.

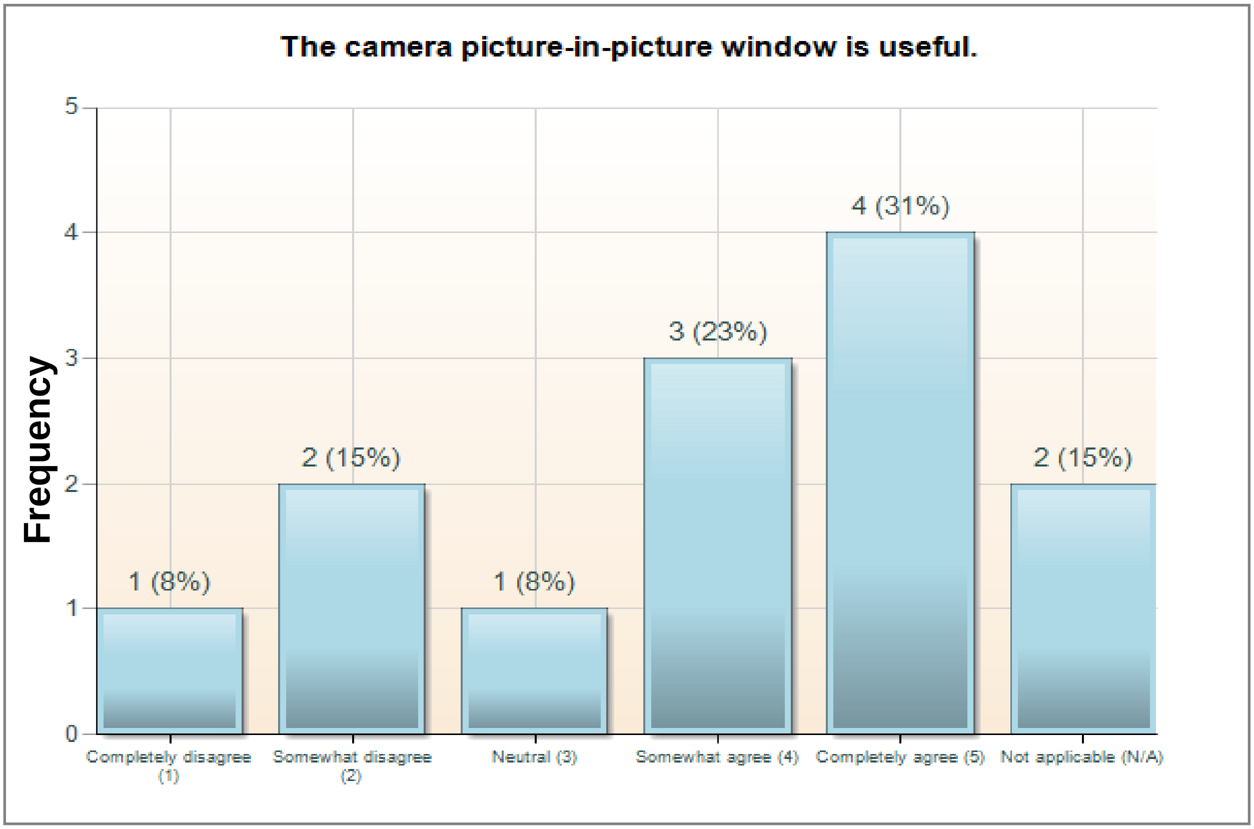

Figure J-27: Usefulness of camera picture-in-picture window

As shown in Figure J-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.

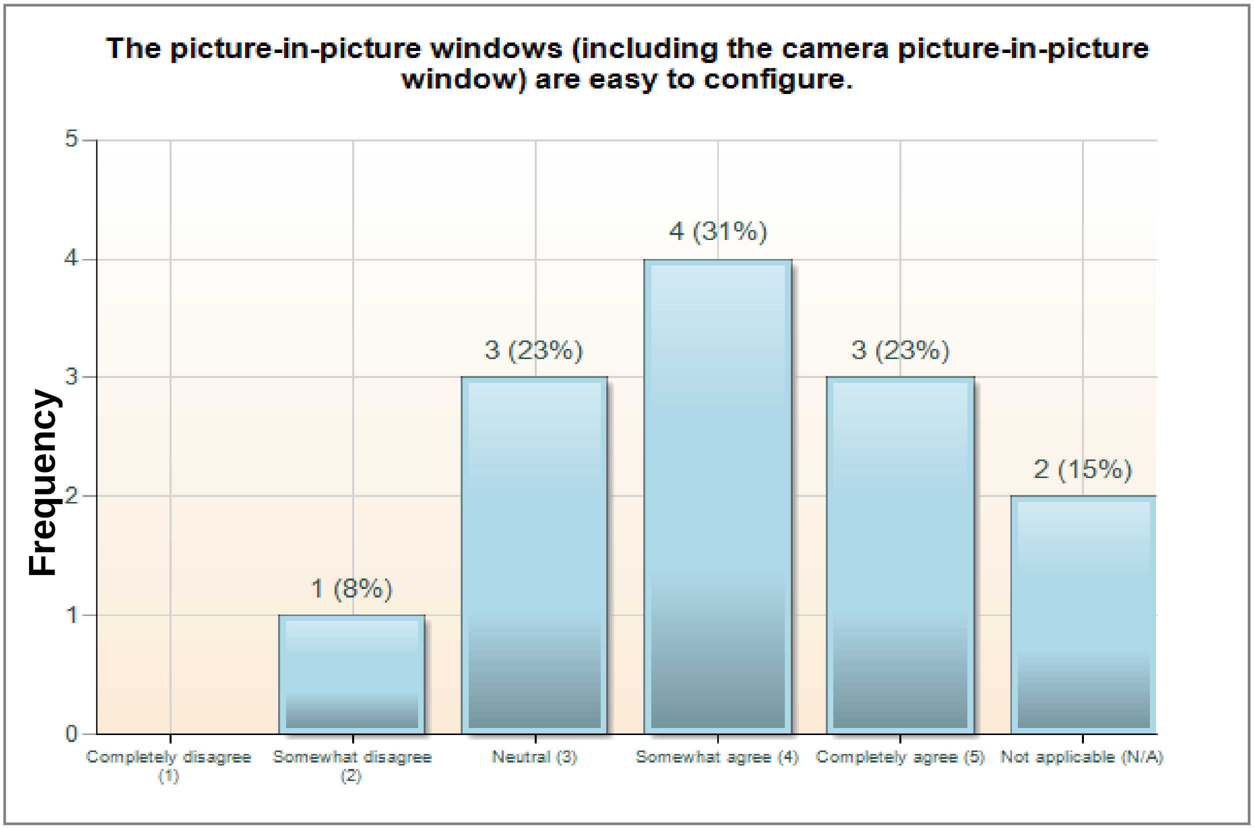

Figure J-28: Ease of configuration of picture-in-picture windows

As shown in Figure J-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.

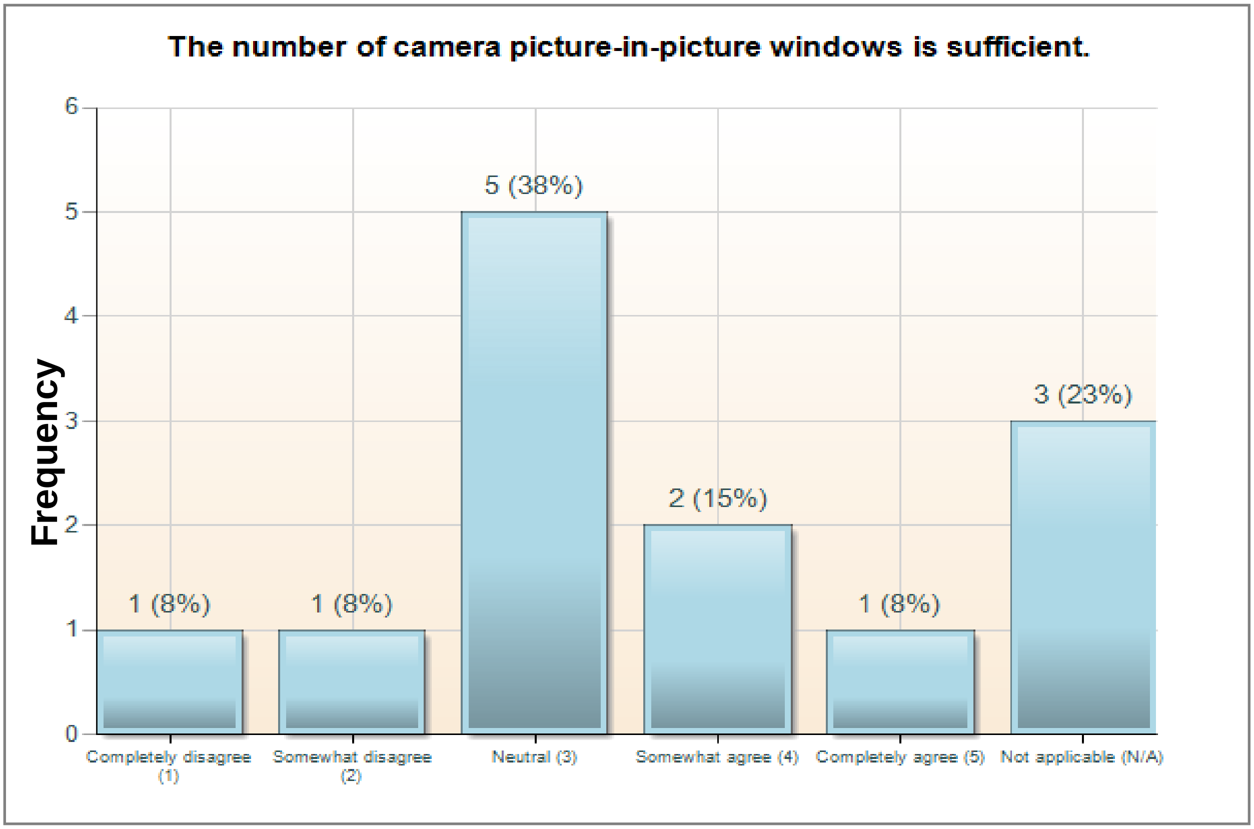

Figure J-29: Sufficiency of number of camera picture-in-picture windows

As shown in Figure J-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.

J.1.5 Wind Information

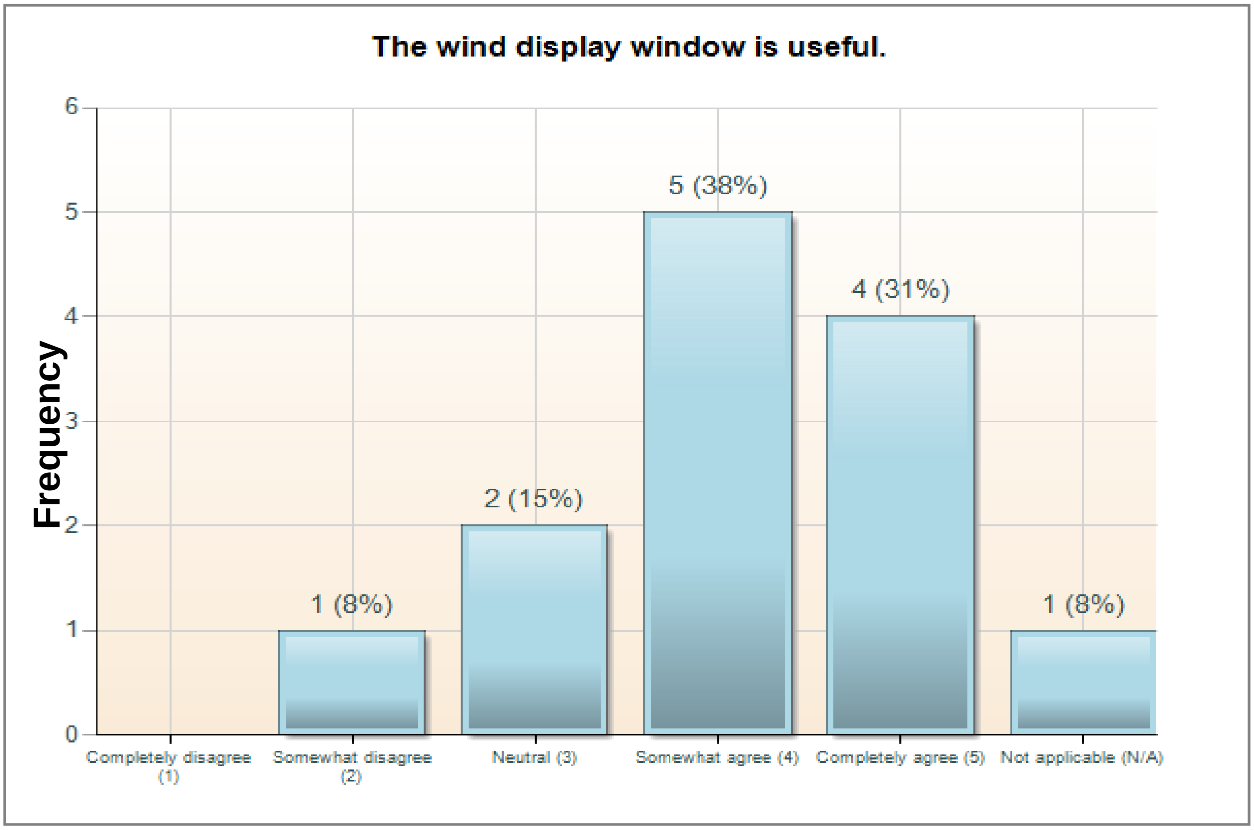

Figure J-30: Usefulness of the wind display window

As shown in Figure J-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.

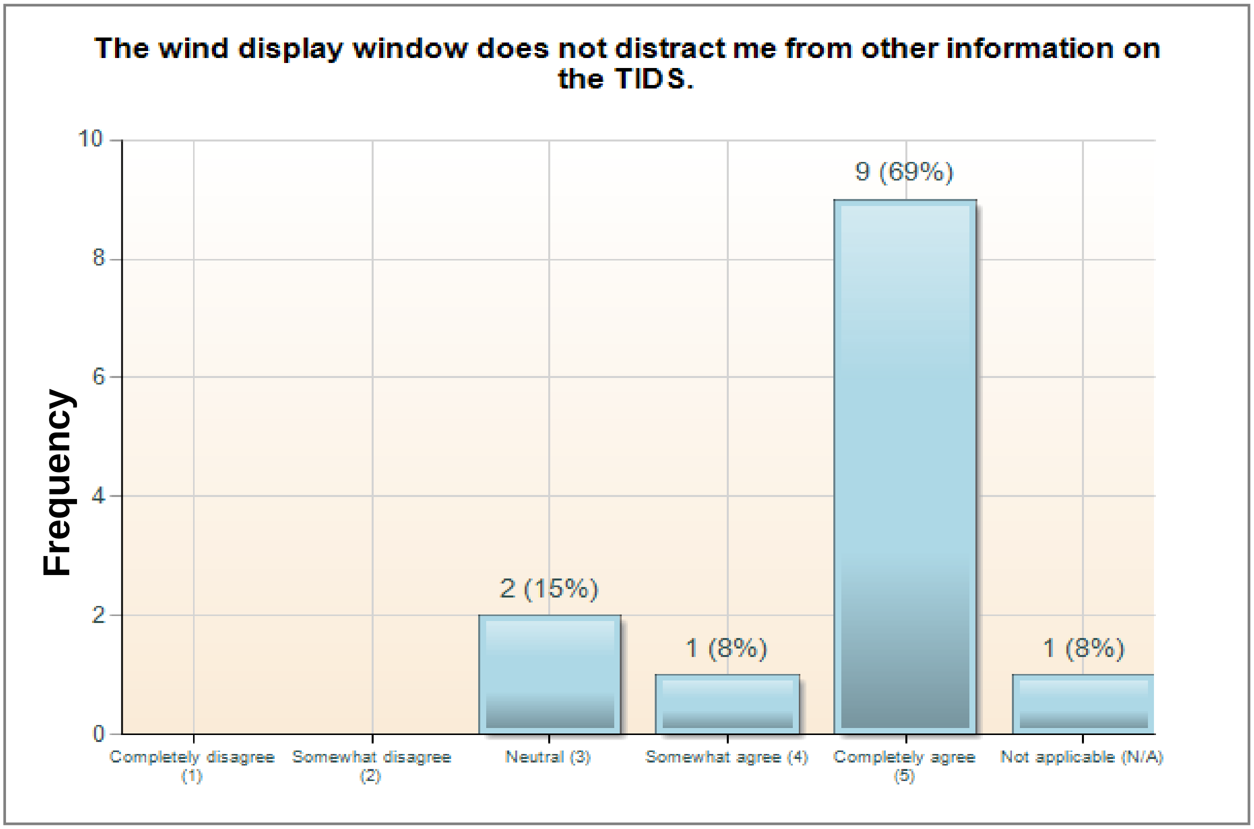

Figure J-31: Distraction of the wind display window

As shown in Figure J-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.

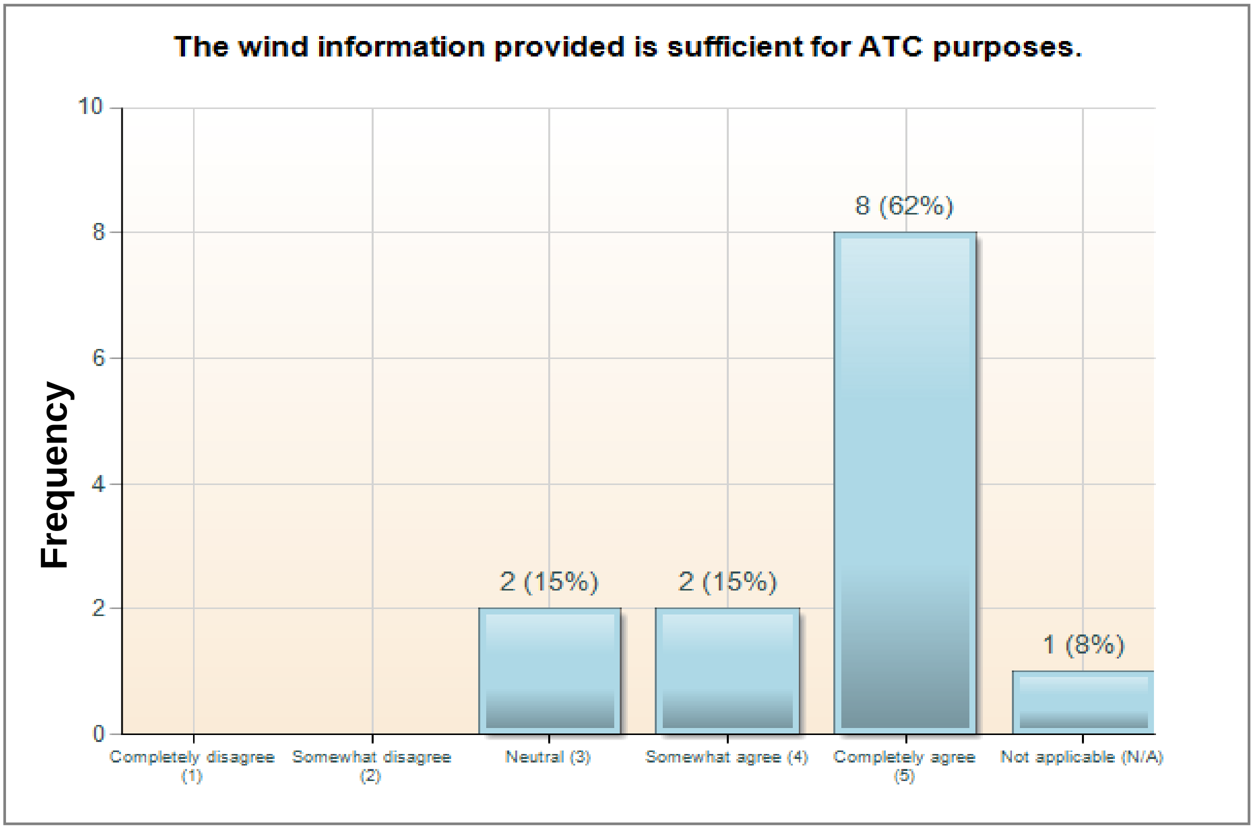

Figure J-32: Wind display sufficiency

As shown in Figure J-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.

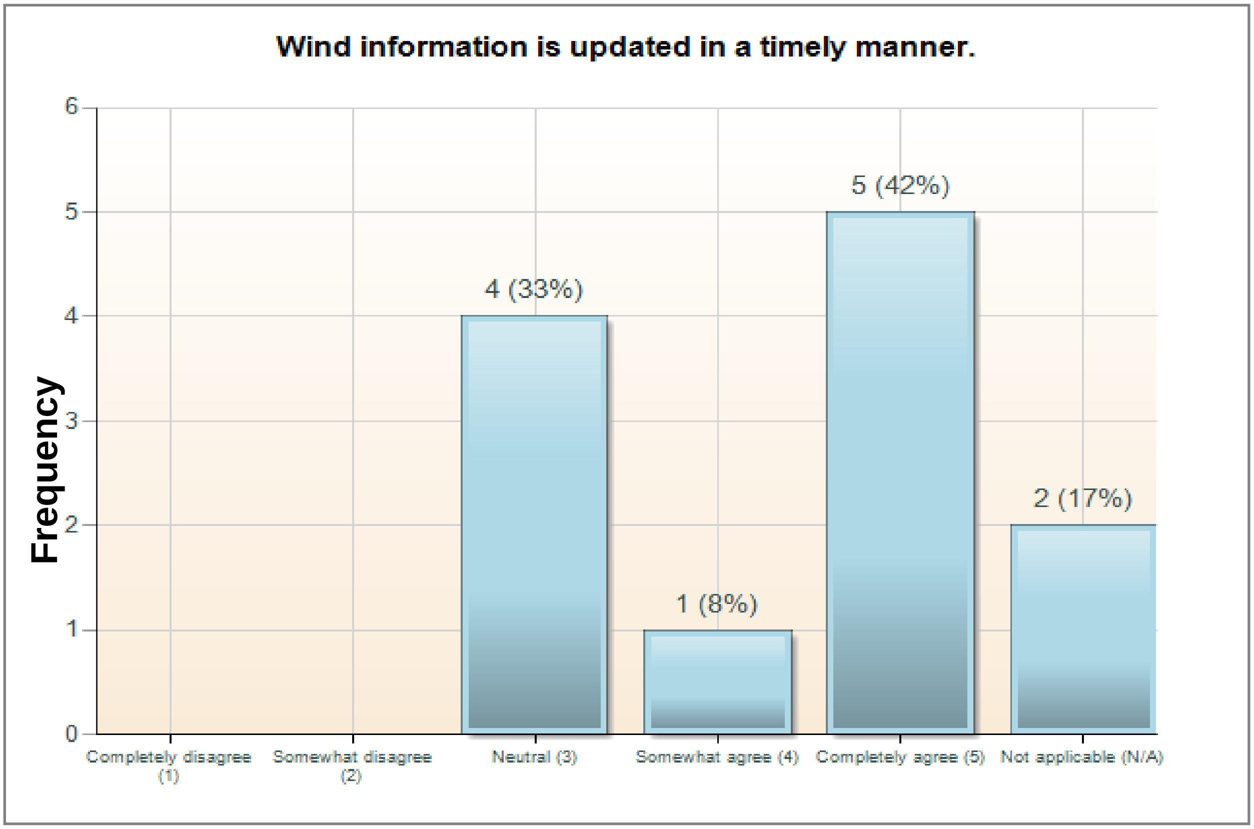

Figure J-33: Timeliness of wind information update

As shown in Figure J-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.

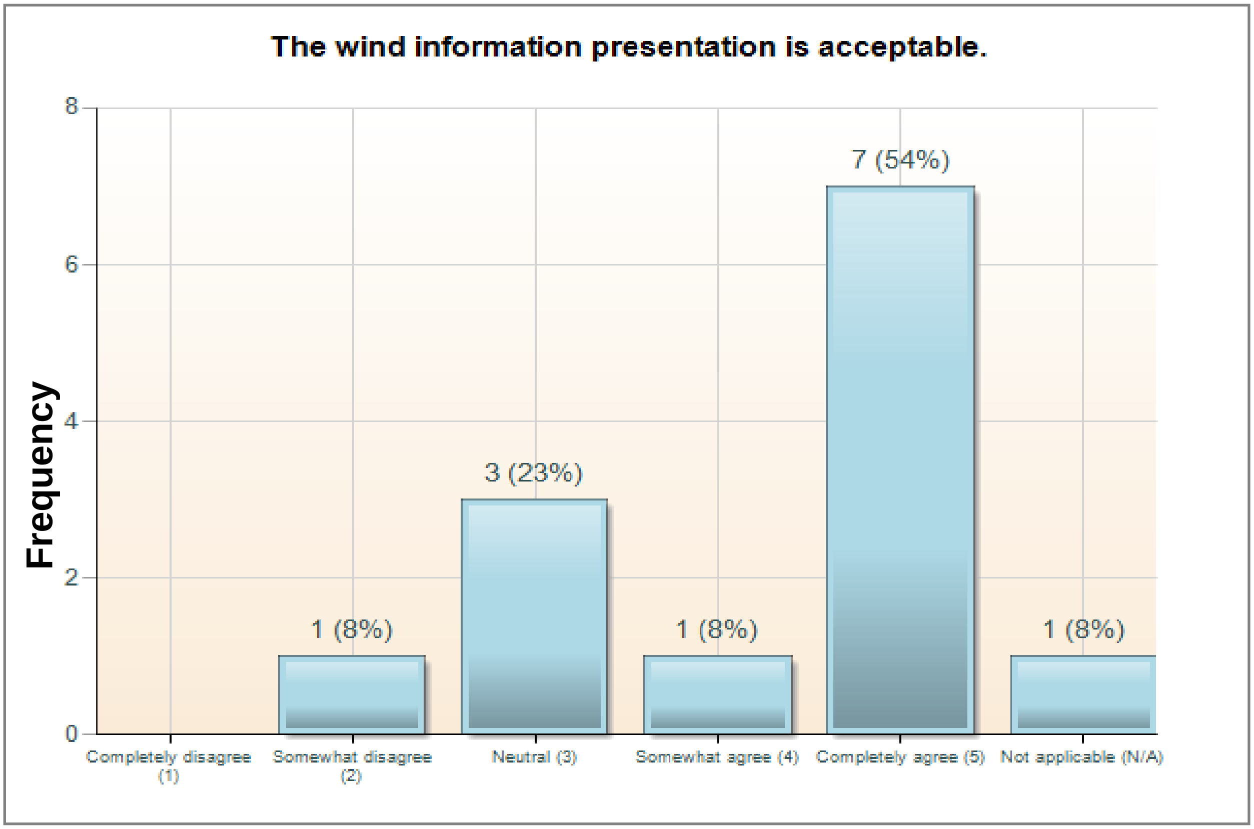

Figure J-34: Acceptability of wind information display

As shown in Figure J-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.

J.1.6 Display Features

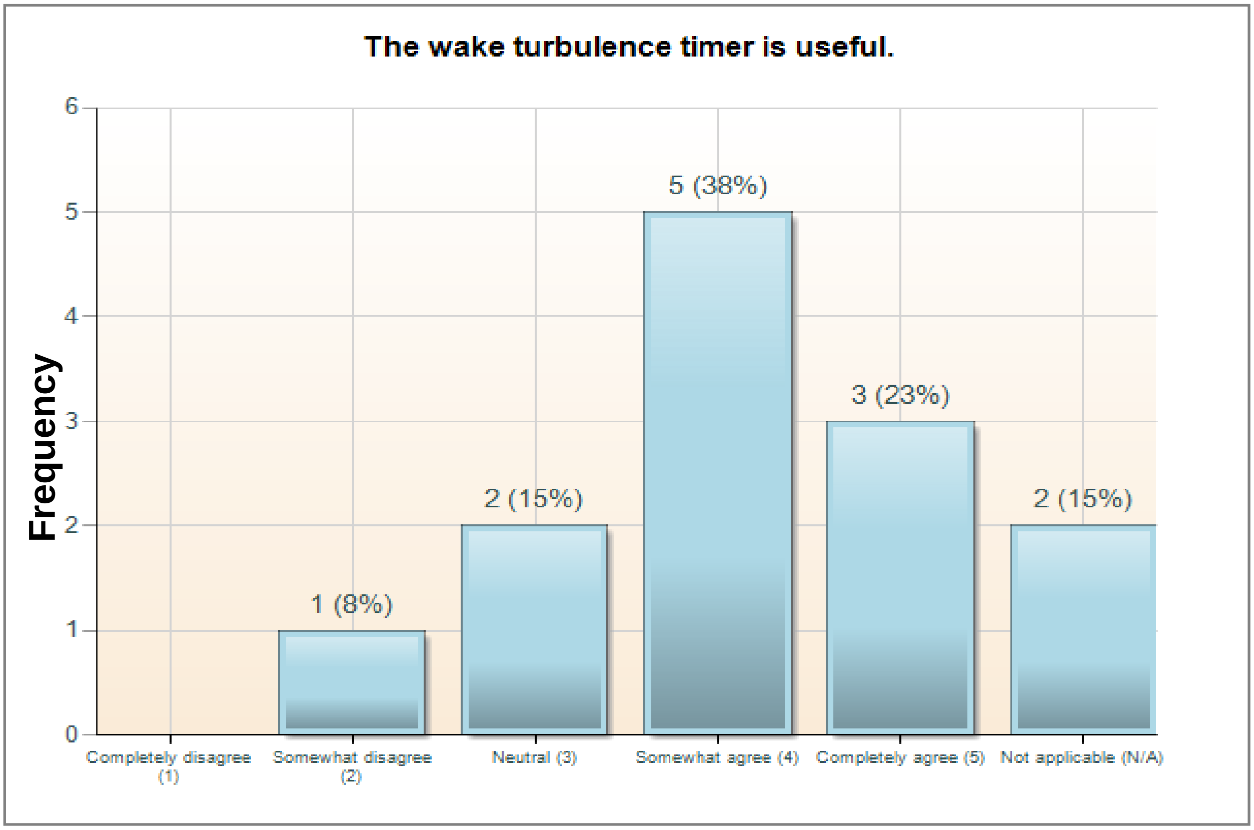

Figure J-35: Usefulness of the wake turbulence timer

As shown in Figure J-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.

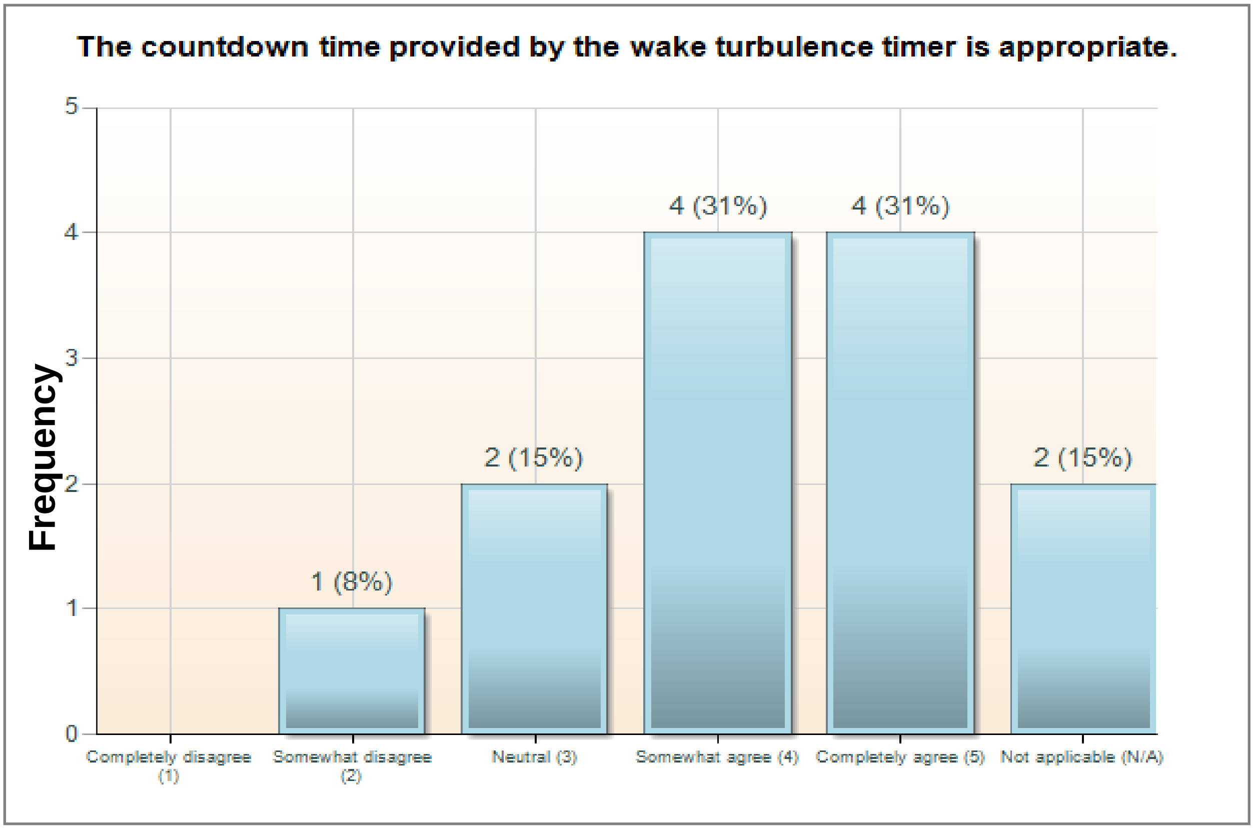

Figure J-36: Appropriateness of wake turbulence timer duration

As shown in Figure J-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.

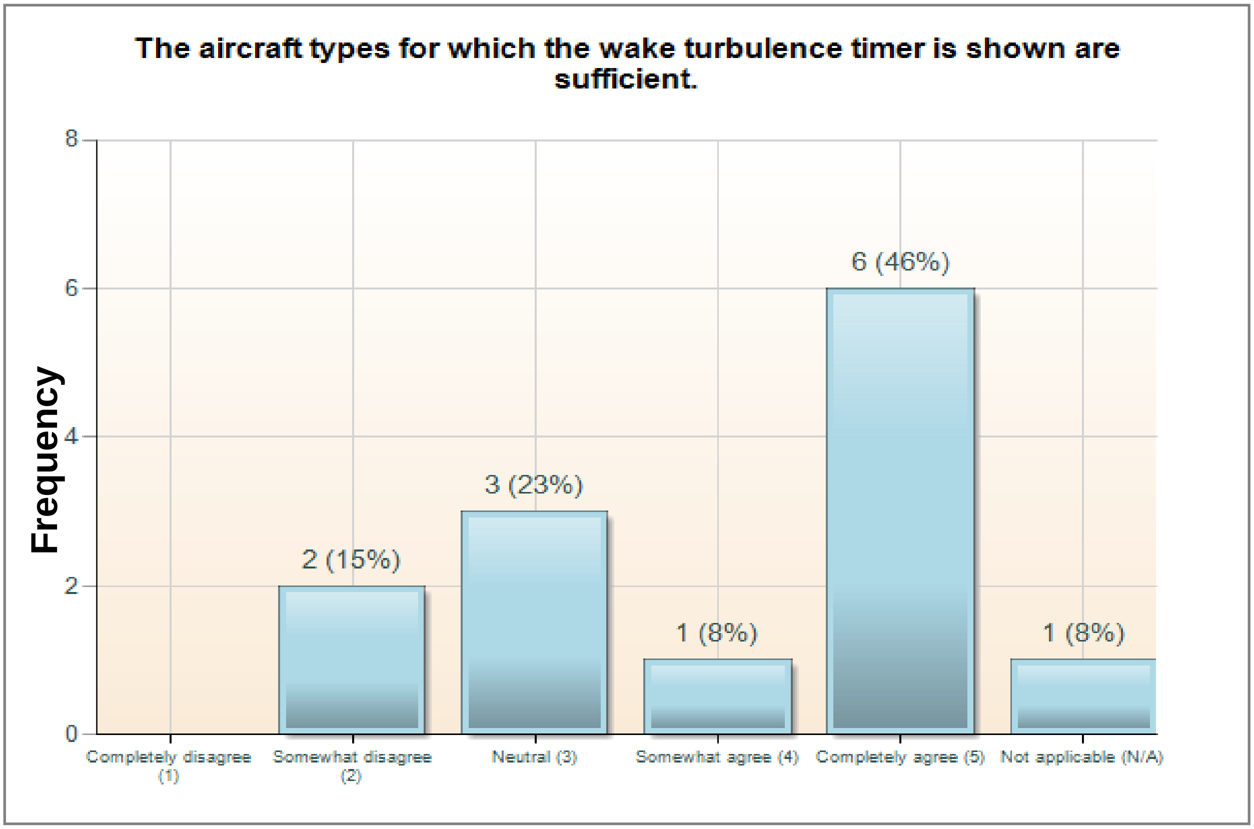

Figure J-37: Sufficiency of aircraft types triggering the wake turbulence timer

As shown in Figure J-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.

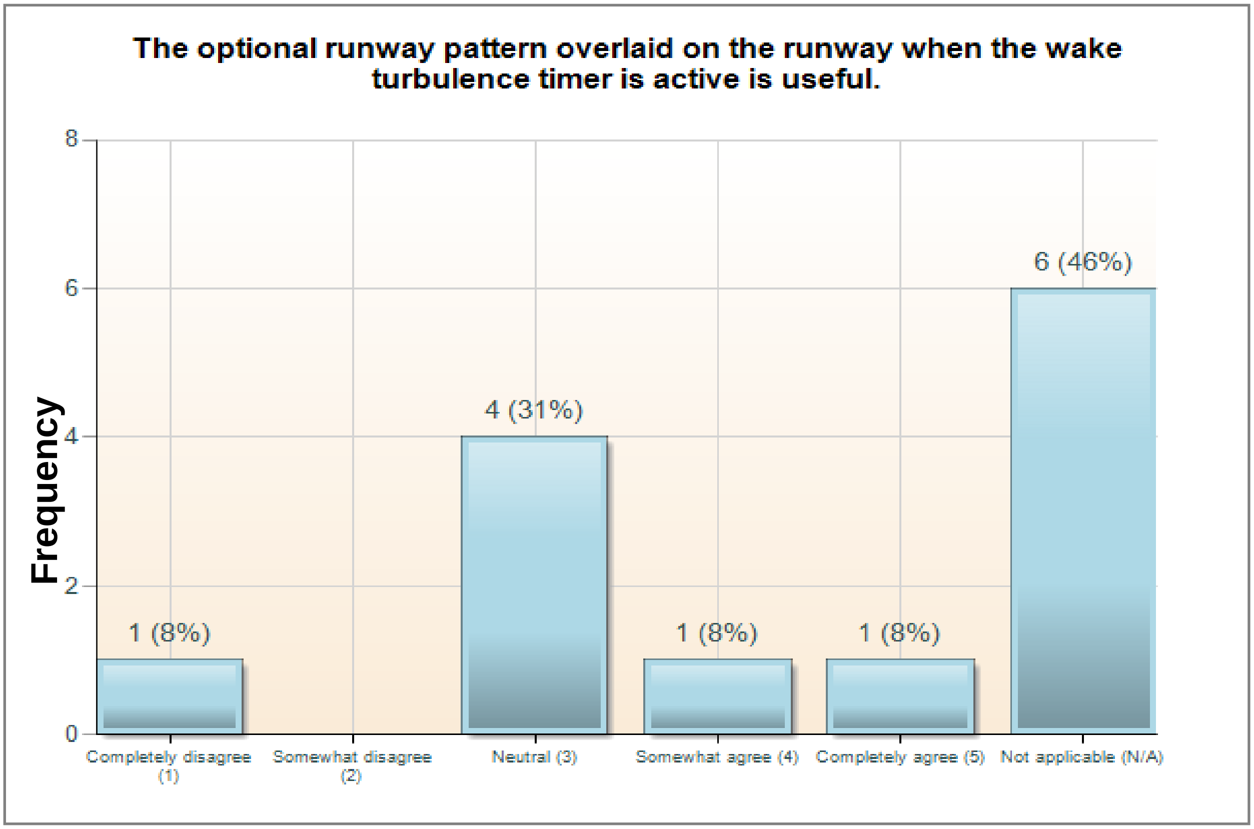

Figure J-38: Usefulness of runway overlay pattern

As shown in Figure J-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.

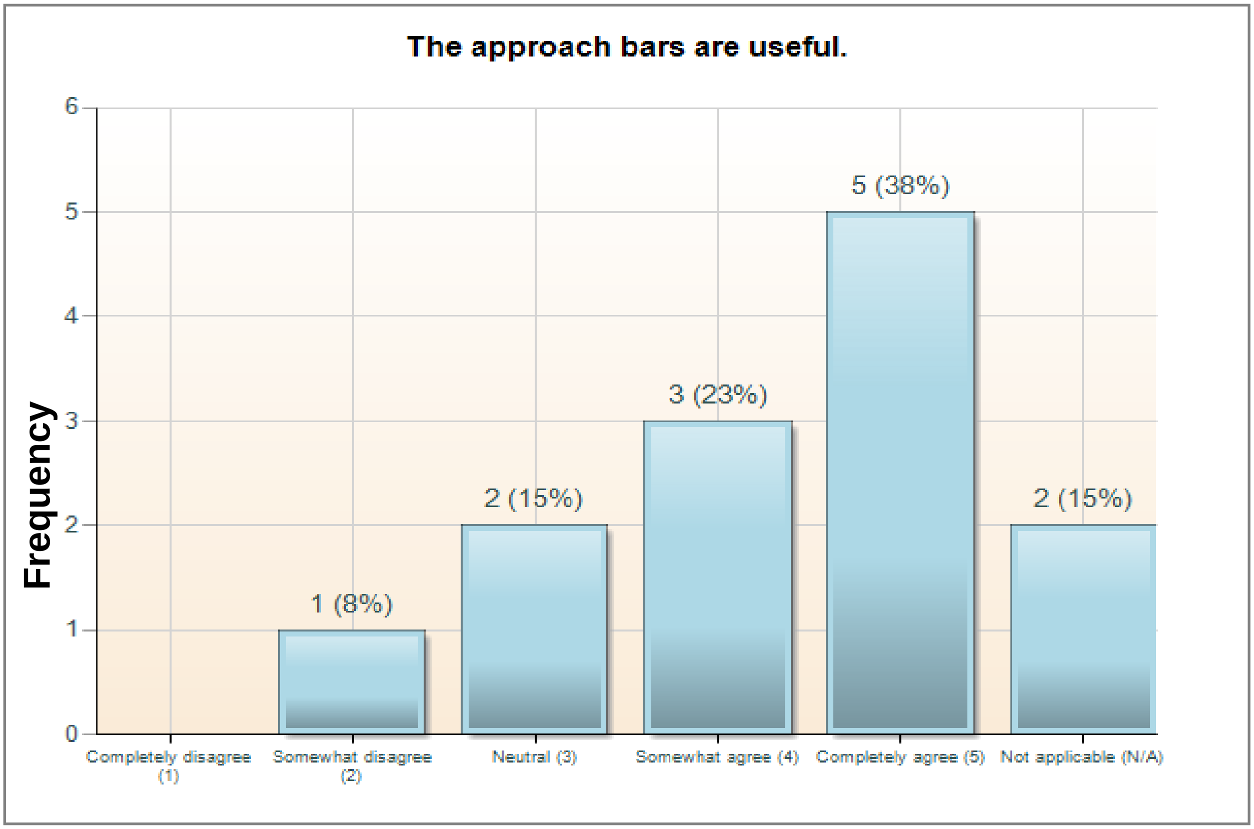

Figure J-39: Usefulness of the approach bars

As shown in Figure J-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.

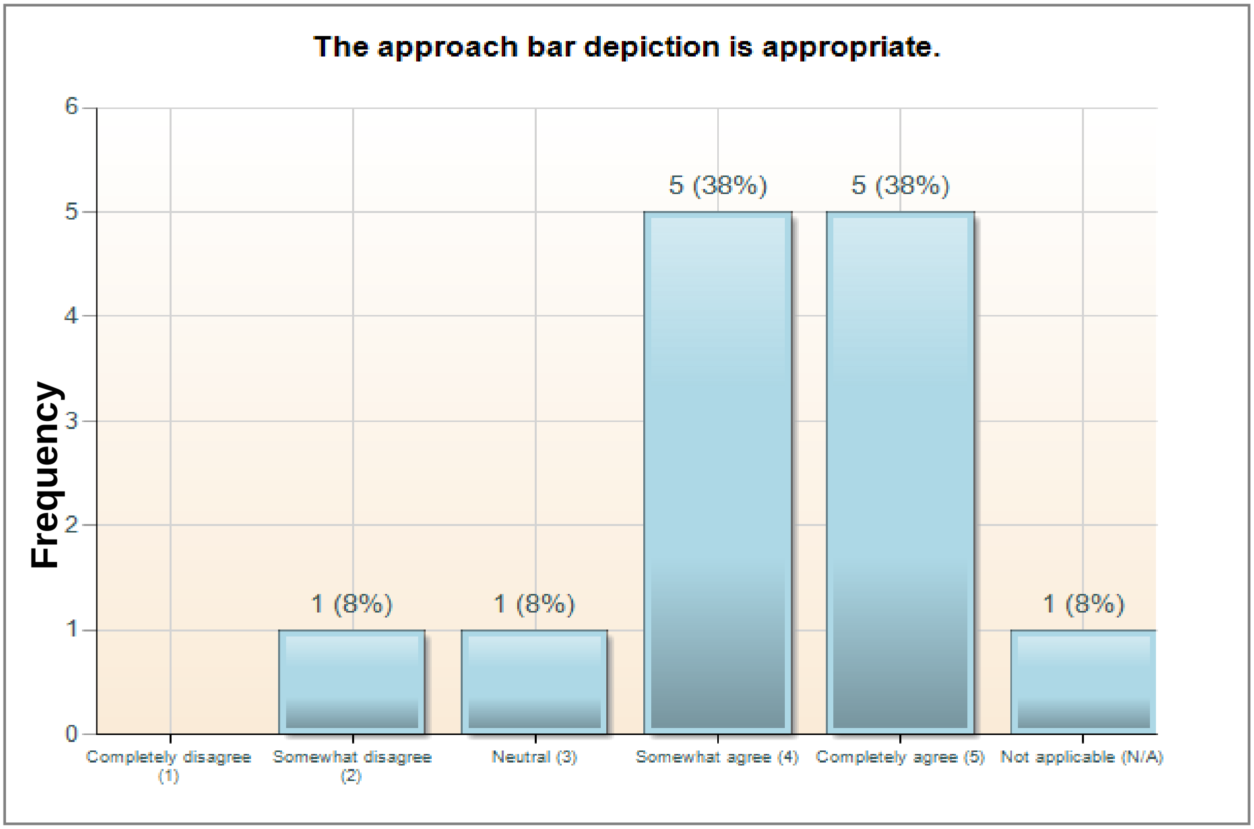

Figure J-40: Appropriateness of the approach bar depiction

As shown in Figure J-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.

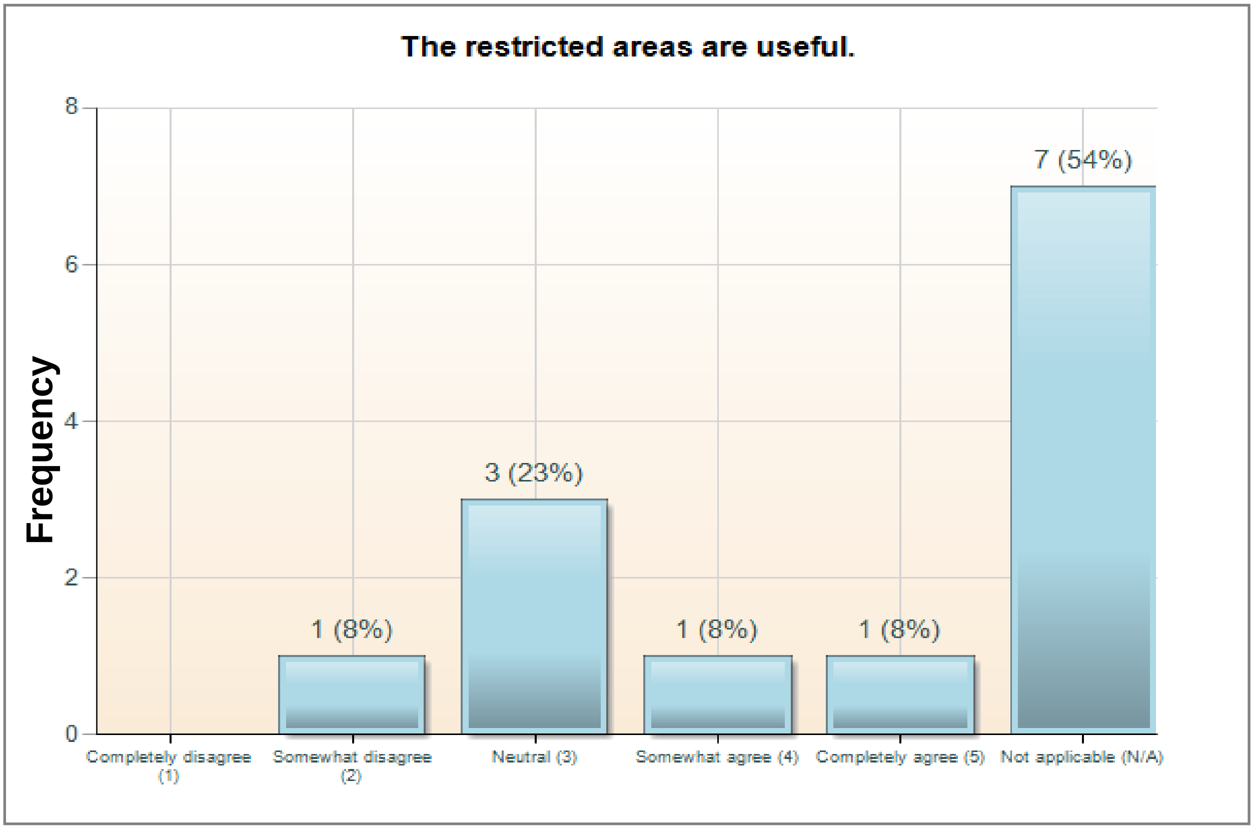

Figure J-41: Usefulness of the restricted areas

As shown in Figure J-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.

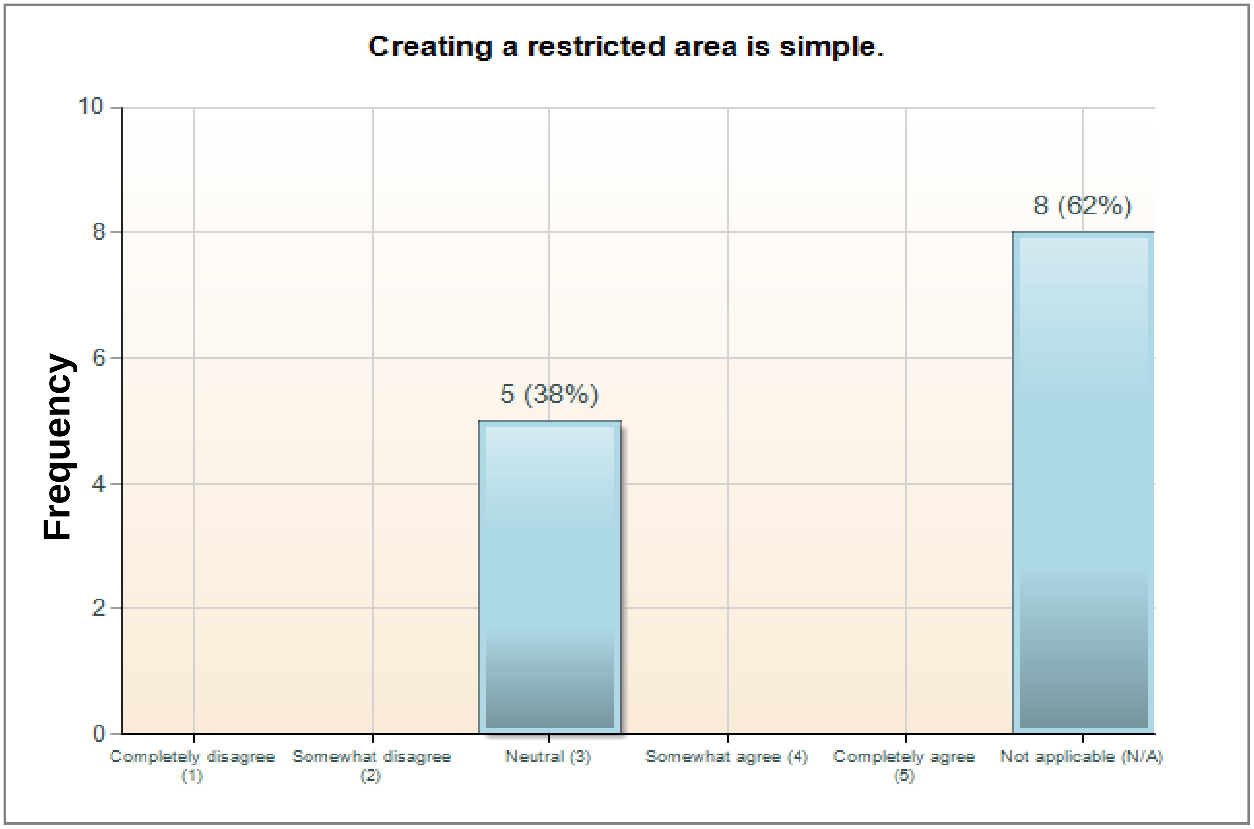

Figure J-42: Simplicity of creating a restricted area

As shown in Figure J-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.

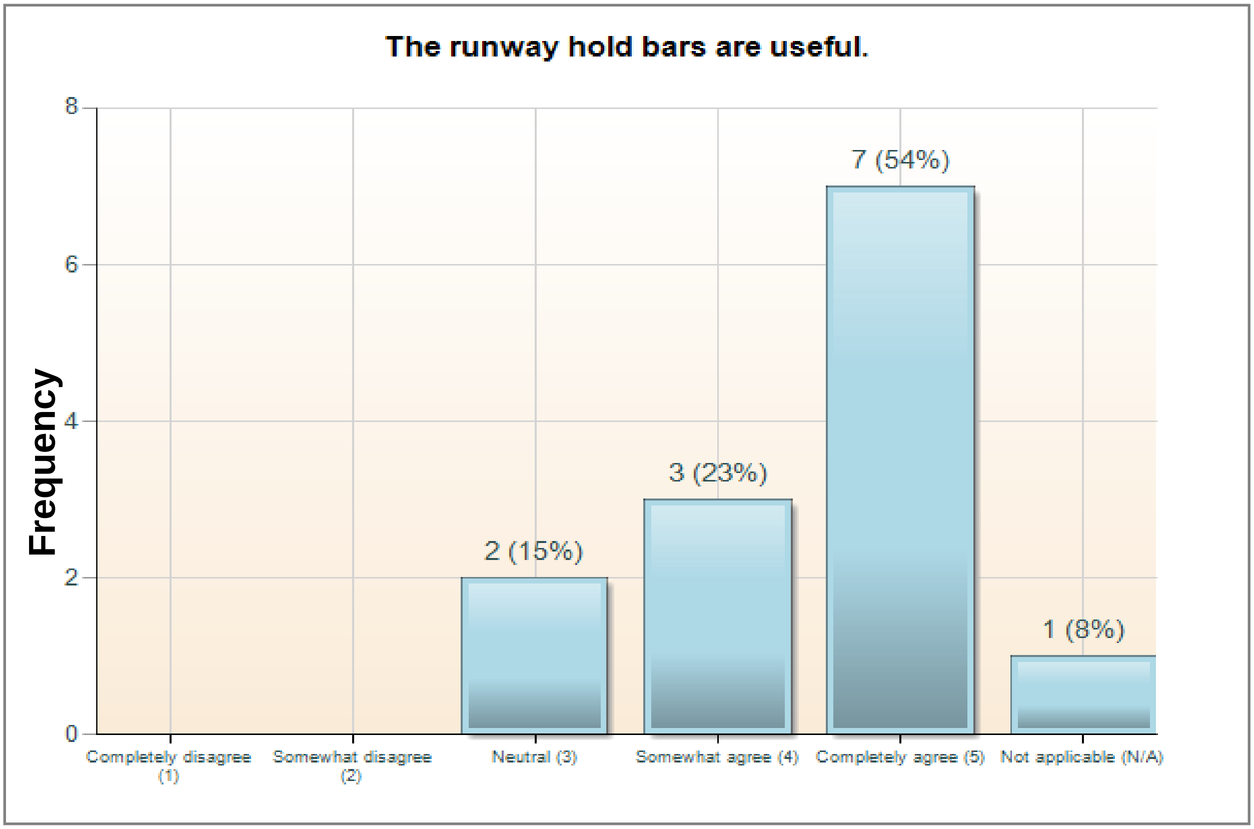

Figure J-43: Usefulness of the runway hold bars

As shown in Figure J-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.

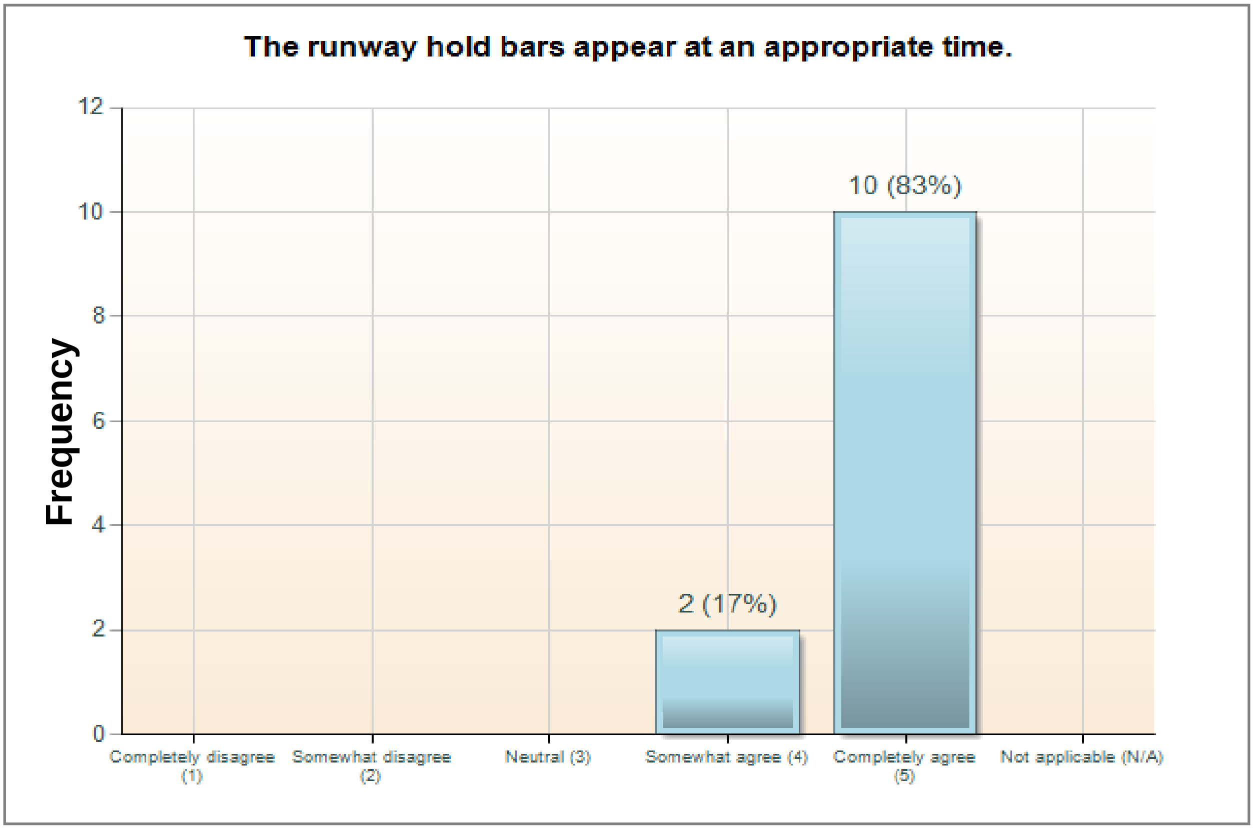

Figure J-44: Appropriateness of the runway hold bar timing

As shown in Figure J-44, there was a significant difference between observed ratings and expected ratings for perceived appropriateness of the runway hold bars appearance time, χ^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.

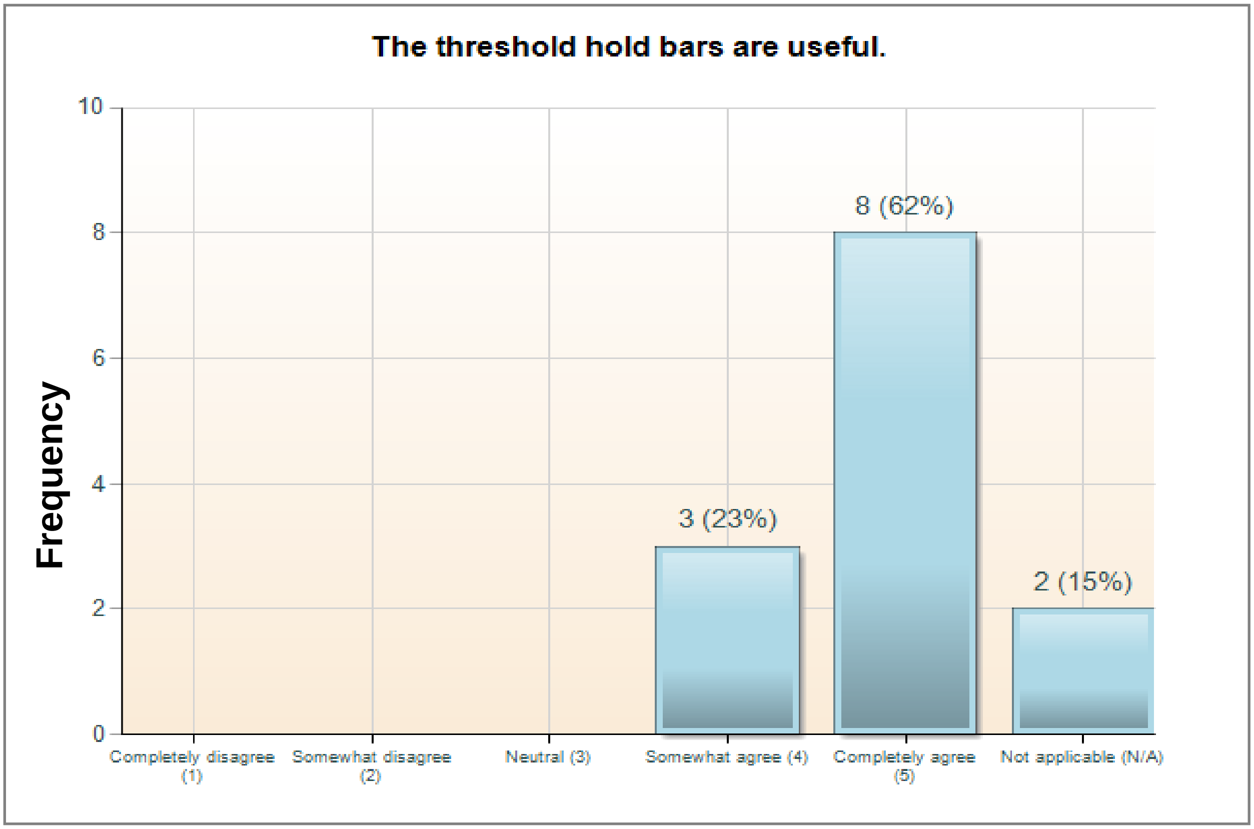

Figure J-45: Usefulness of the threshold hold bars

As shown in Figure J-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.

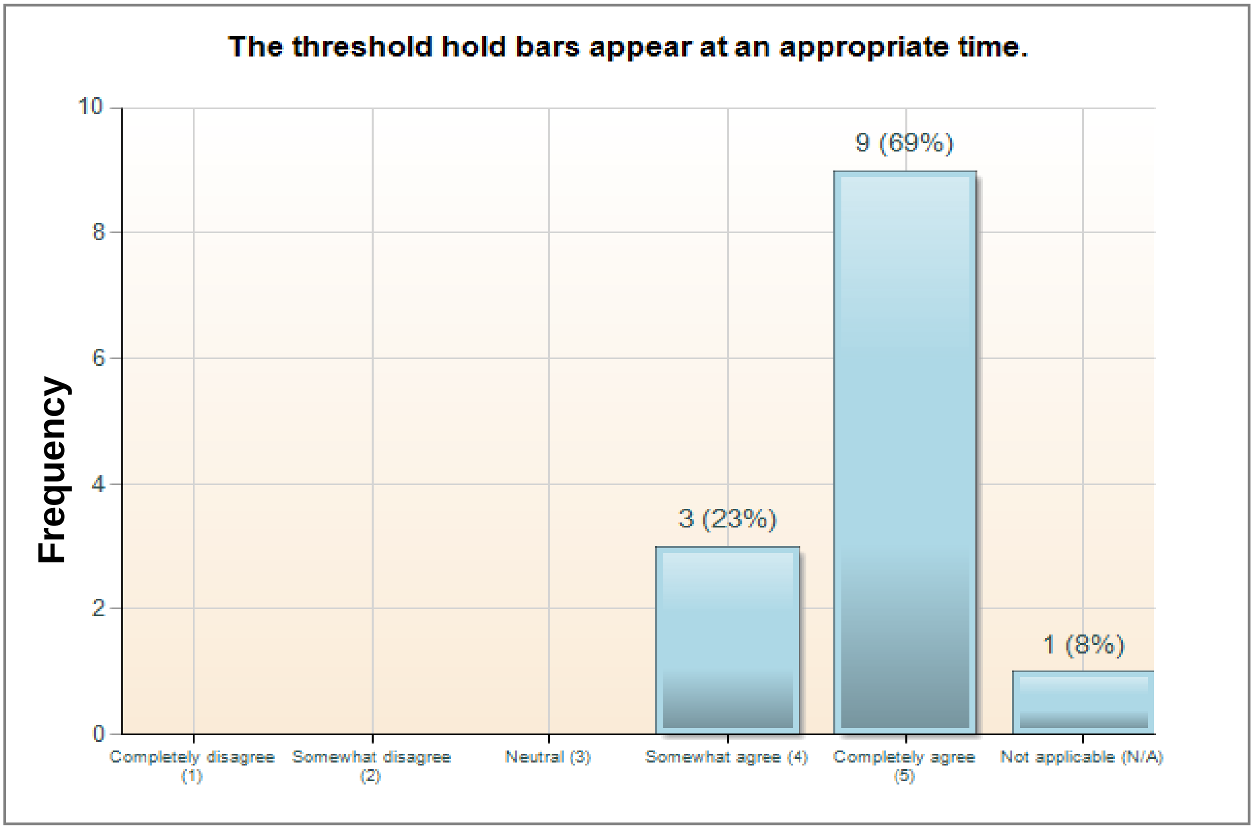

Figure J-46: Appropriateness of the threshold hold bar timing

As shown in Figure J-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.

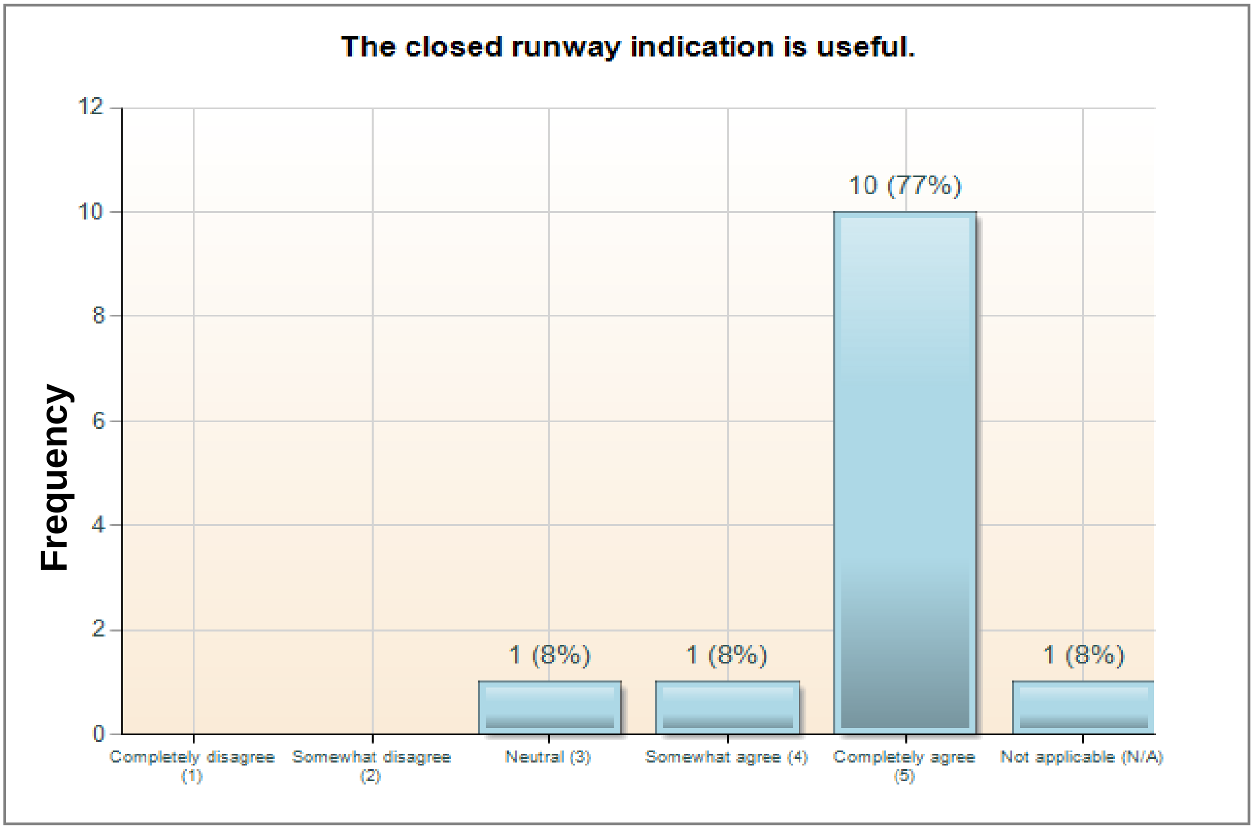

Figure J-47: Usefulness of the closed runway indication

As shown in Figure J-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.

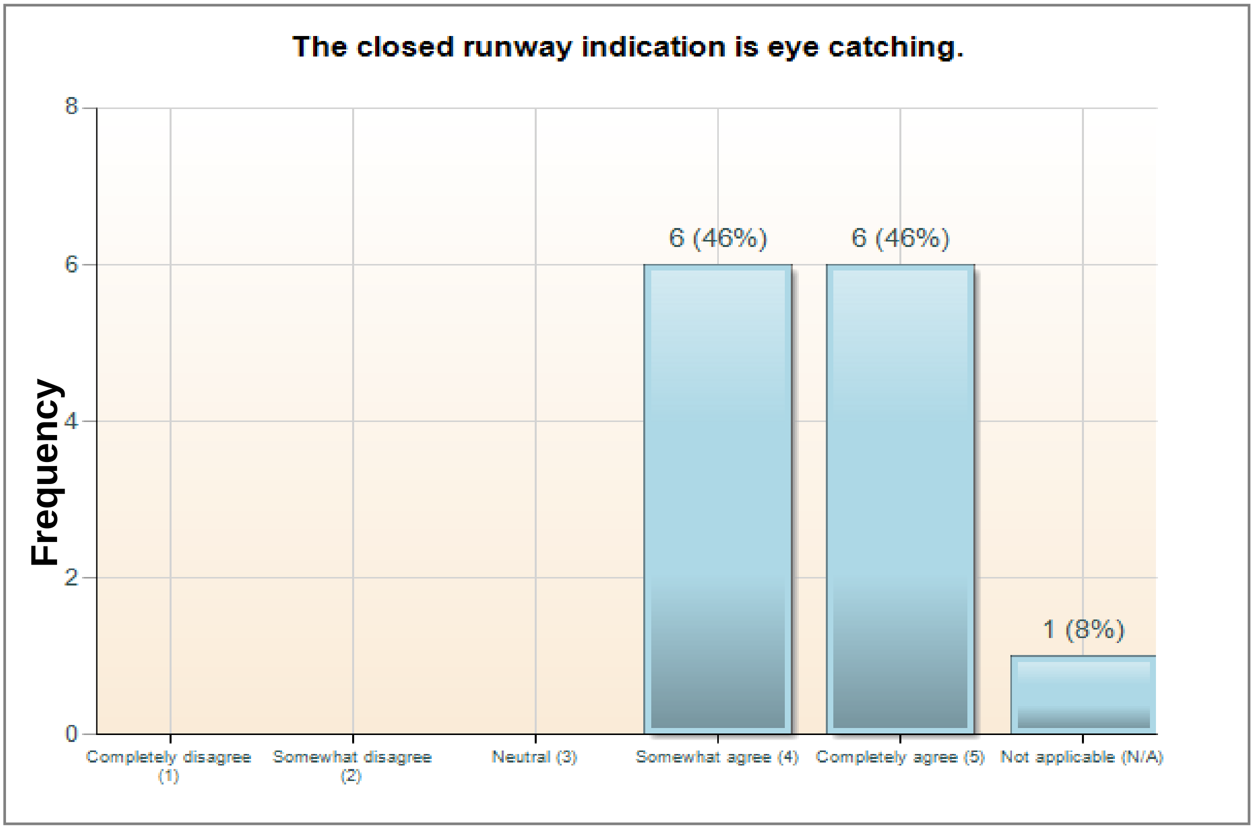

Figure J-48: Salience of the closed runway indication

As shown in Figure J-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.

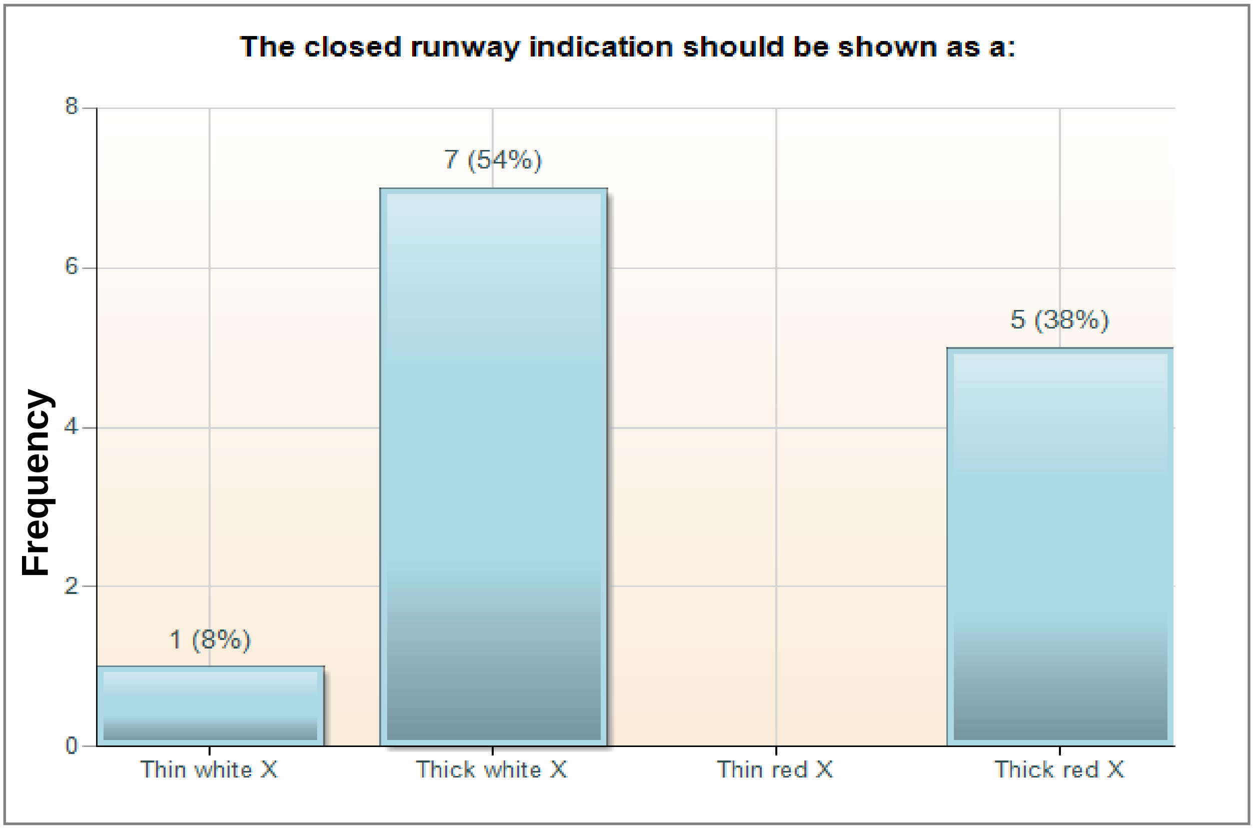

Figure J-49: Preference of the closed runway indication

As shown in Figure J-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.

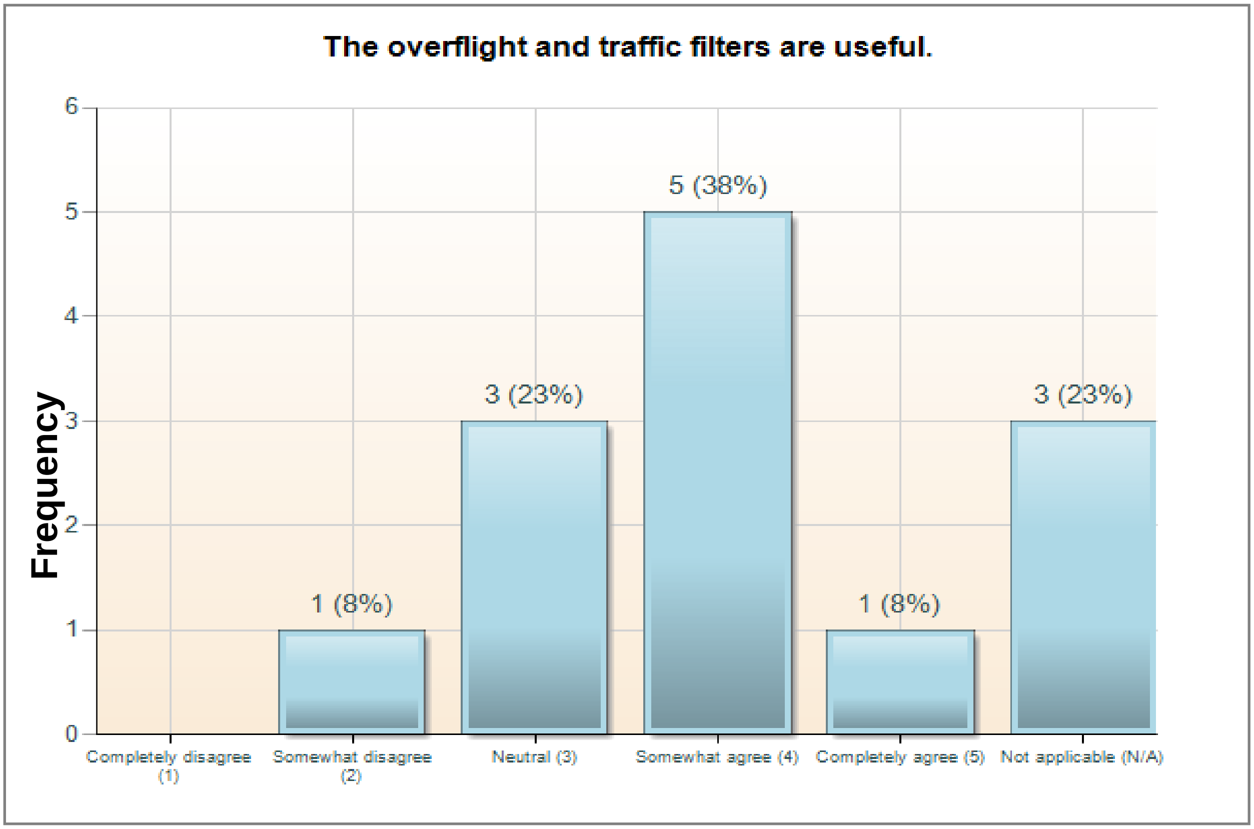

Figure J-50: Usefulness of the overflight and traffic filters

As shown in Figure J-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.

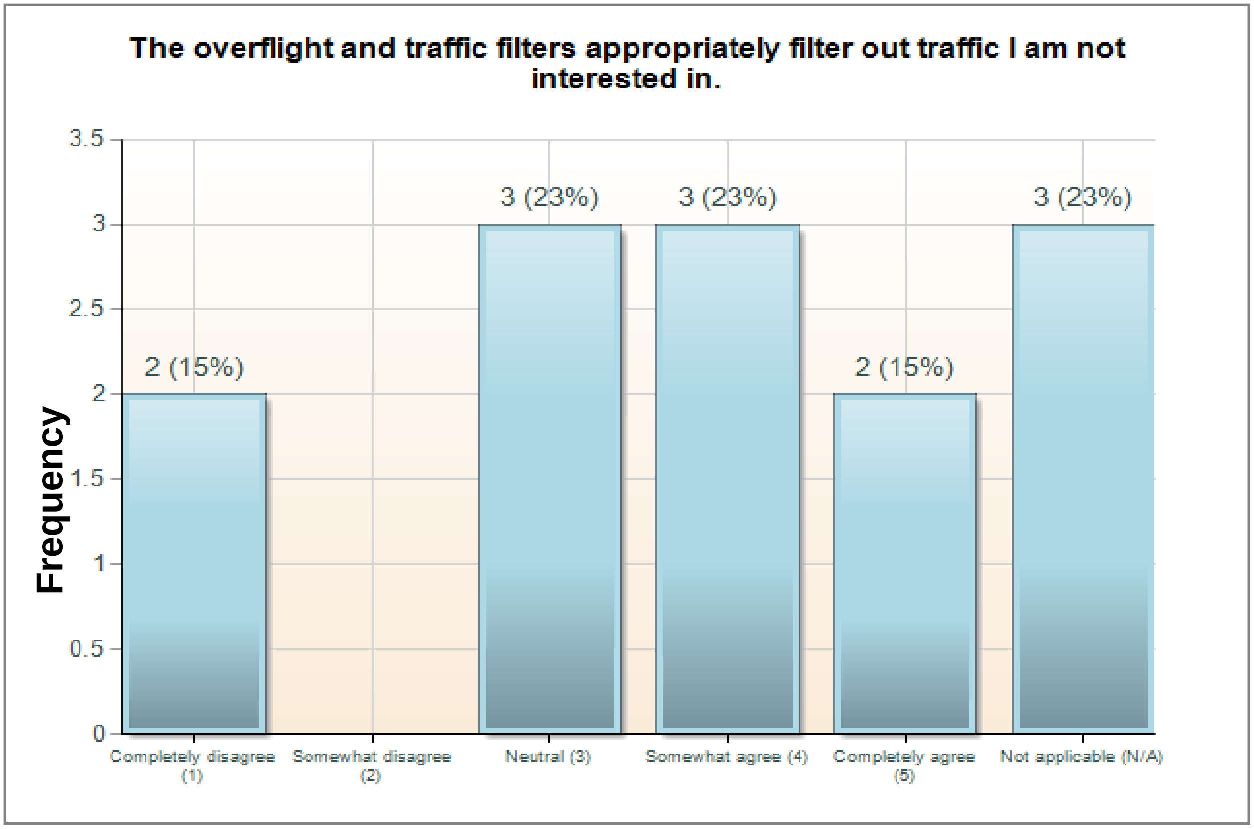

Figure J-51: Ability of overflight and traffic filters

As shown in Figure J-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.

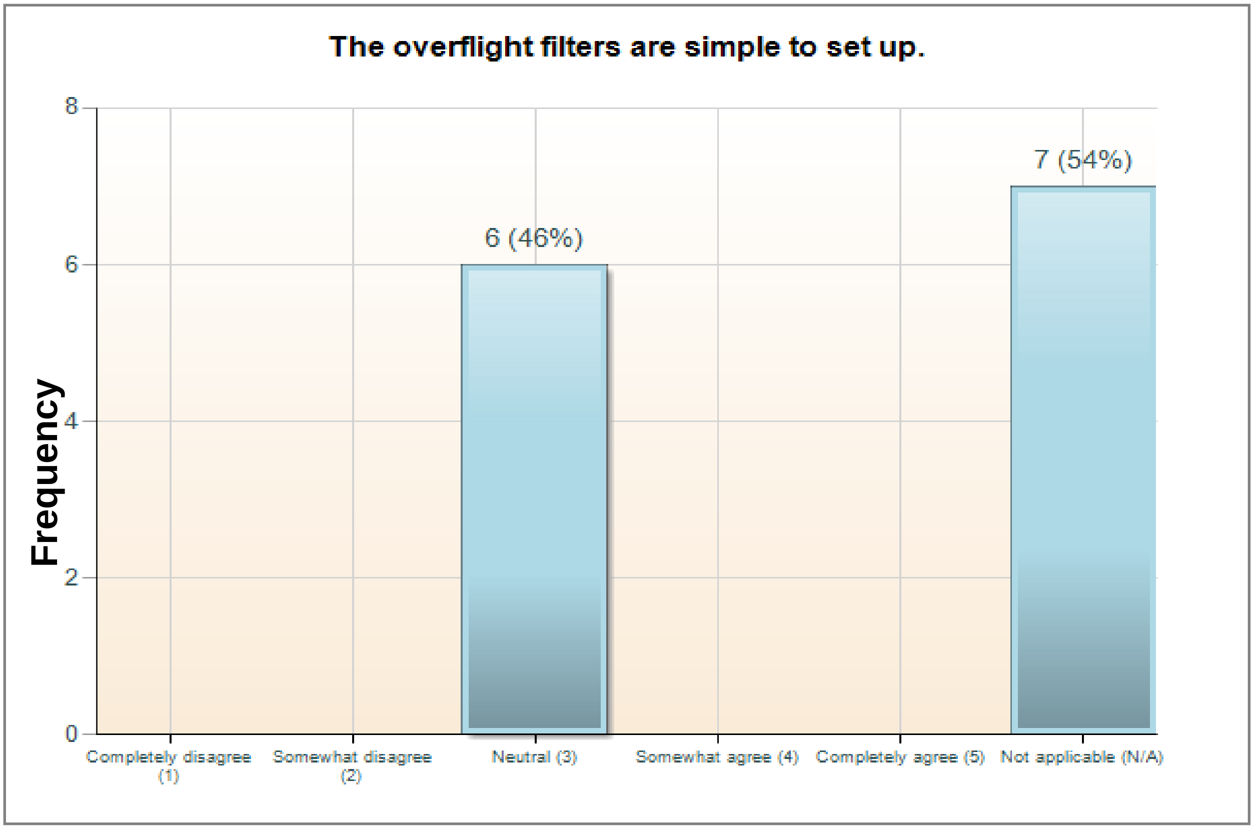

Figure J-52: Simplicity of overflight filters setup

As shown in Figure J-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.

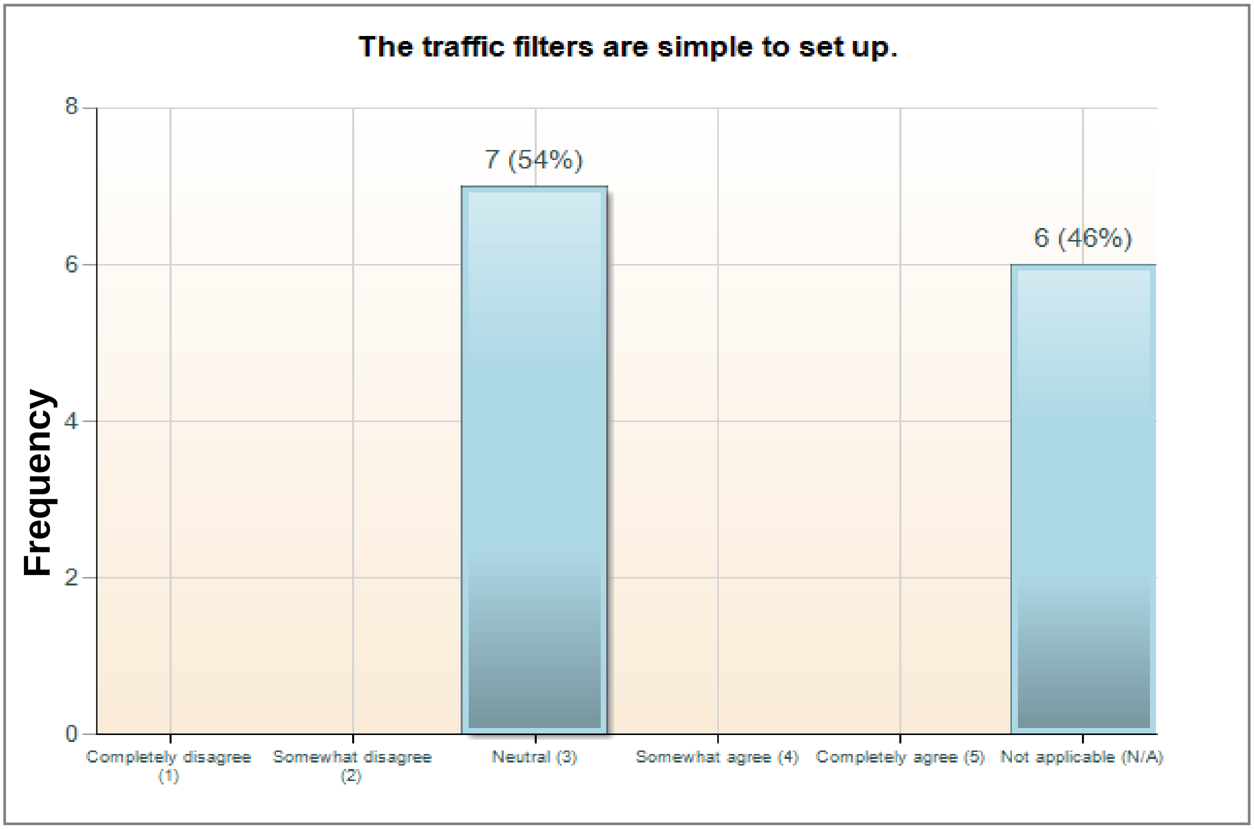

Figure J-53: Simplicity of traffic filter setup

As shown in Figure J-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.

J.1.7 Display Usefulness

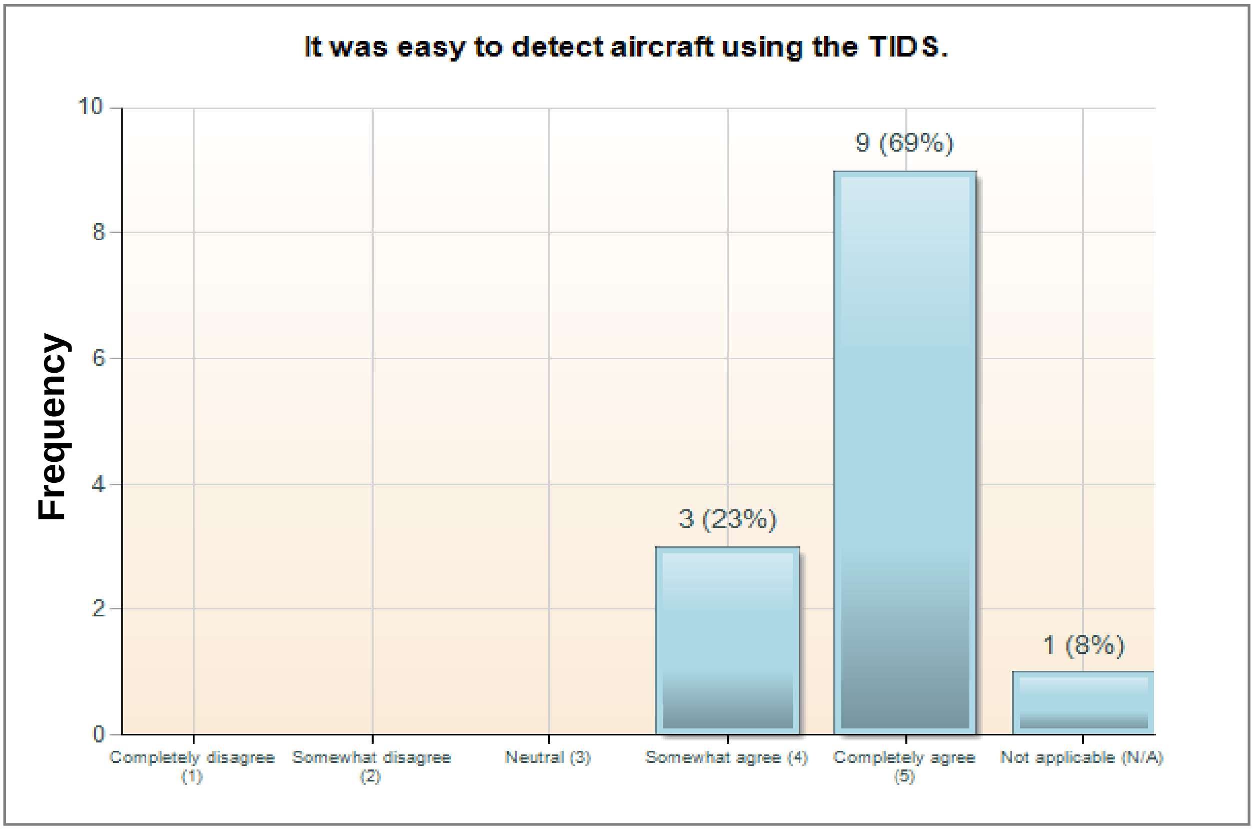

Figure J-54: Ease of detecting aircraft using the TIDS

As shown in Figure J-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.

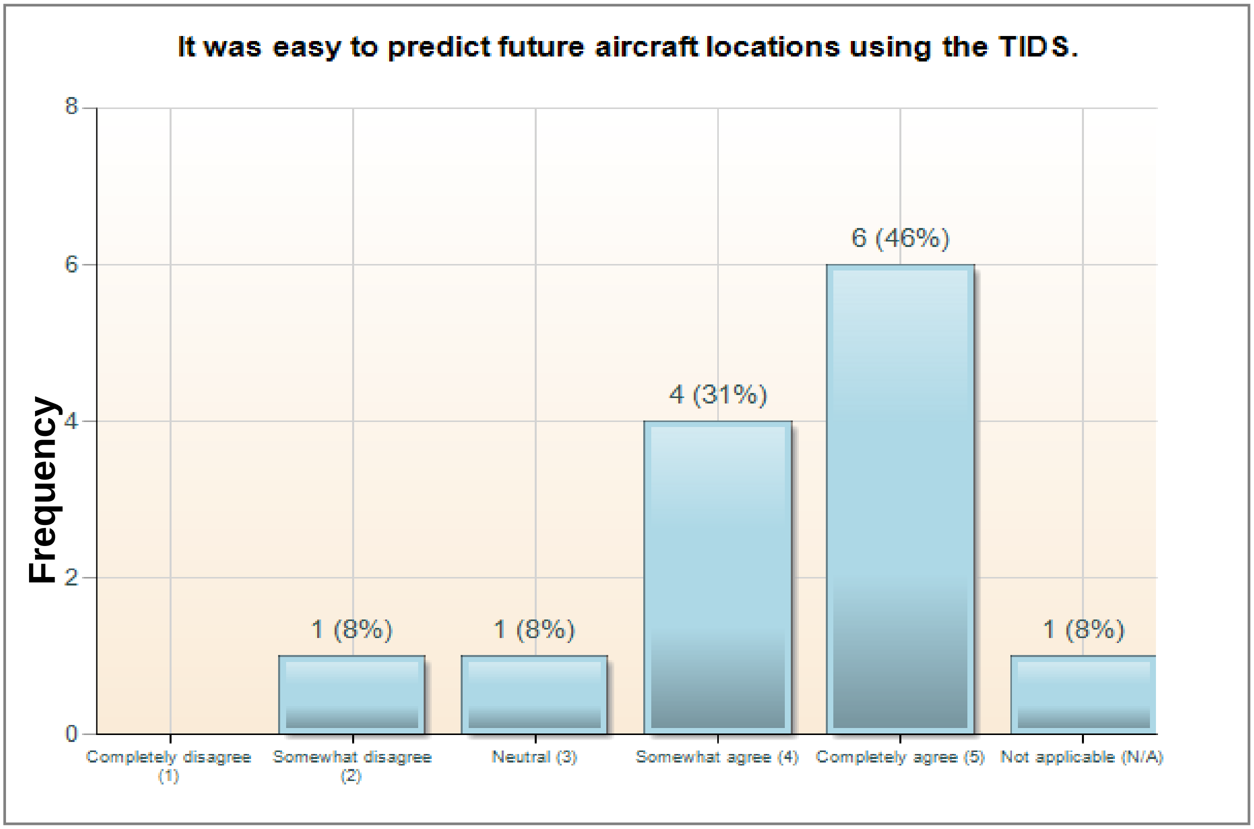

Figure J-55: Ease of predicting aircraft location using the TIDS

As shown in Figure J-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.

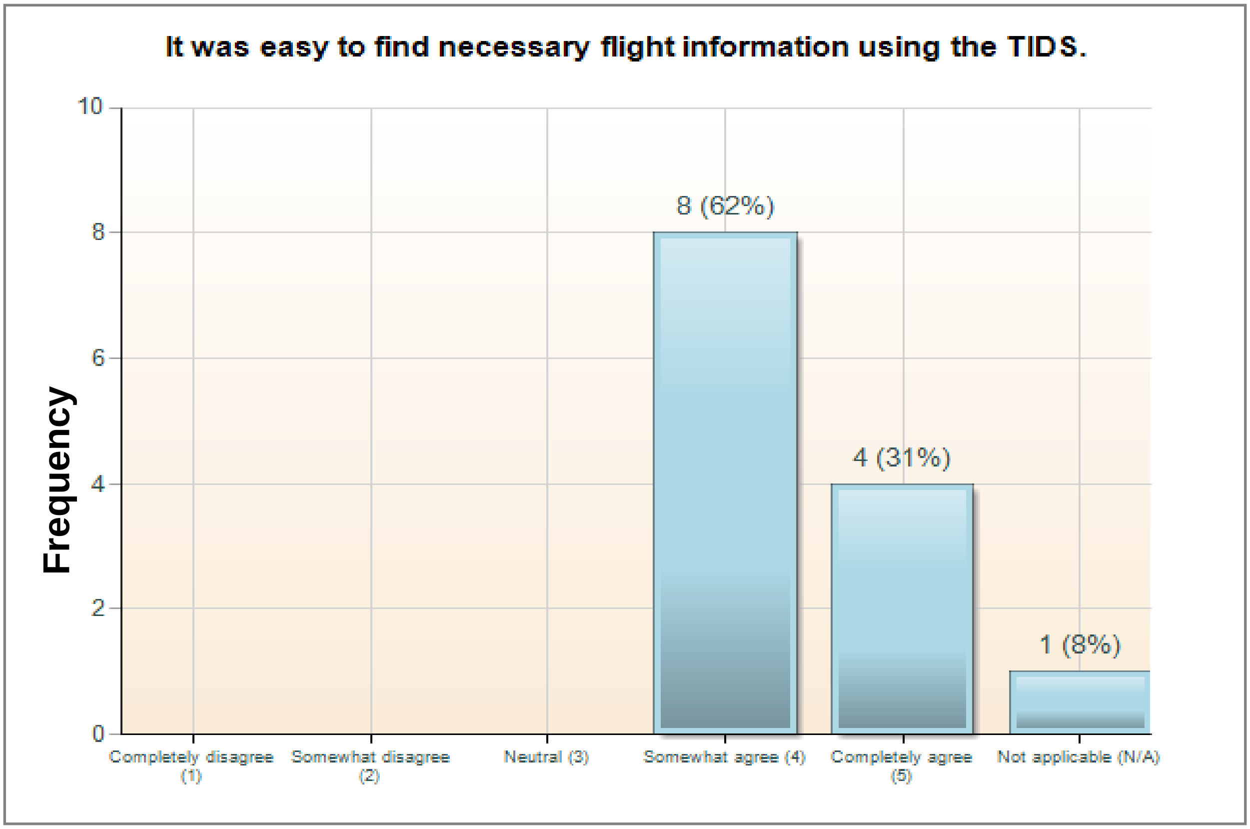

Figure J-56: Ease of finding necessary information using the TIDS

As shown in Figure J-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.

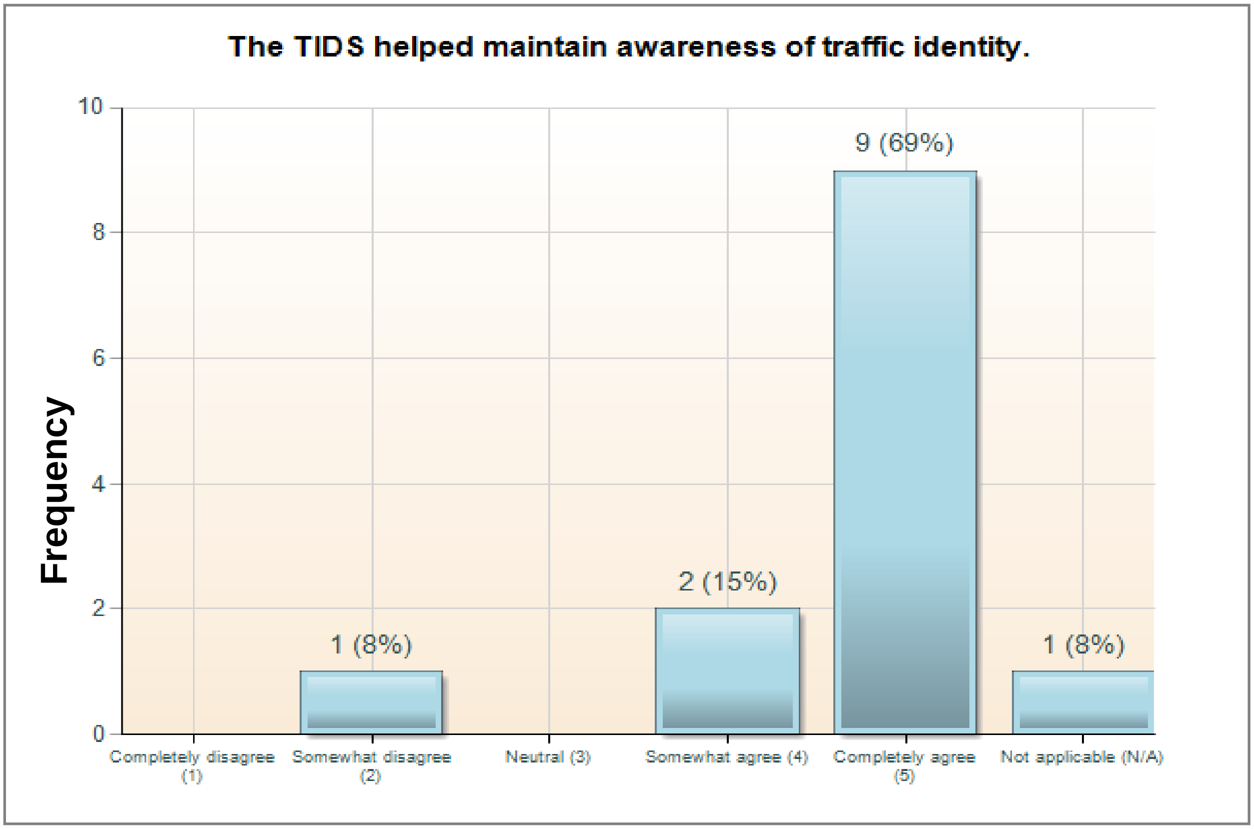

Figure J-57: Ease of maintaining traffic identity awareness

As shown in Figure J-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.

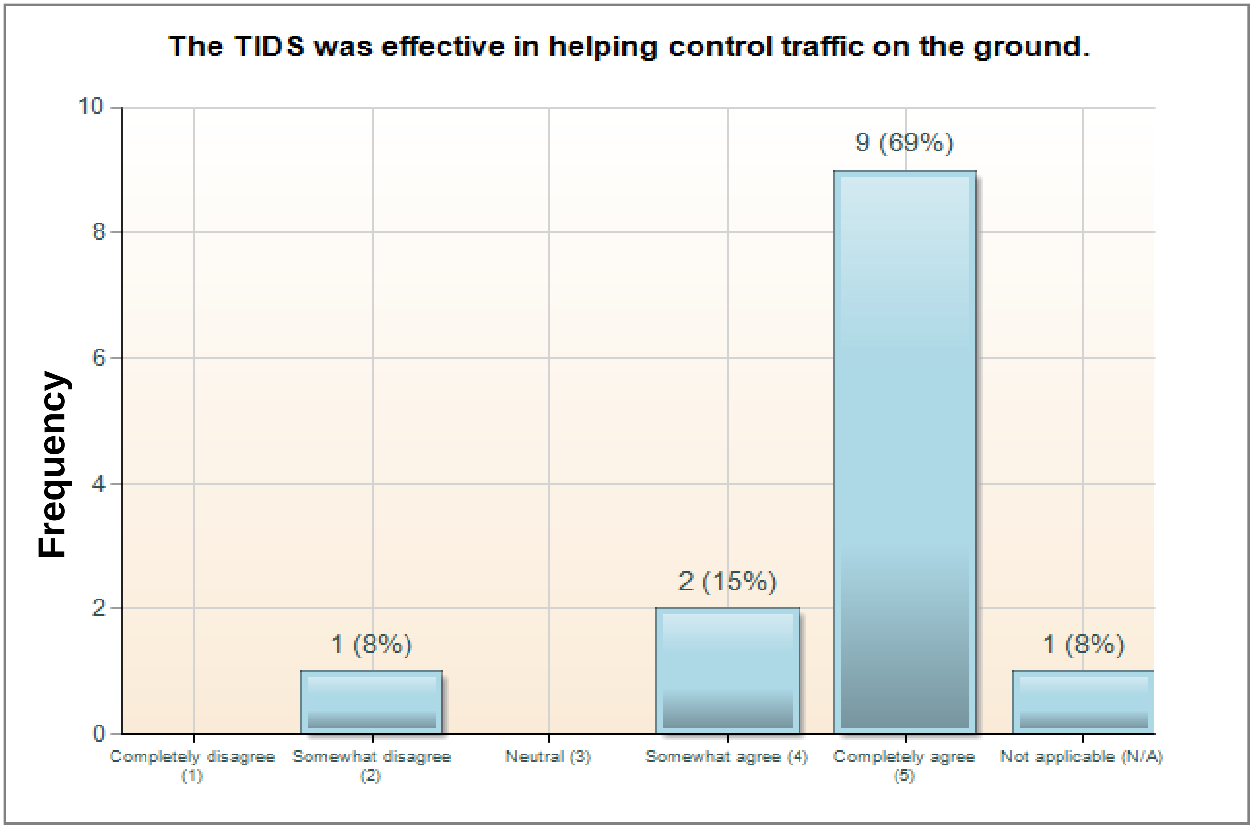

Figure J-58: TIDS helpfulness in helping control traffic on the ground

As shown in Figure J-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.

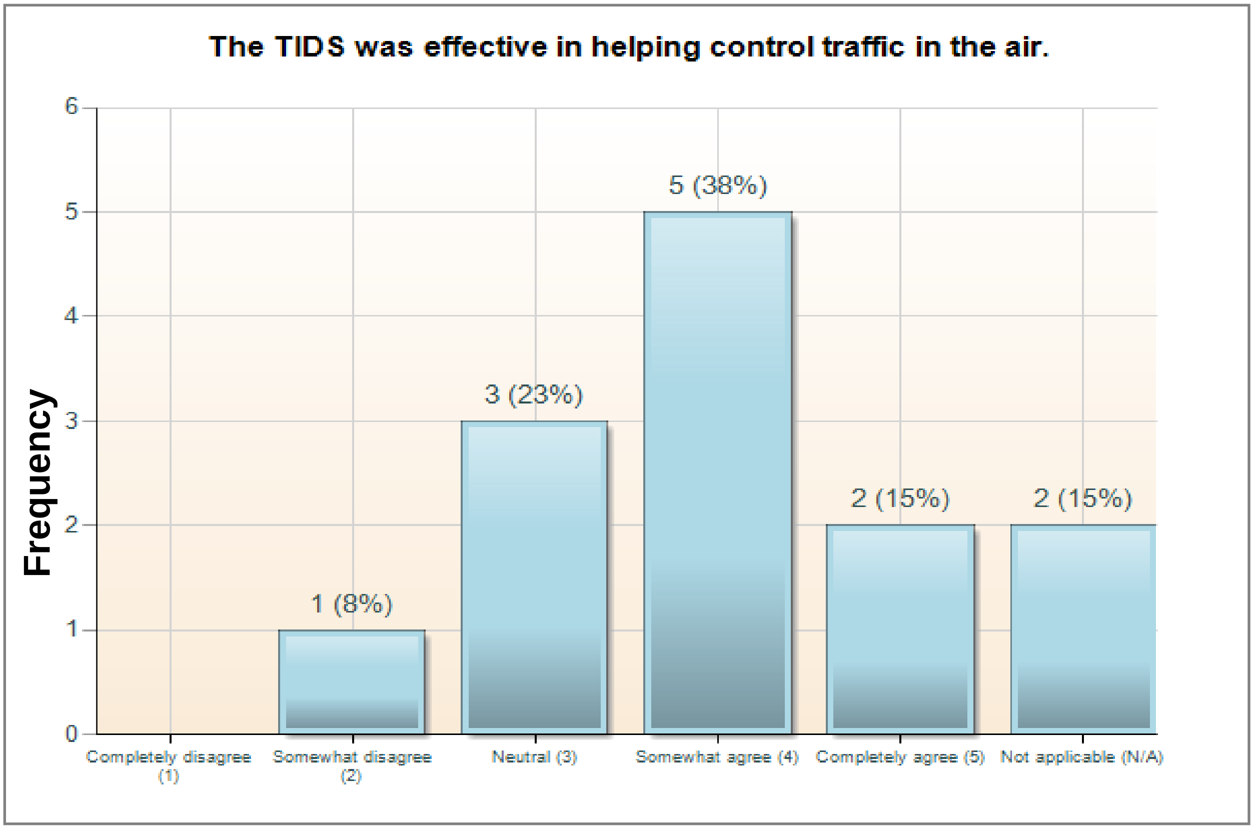

Figure J-59: TIDS effectiveness in helping control traffic in the air

As shown in Figure J-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.

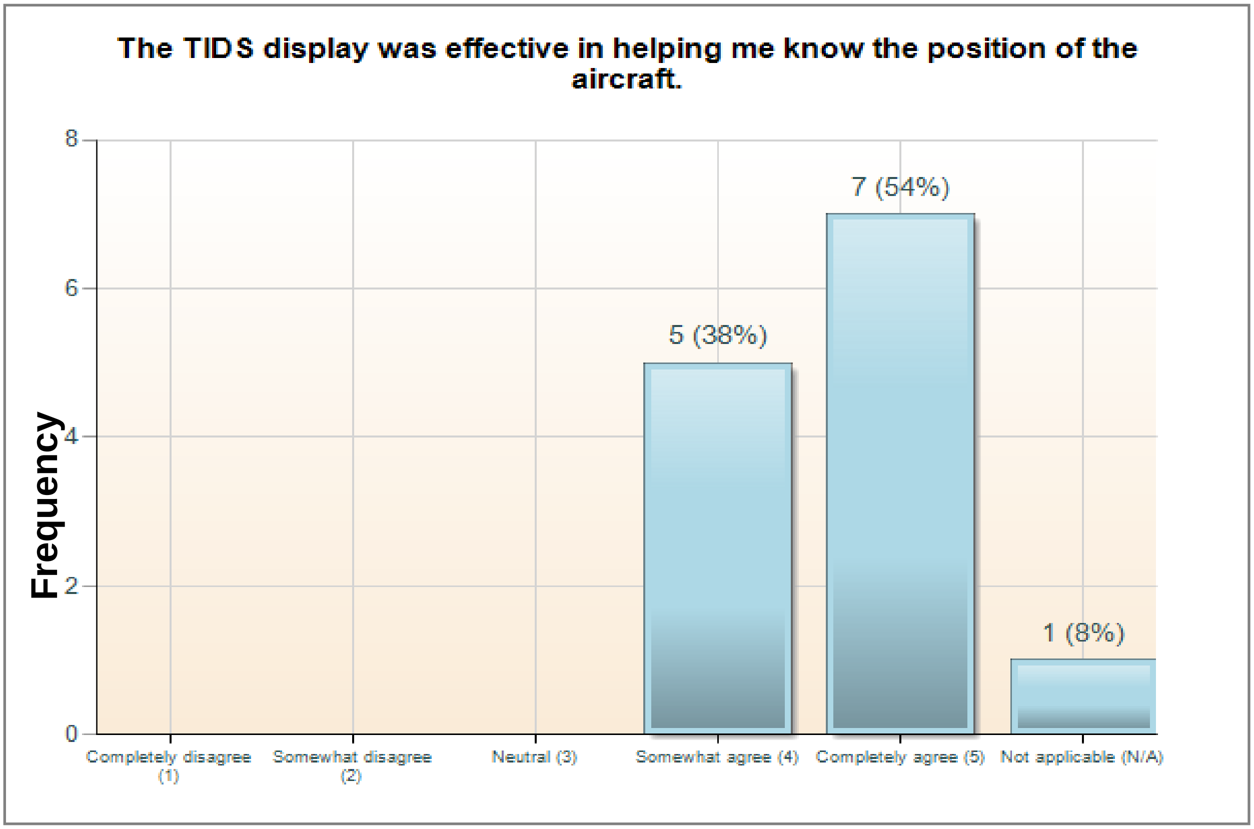

Figure J-60: TIDS effectiveness in helping controllers know position

As shown in Figure J-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.

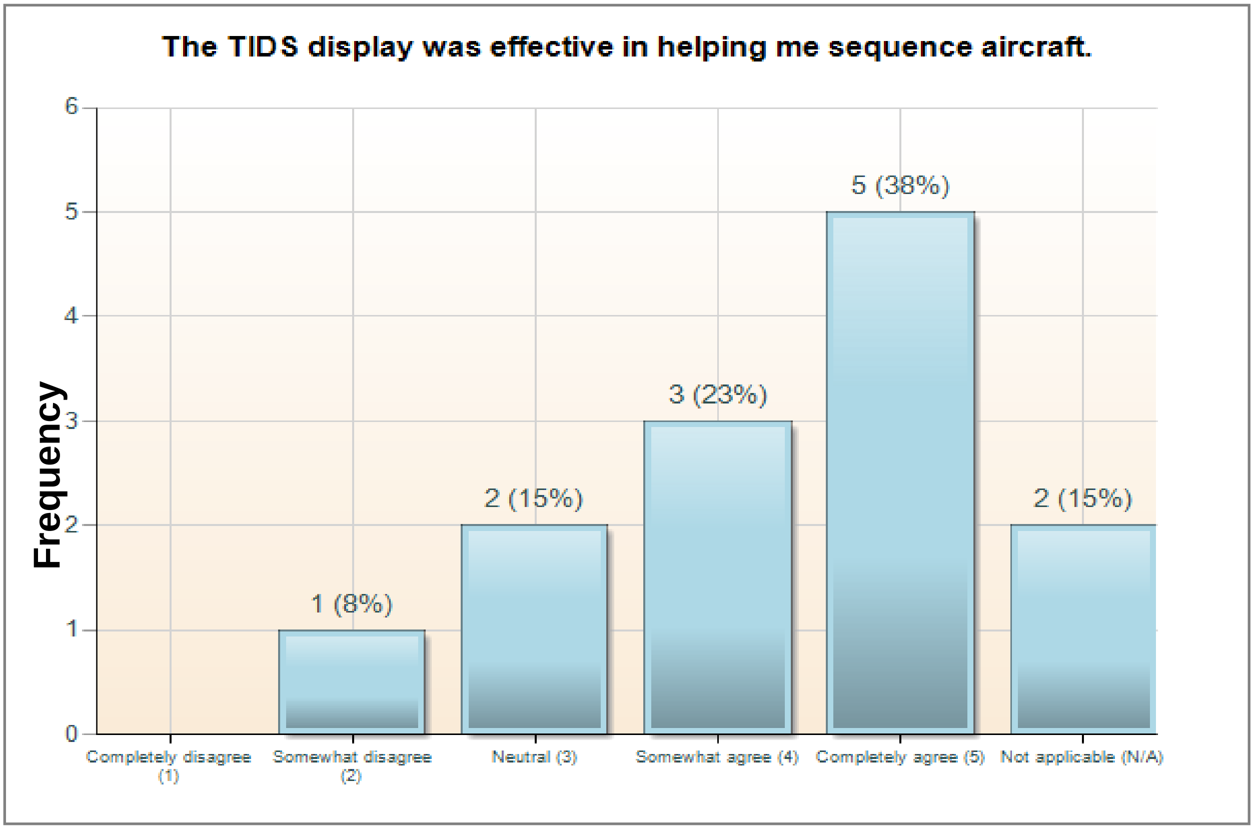

Figure J-61: TIDS display effectiveness in helping controllers sequence aircraft

As shown in Figure J-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.

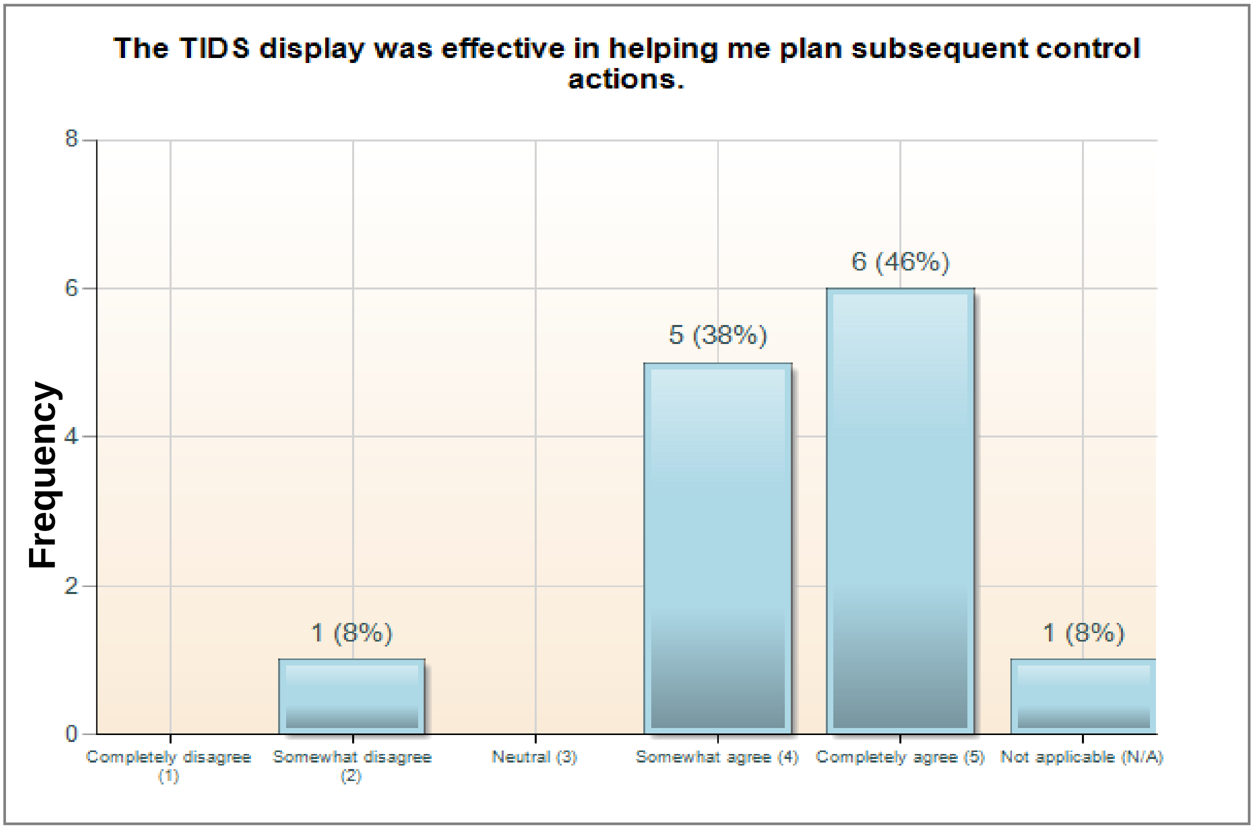

Figure J-62: TIDS display effectiveness in helping controllers plan

As shown in Figure J-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.

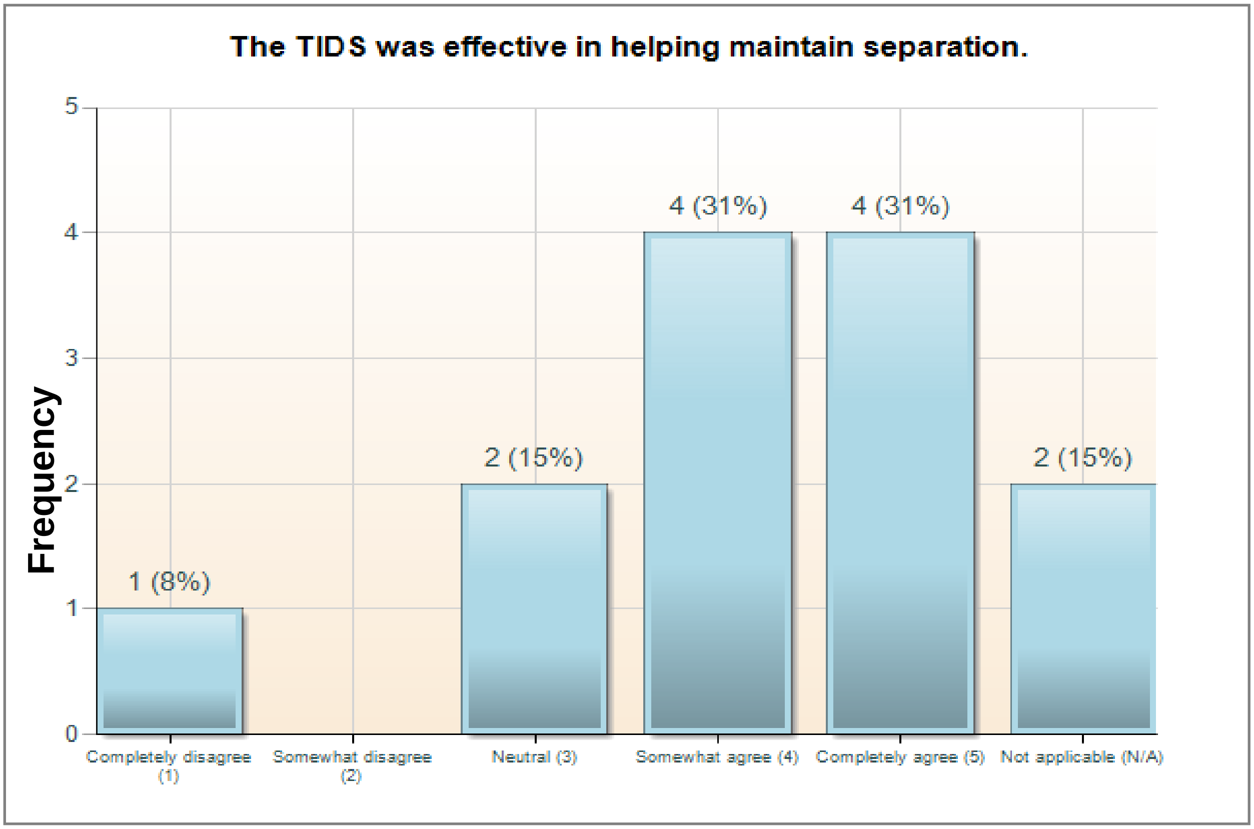

Figure J-63: TIDS effectiveness in helping maintain separation

As shown in Figure J-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.

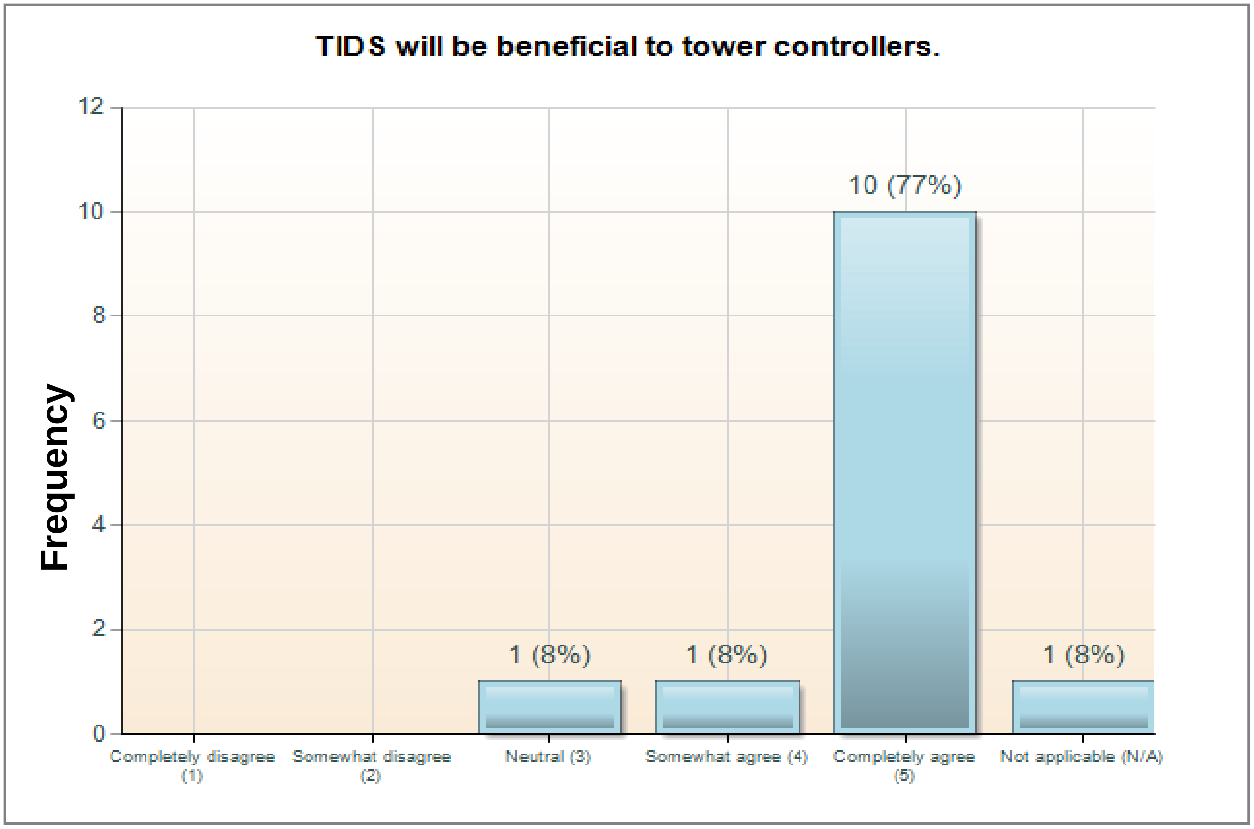

Figure J-64: TIDS benefit to tower controllers

As shown in Figure J-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.

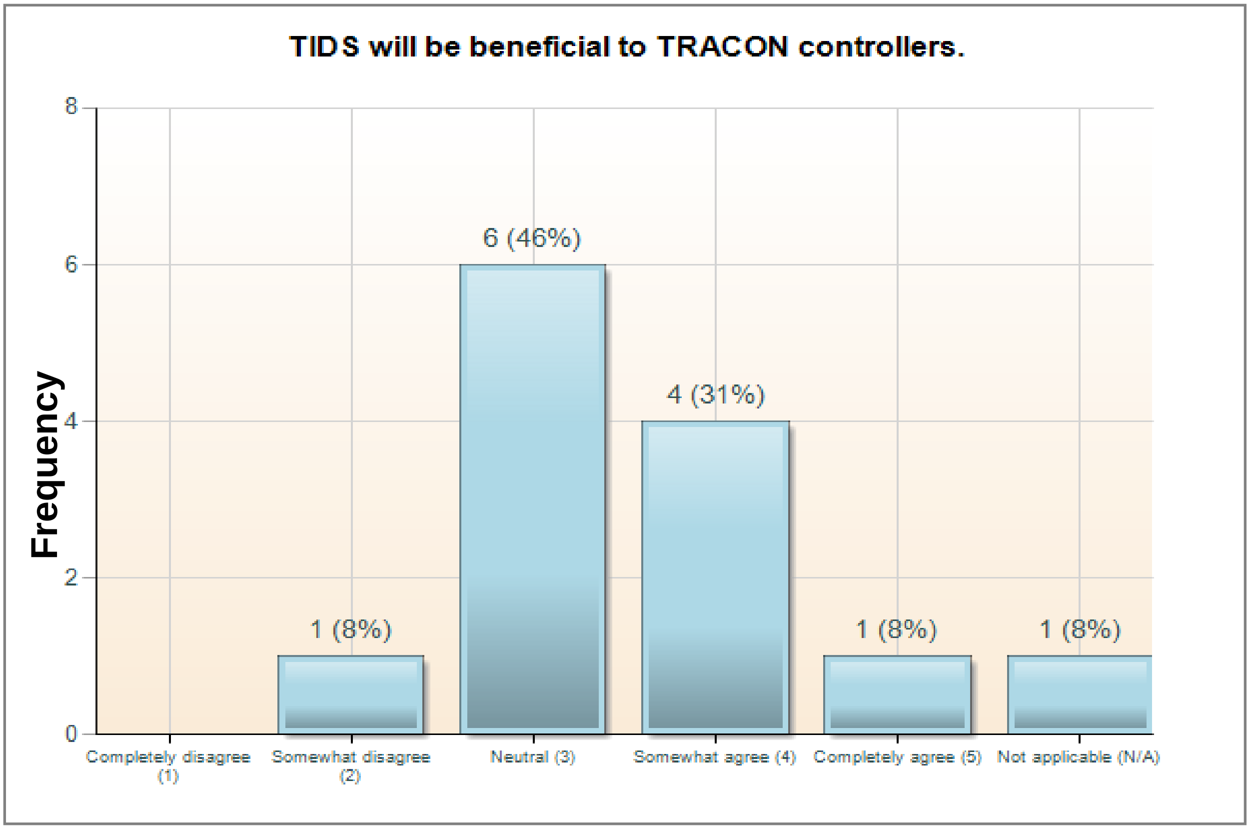

Figure J-65: TIDS benefit to TRACON controllers

As shown in Figure J-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 J-1.

Table J-1: General Summary for TIDS results[7]

		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
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

[7] Note that responses to questions 10, 19, 28, 33, 39, and 59 were presented in Appendix G as they contained controller comments to open-response (not rating scale) questions. 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 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
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

		Chi Square	Mean	SD
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
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

		Chi Square	Mean	SD
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
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

J.2 CAMERA FOR SUPPLEMENTAL SNT OPERATIONS CHI SQUARE RESULTS

The following is a detailed report of the Camera results in the context of supplemental SNT operations. For a general summary with Chi Square values, means, and standard deviations for the camera results, see Table J-2.

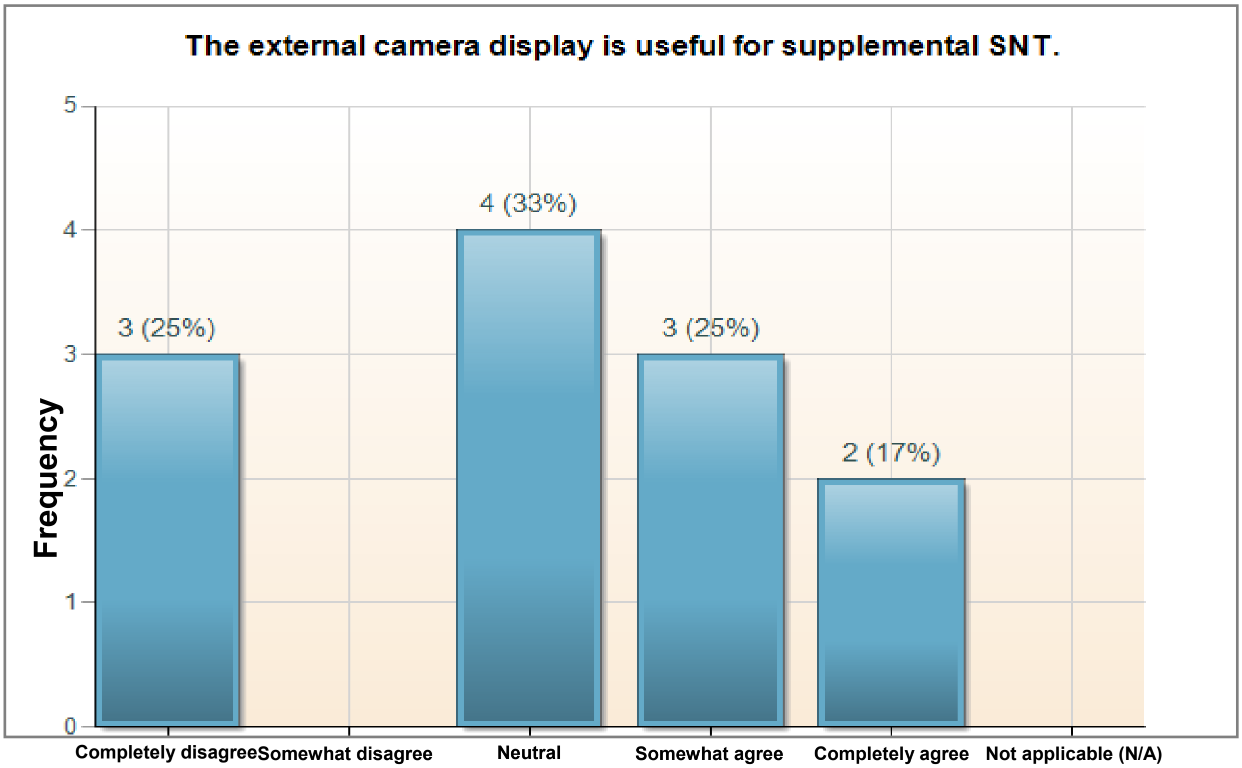

Figure J-66: Usefulness of the external camera for supplemental SNT

As shown in Figure J-66, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the external camera display for supplemental SNT, χ^2 (4, N = 12) = 3.83, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived usefulness of the external camera display.

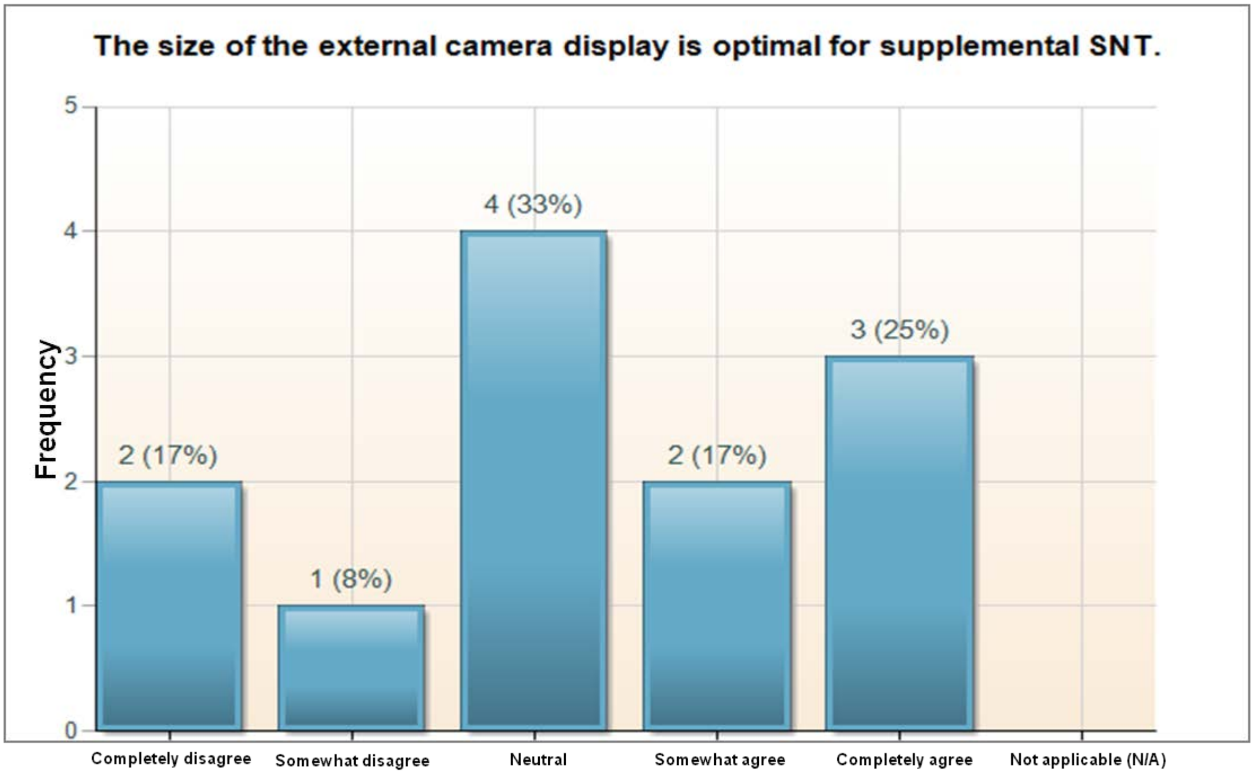

Figure J-67: Optimal size of external camera display for supplemental SNT

As shown in Figure J-67, there was no significant difference between observed ratings and expected ratings for perceived optimal size of the external camera display for supplemental SNT, χ^2 (4, N = 12) = 2.16, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived optimal size of the external camera.

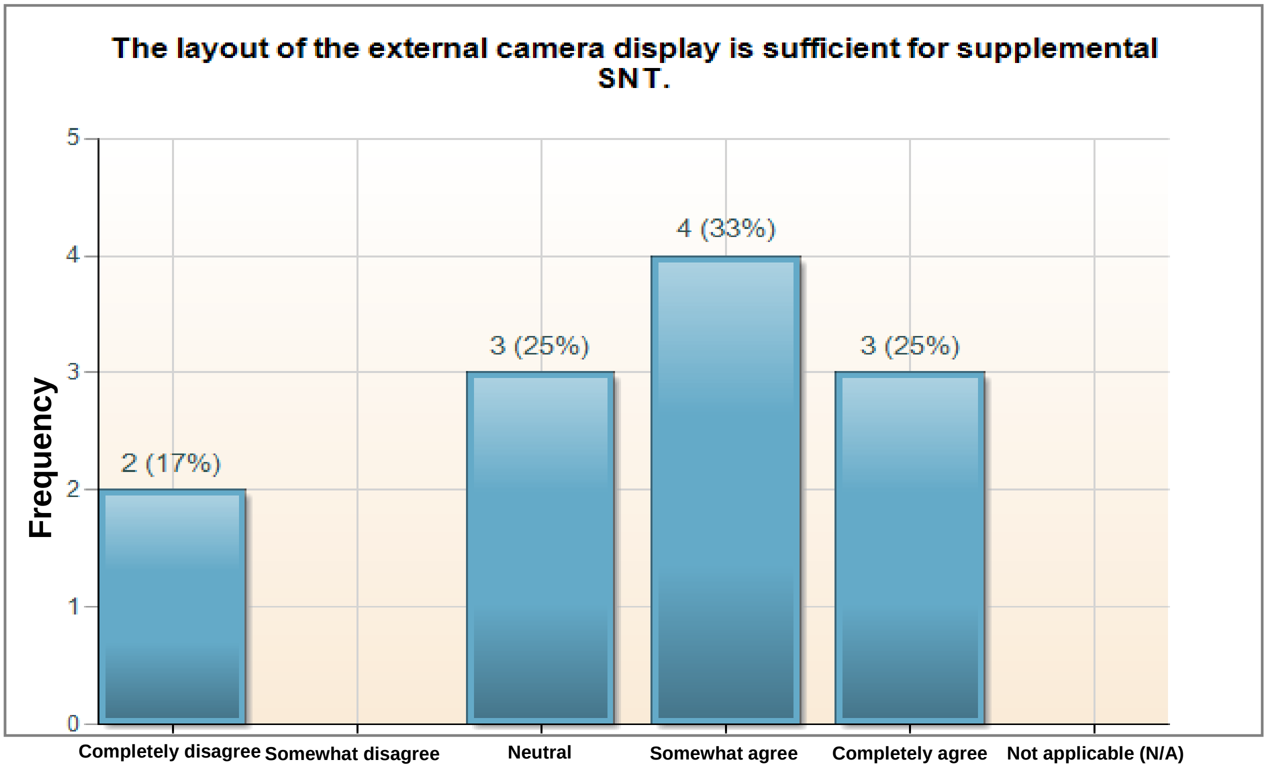

Figure J-68: Sufficiency of the layout of the external camera display for supplemental SNT

As shown in Figure J-68, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the picture-in-picture camera display on the TIDS for supplemental SNT, χ^2 (4, N = 12) = 1.33, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived usefulness of the picture-in-picture camera display on the TIDS.

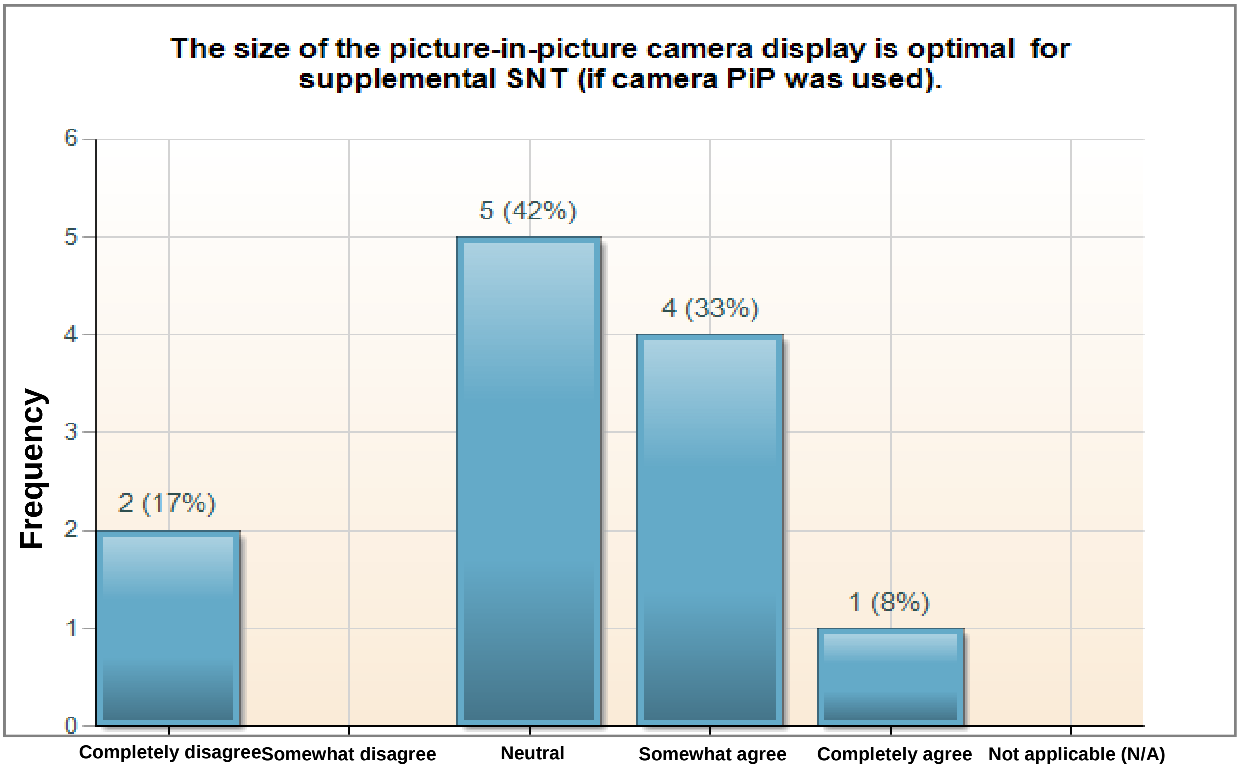

Figure J-69: Optimal size of the picture-in-picture camera display for supplemental SNT

As shown in Figure J-69, there was no significant difference between observed ratings and expected ratings for perceived optimal size of the picture-in-picture camera display for supplemental SNT (if camera picture-in-picture was used), χ^2 (4, N = 12) = 7.16, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived usefulness of the optimal size of the picture-in-picture camera display.

Figure J-70: Usefulness of camera image for air traffic control tasks during supplemental SNT

As shown in Figure J-70, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the camera image for air traffic control in supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived usefulness of the camera image while using a long-range camera external display, χ^2 (4, N = 12) = 1.33, p > .05 or a long-range camera picture-in-picture display, χ^2 (4, N = 12) = 5.5, p > .05.

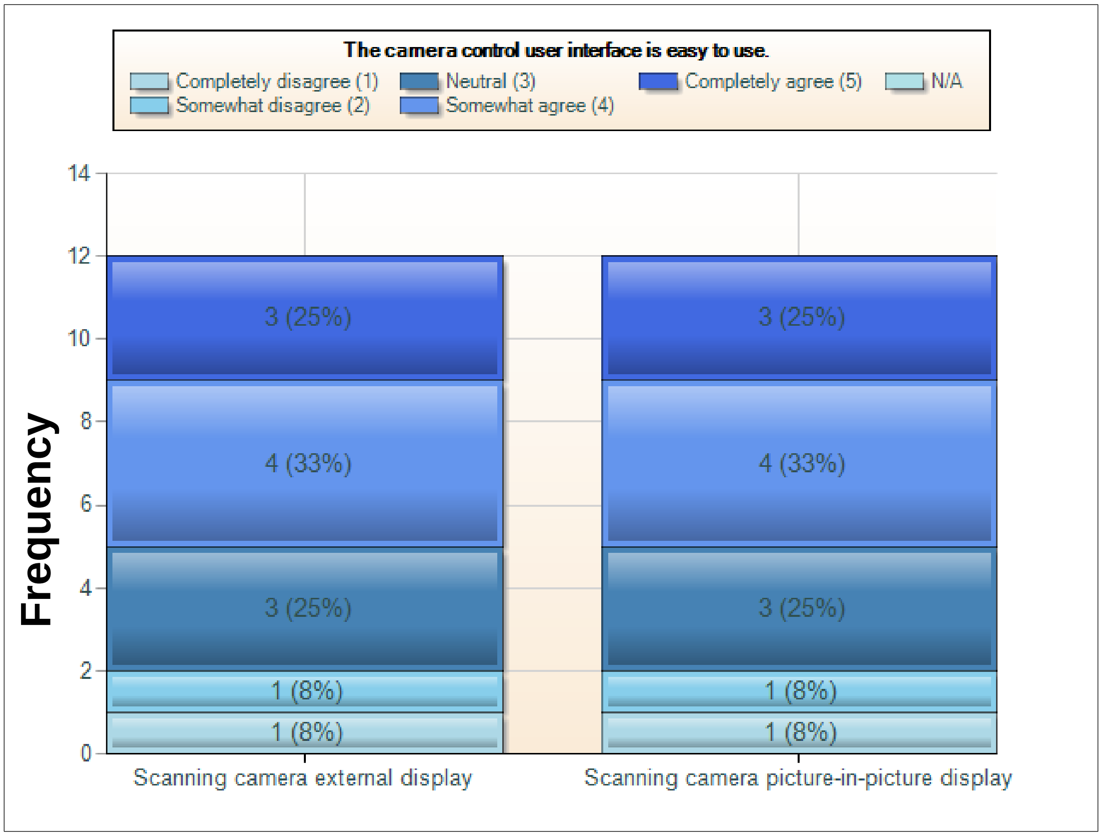

Figure J-71: Ease of use for the camera control user interface for supplemental SNT

As shown in Figure J-71, there was no significant difference between observed ratings and expected ratings for perceived ease of use for the camera control user interface in supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived ease of use for the camera control user interface when using the scanning external display, χ^2 (4, N = 12) = 3.00, p > .05 or a long-range camera picture-in-picture display, χ^2 (4, N = 12) = 3.00, p > .05.

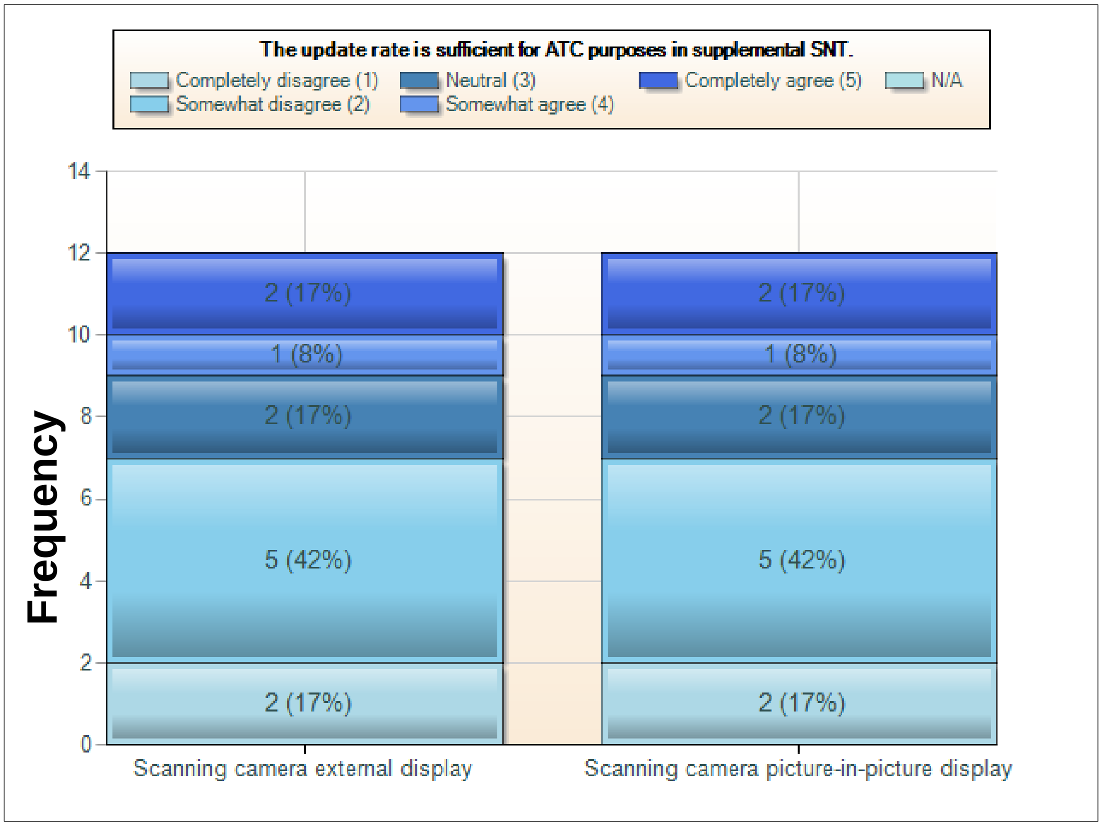

Figure J-72: Perceived sufficiency of the update rate for ATC for supplemental SNT

As shown in Figure J-72, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the update rate for ATC in supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived sufficiency of the update rate for ATC using a long-range camera external display, χ^2 (4, N = 12) = 3.83, p > .05 or a long-range camera picture-in-picture display, χ^2 (4, N = 12) = 3.83, p > .05.

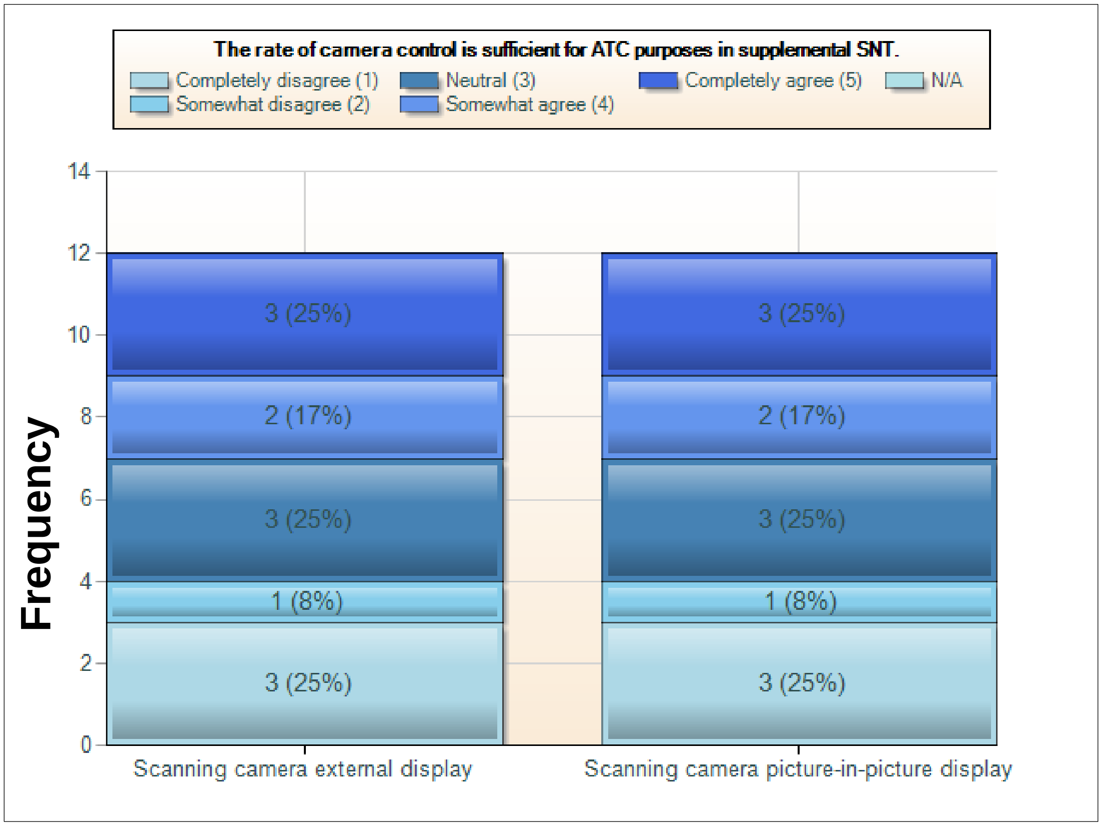

Figure J-73: Sufficiency of the rate of camera control for ATC purposes for supplemental SNT

As shown in Figure J-73, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the rate of camera control for ATC purposes in supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived sufficiency of the rate of camera control for ATC purposes using a long-range camera external display, χ^2 (4, N = 12) = 3.83, p > .05 or a long-range camera picture-in-picture display, χ^2 (4, N = 12) = 3.83, p > .05.

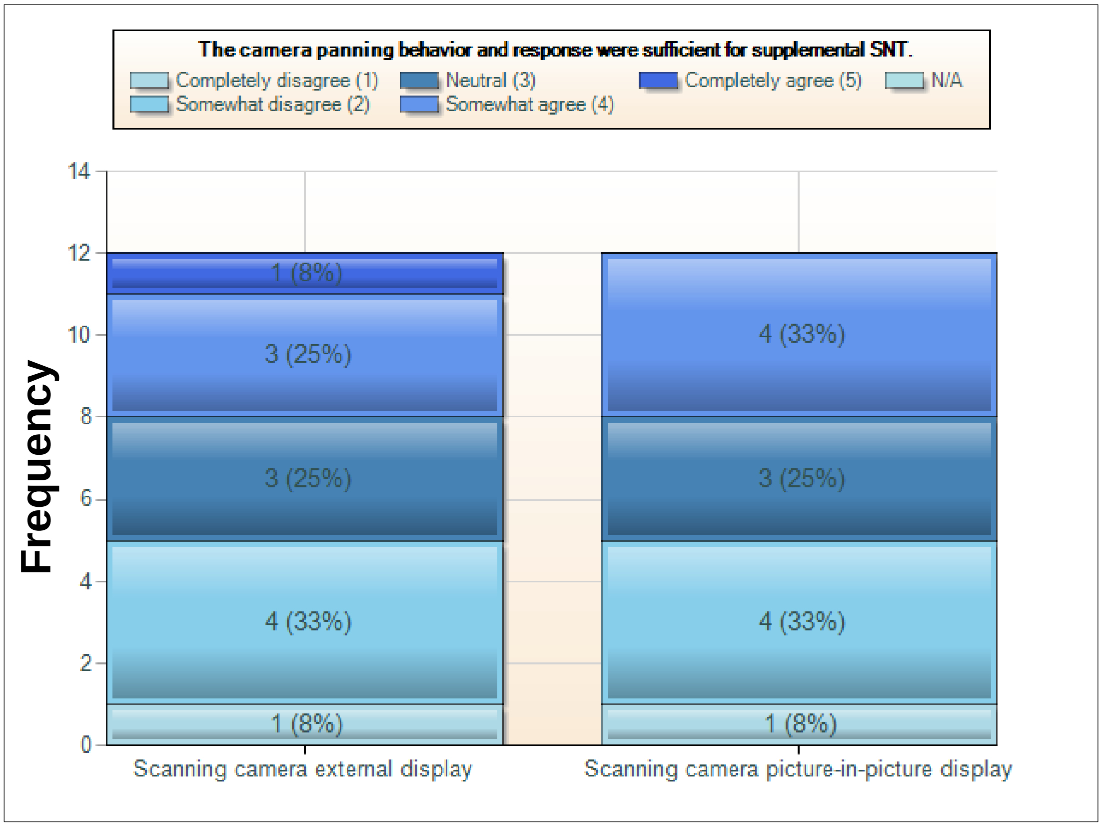

Figure J-74: Sufficiency of the camera panning behavior and response for supplemental SNT

As shown in Figure J-74, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the camera panning behavior and response in supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived sufficiency of the camera panning behavior and response using a long-range camera external display, χ^2 (4, N = 12) = 3.00, p > .05 or long-range camera picture-in-picture display, χ^2 (4, N = 12) = 5.50, p > .05.

Figure J-75: Sufficiency of the camera zoom behavior and response for supplemental SNT

As shown in Figure J-75, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the camera zoom behavior and response in supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived sufficiency of the camera zoom behavior and response using a long-range camera external display, χ^2 (4, N = 12) = 6.33, $p > .05$ or a long-range camera picture-in-picture display, χ^2 (4, N = 12) = 6.33, $p > .05$.

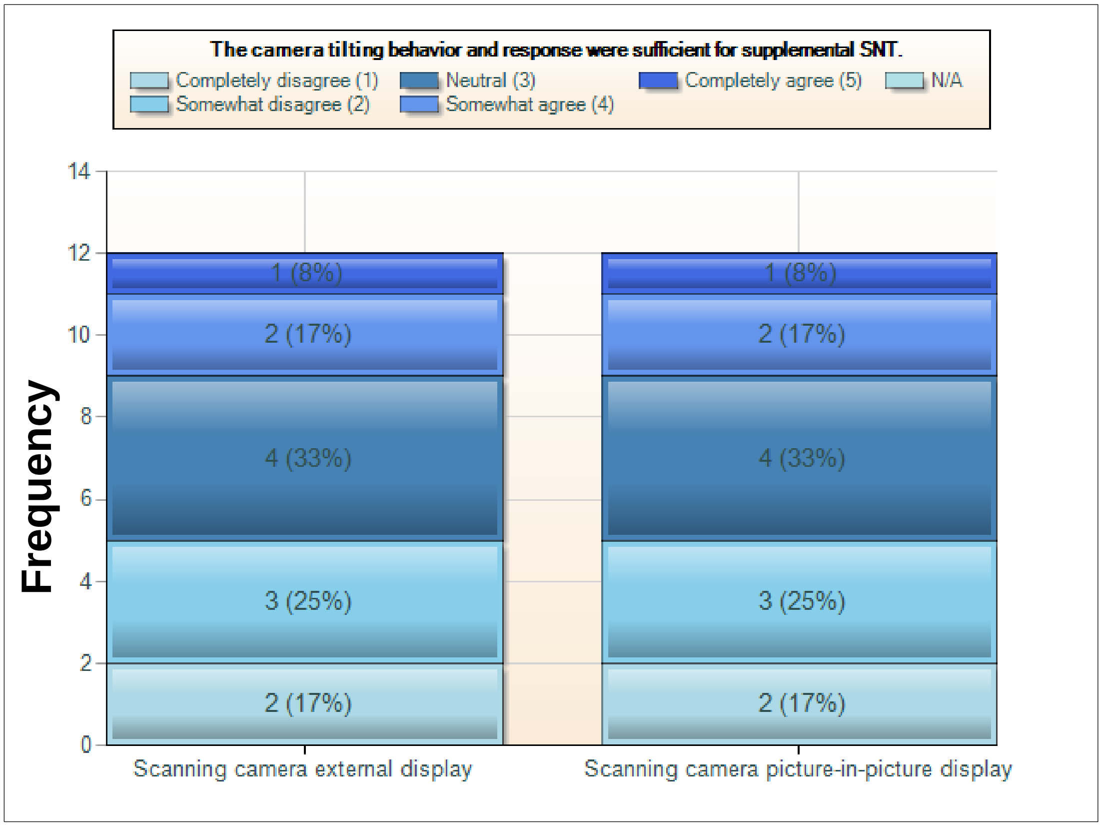

Figure J-76: Sufficiency of the camera tilting behavior and response for supplemental SNT

As shown in Figure J-76, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the camera tilting behavior and response in supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived sufficiency of the camera tilting behavior and response using a long-range camera external display, χ^2 (4, N = 12) = 2.16, p > .05 or a long-range camera picture-in-picture display, χ^2 (4, N = 12) = 2.16, p > .05.

Figure J-77: Sufficiency of the camera focusing behavior and response for supplemental SNT

As shown in Figure J-77, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the camera focusing behavior and response in supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived sufficiency of the camera focusing behavior and response using a long-range camera external display, χ^2 (4, N = 12) = 6.33, p > .05 or a long-range camera picture-in-picture display, χ^2 (4, N = 12) = 8.83, p > .05.

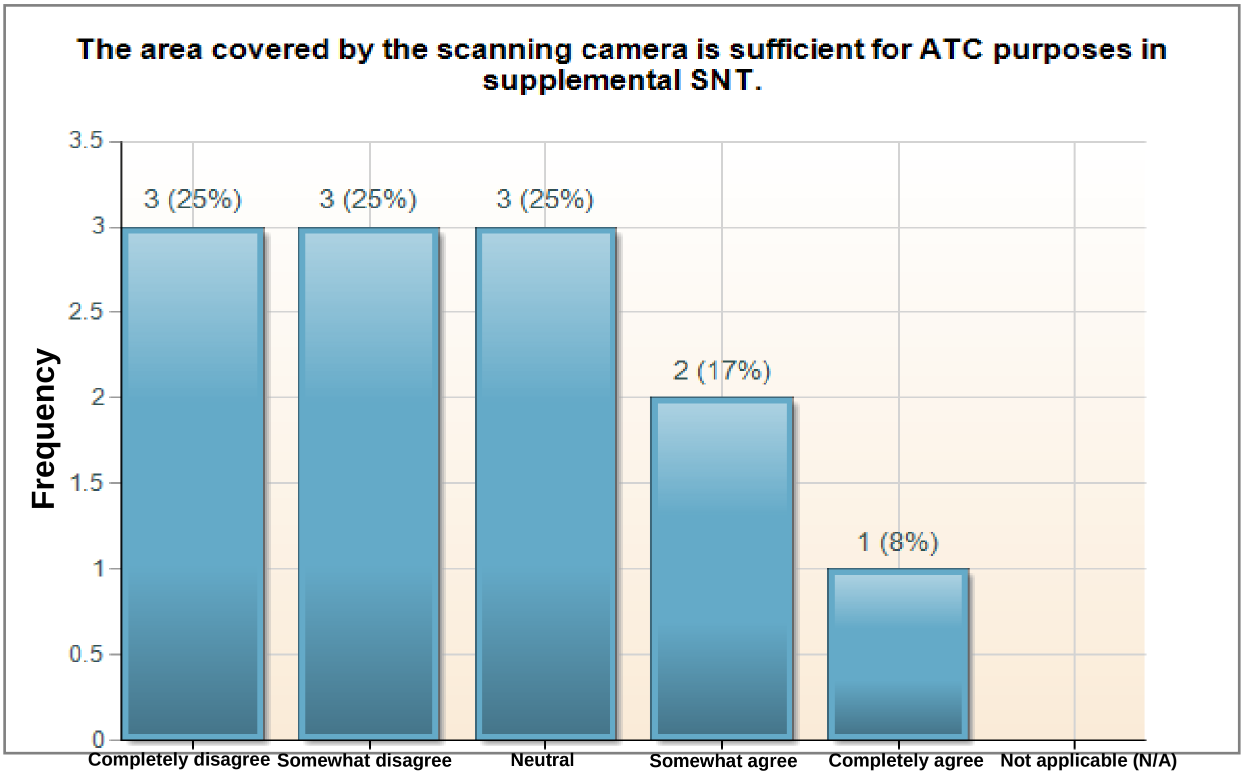

Figure J-78: Sufficiency of the area covered by the long-range camera for ATC purposes in supplemental SNT

As shown in Figure J-78, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the area covered by the long-range camera for ATC purposes in supplemental SNT, χ^2 (4, N = 12) = 1.33, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived sufficiency of the area covered by the long-range camera.

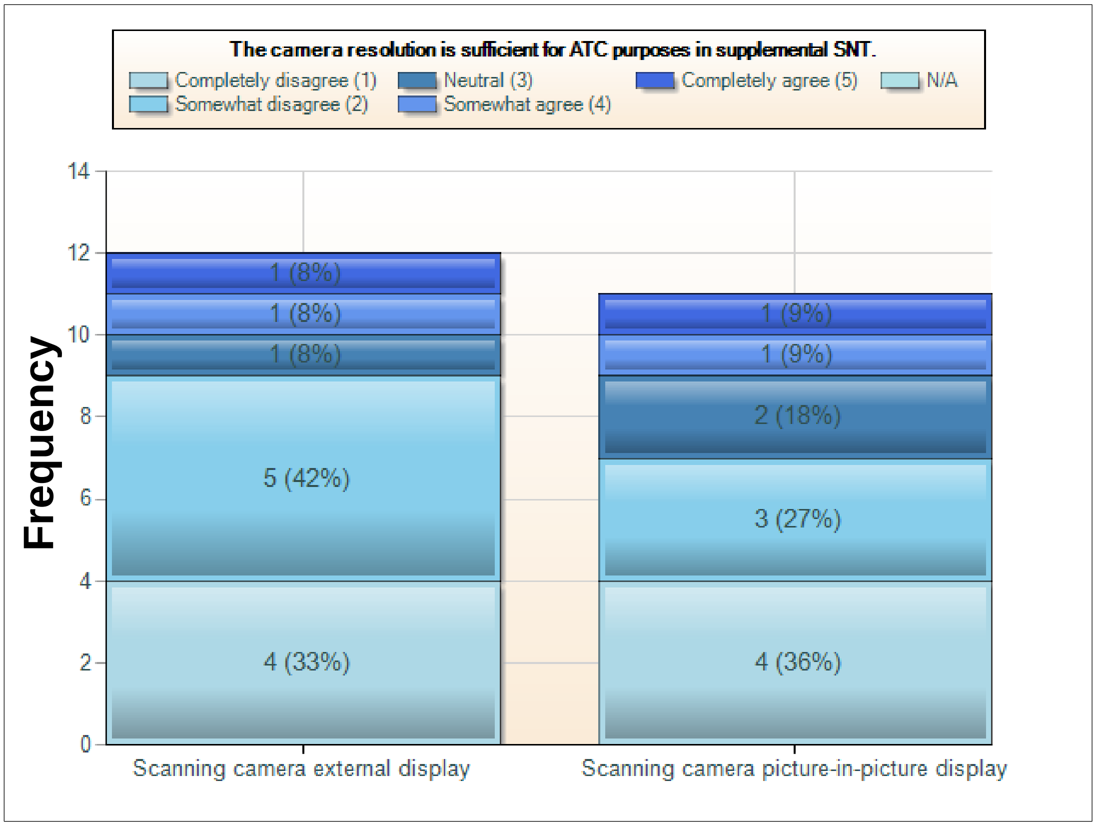

Figure J-79: Sufficiency of the camera resolution for ATC purposes for supplemental SNT

As shown in Figure J-79, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the camera resolution for ATC purposes in supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived sufficiency of the camera resolution using a long-range camera external display, χ^2 (4, N = 12) = 6.33, p > .05 or a long-range camera picture-in-picture display, χ^2 (4, N = 11) = 3.09, p > .05.

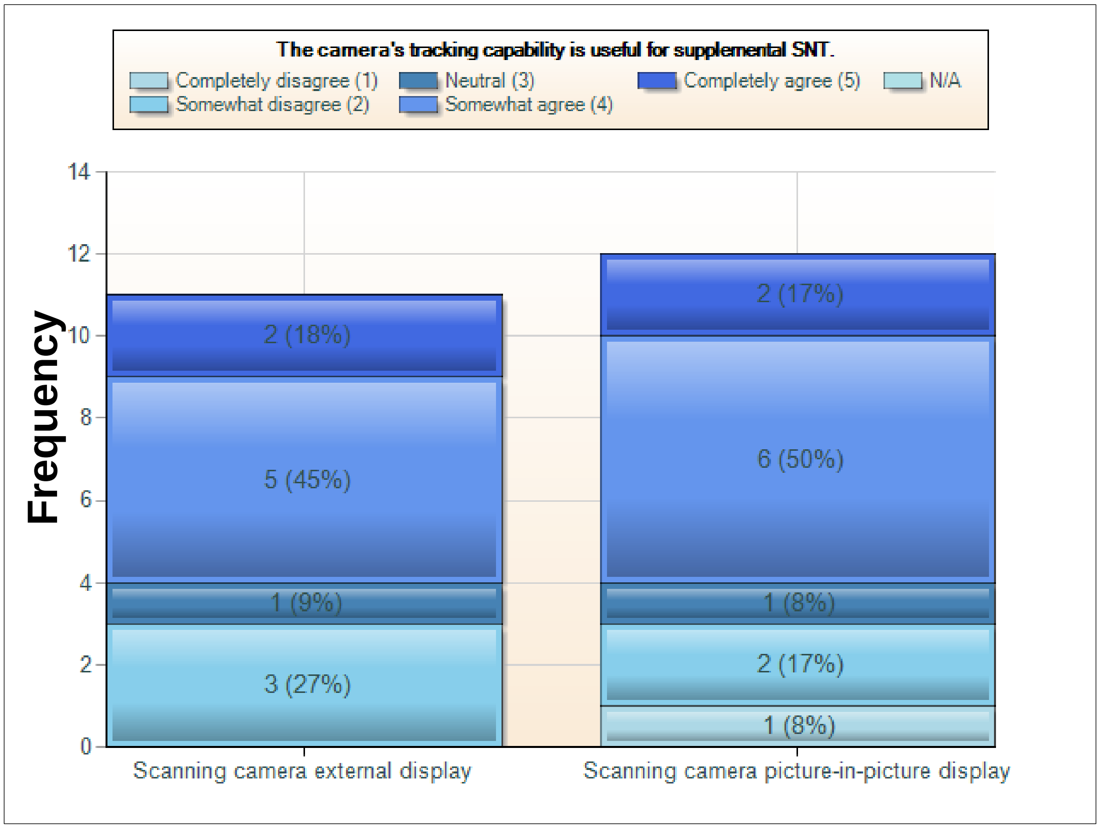

Figure J-80: Usefulness of the camera's tracking capability for supplemental SNT

As shown in Figure J-80, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the camera's tracking capability for supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived usefulness of the camera's tracking capability using a long-range camera external display, χ^2 (4, N = 11) = 6.72, p > .05 or long-range camera picture-in-picture display, χ^2 (4, N = 12) = 7.16, p > .05.

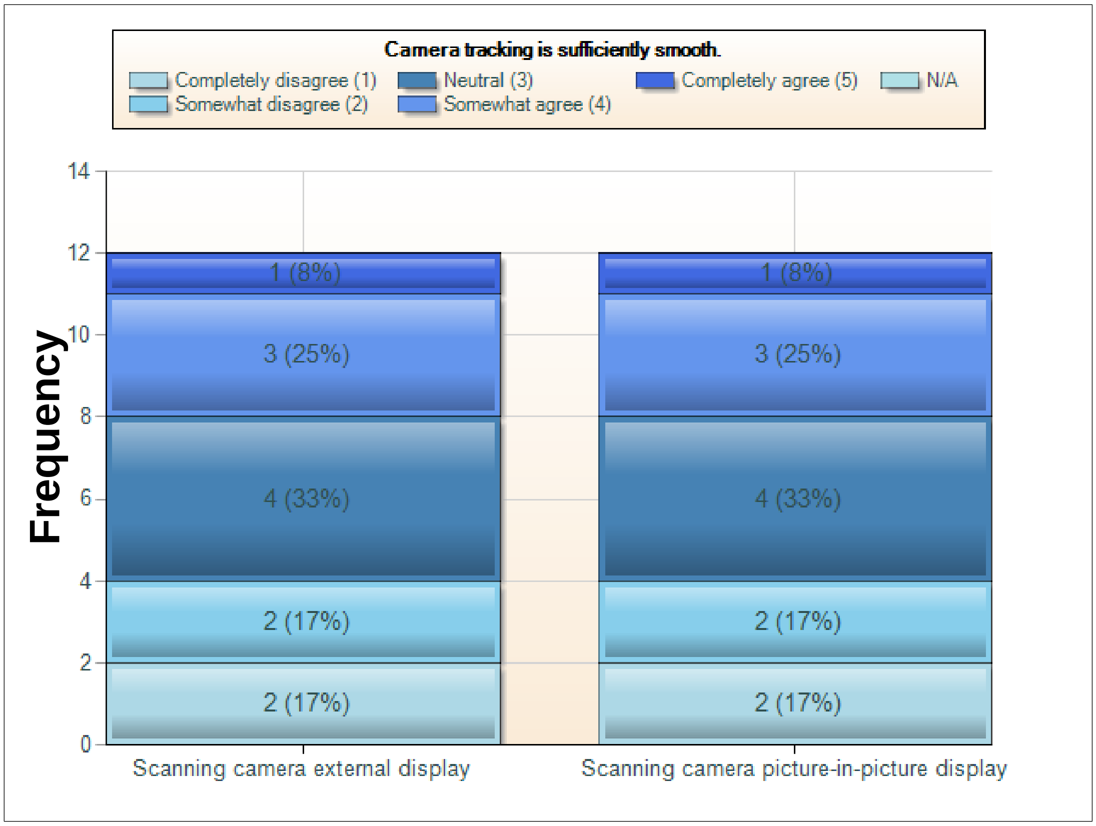

Figure J-81: Sufficiency of smooth camera tracking for supplemental SNT

As shown in Figure J-81, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of smooth camera tracking in supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived sufficiency of smooth camera tracking using a long-range camera external display, χ^2 (4, N = 12) = 2.16, $p > .05$ or a long-range camera picture-in-picture display, χ^2 (4, N = 12) = 2.16, $p > .05$.

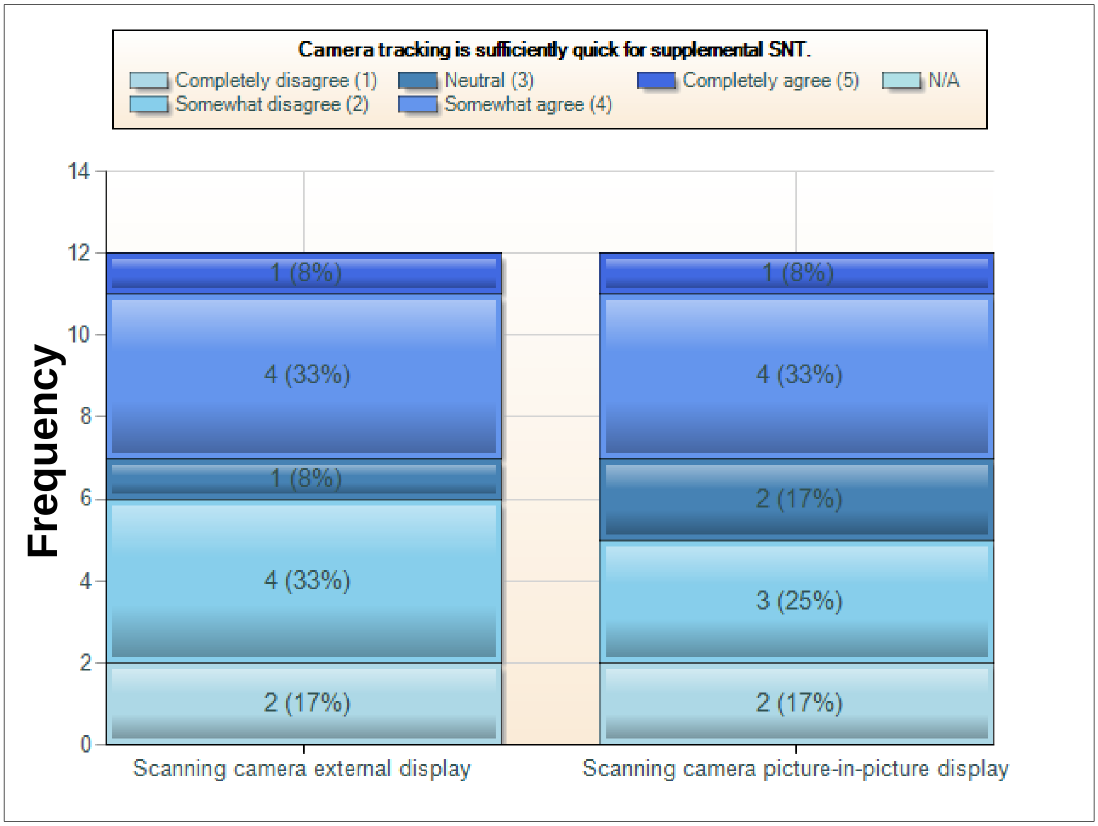

Figure J-82: Sufficiency of quick camera tracking for supplemental SNT

As shown in Figure J-82, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of quick camera tracking in supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived sufficiency of quick camera tracking using a long-range camera external display, χ^2 (4, N = 12) = 3.83, p > .05 or a long-range camera picture-in-picture display, χ^2 (4, N = 12) = 2.16, p > .05.

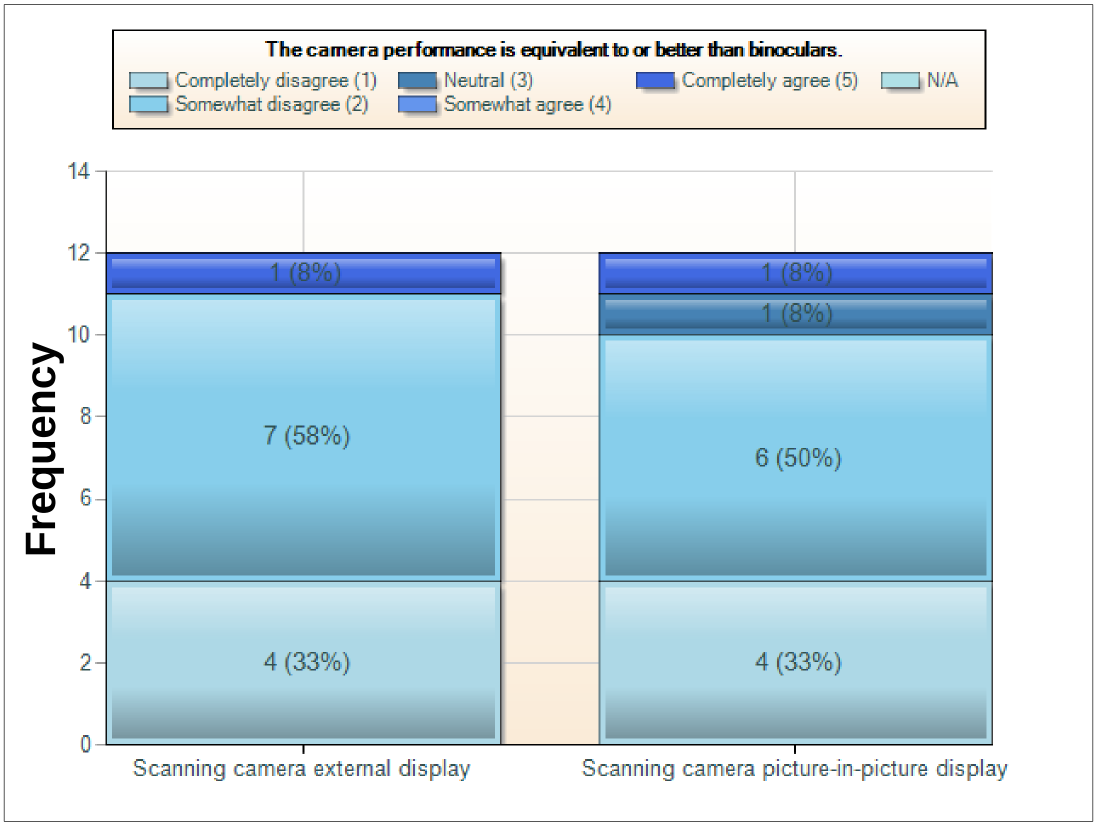

Figure J-83: Perceived camera performance compared to binoculars for supplemental SNT

As shown in Figure J-83, there was a significant difference between observed ratings and expected ratings for perceived camera performance compared to binoculars in supplemental SNT. More participants than expected somewhat disagreed that the camera performance was equivalent to or better than binoculars while using long-range camera external display, χ^2 (4, N = 12) = 15.50, p < .05 or long-range camera picture-in-picture display, χ^2 (4, N = 12) = 10.50, p < .05.

Figure J-84: Helpfulness of camera in controlling traffic for supplemental SNT

As shown in Figure J-84, there was no significant difference between observed ratings and expected ratings for perceived helpfulness of camera in controlling traffic during supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived helpfulness of the camera in controlling traffic while using a long-range camera external display or long-range camera picture-in-picture display, χ^2 (4, N = 12) = 3.83, p > .05.

Figure J-85: Helpfulness of camera view in helping controllers maintain awareness of aircraft identity for supplemental SNT

As shown in Figure J-85, there was no significant difference between observed ratings and expected ratings for perceived helpfulness of camera view in helping controllers maintain awareness of aircraft identity during supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived helpfulness in maintain awareness of aircraft identity while using a long-range camera external display, χ^2 (4, N = 12) = 7.16, p > .05 or long-range camera picture-in-picture display, χ^2 (4, N = 12) = 5.50, p > .05.

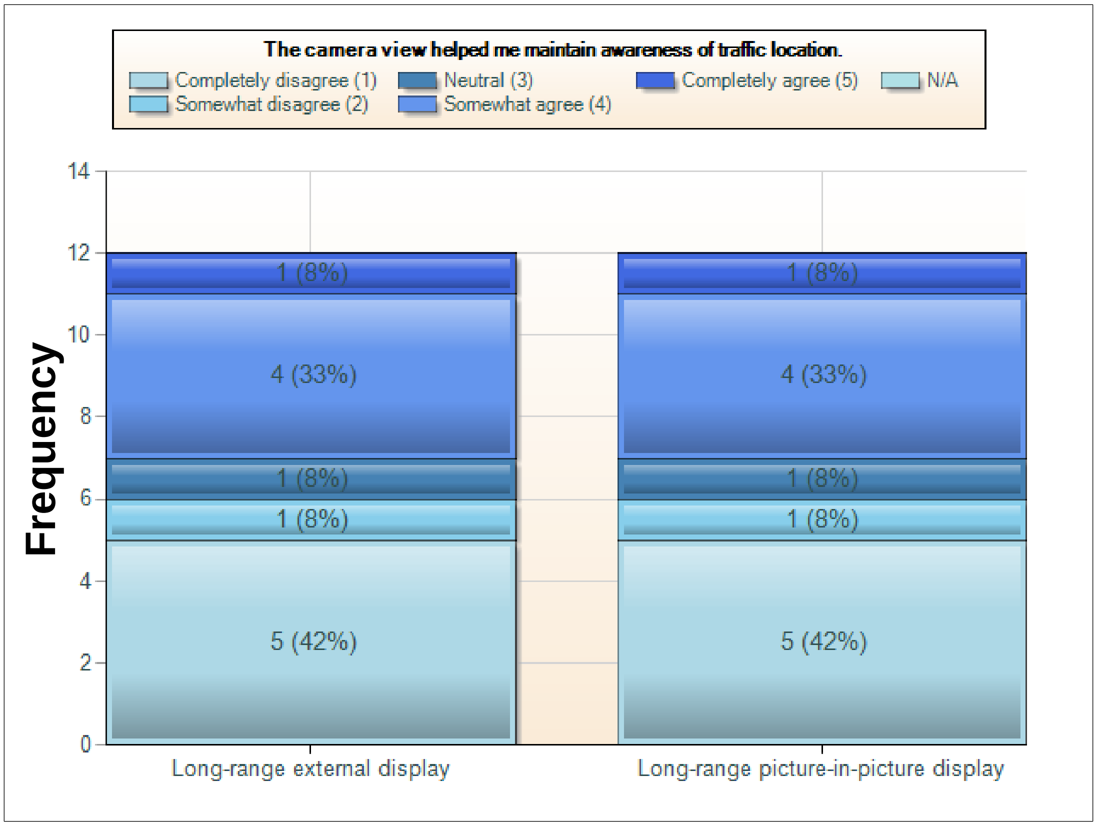

Figure J-86: Helpfulness of camera view in helping controllers maintain awareness of traffic location for supplemental SNT

As shown in Figure J-86, there was no significant difference between observed ratings and expected ratings for perceived helpfulness of camera view in helping controllers maintain awareness of traffic location during supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived helpfulness of camera view in helping controllers maintain awareness of traffic location while using a long-range external display or long-range picture-in-picture display, χ^2 (4, N = 12) = 6.33, p > .05.

Figure J-87: Helpfulness of camera view in helping controllers maintain efficient operations for supplemental SNT

As shown in Figure J-87, there was no significant difference between observed ratings and expected ratings for perceived helpfulness of camera view in helping controllers maintain efficient operations during supplemental SNT. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived helpfulness of camera view in helping controllers maintain efficient operations while using a long-range camera external display, χ^2 (4, N = 12) = 6.33, p > .05 or long-range camera picture-in-picture display, χ^2 (4, N = 12) = 5.50, p > .05.

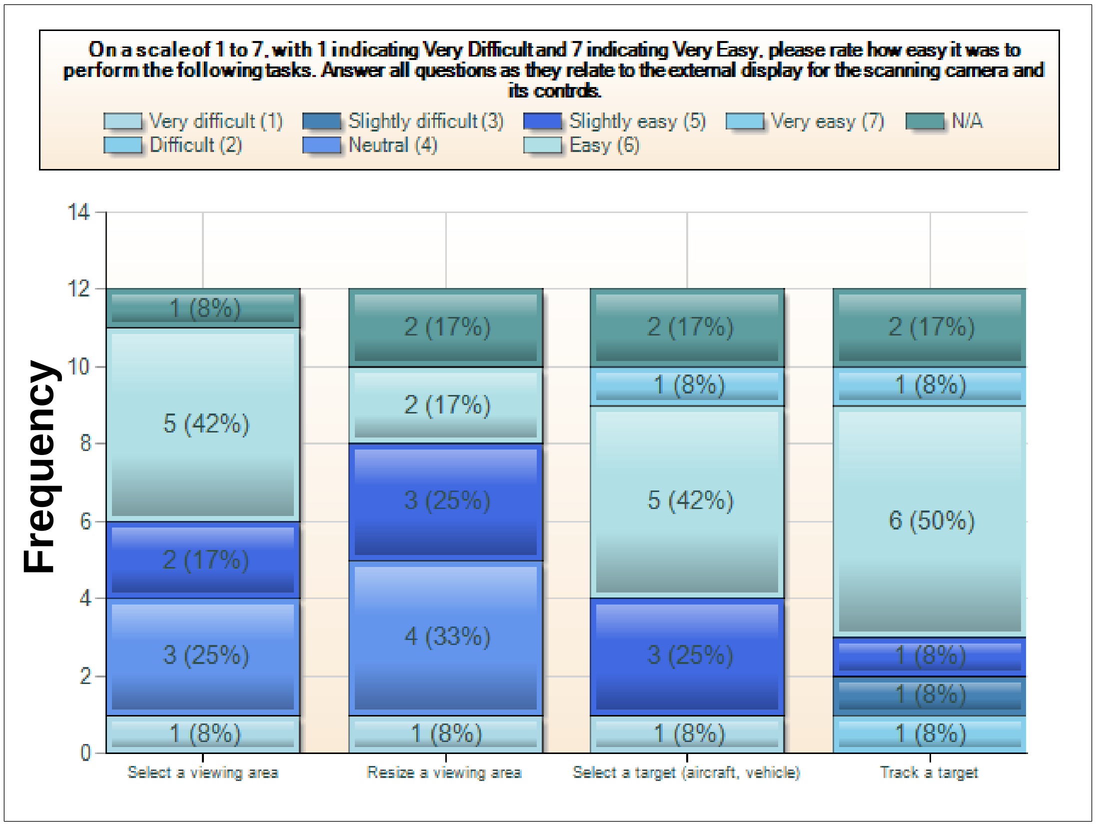

Figure J-88: Ease of using long-range camera views for supplemental SNT tasks

As shown in Figure J-88, there was a significant difference between observed ratings and expected ratings for perceived ease of using long-range camera views for supplemental SNT tasks. More participants than expected believed that using the panning control on picture-in-picture was easy, χ^2 (6, N = 12) = 13.67, $p < .05$. On the other hand, participants were as likely to perceive the ease of using the zoom controls on picture-in-picture, χ^2 (6, N = 12) = 9.00, $p > .05$, tilt controls on picture-in-picture, χ^2 (6, N = 10) = 4.00, $p > .05$, zoom controls on external display, χ^2 (6, N = 12) = 4.33, $p > .05$, panning controls on external display, χ^2 (6, N = 11) = 4.90, $p > .05$, and tilt controls on external display, χ^2 (6, $N = 10^{§}$) = 4.90, $p > .05$, as very easy, easy, slightly easy, neutral, slightly difficult, difficult, or very difficult.

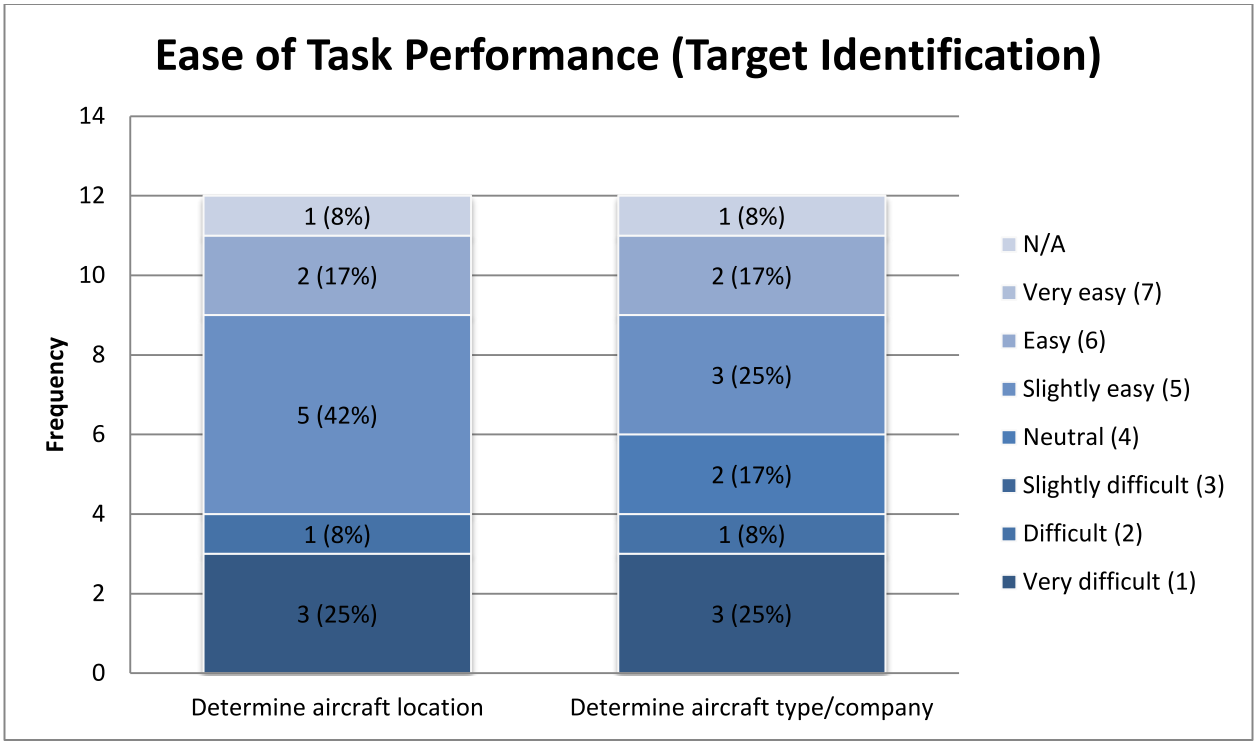

Figure J-89: Ease of determining target location using the long-range camera views for supplemental SNT tasks

As shown in Figure J-89, there was a significant difference between observed ratings and expected ratings for perceived ease of performing tasks using the long-range camera views for supplemental SNT tasks. More participants than expected believed that determining aircraft location was slightly easy, χ^2 (6, N = 11) = 13.81, p < .05. On the other hand, participants were as likely to believe that determining the aircraft type/company was very difficult, difficult, slightly difficult, neutral, slightly easy, easy, or very easy, χ^2 (6, N = 11) = 6.18, p > .05.

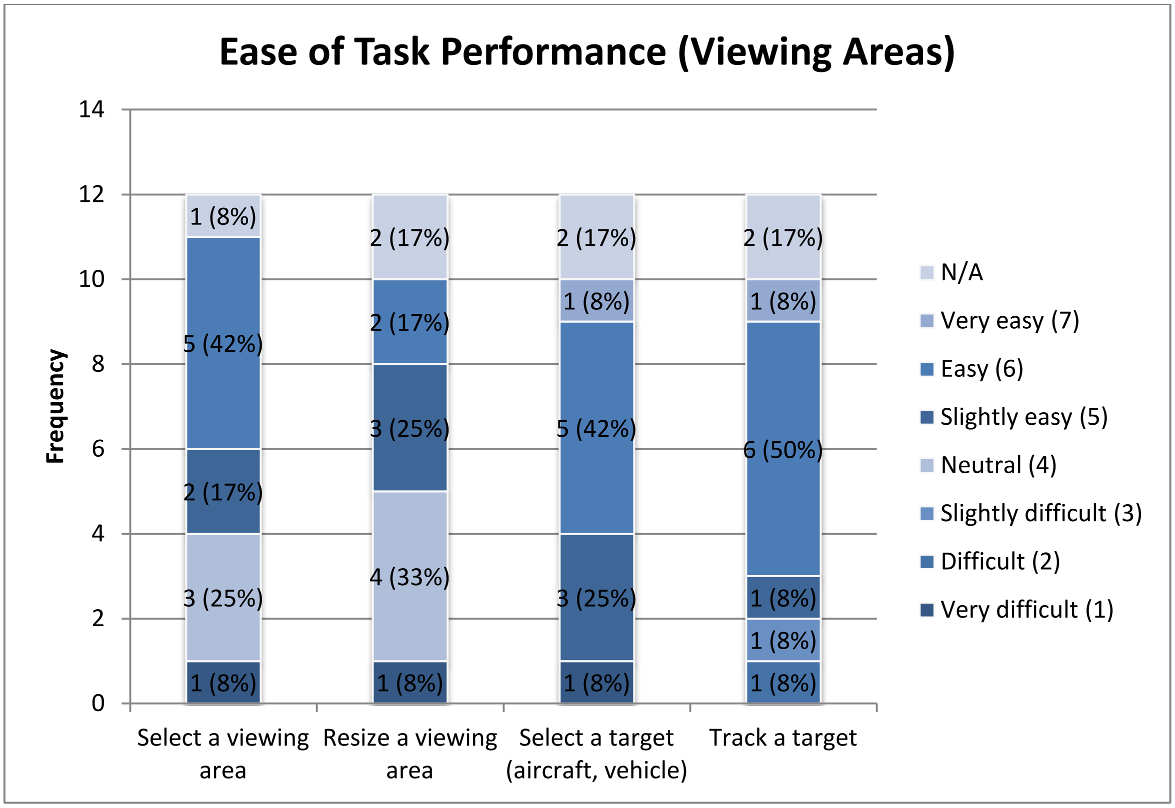

Figure J-90: Ease of viewing areas using the long-range camera external display for supplemental SNT

As shown in Figure J-90, there was a significant difference between observed ratings and expected ratings for perceived ease of performing tasks using the long-range camera external display for supplemental SNT. More participants than expected believed that selecting a viewing area, χ^2 (6, N = 11) = 13.81, $p < .05$ and tracking a target, χ^2 (6, N = 10) = 18.00, $p < .05$, and selecting a target, χ^2 (6, N = 10) = 15.20, $p < .05$ were easy. On the other hand, participants were as likely to believe that resizing a viewing area, χ^2 (6, N = 10) = 11.00, $p < .05$ was very easy, easy, slightly easy, neutral, slightly difficult, difficult, or very difficult.

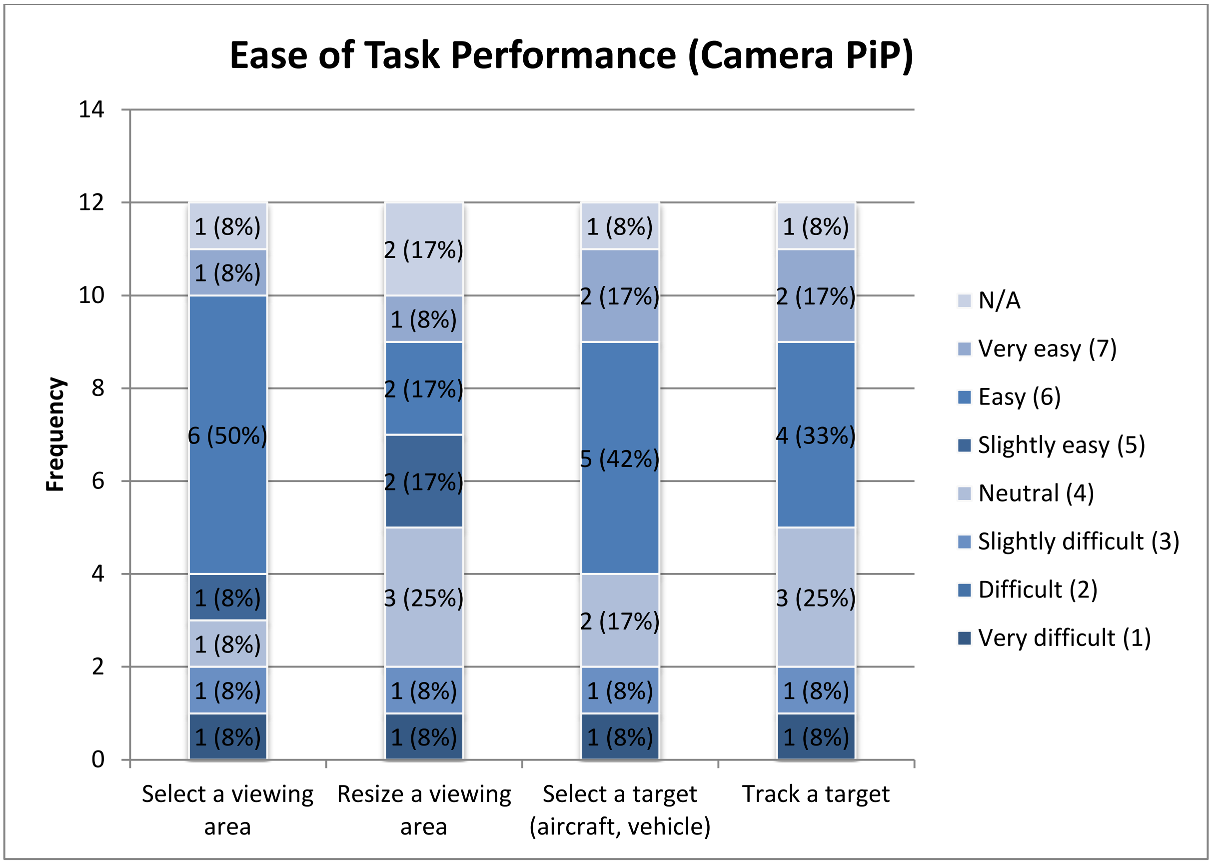

Figure J-91: Ease of performing tasks using the long-range camera picture-in-picture display for supplemental SNT

As shown in Figure J-91, there was a significant difference between observed ratings and expected ratings for perceived ease of performing tasks using the long-range camera picture-in-picture display for supplemental SNT. More participants than expected believed that selecting a viewing area, χ^2 (6, N = 11) = 15.09, p < .05 was easy. On the other hand, participants were as likely to believe that resizing a viewing area, χ^2 (6, N = 10) = 4.00, p > .05, selecting a target (aircraft, vehicle), χ^2 (6, N = 11[§] = 11.27, p > .05, and tracking a target, χ^2 (6, N = 11) = 8.72, p > .05 were very easy, easy, slightly easy, neutral, slightly difficult, difficult, or very difficult.

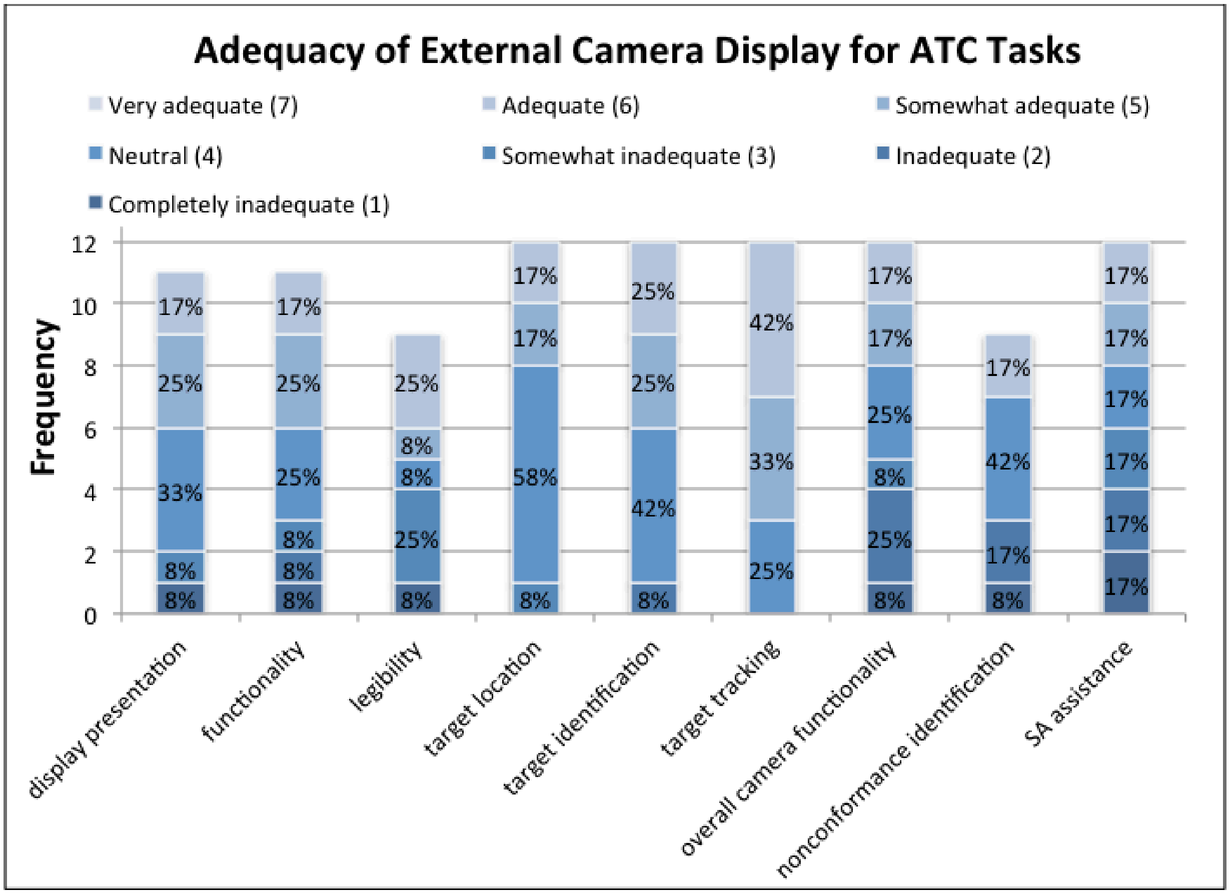

Figure J-92: Perceived adequacy of long-range camera external display attributes for supplemental SNT

As shown in Figure J-92, there was a significant difference between observed ratings and expected ratings for perceived adequacy of long-range camera external display attributes for supplemental SNT. More participants than expected were neutral when asked to indicate the ease with which they can locate a target, χ^2 (6, N = 12) = 21.83, p < .05, or determine aircraft type/company, χ^2 (6, N = 12) = 21.83, p < .05. Furthermore, more participants then expected believed that the ease with which they could track a target was adequate, χ^2 (6, N = 12) = 17.16, p < .05. On the other hand, participants were as likely to believe that the overall external display presentation, χ^2 (6, N = 11) = 4.00, p > .05, overall functionality, χ^2 (6, N = 11) = 11.27, p > .05, text legibility, χ^2 (6, N = 9) = 8.72, p > .05, overall long-range camera functionality, χ^2 (6, N = 12) = 8.72, p > .05, ease with which they could determine nonconformance, χ^2 (6, N = 9) = 8.72, p > .05, and ability to assist in maintaining situational awareness, χ^2 (6, N = 12) = 2.00, p > .05 were very adequate, adequate, somewhat adequate, neutral, somewhat inadequate, inadequate, or completely inadequate.

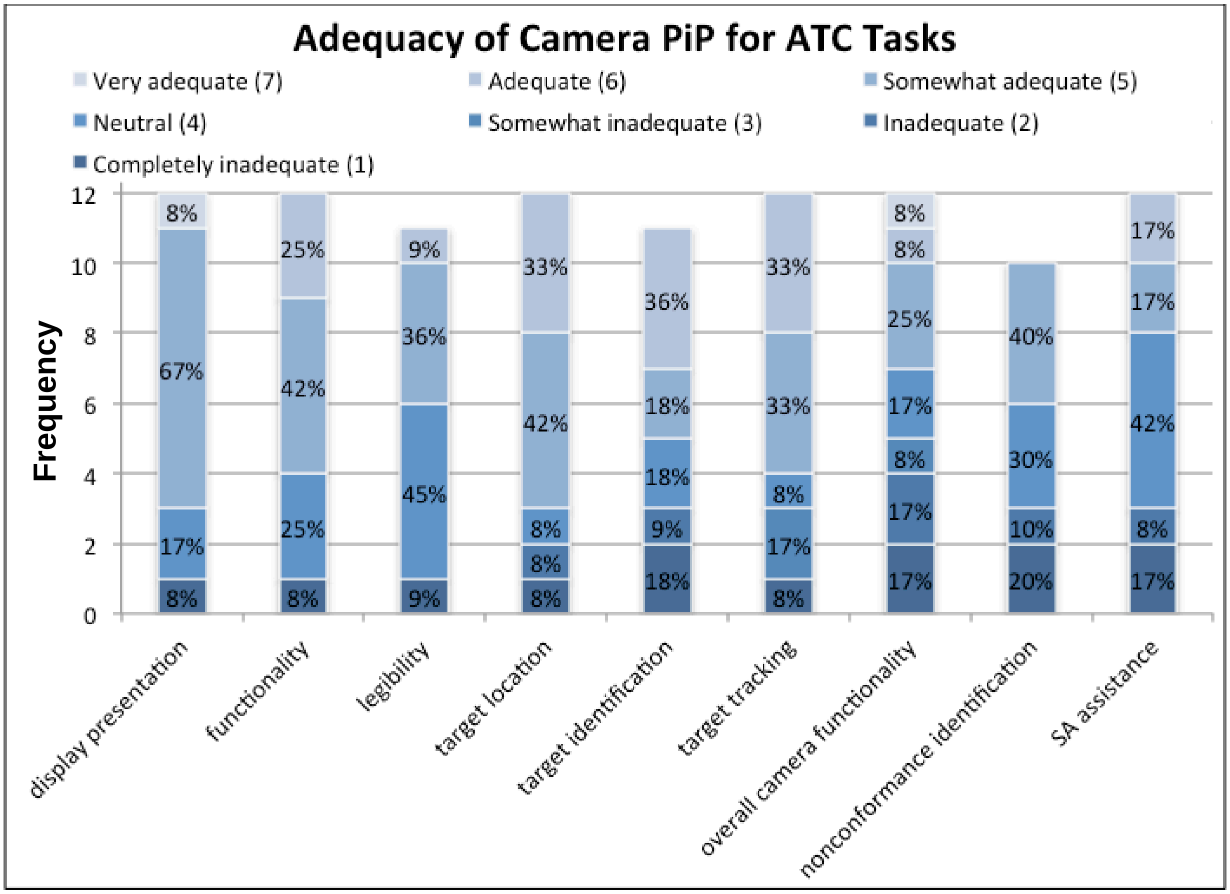

Figure J-93: Perceived adequacy of long-range camera picture-in-picture display attributes on the TIDS for supplemental SNT

As shown in Figure J-93, there was a significant difference between observed ratings and expected ratings for perceived adequacy of long-range camera picture-in-picture attributes on the TIDS for supplemental SNT. More participants than expected were neutral when asked about the text legibility, χ^2 (6, N = 11) = 16.36, p < .05. Furthermore, more participants then expected believed that the overall presentation, χ^2 (6, N = 12) = 28.83, p < .05, functionality, χ^2 (6, N = 12) = 13.66, p < .05, and the ease with which they could locate a target, χ^2 (6, N = 12) = 13.66, p < .05 were somewhat adequate. On the other hand, participants were as likely to believe that the ease with which they could determine aircraft type/company, χ^2 (6, N = 11) = 7.45, p > .05, the ease with which they could track a target, χ^2 (6, N = 12) = 10.16, p > .05, the overall long-range camera functionality, χ^2 (6, N = 12) = 2.00, p > .05, the ease with which they could determine nonconformance, χ^2 (6, N = 10) = 11.00, p > .05, and ability to assist in maintaining situational awareness, χ^2 (6, N = 12) = 10.16, p > .05 were very adequate, adequate, somewhat adequate, neutral, somewhat inadequate, inadequate, or completely inadequate.

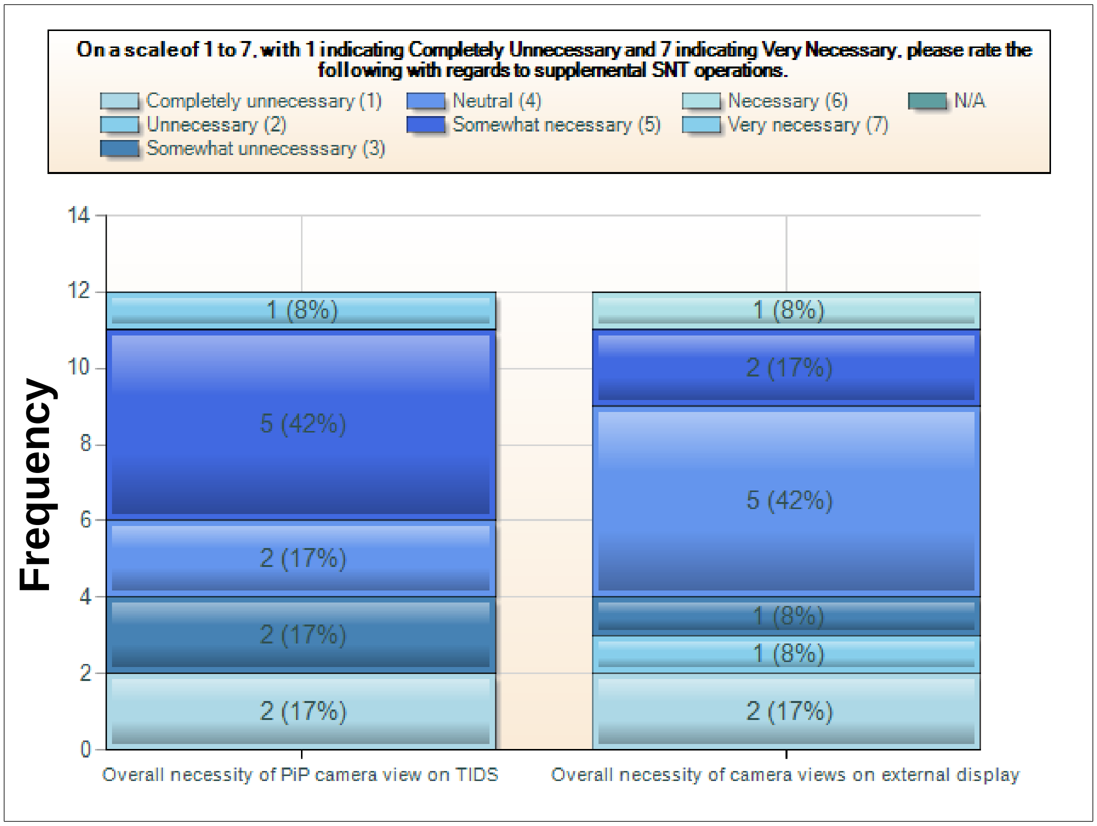

Figure J-94: Perceived necessity of supplemental SNT operations

As shown in Figure J-94, there was no significant difference between observed ratings and expected ratings for perceived necessity of supplemental SNT operations. Participants were as likely to believe that the overall necessity of picture-in-picture view on TIDS, χ^2 (6, N = 12) = 10.16, p > .05 and of camera views on external display, χ^2 (6, N = 12) = 9.00, p > .05 were very necessary, necessary, somewhat necessary, neutral, somewhat unnecessary, unnecessary, or completely unnecessary.

Table J-2 provides a summary of the supplemental SNT camera results.

Table J-2: General summary for camera use in supplemental SNT

		Chi Square	**Mean**	**SD**
Question 1	The external camera display is useful for supplemental SNT	3.83 *(p=.429)*	3.08	1.44
Question 2	The size of the external camera display is optimal for supplemental SNT	2.16 *(p=.705)*	3.25	1.42

		Chi Square	Mean	SD
Question 3	The layout of the external camera display is sufficient for supplemental SNT	3.83 *(p=.429)*	3.50	1.38
Question 4	The picture-in-picture camera display on the TIDS is useful for supplemental SNT	1.33 *(p=.856)*	3.00	1.47
Question 5	The size of the picture-in-picture camera display is optimal for supplemental SNT (if camera PiP was used)	7.16 *(p=.127)*	3.17	1.19
Question 6	The camera image is useful for air traffic control tasks in supplemental SNT			
	Long-range camera external display	1.33 *(p=.856)*	2.92	1.62
	Long-range camera picture-in-picture display	5.50 *(p=.240)*	3.08	1.56
Question 7	The camera control user interface is easy to use			
	Long-range camera external display	3.00 *(p=.558)*	3.58	1.24
	Long-range camera picture-in-picture display	3.00 *(p=.558)*	3.58	1.24
Question 8	The update rate is sufficient for ATC purposes in supplemental SNT			
	Long-range camera external display	3.83 *(p=.429)*	2.67	1.37
	Long-range camera picture-in-picture display	3.83 *(p=.429)*	2.67	1.37
Question 9	The rate of camera control is sufficient for ATC purposes in supplemental SNT			
	Long-range camera external display	1.33 *(p=.856)*	3.08	1.56
	Long-range camera picture-in-picture display	1.33 *(p=.856)*	3.08	1.56
Question 10	The camera panning behavior and response were sufficient for supplemental SNT			
	Long-range camera external display	3.00 *(p=.558)*	2.92	1.16
	Long-range camera picture-in-picture display	5.50 *(p=.240)*	2.83	1.03
Question 11	The camera zoom behavior and response were sufficient for supplemental SNT			
	Long-range camera external display	6.33 *(p=.176)*	2.42	1.16

		Chi Square	Mean	SD
	Long-range camera picture-in-picture display	6.33 *(p=.176)*	2.42	1.16
Question 12	The camera tilting behavior and response were sufficient for supplemental SNT			
	Long-range camera external display	2.16 *(p=.705)*	2.75	1.21
	Long-range camera picture-in-picture display	2.16 *(p=.705)*	2.75	1.21
Question 13	The camera focusing behavior and response were sufficient for supplemental SNT			
	Long-range camera external display	6.33 *(p=.176)*	2.25	1.13
	Long-range camera picture-in-picture display	8.83 *(p=.065)*	2.17	1.11
Question 15	The area covered by the long-range camera is sufficient for ATC purposes in supplemental SNT	1.33 (p=.856)	2.58	1.31
Question 16	The camera resolution is sufficient for ATC purposes in supplemental SNT			
	Long-range camera external display	6.33 *(p=.176)*	2.17	1.26
	Long-range camera picture-in-picture display	3.09 *(p=.543)*	2.27	1.34
Question 17	The camera's tracking capability is useful for supplemental SNT			
	Long-range camera external display	6.72 *(p=.151)*	3.55	1.12
	Long-range camera picture-in-picture display	7.16 *(p=.127)*	3.50	1.24
Question 18	Camera tracking is sufficiently smooth			
	Long-range camera external display	2.16 *(p=.705)*	2.92	1.24
	Long-range camera picture-in-picture display	2.16 *(p=.705)*	2.92	1.24
Question 19	Camera tracking is sufficiently quick for supplemental SNT			
	Long-range camera external display	3.83 *(p=.429)*	2.83	1.33
	Long-range camera picture-in-picture display	2.16 *(p=.705)*	2.92	1.31
Question 20	The camera performance is equivalent to or better than binoculars			

		Chi Square	Mean	SD
	Long-range camera external display	15.50 *(p=.033)*	1.92	1.08
	Long-range camera picture-in-picture display	10.50 *(p=.033)*	2.00	1.12
Question 21	The camera will help me in controlling traffic in supplemental SNT			
	Long-range camera external display	3.83 *(p=.429)*	2.42	1.31
	Long-range camera picture-in-picture display	3.83 *(p=.429)*	2.42	1.31
Question 22	The camera view helped me maintain awareness of aircraft identity			
	Long-range camera external display	7.16 *(p=.127)*	2.33	1.37
	Long-range camera picture-in-picture display	5.50 *(p=.240)*	2.25	1.28
Question 23	The camera view helped me maintain awareness of aircraft identity			
	Long-range external display	6.33 *(p=.176)*	2.58	1.56
	Long-range picture-in-picture display	6.33 *(p=.176)*	2.58	1.56
Question 25	The camera view helped me maintain efficient operations			
	Long-range camera external display	6.33 *(p=.176)*	2.42	1.16
	Long-range camera picture-in-picture display	5.50 *(p=.240)*	2.33	1.15
Very Difficult (1), Difficult (2), Slightly Difficult (3), Neutral (4), Slightly Easy (5), Easy (6), Very Easy (7)				
Question 14	Rate how easy it was to perform the following tasks as they relate to the long-range camera views (external display and/or PiP) and their controls			
	Use zoom controls on picture-in-picture	9.00 *(p=.174)*	5.25	1.91
	Use panning controls on picture-in-picture	13.67 *(p=.034)*	5.17	1.89
	Use tilt controls on picture-in-picture	4.00 *(p=.677)*	4.60	1.89
	Use zoom controls on external display	4.33 *(p=.632)*	4.67	1.96
	Use panning controls external display	4.90	4.91	1.92

		Chi Square	Mean	SD
		(p=.556)		
	Use tilt controls on external display	2.60 *(p=.857)*	4.40	1.95
Question 24	Rate how easy it was to perform the following tasks as they relate to the long-range camera views (external display and/or PIP) and their controls			
	Determine aircraft location	13.81 *(p=.032)*	3.82	2.08
	Determine aircraft type/company	6.18 *(p=.403)*	3.64	2.14
Question 26	Rate how easy it was to perform the following tasks as they relate to the external display for the long-range camera and its controls			
	Select a viewing area	13.81 *(p=.032)*	4.82	1.53
	Resize a viewing area	11.00 *(p=.088)*	4.40	1.43
	Select a target (aircraft, vehicle)	15.20 *(p=.019)*	5.30	1.63
	Track a target	18.00 *(p=.006)*	5.30	1.56
Question 27	Rate how easy it was to perform the following tasks as they relate to the picture-in-picture display for the long-range camera and its controls			
	Select a viewing area	15.09 *(p=.020)*	5.09	1.75
	Resize a viewing area	4.00 *(p=.677)*	4.50	1.71
	Select a target (aircraft, vehicle)	11.27 *(p=.080)*	5.09	1.86
	Track a target	8.72 *(p=.190)*	4.91	1.86
Completely inadequate (1), Inadequate (2), Somewhat inadequate (3), Neutral (4), Somewhat adequate (5), Adequate (6), Very Adequate (7)				
Question 28	Rate the adequacy of the following items with regards to the external display for the long-range camera on the TIDS			
	Overall external display presentation	8.72 *(p=.190)*	4.27	1.42
	Overall functionality of external display	4.90 *(p=.556)*	4.09	1.57
	Text legibility on external display	7.33 *(p=.291)*	4.11	1.76

		Chi Square	Mean	SD
	The ease with which you can locate a target on external display	21.83 *(p=.001)*	4.42	.900
	The ease with which you can determine aircraft type/company on external display	13.66 *(p=.034)*	4.58	1.16
	The ease with which you can track a target on external display	17.16 *(p=.009)*	5.17	.835
	The overall long-range camera functionality on external display	4.33 *(p=.632)*	3.67	1.67
	The ease with which you can determine nonconformance on external display	10.44 *(p=.107)*	3.67	1.73
	Ability to assist in maintaining situational awareness	2.00 *(p=.920)*	3.50	1.78
Question 29	Rate the adequacy of the following items with regards to the picture-in-picture (PiP) display for the long-range camera on the TIDS			
	Overall picture-in-picture presentation	28.83 *(p=.001)*	4.67	1.37
	Overall functionality of picture-in-picture	13.66 *(p=.034)*	4.67	1.37
	Text legibility on picture-in-picture	16.36 *(p=.012)*	4.27	1.27
	The ease with which you can locate a target on picture-in-picture	13.66 *(p=.034)*	4.67	1.61
	The ease with which you can determine aircraft type/company on picture-in-picture	7.45 *(p=.281)*	4.18	1.99
	The ease with which you can track a target on picture-in-picture	10.16 *(p=.118)*	4.58	1.56
	The overall long-range camera functionality on picture-in-picture	2.00 *(p=.920)*	3.75	1.96
	The ease with which you can determine nonconformance on picture-in-picture	11.00 *(p=.088)*	3.60	1.64
	Ability to assist in maintaining situational awareness	10.16 *(p=.118)*	3.83	1.69
Completely unnecessary (1), Unnecessary (2), Somewhat unnecessary (3), Neutral (4), Somewhat necessary (5), Necessary (6), Very necessary (7)				
Question 30	Rate the following with regards to supplemental SNT operations			
	Overall necessity of picture-in-picture camera view on	10.16 *(p=.118)*	4.00	1.75

		Chi Square	Mean	SD
	TIDS			
	Overall necessity of camera views on external display	9.00 *(p=.174)*	3.58	1.56

J.3 CAMERA FOR CONTINGENCY/FLEXIBLE SNT OPERATIONS CHI SQUARE RESULTS

The following is a detailed report of the Camera results in the context of contingency/flexible SNT operations. For a general summary reference, please see Table J-3.

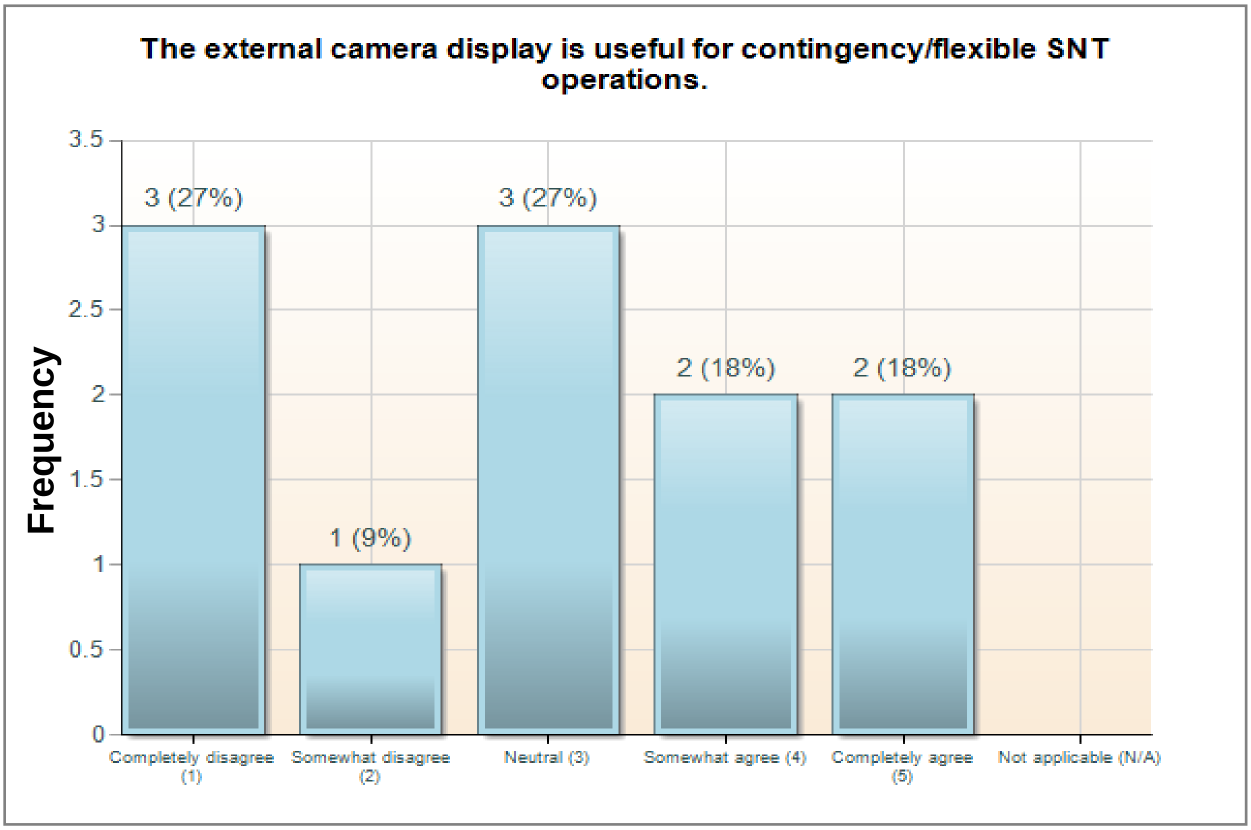

Figure J-95: Usefulness of the external camera display for contingency/flexible SNT operations

As shown in Figure J-95, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the external camera display for contingency/flexible SNT operations, χ^2 (4, N = 11) = 1.27, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived usefulness of the external camera display for contingency/flexible SNT operations.

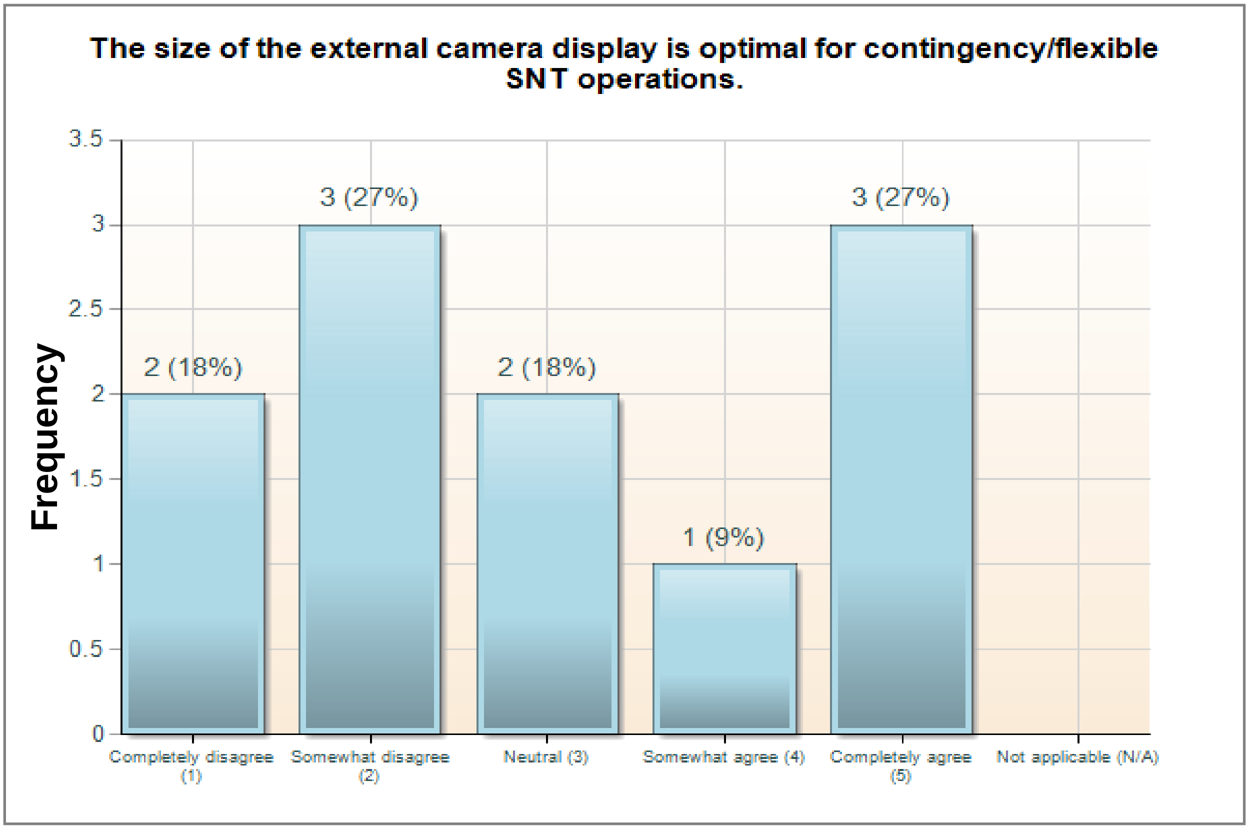

Figure J-96: Size of the external camera display for contingency/flexible SNT operations

As shown in Figure J-96, there was no significant difference between observed ratings and expected ratings for perceived optimal size of the external camera display for contingency/flexible SNT operations, χ^2 (4, N = 11) = 1.27, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived optimal size of the external camera display for contingency/flexible SNT operations.

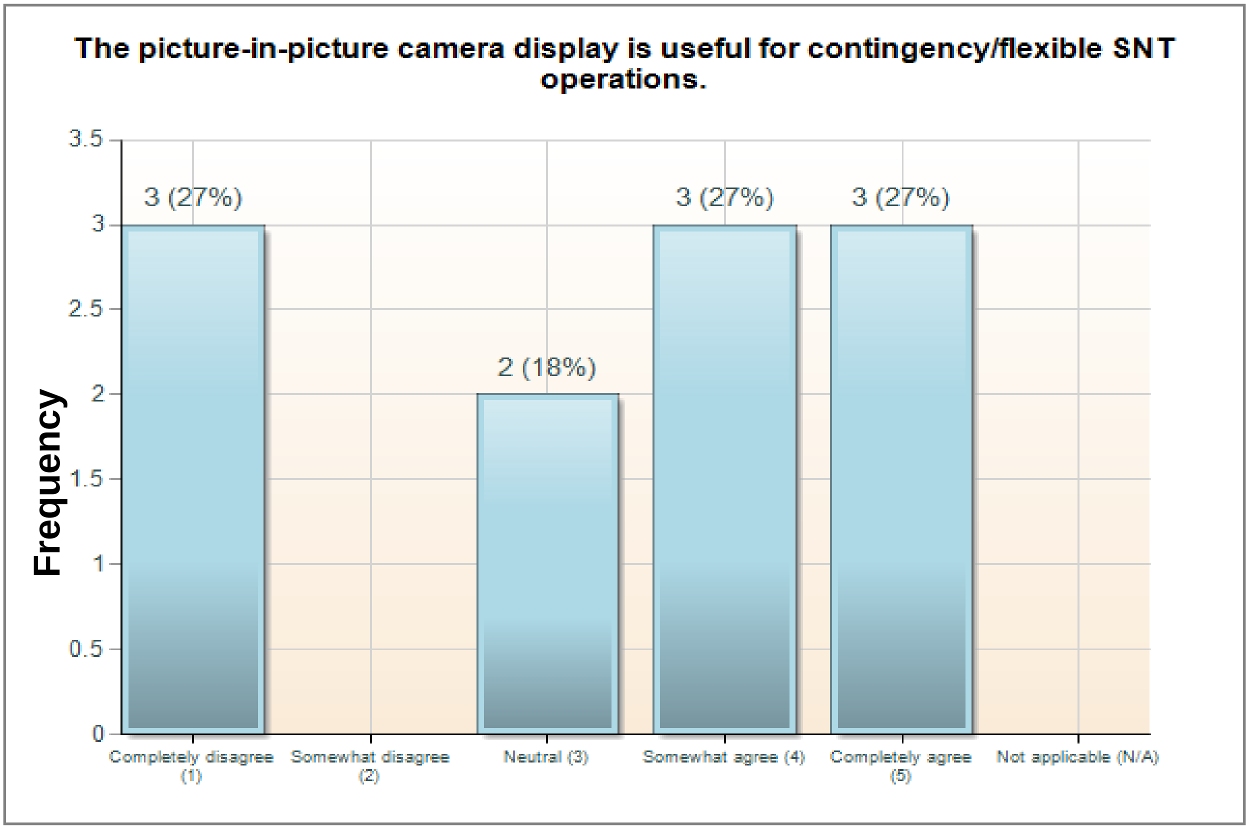

Figure J-97: Usefulness of the PiP camera display for contingency/flexible SNT operations

As shown in Figure J-97, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the picture-in-picture camera display for contingency/flexible SNT operations, χ^2 (4, N = 11) = 3.09, p > .05. Participants were as likely to completely agree, somewhat agree, be neutral, or completely disagree with the perceived usefulness of the picture-in-picture camera display for contingency/flexible SNT operations.

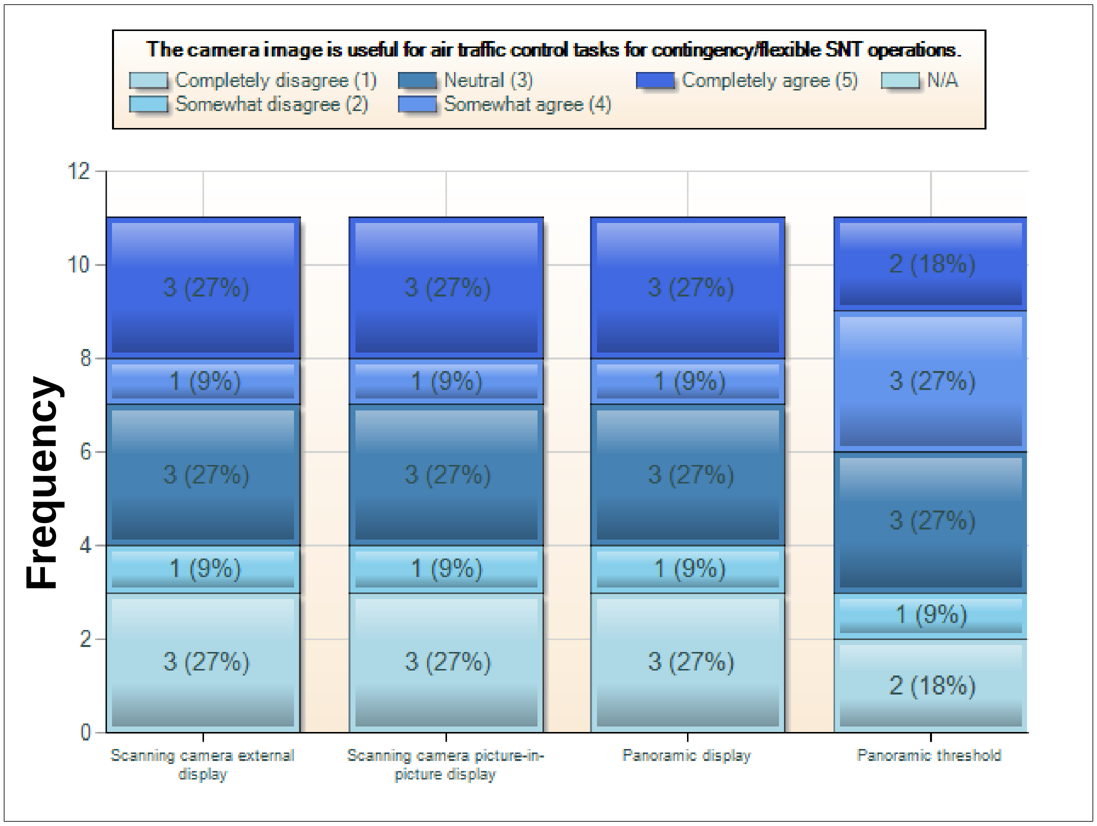

Figure J-98: Usefulness of the camera display for contingency/flexible SNT operations

As shown in Figure J-98, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the camera image in air traffic control tasks during contingency/flexible SNT operations. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived usefulness of the camera image while using a long-range camera external display, χ^2 (4, N = 11) = 2.18, p > .05, long-range camera picture-in-picture display, χ^2 (4, N = 11) = 2.18, p > .05, panoramic display, χ^2 (4, N = 11) = 2.18, p > .05, or panoramic threshold, χ^2 (4, N = 11) = 1.27, p > .05.

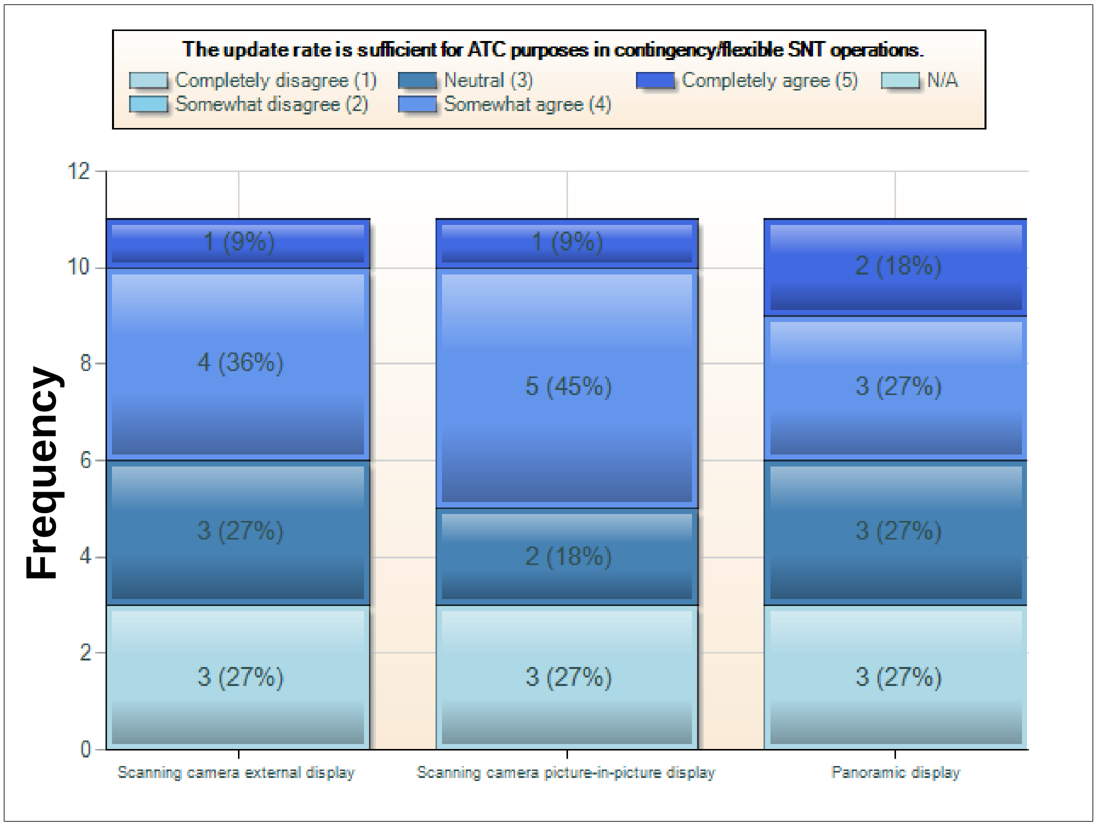

Figure J-99: Sufficiency of the update rate for ATC purposes for contingency/flexible SNT operations

As shown in Figure J-99, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the update rate for ATC purposes in contingency/flexible SNT operations. Participants were as likely to completely agree, somewhat agree, be neutral, or completely disagree with the perceived sufficiency of the update rate while using a long-range camera external display, χ^2 (4, N = 11) = 4.90, $p > .05$, long-range camera picture-in-picture display, χ^2 (4, N = 11) = 6.72, $p > .05$, or panoramic display, χ^2 (4, N = 11) = 3.09, $p > .05$.

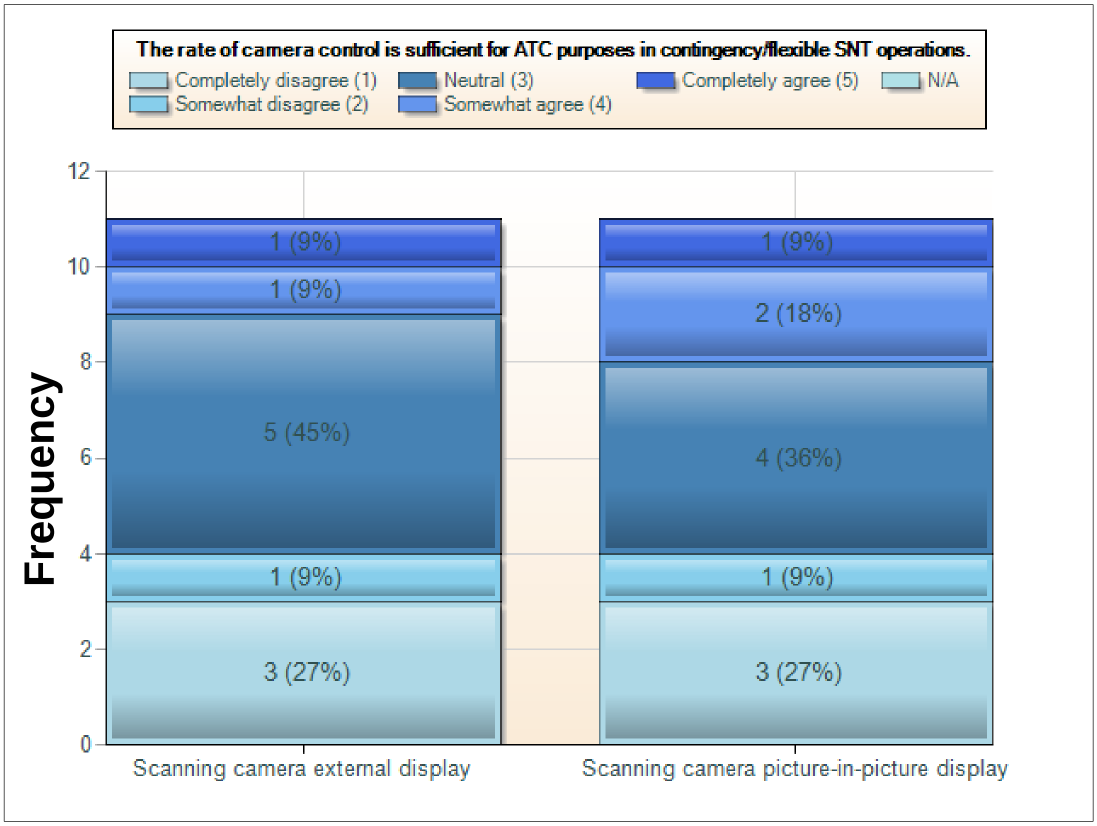

Figure J-100: Sufficiency of the camera control rate for ATC purposes for contingency/flexible SNT operations

As shown in Figure J-100, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the rate of camera control for ATC purposes in contingency/flexible SNT operations. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived sufficiency of the rate of camera control while using a long-range camera external display, χ^2 (4, N = 11) = 5.81, p > .05, or long-range camera picture-in-picture display, χ^2 (4, N = 11) = 3.09, p > .05.

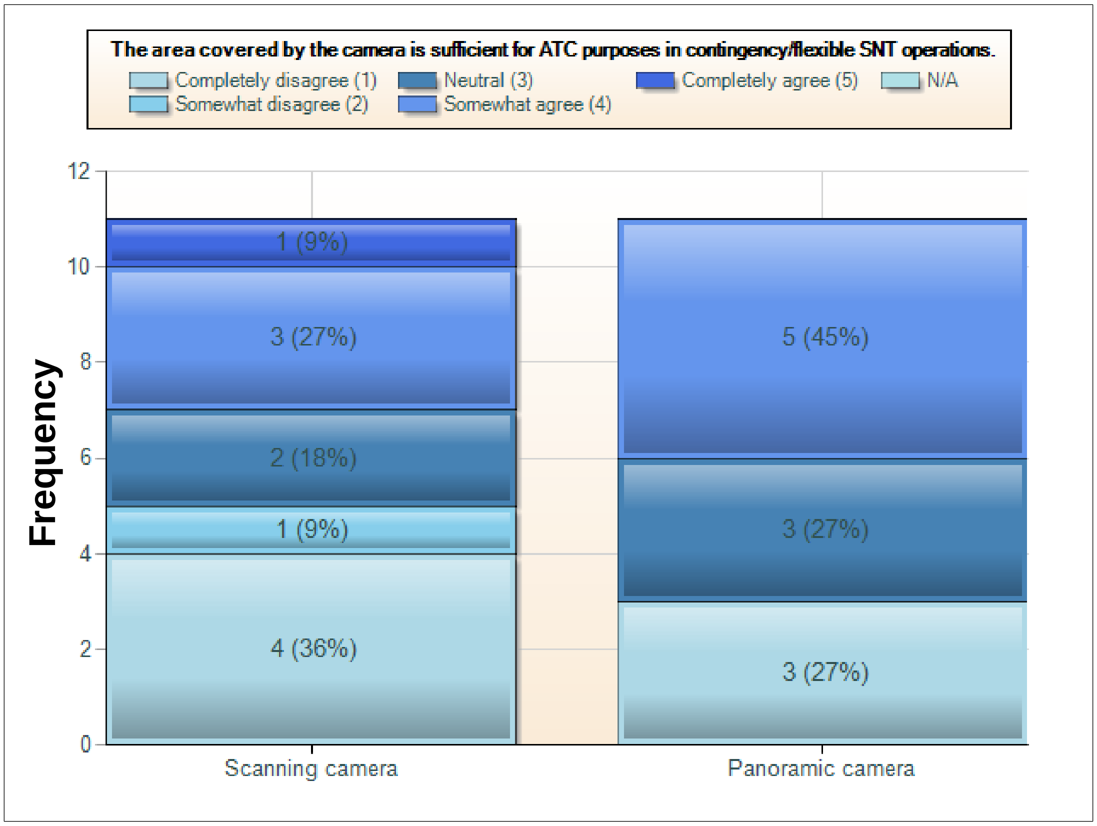

Figure J-101: Sufficiency of the coverage area for ATC purposes for contingency/flexible SNT operations

As shown in Figure J-101, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the area covered by the camera for ATC purposes in contingency/flexible SNT operations. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived sufficiency of the area covered by the camera while using a long-range camera, χ^2 (4, N = 11) = 3.09, p > .05, and were as likely to somewhat agree, be neutral, or completely disagree with the perceived sufficiency while using a panoramic camera, χ^2 (4, N = 11) = 8.54, p > .05.

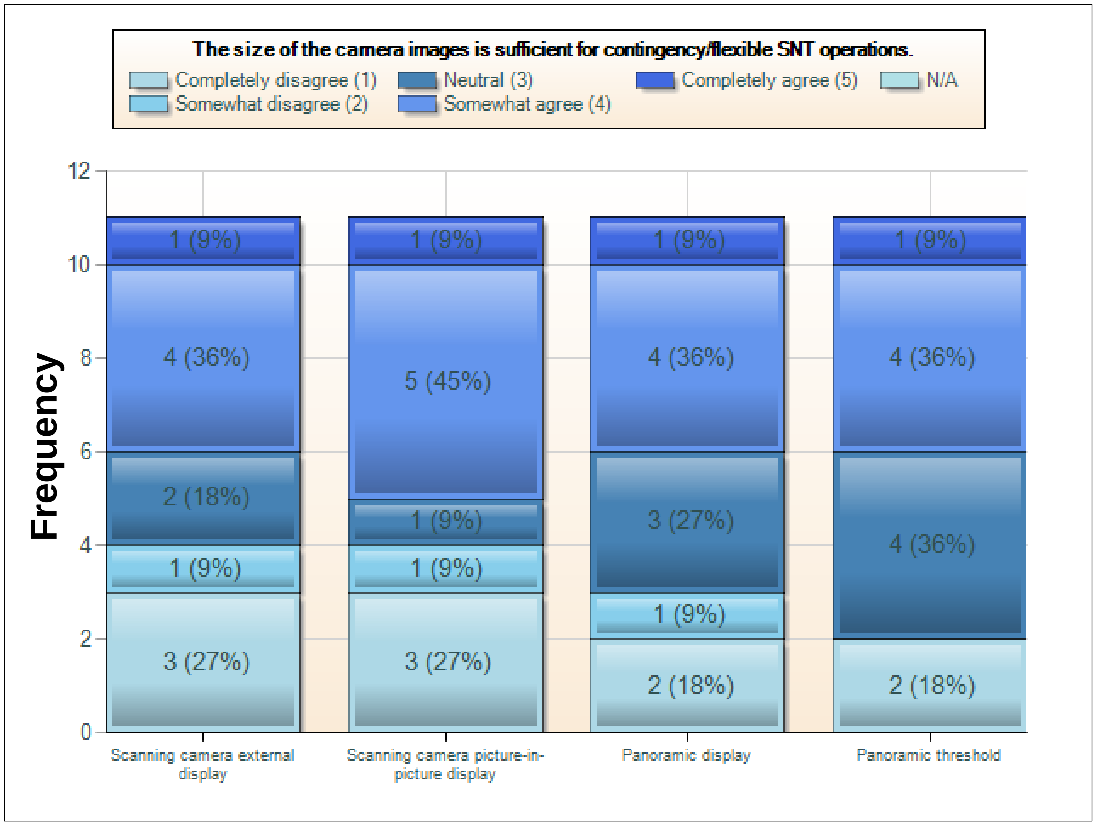

Figure J-102: Sufficiency of the camera image size for contingency/flexible SNT operations

As shown in Figure J-102, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the camera image size for contingency/flexible SNT operations. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat agree, or completely disagree with the perceived sufficiency of the camera image size while using a long-range camera external display, χ^2 (4, N = 11) = 3.09, p > .05, long-range camera picture-in-picture display, χ^2 (4, N = 11) = 5.81, p > .05, or panoramic display, χ^2 (4, N = 11) = 3.09, p > .05. Participants were also as likely to completely agree, somewhat agree, be neutral, or completely disagree with the perceived sufficiency of the camera image size while using a panoramic threshold, χ^2 (4, N = 11) = 5.81, p > .05.

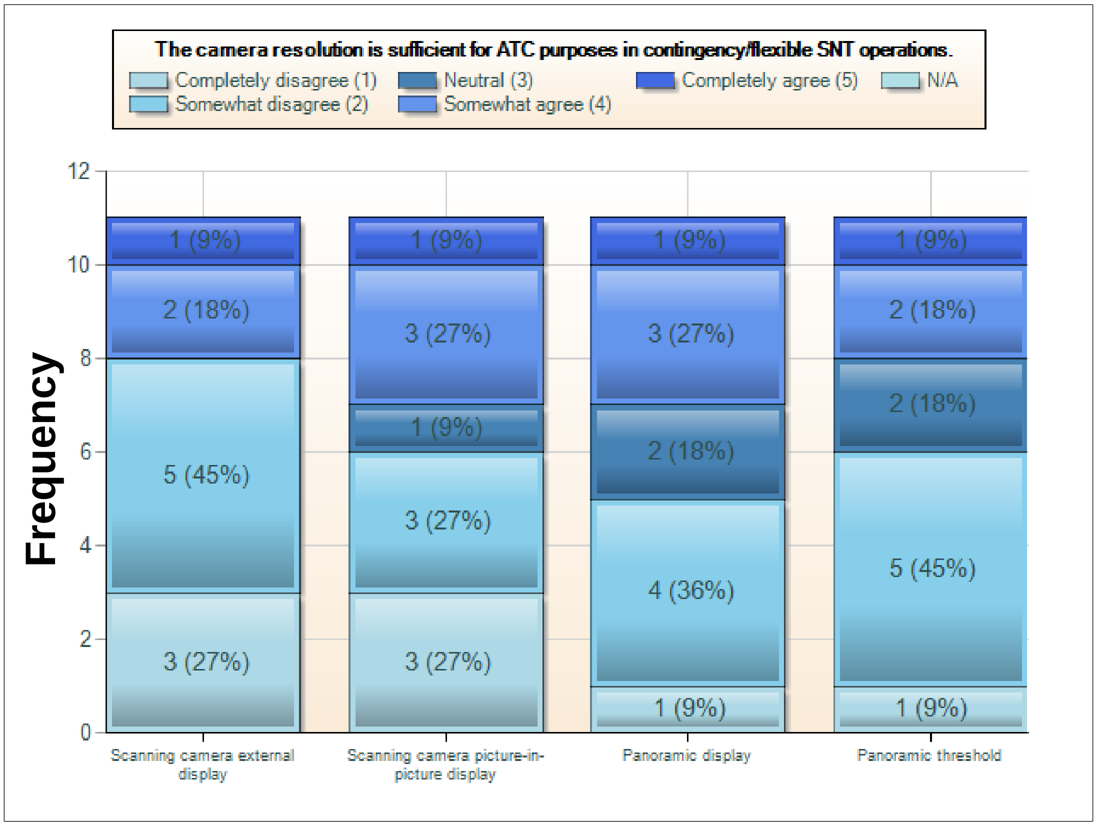

Figure J-103: Sufficiency of the camera resolution for contingency/flexible SNT operations

As shown in Figure J-103, there was no significant difference between observed ratings and expected ratings for perceived sufficiency of the camera resolution for ATC purposed in contingency/flexible SNT operations. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat agree, or completely disagree with the perceived sufficiency of the camera resolution while using a long-range camera picture-in-picture display, χ^2 (4, N = 11) = 2.18, p > .05, panoramic display, χ^2 (4, N = 11) = 3.09, p > .05, or a panoramic threshold, χ^2 (4, N = 11) = 4.90, p > .05. Participants were also as likely to completely agree, somewhat agree, somewhat disagree, or completely disagree with the perceived sufficiency of the camera resolution while using a long-range camera external display, χ^2 (4, N = 11) = 6.72, p > .05.

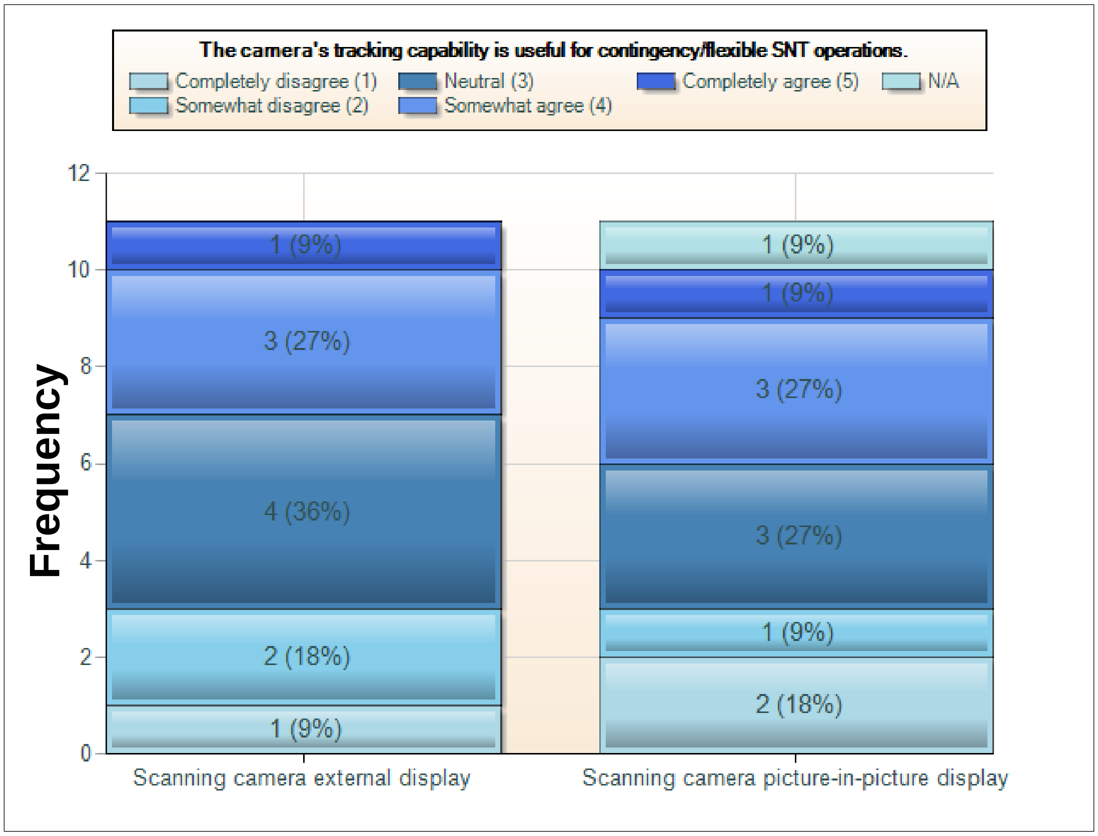

Figure J-104: Usefulness of the camera's tracking capability for contingency/flexible SNT operations.

As shown in Figure J-104, there was no significant difference between observed ratings and expected ratings for perceived usefulness of the camera's tracking capability for contingency/flexible SNT operations. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat agree, or completely disagree with the perceived usefulness of the camera's tracking capability while using a long-range camera external display, χ^2 (4, N = 11) = 3.09, p > .05, or a long-range camera picture-in-picture display, χ^2 (4, N = 10) = 2.00, p > .05.

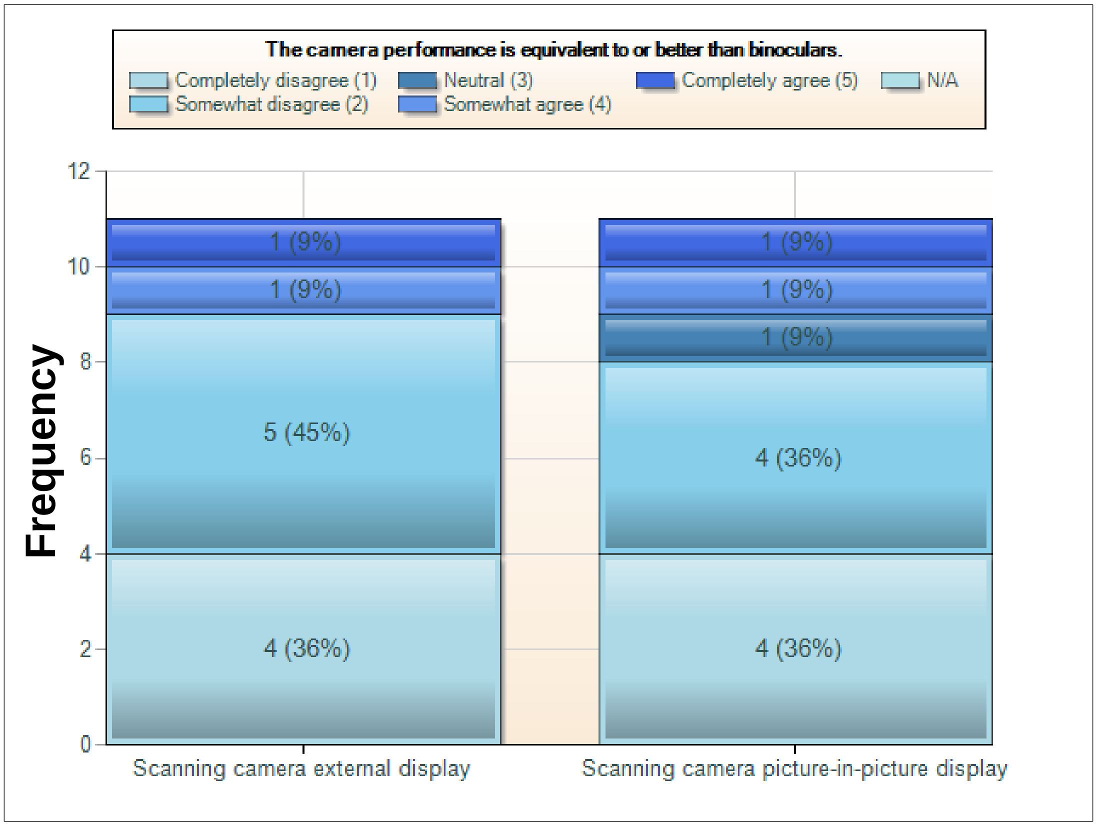

Figure J-105: Comparison of camera performance versus binoculars

As shown in Figure J-105, there was no significant difference between observed ratings and expected ratings for perceived camera performance compared to binoculars. Participants were as likely to completely agree, somewhat agree, somewhat disagree, or completely disagree that the camera performance was equivalent to or better than binoculars while using a long-range camera external display, χ^2 (4, N = 11) = 8.54, p > .05. Similarly, participants were as likely to completely agree, somewhat agree, be neutral, somewhat agree, or completely disagree that the camera performance was equivalent to or better while using a long-range camera picture-in-picture display, χ^2 (4, N = 11) = 4.90, p > .05.

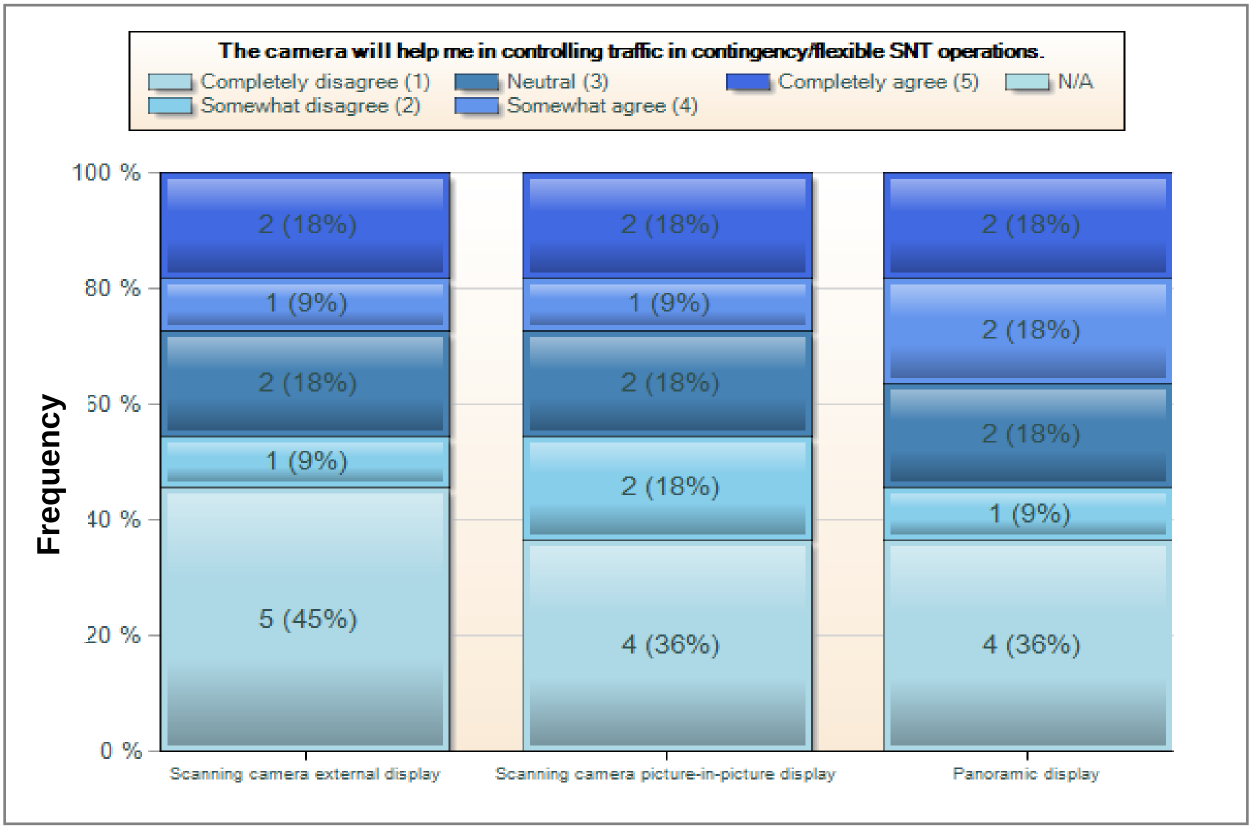

Figure J-106: Helpfulness of the camera to controlling traffic for contingency/flexible SNT operations

As shown in Figure J-106, there was no significant difference between observed ratings and expected ratings for perceived helpfulness of the camera to controlling traffic in contingency/flexible SNT operations. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived helpfulness of the camera while using a long-range camera external display, χ^2 (4, N = 11) = 4.90, p > .05, long-range camera picture-in-picture display, χ^2 (4, N = 11) = 2.18, p > .05, or a panoramic display, χ^2 (4, N = 11) = 2.18, p > .05.

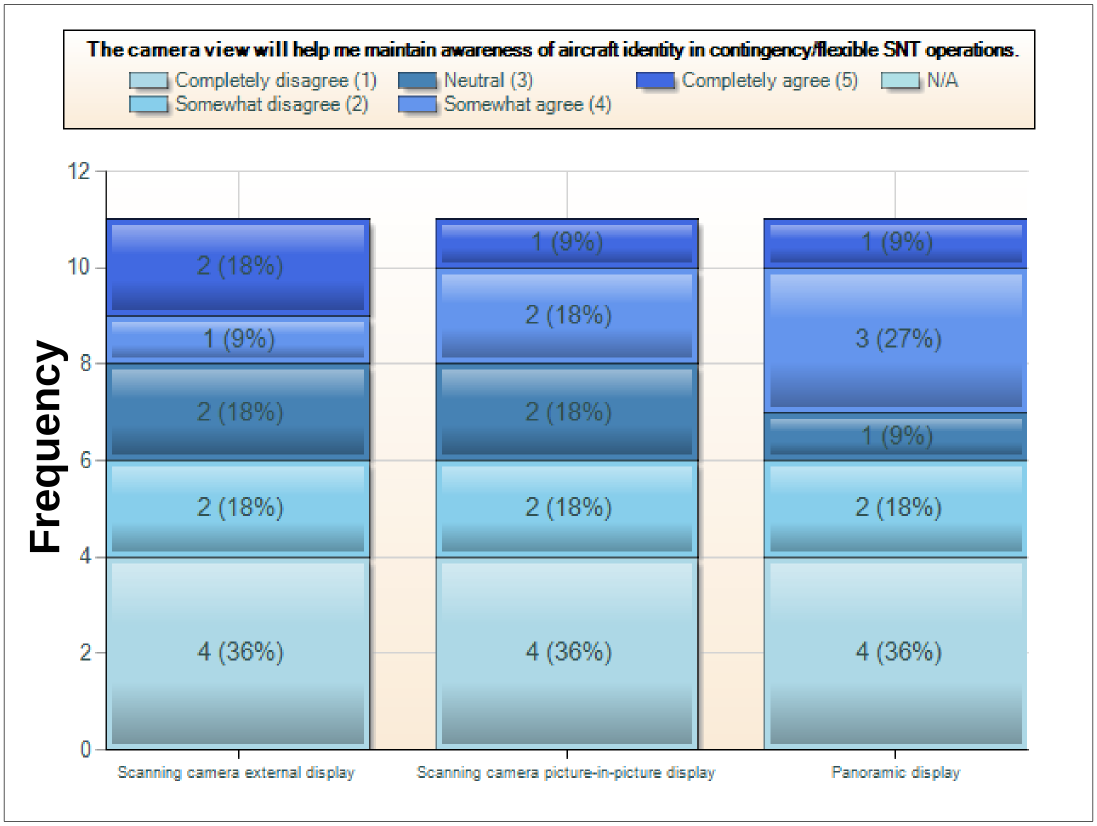

Figure J-107: Helpfulness of the camera in maintaining awareness of aircraft identity for contingency/flexible SNT operations

As shown in Figure J-107, there was no significant difference between observed ratings and expected ratings for perceived helpfulness of the camera view to maintain awareness of aircraft identity in contingency/flexible SNT operations. Participants were as likely to completely agree, somewhat agree, be neutral, somewhat disagree, or completely disagree with the perceived helpfulness of the camera view while using a long-range camera external display, χ^2 (4, N = 11) = 2.18, p > .05, long-range camera picture-in-picture display, χ^2 (4, N = 11) = 2.18, p > .05, or a panoramic display, χ^2 (4, N = 11) = 3.09, p > .05.

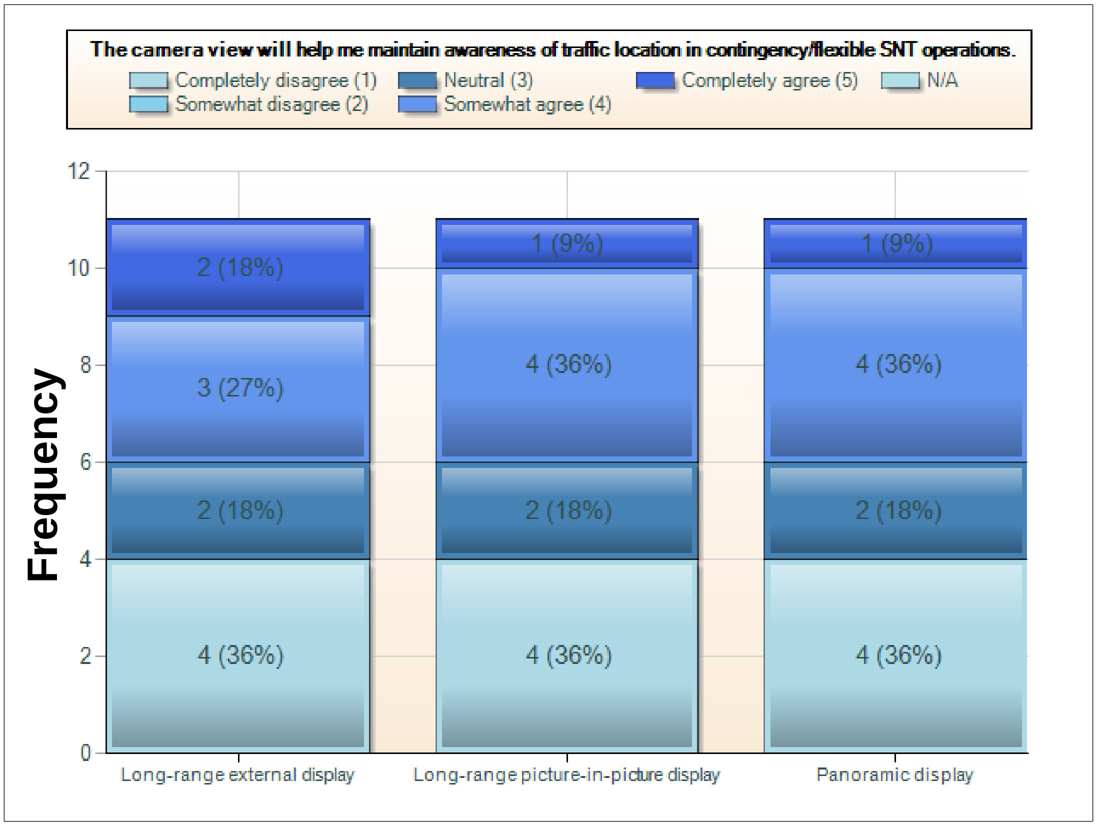

Figure J-108: Helpfulness of the camera view to maintain awareness of traffic location for contingency/flexible SNT operations

As shown in Figure J-108, there was no significant difference between observed ratings and expected ratings for perceived helpfulness of the camera view to maintain awareness of traffic location in contingency/flexible SNT operations. Participants were as likely to completely agree, somewhat agree, be neutral, or completely disagree with the perceived helpfulness of the camera view while using a long-range external display, χ^2 (4, N = 11) = 4.00, $p > .05$, long-range picture-in-picture display, χ^2 (4, N = 11) = 5.81, $p > .05$, or a panoramic display, χ^2 (4, N = 11) = 5.81, $p > .05$.

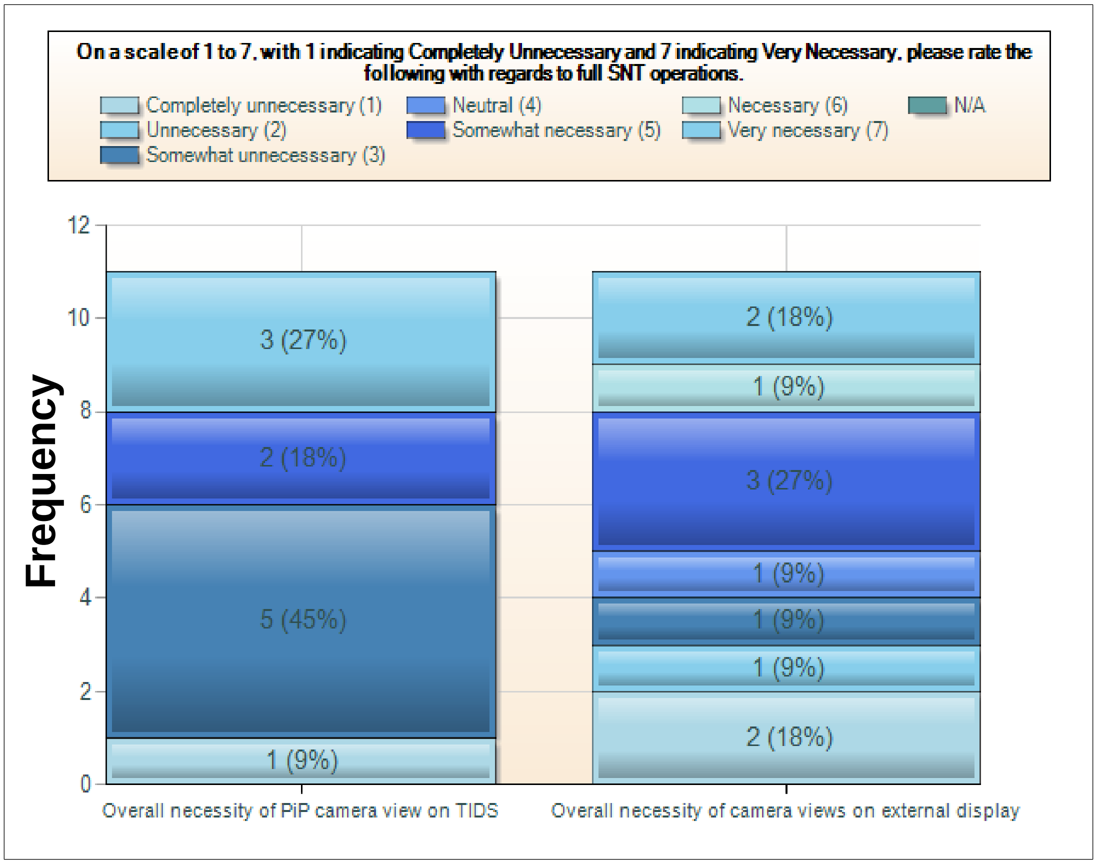

Figure J-109: Necessity of the PiP and external camera views for contingency/flexible SNT operations

As shown in Figure J-109, more participants than expected believed that the overall necessity of picture-in-picture camera view on TIDS was somewhat unnecessary, χ^2 (6, N = 11) = 10.75, p < .05. On the other hand participants were as likely to believe that the overall necessity of camera views on external display was completely unnecessary, unnecessary, somewhat unnecessary, neither, somewhat necessary, necessary, or very necessary, χ^2 (6, N = 11) = 2.00, p > .05.

Table J-3 provides a summary of the human factors results for contingency/flexible SNT operations.

Table J-3: General summary reference for camera use in contingency/flexible SNT operations

		Chi Square	Mean	SD
Question 1	External camera display was useful	1.27 *(p=.866)*	2.91	1.51
Question 2	Size of external camera display was optimal	1.27 *(p=.866)*	3.00	1.54
Question 3	Picture-in-picture camera display was useful	3.09 *(p=.543)*	3.27	1.61
Question 4	Camera image was useful for air traffic control tasks using			
	Long-range camera external display	2.18 *(p=.702)*	3.00	1.61
	Long-range camera picture-in-picture display	2.18 *(p=.702)*	3.00	1.61
	Panoramic display	2.81 *(p=.702)*	3.00	1.61
	Panoramic threshold	1.27 *(p=.866)*	1.40	1.96
Question 5	Update rate was sufficient for ATC purposes using			
	Long-range camera external display	4.90 *(p=.297)*	3.00	1.41
	Long-range camera picture-in-picture display	6.27 *(p=.151)*	3.09	1.44
	Panoramic display	3.09 *(p=.543)*	3.09	1.51
Question 6	Rate of camera control was sufficient for ATC purposes using			
	Long-range camera external display	5.81 *(p=.213)*	2.64	1.28
	Long-range camera picture-in-picture display	3.09 *(p=.543)*	2.73	1.34
Question 7	Area covered by the camera was sufficient for ATC purposes using			
	Long-range camera	3.09 *(p=.543)*	2.64	1.50
	Panoramic camera	8.54 *(p=.074)*	2.91	1.30
Question 8	Size of the camera image was sufficient using			

		Chi Square	Mean	SD
	Long-range camera external display	3.09 *(p=.543)*	2.91	1.44
	Long-range camera picture-in-picture display	5.81 *(p=.213)*	3.00	1.48
	Panoramic display	3.09 *(p=.543)*	3.09	1.30
	Panoramic threshold	5.81 *(p=.213)*	3.18	1.25
Question 9	Camera resolution was sufficient for ATC purposes using			
	Long-range camera external display	6.72 *(p=.151)*	2.36	1.36
	Long-range Camera picture-in-picture display	2.18 *(p=.702)*	3.64	1.43
	Panoramic display	3.09 *(p=.543)*	2.91	1.22
	Panoramic threshold	4.90 *(p=.297)*	2.73	1.19
Question 10	Camera's tracking capability was useful using			
	Long-range camera external display	3.09 *(p=.543)*	3.09	1.13
	Long-range camera picture-in-picture display	2.00 *(p=.736)*	3.00	1.33
Question 11	Camera performance was equivalent to or better than binoculars using			
	Long-range camera external display	8.54 *(p=.074)*	2.09	1.30
	Long-range camera picture-in-picture display	4.90 *(p=.297)*	2.18	1.32
Question 12	Camera will help controllers in controlling traffic using			
	Long-range camera external display	4.90 *(p=.297)*	2.45	1.63
	Long-range camera picture-in-picture display	2.18 *(p=.702)*	2.55	1.57
	Panoramic display	2.18 *(p=.702)*	2.73	1.61
Question 13	Camera view will help controllers maintain awareness of aircraft identify using			
	Long-range camera external display	2.18 *(p=.702)*	2.55	1.57

		Chi Square	Mean	SD
	Long-range camera picture-in-picture display	2.18 *(p=.702)*	2.45	1.44
	Panoramic display	3.09 *(p=.543)*	2.55	1.50
Question 14	Camera view will help controllers maintain awareness of traffic location using			
	Long-range external display	4.00 *(p=.406)*	2.91	1.64
	Long-range picture-in-picture display	5.81 *(p=.213)*	2.82	1.53
	Panoramic display	5.81 *(p=.213)*	2.82	1.53
Completely unnecessary (1), Unnecessary (2), Somewhat unnecessary (3), Neutral (4), Somewhat necessary (5), Necessary (6), Very necessary (7)				
Question 15	**Rate the following with regards to full SNT operations**			
	Overall necessity of picture-in-picture camera view on TIDS	**10.75** ***(p=.030)***	**4.18**	**2.05**
	Overall necessity of camera views on external display	**2.00** ***(p=.736)***	**4.18**	**2.18**

APPENDIX K
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 J.1.

K.1 TOWER INFORMATION DISPLAY SYSTEM

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

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, TIDS provided appropriate information to local controllers, data block was accurate, timesharing of the departure fix and assigned runway in the data block was useful, data block's aircraft state indications were accurate, airport configuration information was accurate, taxiway status information was accurate, and that the information provided on TIDS accurately reflected the operational environment.

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

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, the wind information provided was sufficient for ATC purposes, and that the wind information presentation was acceptable. In addition, most participants completely agreed or were neutral when asked if the wind information was updated in a timely manner.

Display features. When asked about the display features, most participants completely agreed that the runway hold bars were useful, hold bars appeared at an appropriate time, threshold hold bars were useful, threshold hold bars appeared at an appropriate time, and that the closed runway indication was useful. Also, most participants completely agreed or somewhat agreed that the approach bar depiction was appropriate and that the closed runway indication was eye catching. In addition, most participants preferred to show the closed runway indications as a thick white X or a thick red X. Finally, most participants were neutral when asked if creating a restricted area was simple, if the overflight filters were simple to set up, or if the traffic filters were simple to set up.

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

K.2 CAMERA FOR SUPPLEMENTAL OPERATIONS CHI SQUARE RESULTS SUMMARY

The following is a summary of the supplemental camera results for items that passed the success criteria of ≥4 out of 5 on a five-point Likert scale or ≥5 out of 7 on a seven-point Likert scale, as presented in Appendix L. For a general summary reference, see Table J-2. All findings are presented in the context of supplemental SNT operations.

Most participants somewhat disagreed that the camera performance was equivalent to or better than binoculars while using long-range camera external display or long-range camera picture-in-picture display, believed that using the panning control on the picture-in-picture display while using the long-range camera views was easy, believed that determining aircraft location was slightly easy, selecting a viewing area, tracking a target and selecting a target using the long-range camera external display were easy, believed that selecting a viewing area using the long-range camera picture-in-picture display was easy, were neutral when asked to indicate the ease with which they could locate a target or determine aircraft type/company while using the long-range camera external display on the TIDS, believed that the ease with which they could track a target while using the long-range camera external display on the TIDS was adequate, were neutral when asked about the text legibility while using the long-range camera picture-in-picture display on the TIDS, believed that the overall presentation, functionality and the ease with which they were able to locate a target were somewhat adequate while using the long-range camera picture-in-picture display on the TIDS.

K.3 CAMERA FOR CONTINGENCY/FLEXIBLE SNT OPERATIONS CHI SQUARE RESULTS SUMMARY

There were no average ratings that passed the human factors success criteria in the contingency/flexible camera results presented in Appendix J.3 and summarized in Table J-3.

APPENDIX L
EVALUATION QUESTIONNAIRES[8]

L.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?

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

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[8] 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 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?

L.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?

L.3 SUPPLEMENTAL SNT CAMERA QUESTIONNAIRE

DFW-2 TFDM/SNT Evaluation
Supplemental Camera

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 camera display for supplemental SNT. Please respond and comment about your assessment of SNT and TFDM at DFW. If necessary, use your browser BACK button to return to the previous survey page. Click SUBMIT at the bottom of each page to continue with the survey.

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

In supplemental SNT, the camera display provides controllers with visual information to supplement the information currently provided by the out-the-window (OTW) view and on the Tower Information Display System (TIDS) and Flight Data Manager (FDM).

Camera information is received from a long-range camera. Long-range camera information is provided on the TIDS via an optional picture-in-picture window and on a 30" external display located near the TIDS. The long-range camera can be cued to track aircraft or vehicle target movement or to monitor an area of the airport.

For these questions, assume that the cameras are certified for providing ATC services.

Question 1 The external camera display is useful for supplemental SNT.

Question 2 The size of the external camera display is optimal for supplemental SNT.

Question 3 The layout of the external camera display is sufficient for supplemental SNT.

Question 4 The picture-in-picture camera display on the TIDS is useful for supplemental SNT.

Question 5 The size of the picture-in-picture camera display is optimal for supplemental SNT (if camera PiP was used).

Question 6 The camera image is useful for air traffic control tasks in supplemental SNT.
- External display
- Picture-in-picture display

Question 7 The camera control user interface is easy to use.
- External display
- Picture-in-picture display

Question 8 The update rate is sufficient for ATC purposes in supplemental SNT.
- External display
- Picture-in-picture display

Question 9 The rate of camera control is sufficient for ATC purposes in supplemental SNT.
- External display
- Picture-in-picture display

Question 10 The camera panning behavior and response were sufficient for supplemental SNT.
- External display
- Picture-in-picture display

Question 11 The camera zoom behavior and response were sufficient for supplemental SNT.
- External display
- Picture-in-picture display

Question 12 The camera tilting behavior and response were sufficient for supplemental SNT.
- External display
- Picture-in-picture display

Question 13 The camera focusing behavior and response were sufficient for supplemental SNT.
- External display
- Picture-in-picture display

Question 14 On a scale of 1 to 7, with 1 indicating Very Difficult and 7 indicating Very Easy, please rate how easy it was to perform the following tasks. Answer all questions as they relate to the long-range camera views (external display and/or PiP) and their controls.
- Use zoom controls on PiP
- Use panning controls on PiP
- Use tilt controls on PiP
- Use zoom controls on external display
- Use panning controls on external display
- Use tilt controls on external display

Question 15 The area covered by the long-range camera is sufficient for ATC purposes in supplemental SNT.

Question 16 The camera resolution is sufficient for ATC purposes in supplemental SNT.
- External display
- Picture-in-picture display

Question 17 The camera's tracking capability is useful for supplemental SNT.
- External display
- Picture-in-picture display

Question 18 Camera tracking is sufficiently smooth.
External display
Picture-in-picture display

Question 19 Camera tracking is sufficiently quick for supplemental SNT.
External display
Picture-in-picture display

Question 20 The camera performance is equivalent to or better than binoculars.
External display
Picture-in-picture display

Question 21 The camera will help me in controlling traffic in supplemental SNT.
External display
Picture-in-picture display

Question 22 The camera view helped me maintain awareness of aircraft identity.
External display
Picture-in-picture display

Question 23 The camera view helped me maintain awareness of traffic location.
External display
Picture-in-picture display

Question 24 On a scale of 1 to 7, with 1 indicating Very Difficult and 7 indicating Very Easy, please rate how easy it was to perform the following tasks. Answer all questions as they relate to the long-range camera views (external display and/or PIP) and their controls.
Determine aircraft location
Determine aircraft type/company

Question 25 The camera view helped me maintain efficient operations.
External display
Picture-in-picture display

Question 26 On a scale of 1 to 7, with 1 indicating Very Difficult and 7 indicating Very Easy, please rate how easy it was to perform the following tasks. Answer all questions as they relate to the external display for the long-range camera and its controls.
Select a viewing area
Resize a viewing area
Select a target (aircraft, vehicle)
Track a target

Question 27 On a scale of 1 to 7, with 1 indicating Very Difficult and 7 indicating Very Easy, please rate how easy it was to perform the following tasks. Answer all questions as they relate to the PiP display for the long-range camera and its controls.

Select a viewing area
Resize a viewing area
Select a target (aircraft, vehicle)
Track a target

Question 28 On a scale of 1 to 7, with 1 indicating Completely Inadequate and 7 indicating Very Adequate, please rate the adequacy of the following items with regards to the external display for the long-range camera on the TIDS.
Overall external display presentation
Overall functionality of external display
Text legibility on external display
The ease with which you can locate a target on the external display
The ease with which you can determine aircraft type or company on external display
The ease with which you can track a target on external display
The ease with which you can determine nonconformance on external display
Ability to assist in maintaining situational awareness

Question 29 On a scale of 1 to 7, with 1 indicating Completely Inadequate and 7 indicating Very Adequate, please rate the adequacy of the following items with regards to the picture-in-picture (PiP) display for the long-range camera on the TIDS.
Overall PiP presentation
Overall functionality of PiP
Text legibility on PiP
The ease with which you can locate a target on the PiP
The ease with which you can determine aircraft type or company on PiP
The ease with which you can track a target on PiP
The ease with which you can determine nonconformance on PiP
Ability to assist in maintaining situational awareness

Question 30 On a scale of 1 to 7, with 1 indicating Completely Unnecessary and 7 indicating Very Necessary, please rate the following with regards to supplemental SNT operations.
Overall necessity of PiP camera views on TIDS
Overall necessity of camera views on external display

Question 31 Please provide your comments on the overall usefulness of cameras (scanning and panoramic) in supplemental SNT operations.

Question 32 Please provide your comments on the use of cameras (scanning and panoramic) in remote operations.

Question 33 Are there any existing features that should be removed from the external camera display? From the PiP?

Question 34 Is there anything that would improve the external camera display or camera PiP for controllers' use?

Question 35 Are there any additional information or features that should be considered for the external camera display? For the PiP?

L.4 FLEXIBLE/CONTINGENCY CAMERA QUESTIONNAIRE

DFW-2 TFDM/SNT Evaluation
Flexible/Contingency Camera 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 research concept of the use of TFDM in contingency or flexible SNT operations. Please respond and comment about your assessment of SNT and TFDM at DFW. If necessary, use your browser BACK button to return to the previous survey page. Click SUBMIT at the bottom of each page to continue with the survey.

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

In the research concept of SNT for contingency or flexible operations, the camera display provides controllers with visual information that would provide information currently provided by the out-the-window (OTW) view. This visual information will supplement the information provided on the Tower Information Display System (TIDS) and Flight Data Manager (FDM).

Camera information is received from a long-range camera and also from a stitched panoramic camera view obtained from four fixed cameras. Long-range camera information is provided on the TIDS via an optional picture-in-picture window and on a 30" external display located near the TIDS, while the panoramic view is provided on the external display only. The long-range camera can track and follow aircraft or vehicle target movement, and may be done manually or automatically.

Question 1 The external camera display is useful for contingency/flexible SNT operations.

Question 2 The size of the external camera display is optimal for contingency/flexible SNT operations.

Question 3 The picture-in-picture camera display is useful for contingency/flexible SNT operations.

Question 4 The camera image is useful for air traffic control tasks for contingency/flexible SNT operations.

- Long-range camera external display
- Long-range camera PiP display
- Panoramic display
- Panoramic threshold

Question 5 The update rate is sufficient for ATC purposes in contingency/flexible SNT operations.

- Long-range camera external display
- Long-range camera PiP display
- Panoramic display

Question 6 The rate of camera control is sufficient for ATC purposes in contingency/flexible SNT operations.

- Long-range camera external display
- Long-range camera PiP display

Question 7 The area covered by the camera is sufficient for ATC purposes in contingency/flexible SNT operations.

- Long-range camera
- Panoramic camera

Question 8 The size of the camera images is sufficient for contingency/flexible SNT operations.

- Long-range camera external display
- Long-range camera PiP display
- Panoramic display
- Panoramic threshold

Question 9 The camera resolution is sufficient for ATC purposes in contingency/flexible SNT operations.

- Long-range camera external display
- Long-range camera PiP display
- Panoramic display
- Panoramic threshold

Question 10 The camera's tracking capability is useful for contingency/flexible SNT operations.

- Long-range camera external display
- Long-range camera PiP display

Question 11 The camera performance is equivalent to or better than binoculars.
Long-range camera external display
Long-range camera PiP display

Question 12 The camera will help me in controlling traffic in contingency/flexible SNT operations.
Long-range camera external display
Long-range camera PiP display
Panoramic display

Question 13 The camera view will help me maintain awareness of aircraft identity in contingency/flexible SNT operations.
Long-range camera external display
Long-range camera PiP display
Panoramic display

Question 14 The camera view will help me maintain awareness of traffic location in contingency/flexible SNT operations.
Long-range camera external display
Long-range camera PiP display
Panoramic display

Question 15 On a scale of 1 to 7, with 1 indicating Completely Unnecessary and 7 indicating Very Necessary, please rate the following with regards to full SNT operations.
Overall necessity of PiP camera views on TIDS
Overall necessity of camera views on external display

Question 16 Are there any existing features that should be removed from the external camera display for full SNT? From the PiP?

Question 17 Is there anything that would improve the external camera display or camera PiP for controllers' use in full SNT?

Question 18 Are there any additional information or features that should be considered for the external camera display to assist in full SNT? For the PiP?

L.5 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
- Long-range 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
- Long-range camera
- OTW

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

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

Question 22 The display provided appropriate information to deal with the situation.
- TIDS
- FDM
- Long-range 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?

L.6 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
- Long-range 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.

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