DOT/FAA/TC-13/45

Federal Aviation Administration
William J. Hughes Technical Center
Atlantic City International Airport, NJ 08405

Staffed NextGen Tower: A Camera Integration and Computer-Human Interface Part-Task Evaluation

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September 2013

Technical Report

U.S. Department of Transportation
Federal Aviation Administration

NOTICE

Technical Report Documentation Page

1. Report No. DOT/FAA/TC-13/45	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Staffed NextGen Tower: A Camera Integration and Computer-Human Interface Part-Task Evaluation		**5. Report Date** September 2013 **6. Performing Organization Code** ANG-E25 (formerly AJP-6110)
7. Author(s) Ferne Friedman-Berg, FAA Human Factors Branch Nicole Racine, CSSI, Inc.		**8. Performing Organization Report No.** DOT/FAA/TC-13/45
9. Performing Organization Name and Address Federal Aviation Administration Aviation Research Division - Human Factors Branch William J. Hughes Technical Center Atlantic City International Airport, NJ 08405		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.**
12. Sponsoring Agency Name and Address Federal Aviation Administration ATS Concept Development and Validation Group 800 Independence Avenue, S.W. Washington, DC 20591		**13. Type of Report and Period Covered** Technical Report **14. Sponsoring Agency Code** AJP-66
15. Supplementary Notes		

16. Abstract

Objective: The purpose of this study was to elicit user feedback and identify computer-human interface issues related to integrating the camera views onto the Staffed NextGen Tower (SNT) displays prior to full human-in-the-loop simulations. **Background**: Tower controllers in proposed SNT environments will use certified surveillance and camera views instead of the out-the-window view while providing Air Traffic Control services. As the use of cameras for this purpose is a new concept, there are many different ways this concept could be implemented. This study examined some of the alternatives for implementing the SNT concept in a realistic environment. **Method**: In this study, four NextGen Air Traffic Control Management Cadre members controlled traffic and evaluated camera use during nine 15-minute, low-level traffic scenarios that included off-nominal events. At the end of each scenario and at the end of the study, the participants completed a questionnaire, suggested improvements, and provided comments on adequacy, necessity, and usability of the cameras and displays. **Results**: The participants suggested making several changes to the camera system prior to future studies. These suggestions included changing the camera placement, increasing the camera resolution, and providing independent cameras for each control position. The participants identified *viewing aircraft on final approach* and *holding short of runways* as potential applications for cameras in an SNT environment. Participants also identified the need for some type of alerting decision-support tool. **Conclusion**: Participants provided specific feedback that can lead to changes in the way the SNT concept is implemented. **Applications**: Suggested improvements from this study will be incorporated into a future SNT human-in-the-loop simulation and into field demonstrations. The changes identified in this study will guide the future implementation of the SNT concept.

17. Key Words Cameras Ground-Level Facility Human-in-the-Loop Off-Nominals Staffed NextGen Tower Tower Information Display System		**18. Distribution Statement** This document is available to the public through the National Technical Information Service, Alexandria, Virginia, 22312. A copy is retained for reference at the William J. Hughes Technical Center Library.	
19. Security Classification (of this report) Unclassified	**20. Security Classification (of this page)** Unclassified	**21. No. of Pages** 66	**22. Price**
Form DOT F 1700.7 (8-72)	**Reproduction of completed page authorized**		

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Acknowledgments

This report represents the culmination of the tremendous effort in the development of new capabilities through the collaborative effort of many individuals from various organizations. The authors would like to acknowledge and thank them for their hard work in developing new components of this prototype system.

We thank the ATS Concept Development and Validation Group (AJP-66) for sponsoring this project. Thanks to Michele Triantos for her invaluable leadership and guidance, Levent Ileri for his sponsorship, and Laura Emrick (Booz Allen Hamilton) for her meticulous scheduling and organizational skills. We thank Giovanni DiPierro (DFW) and Kevin Hatton (FAA) for their subject matter expertise, and we thank Robert Beck (from DFW Tower) for graciously providing us with staff to participate in this and other SNT studies.

We thank the following people from the NextGen Integration and Evaluation Capability (NIEC) laboratory for their diligent work integrating many components for this effort: Hilda Dimeo, Mary Delemarre, Terence Moore, Cindy Salas, Gordon Bond, Dan Fumosa, Christian Sassi, and Nick Marzelli.

We thank Dan Warburton, Samantha Fullerton, Jonathan Lykens, Christopher Best, Joseph Schnurr, Joseph Haubrich, John Cunningham, Rhoma Gordillo, Jordan Apgar, Sim Pilots, and support staff (FAA Target Generation Facility Group) for ensuring that our scenarios ran properly across multiple component systems.

In addition, we thank the Massachusetts Institute of Technology Lincoln Laboratory (MIT LL) staff for developing the prototype tools—including the TIDS, FDM, and camera capabilities—and for working with the FAA laboratory staff to integrate these systems, which enabled us to conduct this study. We would also like to acknowledge Edward Campbell, Kevin Roll, Christopher Edwards, Sam Provencher, Bruce Taylor, Elizabeth Kramer, Steve Campbell, and Maria Kuffner.

From Booz Allen and Hamilton, we thank Brian Hill and Steve Jones for their simulation support and we thank Michael Baptiste for his subject matter expertise.

We also thank April Jackman (TASC, Inc.) for carefully reviewing and editing this document.

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Executive Summary

The Joint Planning and Development Office has outlined a plan to address the future needs of the National Airspace System in the Next Generation Air Transportation System (NextGen) concept. One component of this concept is the Staffed NextGen Tower (SNT) concept, which envisions a shift from using the out-the-window (OTW) view as the primary means for providing tower control services to using certified surveillance as the primary means for providing tower control services. By shifting from a model of control that relies on the OTW view to one that relies on certified surveillance, air traffic controllers could perform remote operations from a ground-level facility, which would increase capacity during periods of inclement weather when impaired visual observation from an Airport Traffic Control Tower could result in delays or reduced levels of access to the airport.

This study explores the use of cameras to augment certified surveillance within either a supplemental (within the existing tower cab) or a remote configuration (a ground-level, remote facility). In this study, researchers from the Research Development and Human Factors Laboratory at the William J Hughes Technical Center elicited user feedback and identified computer-human interaction issues related to integrating the camera views onto the SNT displays. The findings from this study benefit the overall SNT system development, the second field demonstration at Dallas Fort-Worth International Airport, and the SNT human-in-the-loop 2 simulation (Friedman-Berg & Racine, 2013). User feedback will provide guidance for the development of the concept of operations for incorporating cameras into the SNT environment.

Four Air Traffic Control NextGen Management Cadre members already familiar with the SNT concept provided their expertise in refining the use of cameras within the SNT environment. Team members controlled traffic and evaluated camera use during nine 15-minute, low-level traffic scenarios that included off-nominal events. The participants completed a questionnaire and provided comments at the end of each scenario and at the conclusion of the simulation. The participants suggested making several improvements to the camera system prior to inclusion into future studies, including increasing the camera resolution and providing independent cameras for each control position. In addition, the participants provided input on camera view display configuration and identified interface control and response issues.

The participants indicated that there may be some applications for use of the cameras, such as viewing aircraft on final approach or holding short of runways. They believed that the cameras would be ineffective for viewing off-nominal events without the aid of some type of alerting decision-support tool.

When defining the concept of operations for camera use in an SNT environment and in subsequent SNT studies, we recommend the use of a higher camera resolution, an alternate camera placement, and an alternate interface configuration. We also recommend the development and validation of an intelligent alerting logic for detecting off-nominal events.

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1. INTRODUCTION

The Joint Planning and Development Office has outlined a plan to address the future needs of the National Airspace System (NAS) in the Next Generation Air Transportation System (NextGen) concept. One component of this concept is the Staffed NextGen Tower (SNT) concept, which envisions a shift from using the out-the-window (OTW) view as the primary means for providing tower control services to using certified surveillance as the primary means for providing tower control services. By shifting from a model of control that relies on the OTW view to one that relies on certified surveillance, we would enable air traffic controllers to increase capacity during periods of inclement weather when impaired visual observation from an Airport Traffic Control Tower (ATCT) results in delays or a reduced level of access to the airport and to perform remote operations from a ground-level facility.

In this study, we explored how cameras might be integrated onto these displays and what type of purpose they may serve as part of the SNT concept. Camera views may be useful for the controllers in a variety of situations. For example, the controllers may use cameras to view areas where there are blocked lines of site, to view critical movement areas, and to identify and track off-nominal situations when conducting remote operations.

1.1 Background

The Federal Aviation Administration (FAA) plans to implement the SNT concept using a phased approach. This approach contains the following three phases:

- **Implementation 1: Supplemental SNT** – In Phase 1 of SNT, controllers will have certified surveillance displayed on an integrated display suite within the existing tower cab. The controllers will be able to use the certified surveillance as the primary means of providing Air Traffic Control (ATC) services.
- **Implementation 2: Contingency SNT** – In Phase 2 of SNT, the integrated display suite would be available in both the tower facility and in a ground-level SNT facility. This would serve as a transitional phase, moving the controller from the conventional tower cab to a ground-level facility. However, the tower cab would remain available to the controllers and would serve as a safety backup.
- **Phase 3: Full SNT Configuration** – In Phase 3 of SNT, the controllers would provide ATC services exclusively from a ground-level SNT facility.

While the surveillance systems presented on the primary situation displays will provide information that is vital for air traffic operations, there may still be a need to provide the tower controllers with some form of visual capability in Phases 2 and 3 of SNT in order to maintain an acceptable level of safety.

This part-task study was the next step in continuing SNT research efforts that have included Quick Look studies (Hannon, 2009), Cognitive Walkthrough studies (George Mason University, 2009), and Human-in-the-Loop (HITL) studies (Hannon, Lee, Geyer et al., 2008, Hannon, Lee, Sheridan, & Donohoe, 2008). In the spring of 2010, the FAA conducted the HITL 1 study, which provided an initial evaluation of the impact of a Phase I SNT environment on heads up and heads down time, workload, and situation awareness. The study also provided a preliminary examination of the controllers' abilities to identify and respond to off-nominal events.

1.2 Scope

The scope of this evaluation was limited to an evaluation of the human-computer interface for the SNT display systems, the camera integration with the SNT displays, the camera integration concept, and the inclusion of off-nominal events within the simulation environment. Although most of the information collected in this study was not site specific, the placement of the cameras and the available camera views were specific to the Dallas Fort-Worth International Airport (DFW) Tower.

1.3 Purpose

This part-task study had several objectives. The first objective was to elicit user feedback and identify CHI issues related to integrating the camera views onto the SNT displays. The findings from this study benefit overall SNT system development, the second field demonstration at DFW, and SNT HITL 2 (Friedman-Berg & Racine, 2013). In addition, user feedback will help the FAA to develop the concept of operations for incorporating cameras into the SNT environment. Another objective of this study was to determine the optimal approach for including off-nominal events in HITL 2 while beginning a preliminary examination of any technical aspects involved in integrating camera technology onto ATC primary situation display systems. This study was a collaborative effort involving support personnel from the Target Generation Facility (TGF), the NextGen Integration and Evaluation Capability (NIEC), and the Massachusetts Institute of Technology Lincoln Laboratory (MIT LL).

2. METHOD

2.1 Controllers

Four ATC NextGen Management Cadre members participated in this part-task study on November 2-4, 2010, at the FAA William J. Hughes Technical Center (WJHTC), NIEC laboratory in Atlantic City, NJ. These members comprise a user group formed in 2009 to provide feedback on concept development for NextGen tower automation and to evaluate CHI concepts.

2.2 Personnel

A research team led by the Principal Investigator from the Human Factors Team–Atlantic City conducted this study. The research team was composed of Human Factors Engineers (HFEs), ATC Subject Matter Experts (SMEs), System Engineers, Software Developers, Aeronautical Engineers, and Computer Scientists. The HFEs designed and managed the study, data collection, and procedures. The engineers and software developers from the Massachusetts Institute of Technology Lincoln Laboratory (MIT LL), TGF, and NIEC laboratories developed and supported the simulation platform and the prototype systems. Ten simulation pilots controlled the simulated aircraft.

2.3 Facilities

2.3.1 NextGen Integration and Evaluation Capability

The NIEC lab, which is located at the WJHTC, is a facility that allows the FAA to explore, integrate, and evaluate the NextGen concepts in a unified simulation research environment. The NIEC Tower Visualization System has a six channel, 180° field of view, out the window tower simulation capability. The OTW view is displayed on six 73-inch Mitsubishi high-definition (1080p) television screens. Based on the open source projects Open Scene Graph and Multi-Purpose Viewer, the OTW tower simulation capability is integrated fully with the NIEC systems. This tower simulation is based on the Common Image Generator Interface standard.

2.3.2 Target Generation Facility

The TGF infrastructure is capable of simulating air and ground traffic and driving terminal, en route, and developmental laboratories. The TGF enables researchers to investigate new systems and procedures without having to fly hundreds of actual aircraft. The TGF has the capability to simultaneously generate up to 600 aircraft targets from a selection of nearly 135 different aircraft types. The automation systems view the targets generated by the TGF as identical to real targets.

2.3.3 TGF Simulation Pilot Laboratory

In the TGF Simulation Pilot Laboratory, up to 400 of the simulated targets can be piloted, in real-time, by a cadre of simulation pilots. Simulation pilots enter commands at workstations and these workstations are designed to control up to 15 aircraft each. An audio system connects the simulation pilots and air traffic personnel, with each simulation pilot communicating to the controllers on unique control frequencies. This creates a realistic party-line effect on the radio channels. The TGF provides target information in radar data format, including azimuth reference information, for up to 50 simulated radars and allows for the testing of any radar-dependent ATC system.

2.4 Hardware and Software

2.4.1 DESIREE and Standard Terminal Automation Replacement System

The Distributed Environment for Simulation, Rapid Engineering, and Experimentation (DESIREE) environment consists of a series of interchangeable Human Machine Interfaces, which are used by Engineering Research Psychologists to develop user-interface enhancements for future inclusion in the NAS. The DESIREE software is run on a PC using Redhat Linux 5.3.

DESIREE contains a Standard Terminal Automation Replacement System (STARS) interface, which we used to emulate the DFW's Common Automated Radar Terminal System (CARTS) system. The emulated CARTS display was presented on a 20-inch flat-panel monitor, which measured 16" x 20" (h x w), with 1200 x 1600 resolution. The monitor was mounted on a Video Electronics Standards Association (VESA) articulated arm.

The TGF provided aircraft location and movement data. The STARS interface had neither a keyboard nor a trackball due to space limitations. However, this was not a problem in the tower environment because there was no need to alter the display once it was properly configured.

2.4.2 Tower Information Display System

The Tower Information Display System (TIDS) provided the controllers with a visual representation of the airport and air traffic. This representation could be tailored to allow the controllers to access the information most pertinent for their position (see Figure 1). The airport surface map was depicted on a 30-inch flat-panel monitor, which measured 17.9" x 27.2" (h x w) with 1600 x 2560 resolution and was mounted on a VESA articulated arm. The TIDS incorporated a variety of situation awareness tools, such as data tag information for each flight, runway hold bars, and a wake-turbulence countdown clock.

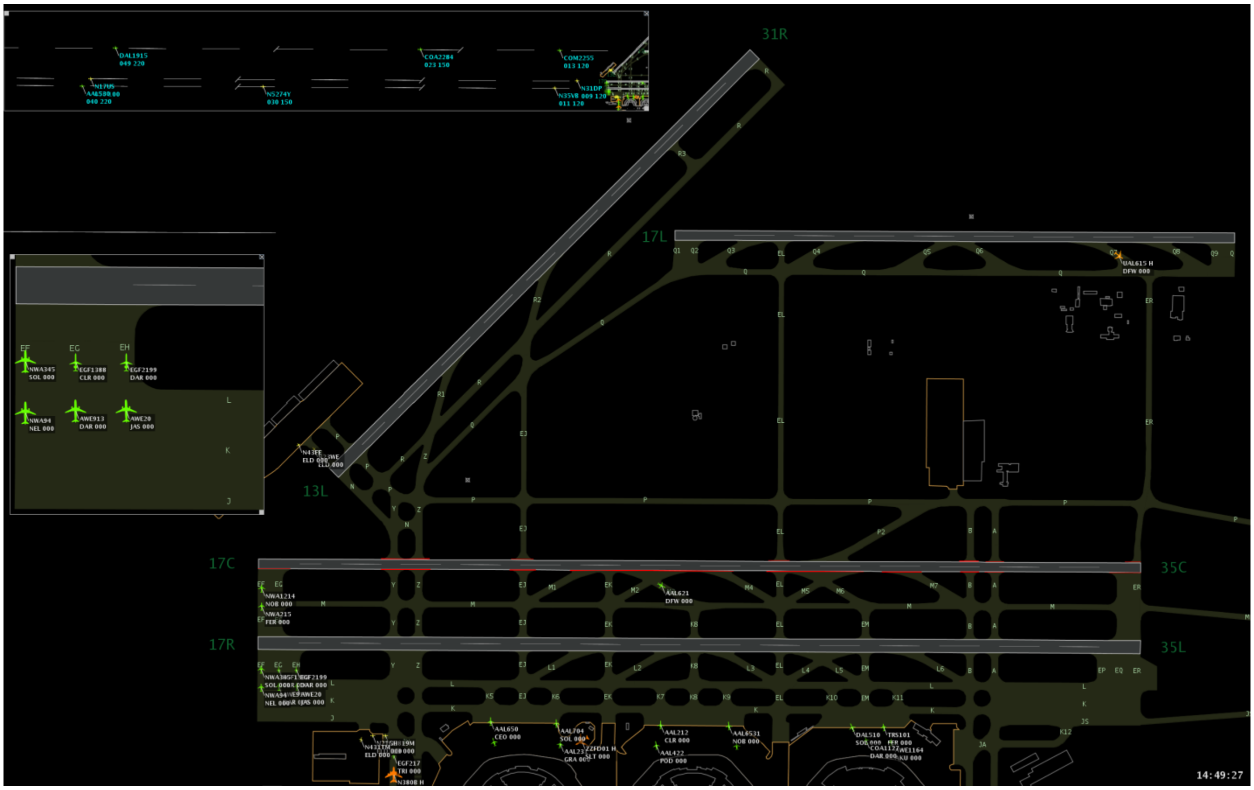

Figure 1. An example of the Tower Information Display System.

2.4.3 Flight Data Manager

The Flight Data Manager (FDM) is a tool that replaces paper flight strips by providing an electronic display of flight information relevant for ATC (see Figure 2). As with the TIDS displays, the flight information provided by the FDM is configurable so that it can provide the most pertinent information for each control position. The FDM was displayed on a 24-inch flat-panel monitor, which measured 16" x 20" (h x w) with 1200 x 1600 resolution and was mounted on a VESA articulated arm. The FDM monitors had touch screen capability and enabled the controllers to drag and drop flight strips, execute aircraft clearances, and transfer control of aircraft across positions. Data entered into the FDM automatically updated the TIDS display.

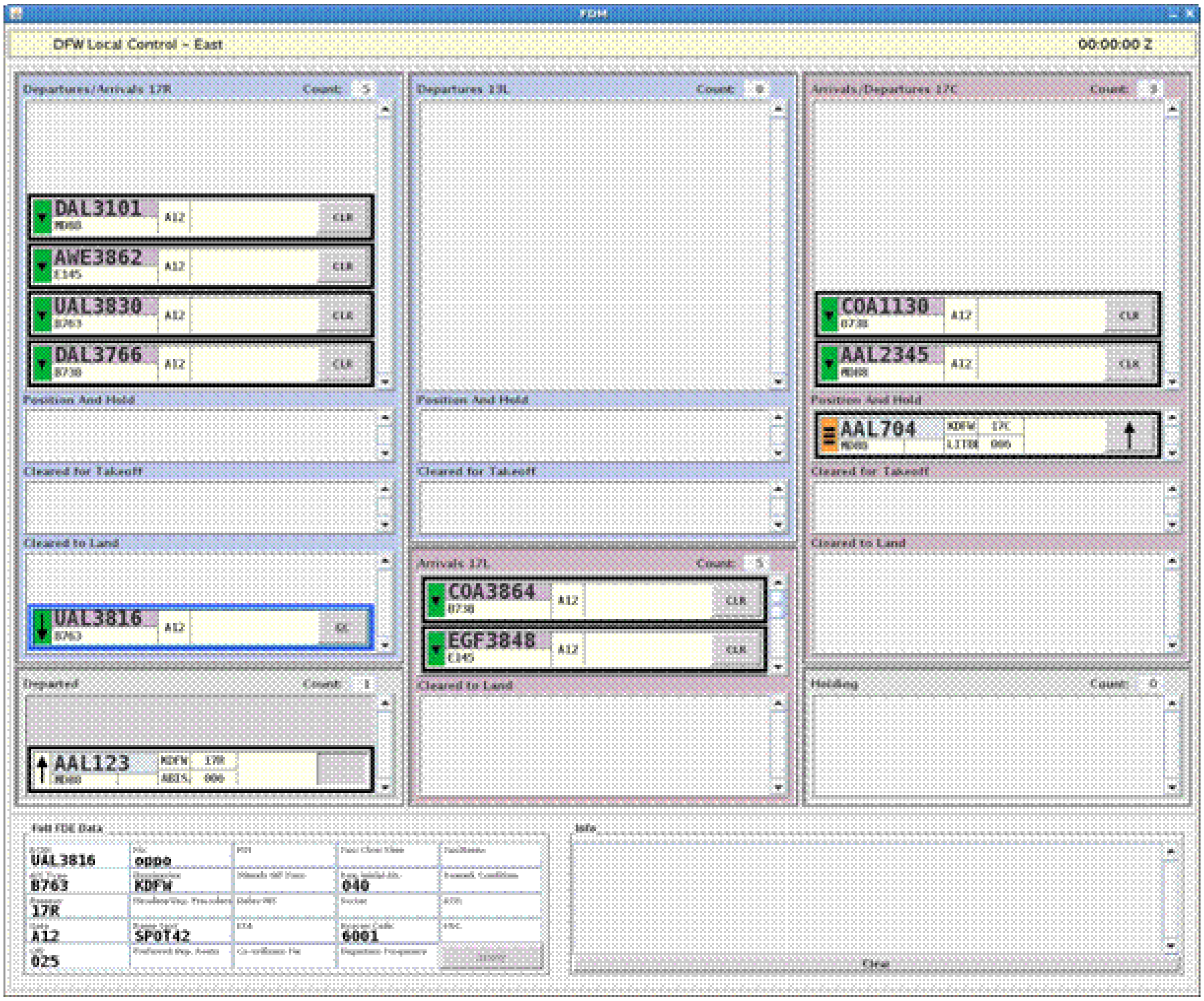

Figure 2. An example of the Flight Data Manager.

2.4.4 Cohu 6960 Camera

In this study, we created an emulation of the Cohu 6960 Series camera (www.cohu-cameras.com, 2009). The Cohu 6960 Series is a two-camera system mounted on a single positioner that provides surveillance in daylight, no light, and obscured visibility conditions. One camera in the system is a day/night optical camera and one is a thermal imager. The thermal imager may be used in extreme low light conditions, or environments clouded by haze, rain, smoke, or fog, whereas the optical camera may be used for precise recognition, identification, or assessment. The optical camera provides color images in the daylight, but in low light conditions, the camera automatically switches to a monochrome mode. The camera system is designed for fast (90 deg/s) and accurate (+/-0.1° precision) positioning and provides the user with the capability to look straight up and down and in a 360° sweep. It may be programmed with up to 64 preset positions, and up to 16 programmable zones. For the part-task effort, we only emulated the Cohu optical camera.

2.5 Simulation Environment

2.5.1 Airspace

For this evaluation, we used the DFW airspace and airport. To maintain consistency, we selected DFW as the SNT test site for the field demonstrations, HITL 1, and HITL 1.5. This allowed us to make use of the work already completed for this airspace in HITL 1, and it will facilitate the development process for future research.

The DFW airport is divided into the east and west sides. The east and west sides of the airport operate independently and maintain separate control towers. The east tower controls arrivals and departures to and from the east, and the west tower controls arrivals and departures to and from the west. The east side of DFW features five parallel runways, and the controllers on the east side can use three of these to conduct simultaneous instrument approaches. Four one-way bridges—two eastbound and two westbound—connect the two sides of the airport. Peripheral taxiways on the east side of the airport greatly reduce the need to cross active runways. The airport has no intersecting runways.

For the SNT activities, we emulated the east side of the airport as it would be viewed from the center tower. We selected the center tower for HITL 1.5 because it is currently being used for the SNT field demonstrations. The center tower was chosen for the field demonstrations because it is currently not in use and serves as a contingency facility, which allows the field evaluations to be conducted without having an impact on live operations. The HITL 1.5 simulation incorporated modified DFW operations to increase complexity. As part of the configuration changes,

- All arrivals and departures, regardless of where they were coming from or going to, used the east side of the airport in a south traffic flow configuration, utilizing runways 17R, 17C, 17L, and 13L (see Figure 3).
- All arrivals from the west and departures to the west used runway 17R. This forced the controllers to mix and balance the departure and arrival streams.
- All eastbound departures and a small proportion of arrivals from the east used runway 17C, while the majority of arrivals from the east used runway 17L. Several general aviation departures from runway 13L were also included. Runways 17L and 13L increased the number of potential runway crossings, increased the complexity of the traffic, and allowed us to examine the potential benefits of SNT operations when using distant runways.

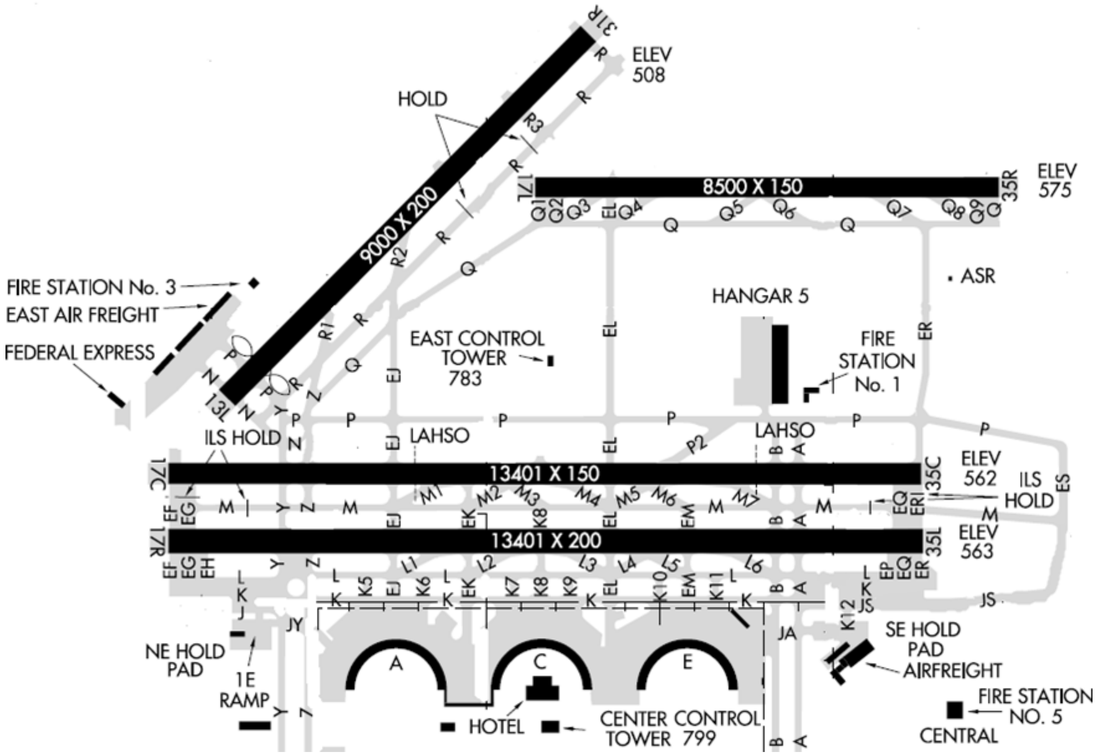

Figure 3. An example of the DFW east side airport map.

2.5.2 Traffic Scenarios

The CHI evaluation used nine moderate-level traffic scenarios—each divided into three15-minute traffic segments for data collection. There was a moderate level 45-minute scenario for training. The nine data collection scenarios were created from the HITL 1 scenarios by dividing the 45-minute scenarios into 15-minute segments, reducing the level of traffic, and introducing one off-nominal event during each segment.[1] We used low levels of traffic because most of the controllers had limited familiarity with the DFW airport. By reducing traffic levels, we enabled the controllers to use and provide feedback on a wide range of control functions during the scenarios.

In the scenarios, the controllers were exposed to daytime and nighttime conditions, operated using Visual Flight Rules (VFR), and had access to both the TIDS and the FDM tools. The OTW view was available during the runs on Day 1 and Day 2. There were 13 nighttime traffic segments and 13 daytime traffic segments.

We scripted the 13 off-nominal events to determine which ones were the most optimal for inclusion in HITL 2 (see Table 1). During the scenarios, we instructed the controllers to control traffic as they would in the field and to verbally report any nonconforming aircraft, unexpected aircraft maneuvers, or other unexpected situations. Observers recorded the controllers' reaction, if any, to the off-nominal events using an over-the-shoulder rating form (see Appendix A).

[1] Note that Run 9 was only 30 minutes.

Table 1. List of Off-Nominal Events

ID#	Off-nominal event
1	Aircraft initiates missed approach/go around
2	Aircraft deviates from taxi route
3	Aircraft takes wrong heading after take-off (FMS programmed incorrectly)
4	Aircraft side-steps to alternate parallel runway during final approach without clearance
5	Aircraft rejects take-off
6	Aircraft fails to continue to climb after *wheels up*, continues on a runway heading at a low altitude
7	Aircraft initiates take-off roll after clearance to taxi and hold
8	Aircraft fails to hold short of active runway crossing
9	Aircraft crashes on airport and on taxiway(s) or runway(s)
10	Controller issues go-around. Vehicle enters movement area w/o clearance
11	Aircraft altitude falls below the minimum safe value
12	Aircraft taxis to the end of runway after rollout
13	Smoke comes from aircraft/brakes during landing or takeoff

Note. FMS = Flight Management System.

There was a camera placement run that attempted to elicit feedback to examine alternative camera views. The remaining runs focused on executing the off-nominal events and evaluating our data collection process for future studies. Of particular interest was whether the controllers observed the off-nominal event via the OTW display, the TIDS, or the camera displays. The controllers were instructed to react to any nonconforming aircraft or assumed simulation pilot errors as they normally would in the field, but to tailor their responses for an SNT environment. A detailed breakdown of the scenario conditions is presented in Table 2.

Table 2. Scenario Condition Matrix

Run number/ Segment number	Off-nominal ID	Night time	PiP	Stand-alone	Subject 1	Subject 2	Scenario	Duration
R1 S1	12			X	A	C	1	0-15 min
R1 S2	9		X	X	A	C	1	15-30 min
R1 S3	10		X		B	A	1	30-45 min
R2 S1	4		X		D	B	2	0-15 min
R2 S2	7	X			B	A	2	15-30 min
R2 S3	4	X		X	A	C	2	30-45 min
R3 S1	11		X		A	B	3	0-15 min
R3 S2	6	X			C	D	3	15-30 min
R3 S3	10	X		X	B	D	3	30-45 min
R4 S1	3	X			C	A	4	0-15 min
R4 S2	9	X			C	D	4	15-30 min
R4 S3	6		X	X	C	A	4	30-45 min
R5 S1	1			X	C	D	5	0-15 min
R5 S2	11	X		X	C	A	5	15-30 min
R5 S3	7		X	X	D	B	5	30-45 min
R6 S1	8	X	X		D	C	1	0-15 min
R6 S2	5			X	B	D	1	15-30 min
R6 S3	12	X	X		D	B	1	30-45 min
R7 S1	8			X	A	B	2	0-15 min
R7 S2	13		X	X	B	D	2	15-30 min
R7 S3	2		X		B	A	2	30-45 min
R8 S1	5	X	X		D	C	3	0-15 min
R8 S2	1	X	X		A	C	3	15-30 min
R8 S3	13	X			D	C	3	30-45 min
R9 S1	2	X		X	B	D	4	0-15 min
R9 S2	3		X	X	A	B	4	15-30 min

Note. PiP = Picture-in-Picture.

2.5.3 Camera Integration

The center control tower at DFW recently built train terminals and other structures that block the view of a number of ramp control spots, both at midfield and at the north end of the airport. Expanded airline terminals also partially block views of both the north and south bridges. Furthermore, the center tower—even though not typically used for east operations—is not optimally located and does not allow controllers to view runways 17L and 13L. In this part-task study, to compensate for these limitations, we provided the controllers with camera views that allowed them to see these obstructed or limited-view areas (see Appendix B) with the simulated camera feed. We determined the camera placement based on input from both the DFW field demonstration team and from a DFW SME. On the last day of the part-task study, we also tested other camera placement options to obtain feedback on these alternate placements for future efforts.

There were two display options for the camera view: a picture-in-picture (PiP) option and a stand-alone option. The PiP view was presented on the TIDS display and the stand-alone option was presented on an auxiliary flat-panel display. For the PiP option, the controllers could move the PiP window anywhere within the TIDS display, but they could not resize the inset window. For both the PiP and stand-alone options, the controllers were able to select either a viewing area or a target aircraft. They were also able to pan, zoom, and tilt the camera to obtain different viewing perspectives. The controllers had access to the PiP view for 10 segments, to the stand-alone view for 10 segments, and both the PiP and the stand-alone camera views for six segments. In addition, because we were simulating a single camera, the ground and local controllers were informed that they had to share the camera controls. At the end of each scenario and at the end of the study, the controllers provided feedback on both the PiP and stand-alone options.

2.5.4 Display Configuration

We used two display configurations for the part-task study (see Figure 4). In one configuration, the FDM, the TIDS, and the stand-alone camera display were all side by side. In the second configuration, the TIDS display was over the FDM display and the stand-alone display was on the right.

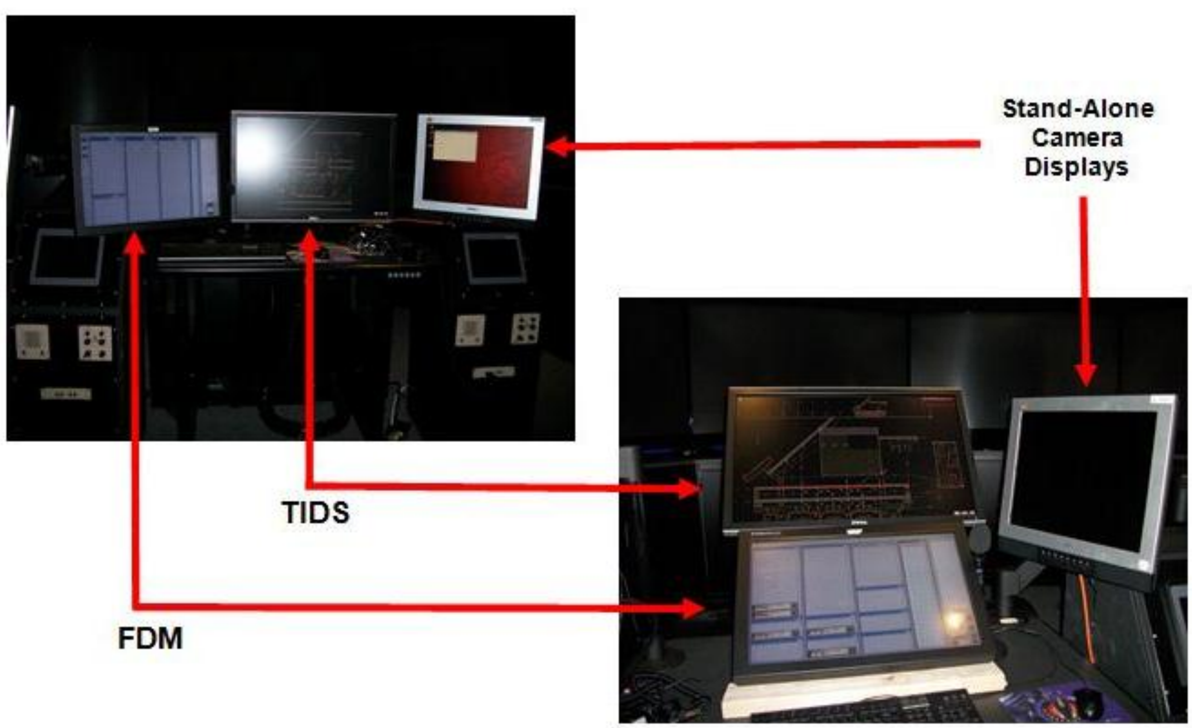

Figure 4. An example of the two display configurations. TIDS = Tower Information Display System and FDM = Flight Data Manager.

2.6 Procedures

The controllers received a briefing on updates or changes made to the TIDS and FDM displays since the last user-group meeting. The controllers were also briefed on the evaluation procedure, the type of data to be collected, and the daily schedule (see Table 3). After the initial briefing, the controllers completed a consent form (see Appendix C) and a background questionnaire (see Appendix D). We also briefed the controllers on the camera integration concept and explained that they would be asked to provide input on potential uses for camera technology in an ATC tower environment.

Table 3. Daily Schedule

Time	Day 1	Time	Day 2	Time	Day 3
8:00-9:00	Briefing Consent/Background Forms	8:00-8:15	In briefing	8:00-8:15	In briefing
9:00-10:00	Searidge Demo/ Concept Discussion	8:15-9:00	Run 3 Segments 7-9	8:15-9:00	Run 8 Segments 22-24
10:00-10:15	Break	9:00-9:30	Debriefing/ Questions	9:00-9:30	Debriefing/ Questions
10:15-11:00	Training Run/ Camera Placement Run	9:30-9:45	Break	9:30-9:45	Break
11:00-11:30	Debriefing/Questions	9:45-10:30	Run 4 Segments 10-12	9:45-10:30	Run 9 Segments 25-26
11:30-12:30	Lunch	10:30-11:00	Debriefing/ Questions	10:30-11:00	Debriefing/ Questions
12:30-1:15	Run 1 Segments 1-3	11:00-11:45	Run 5 Segments 13-15	11:00-12:00	Lunch
1:15-1:45	Debriefing/ Questions	11:45-12:15	Debriefing/ Questions	12:00-4:00	Final Debriefing
1:45-2:00	Break	12:15-1:15	Lunch/ Reconfigure Displays		
2:00-2:45	Run 2 Segments 4-6	1:15-2:00	Run 6 Segments 16-18		
2:45-3:15	Debriefing/ Questions	2:00-2:30	Debriefing/ Questions		
3:15-3:30	Break	2:30-3:15	Run 7 Segments 19-21		
3:30-4:30	Debriefing/ Questions	3:15-4:30	Debriefing/ Questions		

All controllers received an hour of training, during which time they were able to interact with the systems and to ask questions. During the training, we demonstrated the controls for the TIDS, the FDM, and the camera as well as provided controllers with "cheat" sheets to help them remember the control commands (see Appendix E). One of the controllers, who was a current DFW Front Line Manager, conducted a quick briefing on DFW tower. Each controller had an opportunity to practice with the systems in both the ground and the local control positions and to use the cameras with the PiP, Stand-Alone, and PiP + Stand-Alone camera configurations (see Appendix F).

Following the training, the controllers were randomly assigned to work in two groups. Although we used moderate traffic levels during the first run, we reduced the levels for subsequent runs because the controllers indicated that the initial traffic levels were too high and did not provide them with an adequate opportunity to evaluate the camera functions. Each controller had the opportunity to work both the local and the ground positions. The HFEs served as over-the-shoulder observers during the data collection runs. The NIEC and MIT LL personnel were available throughout the part-task evaluation to fix hardware and software issues, to answer questions as needed, and to reconfigure displays when necessary.

As a part of each run, the controllers were presented with a camera view displayed on either the TIDS or on a stand-alone display, or both. The controllers were able to ask questions and provide feedback during the data collection runs. The controllers who were not actively controlling traffic observed and provided comments during the data collection runs. The HFEs recorded comments and observations made during the runs. After each run, the controllers filled out a Post-Run Questionnaire (see Appendix G). At the end of each day, the research team held a debriefing session to gather additional feedback from all of the controllers. All controllers filled out a Post-Evaluation Questionnaire (see Appendix H) at the end of the study.

3. RESULTS

On the background questionnaire, we collected demographic information about the controllers, such as their age and their ATC experience (see Figure 5). The average age of the controllers was 45.5 years (*SE* = 2.4). The controllers had an average of 25.6 years (*SE* = 3.1) experience as Certified Professional Controllers (CPC), an average of 4.5 years (*SE* = 1.3) as supervisors, and an average of 23.3 years (*SE* = 3.0) experience in air traffic control towers. We also asked the controllers about their prior experience with electronic flight strips. Three of the four controllers had some experience with electronic flight strips (see Figure 6).

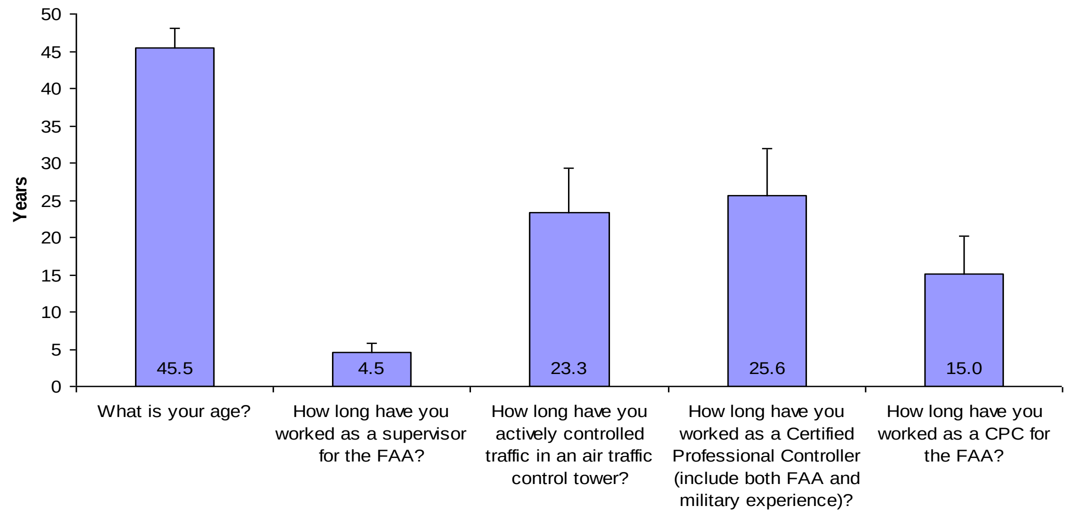

Figure 5. Summary of the background questionnaire.

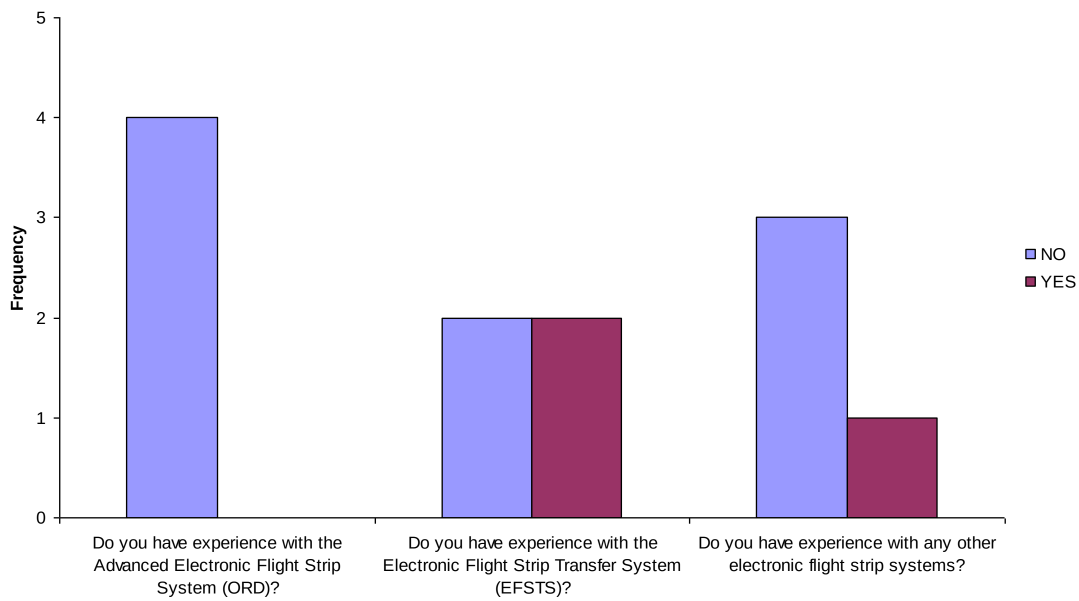

Figure 6. Experience with electronic flight strips.

3.1.1 Post-Run Questionnaire Results

After each run, the controllers rated the degree to which the displays (i.e., FDM, TIDS, OTW) or camera views (i.e., PiP, Stand-Alone, PiP + Stand-Alone) helped them to maintain awareness of aircraft identity, awareness of traffic location, efficient operations, or safe operations (see Figure 7). Their ratings were made using a rating scale of 1 (*very little*) to 7 (*very much*). Based on their responses across all 26 segments, it appeared that the TIDS was the most beneficial for helping the controllers maintain their awareness of aircraft identity, followed by the FDM. Ratings were slightly more variable for the OTW display.

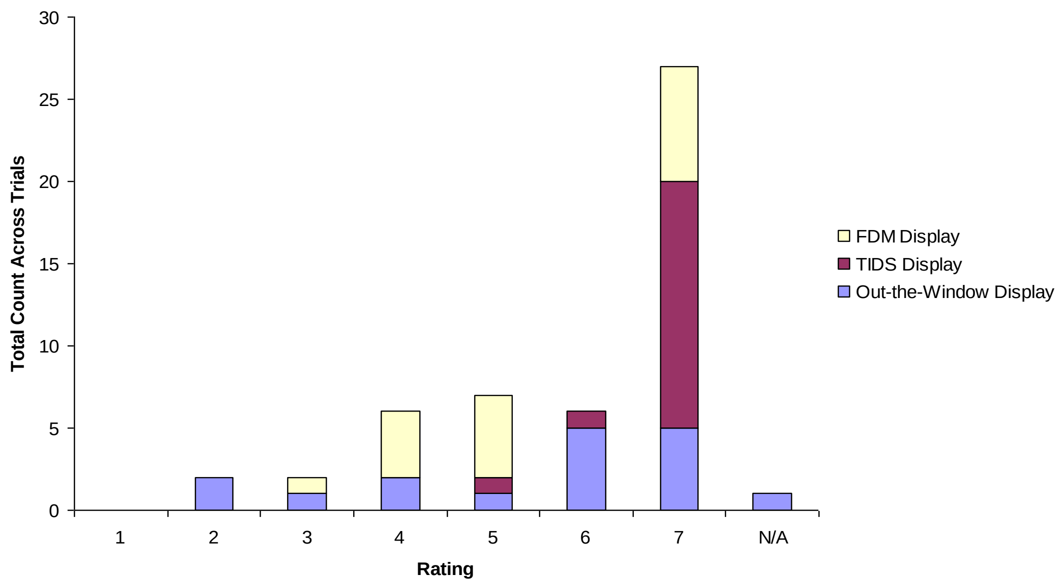

Figure 7. Ratings for awareness of aircraft identity.

The controllers also rated the TIDS display as being the most beneficial for helping them to maintain their awareness of traffic location, followed closely by the FDM and OTW displays (see Figure 8).

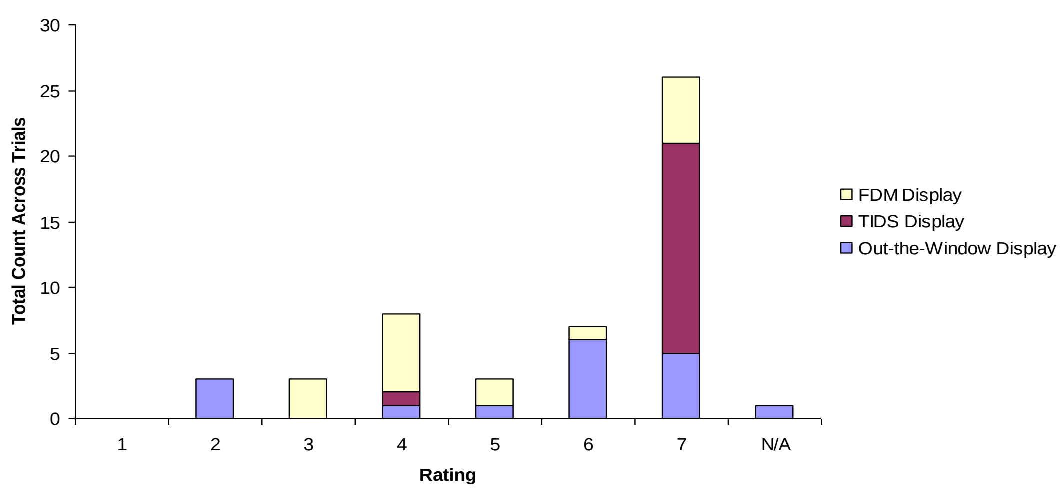

Figure 8. Ratings for awareness of traffic location.

The pattern of ratings for maintaining efficient (see Figure 9) and safe (see Figure 10) operations followed the patterns of ratings for awareness of aircraft identity and awareness of traffic location. The controllers gave the most consistently high ratings to the TIDS display, indicating that it was the most beneficial for helping them to maintain efficient and safe operations. However, the ratings for both the FDM and OTW displays were also high, even though they were slightly more variable.

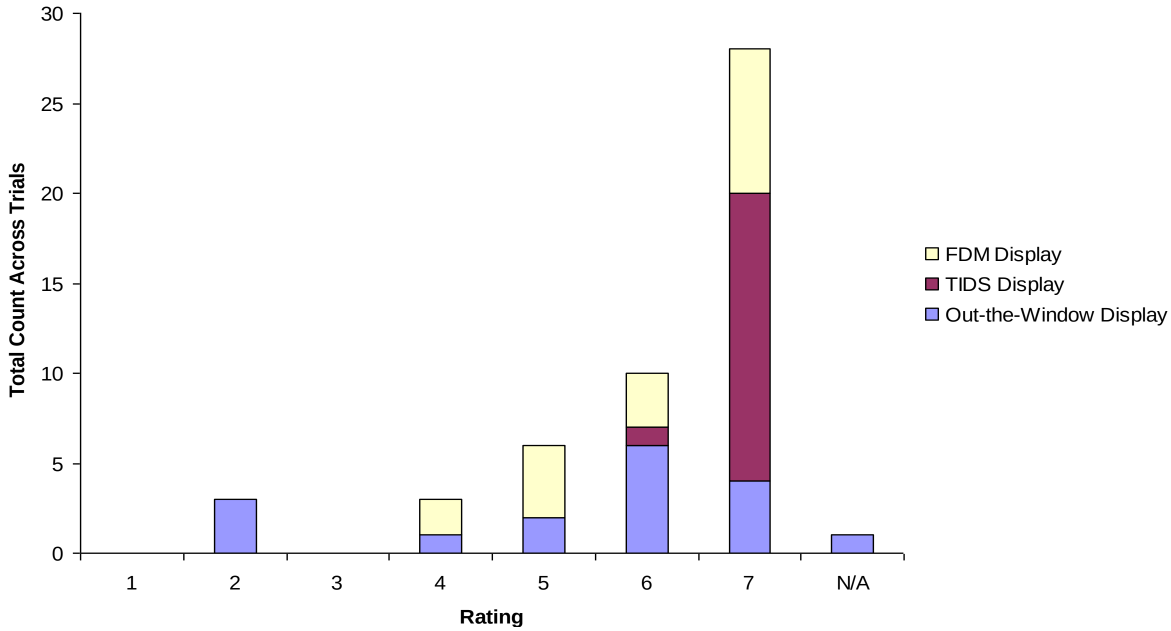

Figure 9. Ratings for maintaining efficient operations.

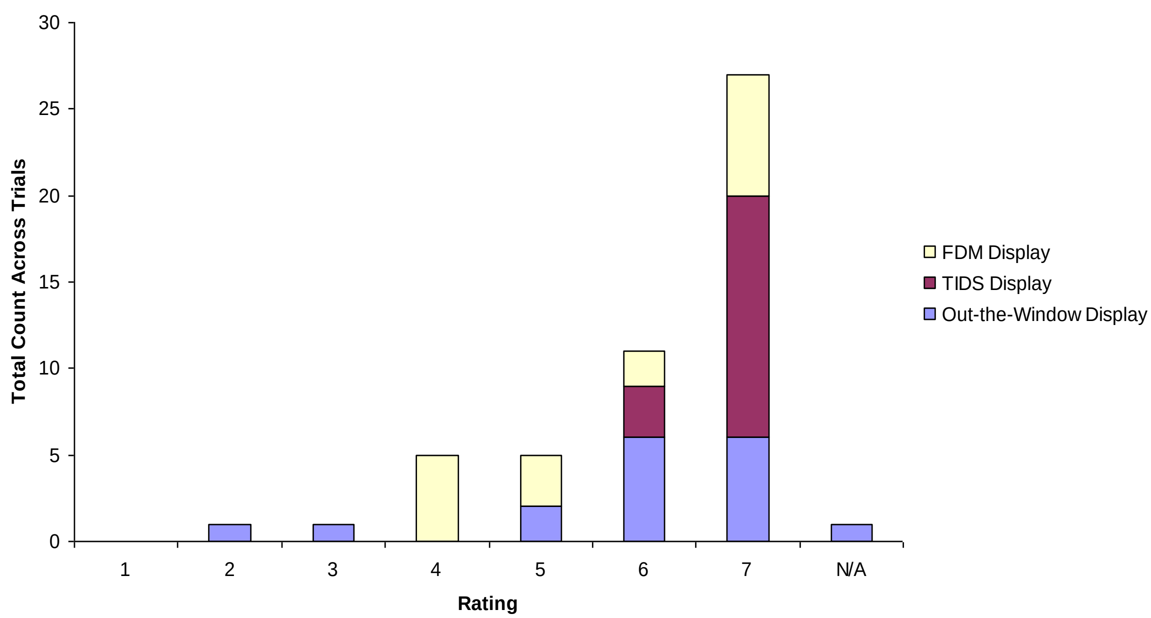

Figure 10. Ratings for maintaining safe operations.

The ratings were not nearly as high for the different camera view options. However, because this was the controllers' preliminary exposure to the camera, we expected lower and more variable ratings for the camera configurations used in the part-task evaluation.

The controllers gave moderate to low ratings to the PiP, the Stand-Alone, and the PiP + Stand-Alone configurations regarding their ability to help the controller maintain awareness of aircraft identity (see Figure 11) and traffic location (Figure 12).

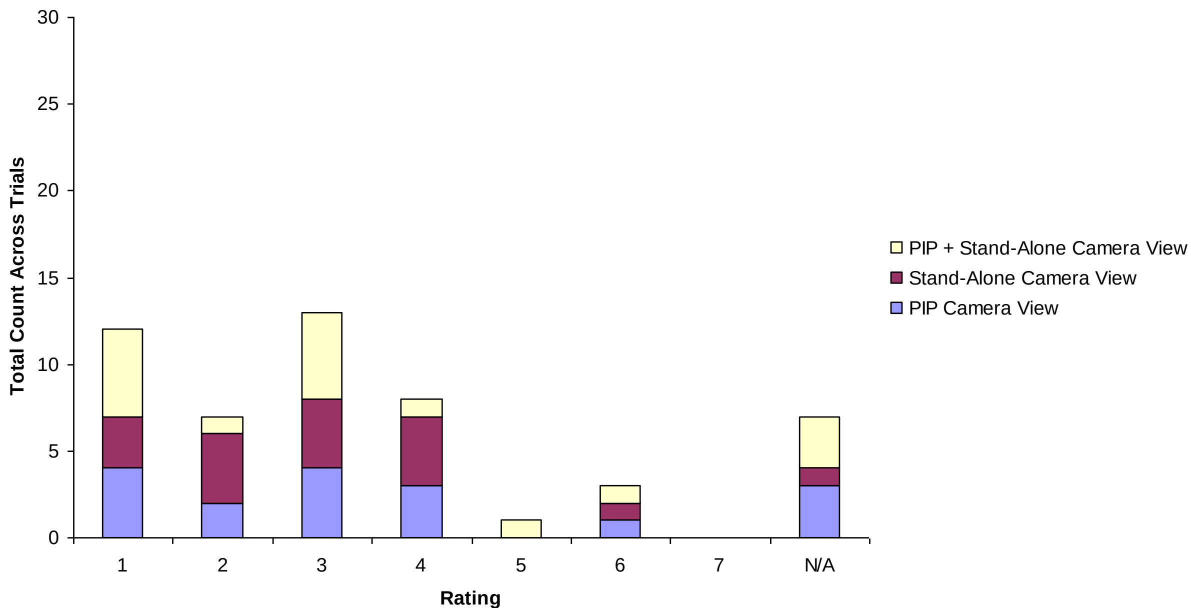

Figure 11. Ratings for maintaining awareness of aircraft identity.

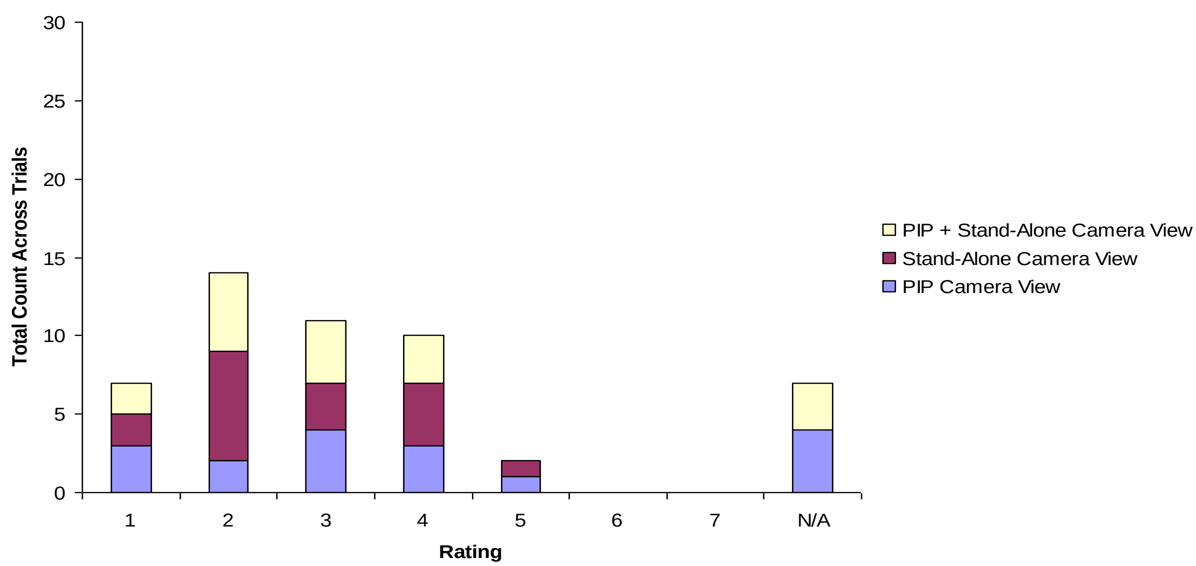

Figure 12. Ratings for maintaining awareness of traffic location.

The controllers also gave moderate to low ratings to the PiP, the Stand-Alone, and the PiP + Stand-Alone configurations regarding their ability to help the controller maintain efficient (see Figure 13) and safe operations (see Figure 14).

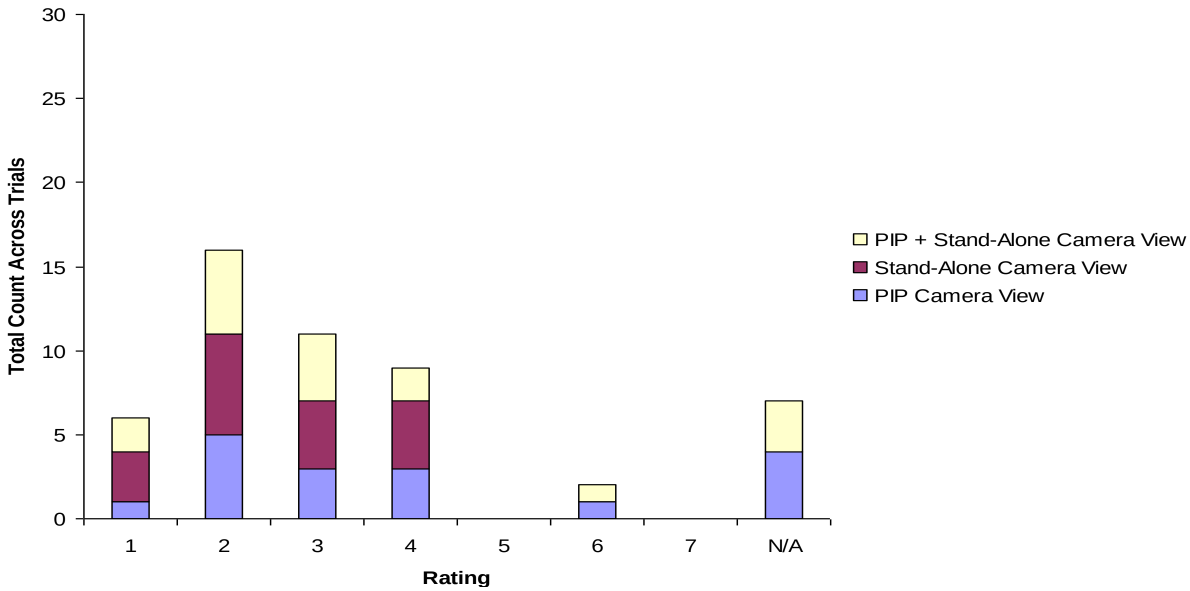

Figure 13. Ratings for maintaining efficient operations.

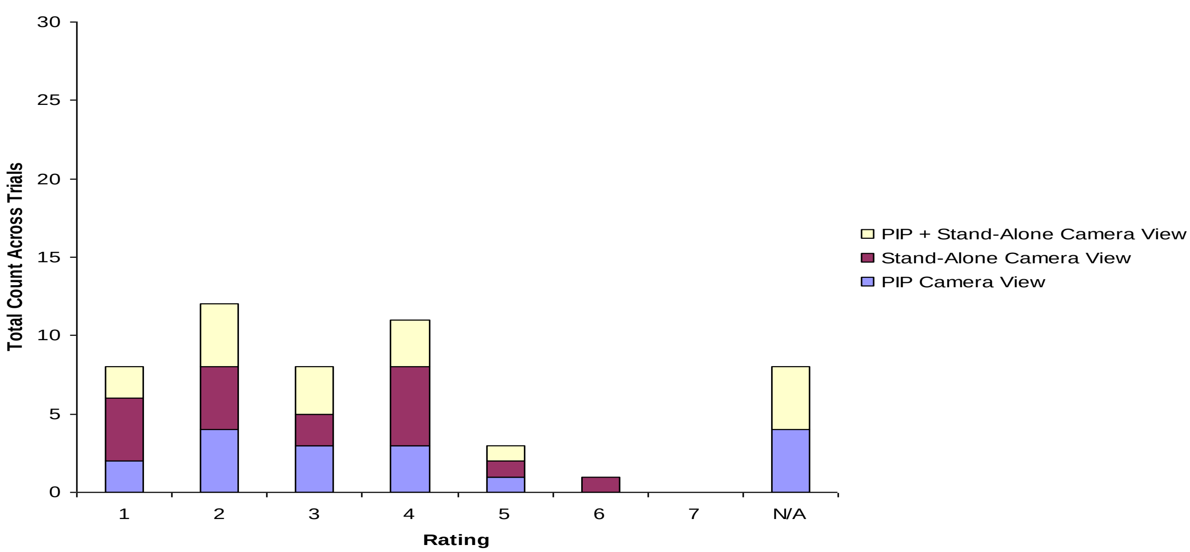

Figure 14. Ratings for maintaining safe operations.

The controllers rated their awareness of runway incursions in a variety of contexts and also provided ratings on how well the cameras helped them to maintain their awareness of different incursion scenarios. The ratings regarding awareness of potential runway incursion involving arrivals on final, aircraft on runways, aircraft holding short on runways, aircraft taxiing into position and holding, and intersection departures were made on a scale from 1 (*very low*) to 7 (*very high*). The ratings indicated that the controllers believed that they were highly aware of runway incursions in a variety of contexts (see Figure 15). However, they did not believe that the cameras in their current configurations (i.e., PiP, Stand-Alone, PiP + Stand-Alone) helped them to maintain this awareness.

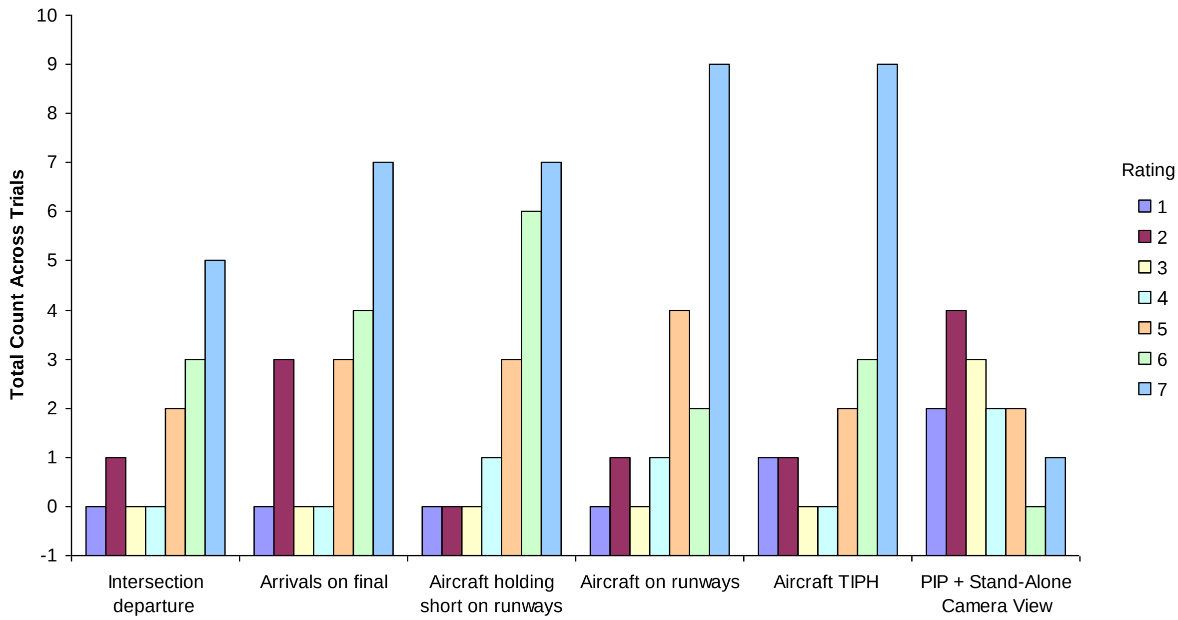

Figure 15. Ratings for controller awareness of runway incursions.

As part of the post-scenario survey, the controllers were asked to provide general feedback regarding the camera interface and its usability. The controllers indicated that the monitors should be angled for better viewing of the OTW display. They also believed that their interactions with the camera view using the mouse drew their attention away from the TIDS and the FDM. The controllers pointed to a problem with the lag time, indicating that there was too much lag time when they used the zooming function. In addition, the controllers suggested that the camera should be capable of automatically zooming to a preset range to view objects at longer distances.

The controllers provided feedback for the TIDS and FDM tools, even though these tools were not the primary focus of this part-task evaluation. The controllers suggested that when they edited a strip using the FDM, they did not want it to remain highlighted when they were finished editing it. The controllers wanted it to return to its original state, prior to when the edit mode was selected.

3.1.2 Post-Evaluation Questionnaire Results

After completing all nine scenarios, the controllers filled out a post-evaluation survey about the TIDS, the FDM, and the cameras. For the TIDS display, the controllers were asked to rate the ease with which they could perform certain functions on a scale from 1 (*very difficult*) to 7 (*very easy*). They were asked how easy it was to determine the aircraft weight class, determine the aircraft airborne/ground status, find necessary flight information, maintain situational awareness, select a data block, deselect a data block, move a data block, maintain data block separation, detect aircraft location/position, and determine aircraft type (see Figure 16 and Figure 17). The ratings for all of these were very high, indicating that the controllers found the TIDS display to be fairly easy to use.

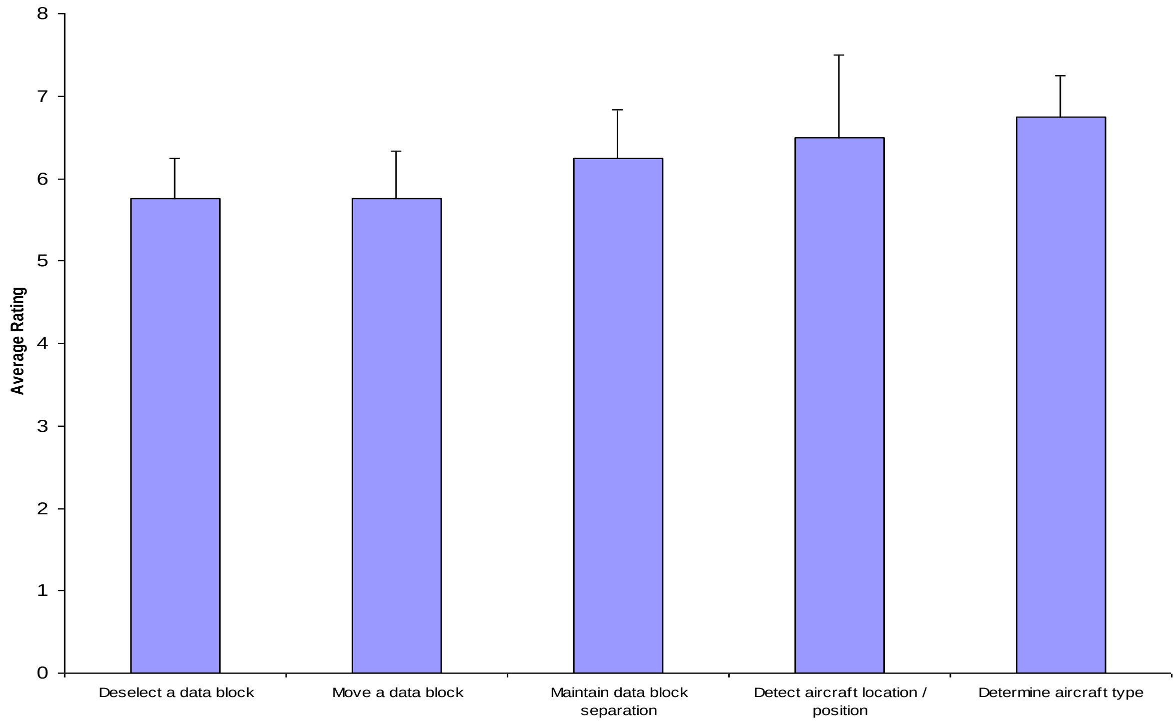

Figure 16. Average rating for ease of TIDS use – 1.

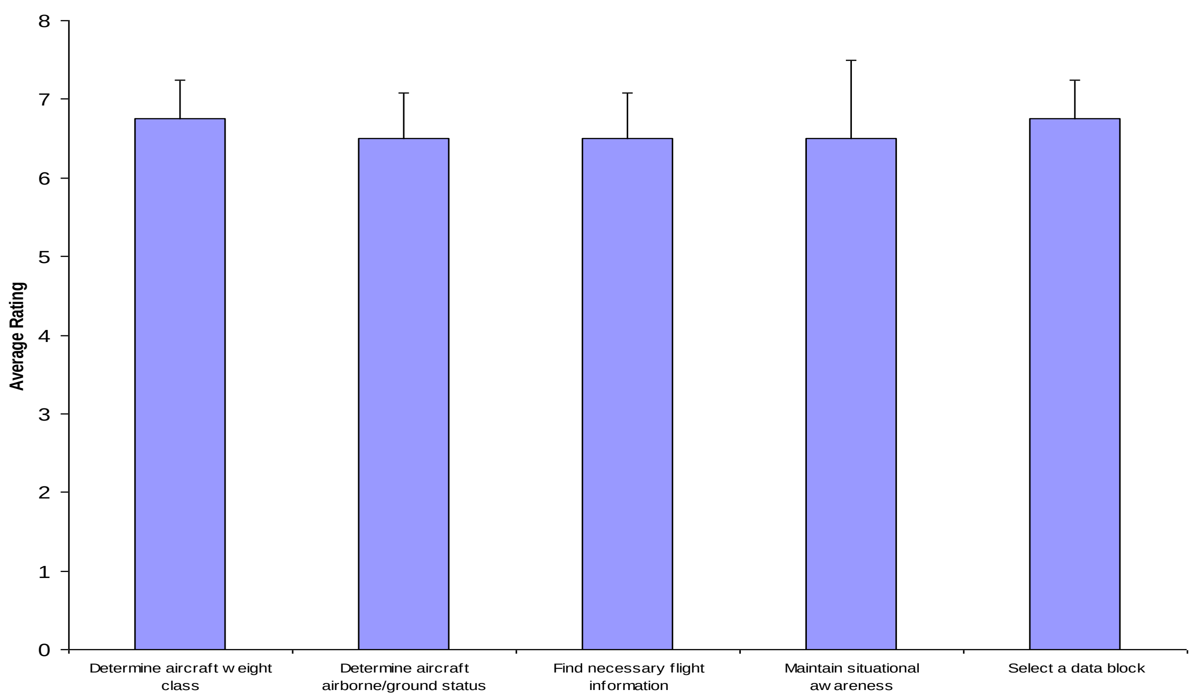

Figure 17. Average rating for ease of TIDS use – 2.

The controllers were also asked to rate the adequacy of different TIDS capabilities and interface design features on a scale from 1 (*very inadequate)* to 7 (*very adequate*). They were asked to rate the adequacy of the size of the overall display; the size of the icons, text, and data blocks; the PiP capability; the color scheme used for the icons and the text, the data block time-sharing feature, and the data block presentation (see Figure 18). The ratings for these were high, indicating that the controllers generally liked the interface for the TIDS. However, there were lower ratings for the PiP capability, indicating only moderate satisfaction with the PiP interface.

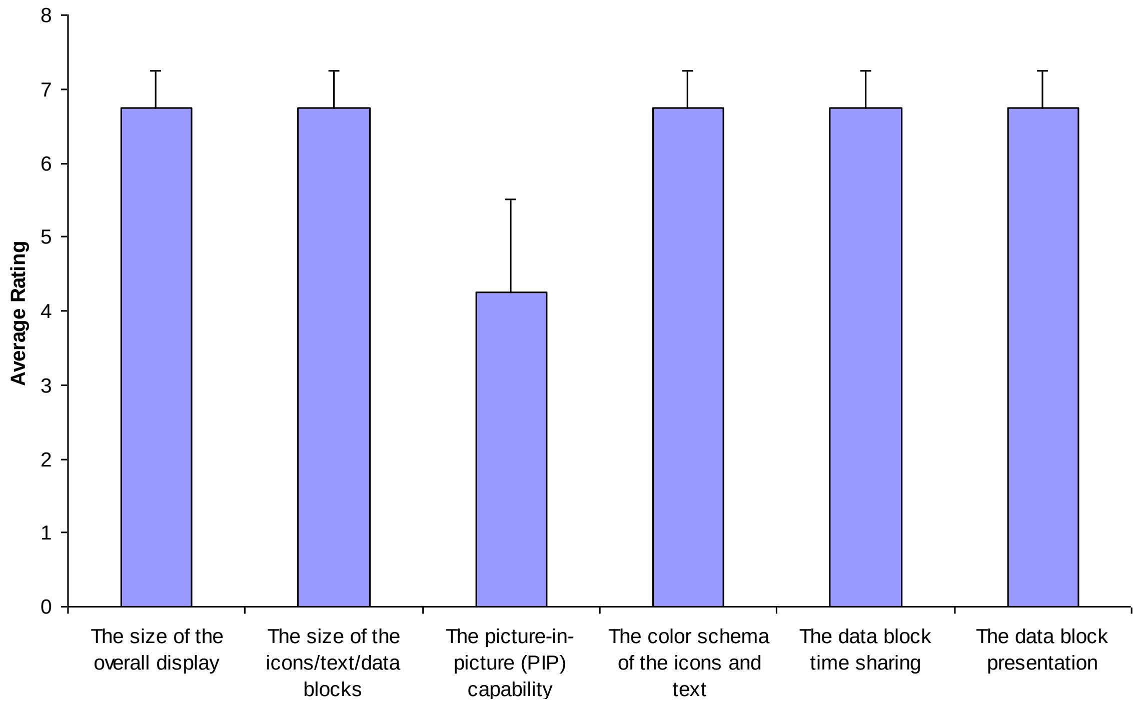

Figure 18. Average rating for the adequacy of the TIDS display.

For the FDM display, the controllers were asked to rate the ease with which they could perform certain functions using the FDM display on a scale from 1 (*very difficult*) to 7 (*very easy*). They were asked how easy it was to select a flight strip, deselect a flight strip, undo an action or correct an error, determine aircraft location, transfer flight information, edit flight information, find flight information, manage flight strips, and retrieve a flight strip (see Figure 19 and Figure 20). The average ratings for all of these were high, indicating that the controllers found the FDM display to be fairly easy to use.

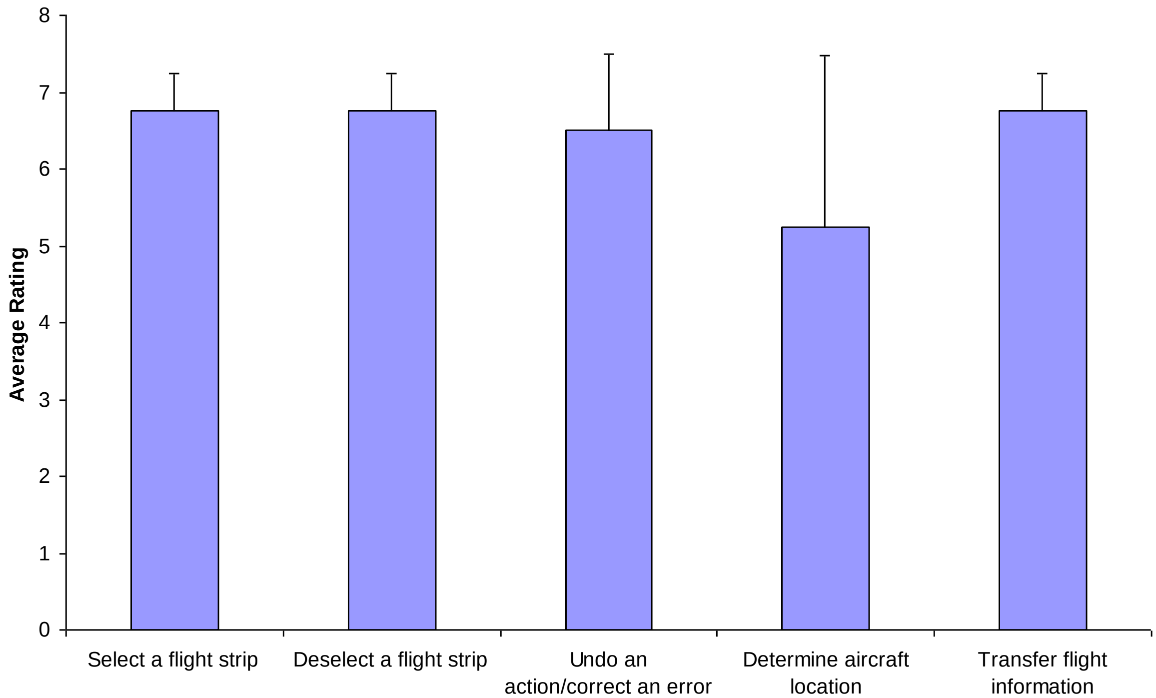

Figure 19. Average rating for ease of FDM use – 1.

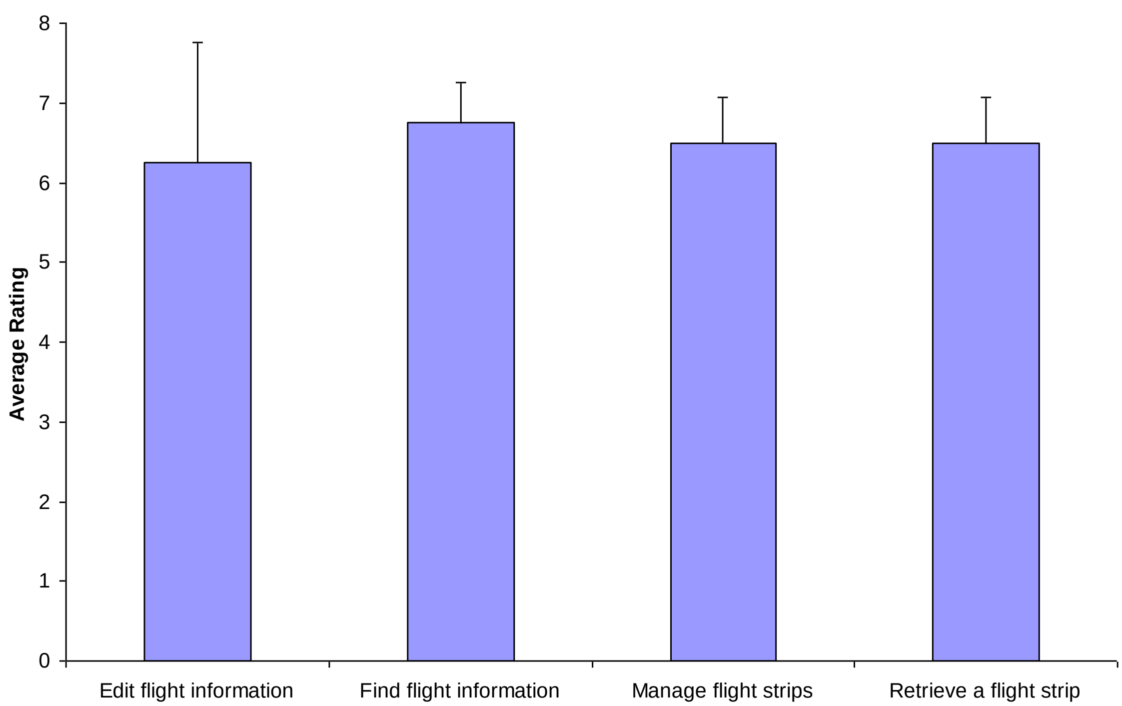

Figure 20. Average rating for ease of FDM use – 2.

The controllers were also asked to rate—on a scale from 1 (*very inadequate*) to 7 (*very adequate*)—different FDM capabilities and interface design features. They were asked to rate the adequacy of the size of the display, the readability and legibility of the text, the strip bay configuration, the information presentation, and the type of information presented (see Figure 21). As with the ratings for the TIDS display, the ratings for the FDM were high, indicating that the controllers generally liked the FDM interface.

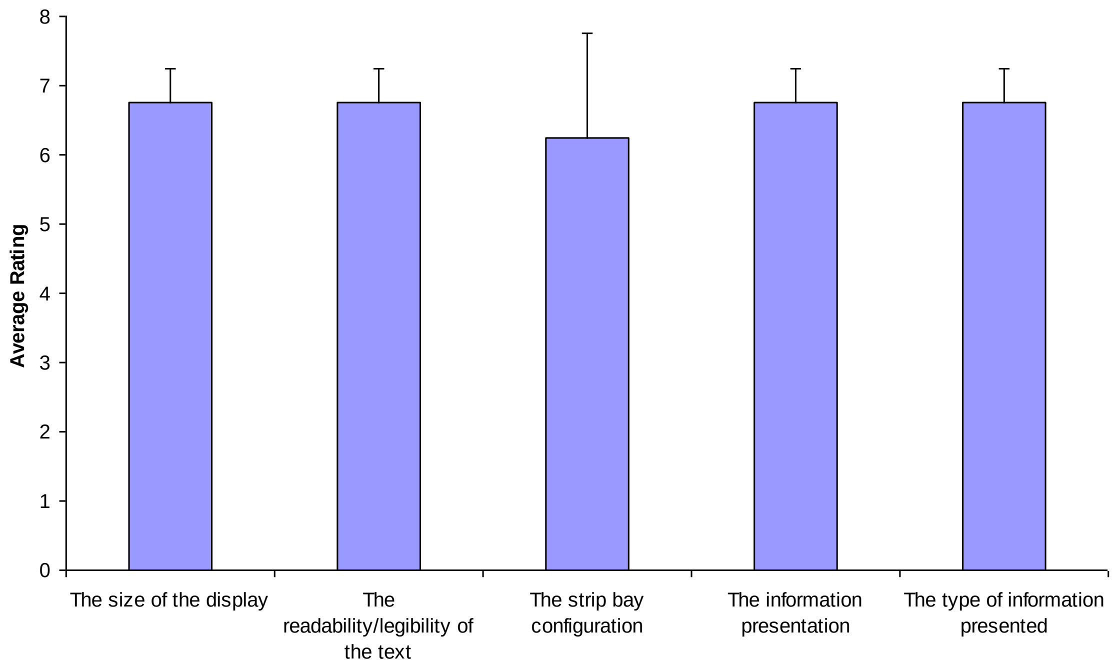

Figure 21. Average rating for the adequacy of the FDM display.

For the camera interface, the controllers were asked to rate—on a scale from 1 (*very difficult)* to 7 (*very easy)*—the ease with which they could perform certain functions. They were asked how easy it was to create, resize and move the PiP window on the TIDS display; select and resize a viewing area; select and track a target (i.e., aircraft or vehicle); use the pan, zoom, and tilt controls on the PiP view; use the pan, zoom, and tilt controls on the stand-alone view; determine the location of an aircraft; and determine the aircraft type or company (see Figure 22 and Figure 23). The average ratings for all of these were in the middle and there was a great deal of variability. Although these ratings were not as high as the ratings for the TIDS and the FDM ease of use ratings, we expected this because this was the controllers first exposure to the camera, and because the goal of this part-task was to determine what design work needed to be done on the camera interfaces to make them ready for HITL 2.0.

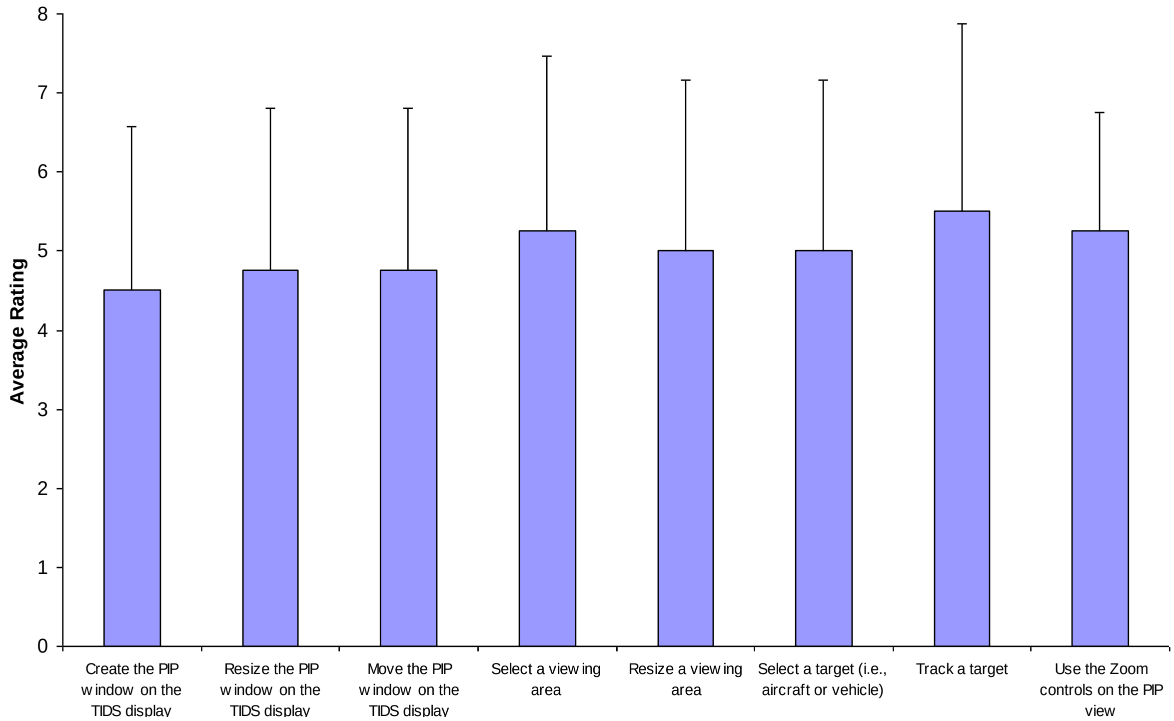

Figure 22. Average rating for the ease of camera use – 1.

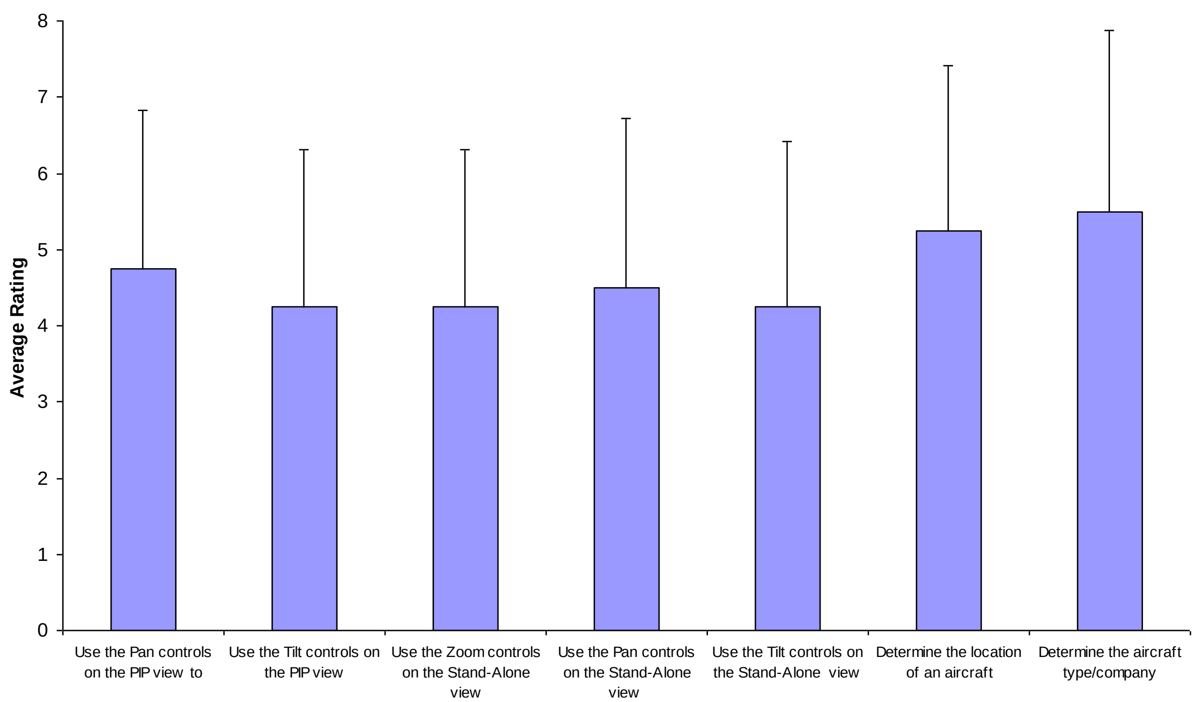

Figure 23. Average rating for the ease of camera use – 2.

The controllers were also asked to rate—on a scale from 1 (*very inadequate*) to 7 (*very adequate*)—the adequacy of the PiP and Stand-Alone cameras. For both the PiP (see Figure 24 and Figure 25) and the Stand-Alone camera views (see Figure 26 and Figure 27), they were asked to rate the overall presentation, the overall functionality, the size, the readability and legibility of the text, the ease with which the camera allowed them to locate a target, the ease with which the camera allowed them to determine the aircraft type or company, the ease with which the camera allowed them to track a target, the overall automatic camera scanning functionality, the ease with which the camera allowed them to detect aircraft nonconformance, the cameras ability to help them to maintain overall situational awareness, the system responsiveness and the system lag. Although these ratings were not as high as the ratings for the TIDS and the FDM, as with ease of use, we did not expect high ratings and were pleased with average ratings of 4 and 5 even though they were somewhat variable. Because this was the first time we presented the controllers with a camera interface, the main goal of this part-task was to elicit feedback to determine the optimal CHI for use in HITL 2.0.

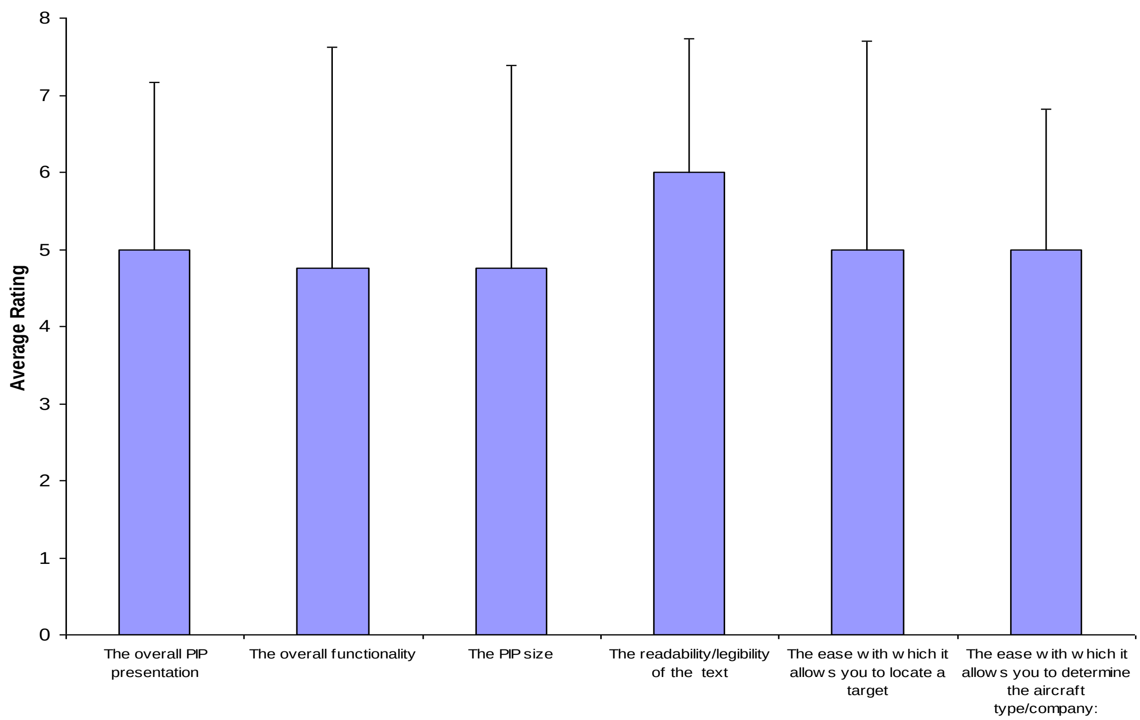

Figure 24. Average rating of the adequacy of the PiP camera – 1.

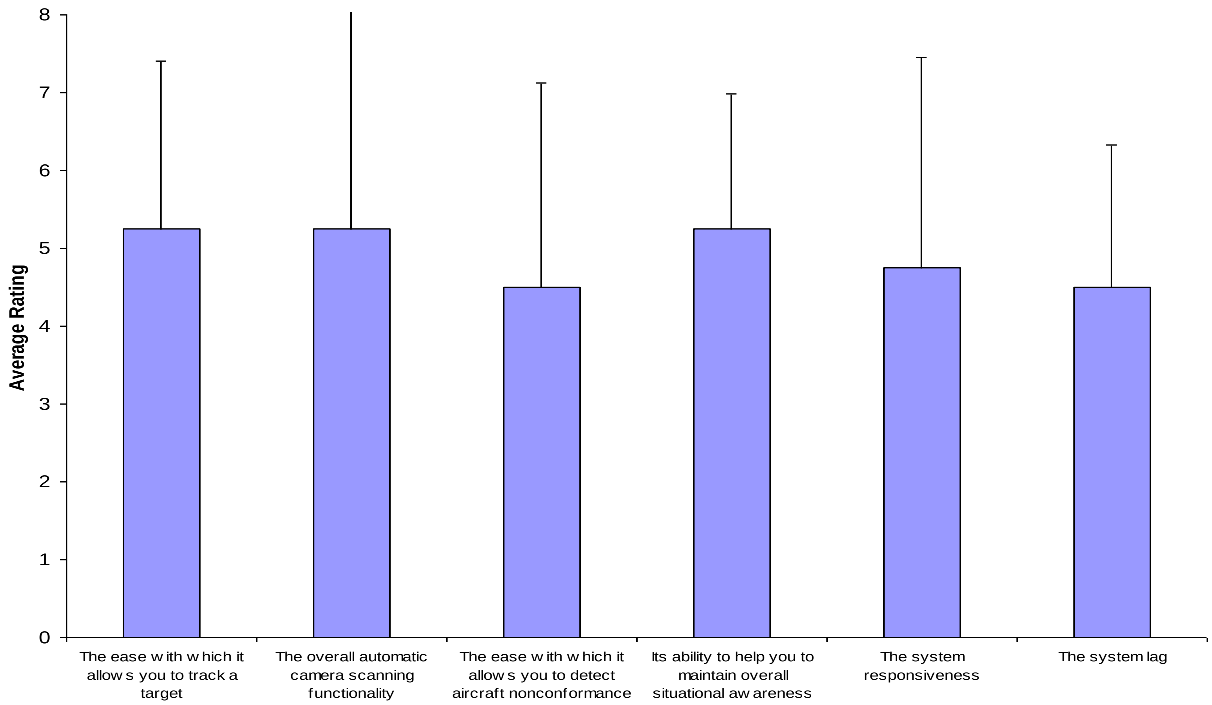

Figure 25. Average rating of the adequacy of the PiP camera – 2.

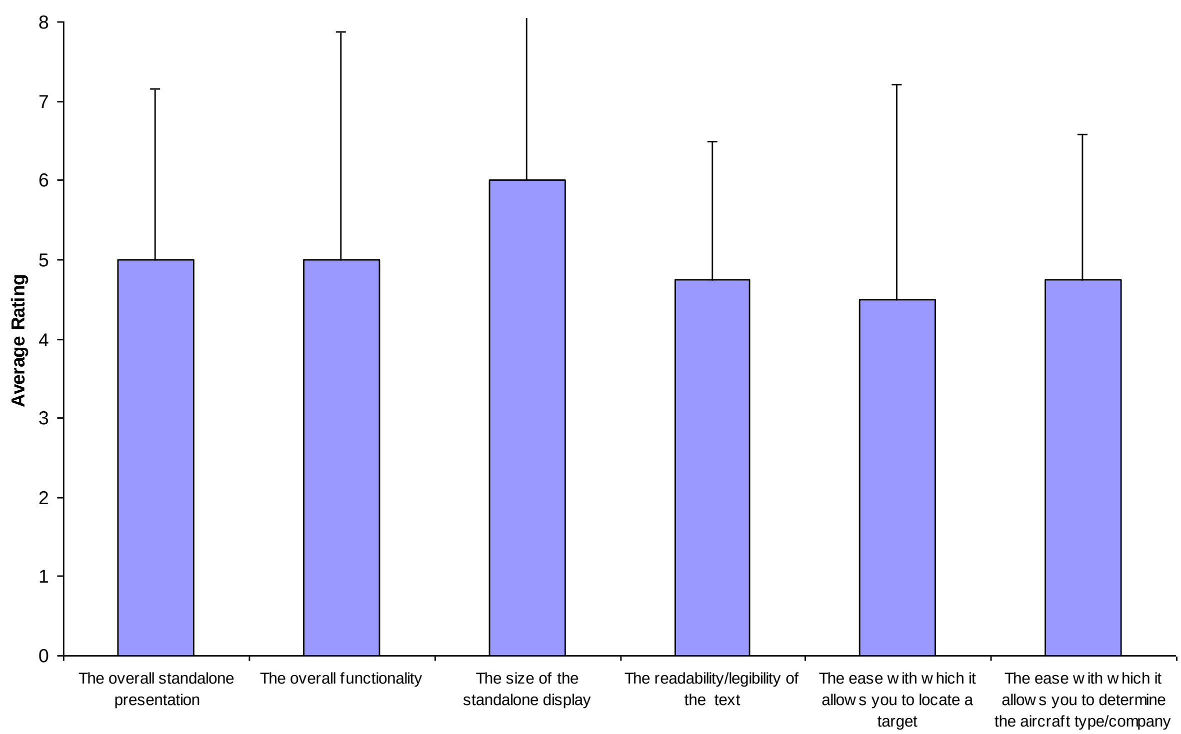

Figure 26. Average rating of the adequacy of the Stand-Alone camera view – 1.

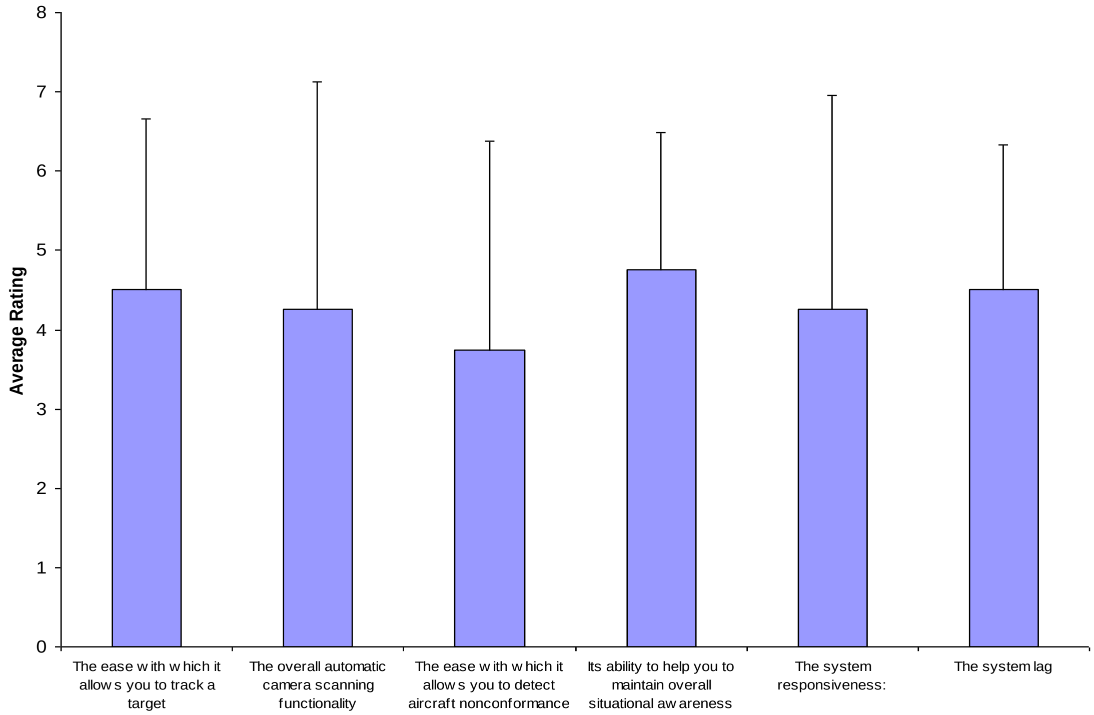

Figure 27. Average rating of the adequacy of the Stand-Alone camera view – 2.

The controllers were asked to rate—on a scale from 1 (*completely unnecessary*) to 7 (*completely necessary*)—the necessity of the camera view on the TIDS and the Stand-Alone monitor for SNT operations (see Figure 28). Consistent with the other feedback we received, the controller ratings indicated that they only believed there was a moderate need for cameras for performing SNT operations.

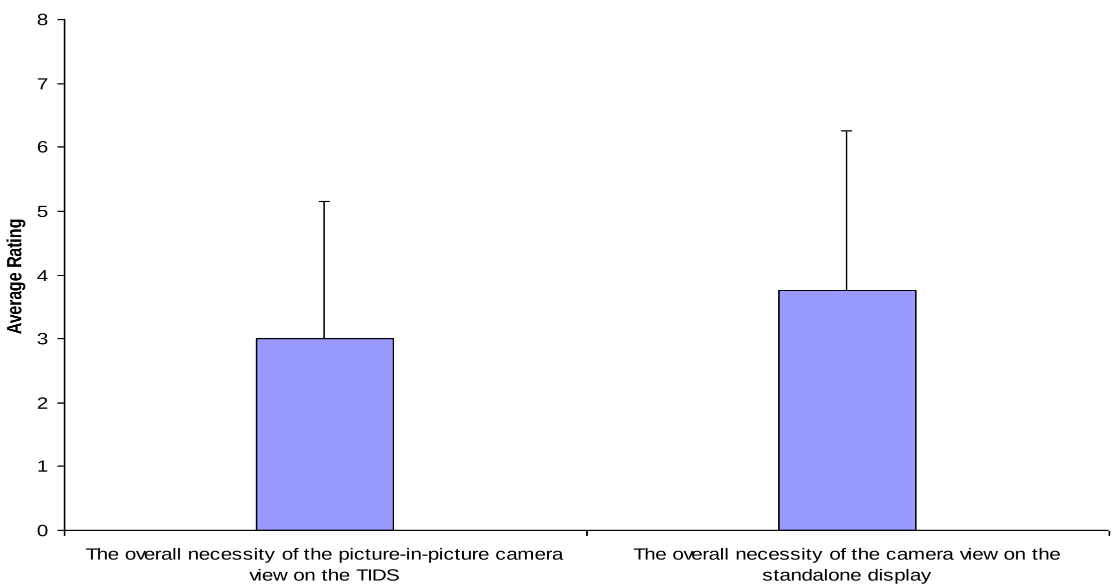

Figure 28. Average rating of the necessity of the PiP and Stand-Alone cameras.

Observers also recorded, when possible, the means by which controllers detected a scripted off-nominal event (see Table 4). Although most off-nominal events were not detected, those that were observed were not observed with the camera views. However, it is important to note that many off-nominal events were difficult to detect in the nighttime conditions.

Table 4. Number of Off-Nominals Detected by Method

	Unobserved	OTW	TIDS	Camera	OTW & TIDS	RACD
Number detected via each method	9	6	5	1	1	1

Note. OTW = Out-the-Window; TIDS = Tower Information Display System; RACD = Remote ARTS Color Display.

To summarize the findings on the camera views, we found that there were mixed opinions among the controllers regarding the effectiveness of the camera views in the tower environment. The controllers expressed a preference for viewing camera images on an external monitor. They disliked the PiP camera image on the TIDS, and they expressed some concern about how they would incorporate the camera view into their normal scanning pattern.

4. CONCLUSION

We have much work to do to optimize the camera interface, its functionality, and its capabilities so that we may further test and decide whether to make cameras an integral and indispensable component of SNT. All four controllers agreed that there is a need for a higher resolution image. The controllers also brainstormed ideas for how the cameras might be used in novel ways. The controllers believed that the local controller might want to use cameras to judge when an aircraft rotated "wheels up," because the controllers use this information to clear the next operation. The controllers also indicated that the local controller might want to focus the camera on aircraft on final to track them until they landed. They also suggested using the camera for both local and ground controllers to view the taxiway hold lines. This suggestion may be mitigated by certified surveillance that provides this information to the system. The controllers also indicated that they would like to see call signs depicted on the camera view.

Although this was not primarily an evaluation of the TIDS or the FDM tools, the controllers did have some suggestions for improving the TIDS. Specifically, they suggested that the data blocks could automatically change orientation to serve as an indication of certain events (e.g., aircraft on a specific runway). There is a need to provide touch and mouse capabilities on both TIDS and FDM.

There was agreement among the controllers that they preferred a display with the TIDS display above the FDM display and the stand-alone display on the right (as shown in Figure 4). All four controllers disliked the PiP view. The controllers did indicate that they might consider having a stand-alone display above the TIDS (in a remote environment only), in single vertical array, but we believe that there are possible ergonomics implications that need to be studied if this configuration is to be considered for operational use. In future efforts, we also might want to consider incorporating low visibility conditions or conditions with no OTW view to explore whether the camera might be useful in these conditions.

4.1 Camera Issues

Although this was a part-task study, it is important to note that there were several camera performance problems that we need to address for HITL 2.0. First, when the controllers used the camera, it sometimes crashed the system. It was difficult for the controllers to control the camera by clicking with the mouse on the camera image. The controllers were informed that there was a workaround, and that they could click on aircraft that they wanted to view or track. However, this did pose a serious limitation for testing the cameras. In addition, the panning controls were sluggish and rough. There was no panoramic camera view and there was only one tracking camera, which had to be shared between the local and the ground controller. The controllers cited the low resolution of camera image as a major issue that we need to address for HITL 2.0. The research team did provide the controllers with a higher resolution image (1620 x 510) on Day 3 that they did prefer. Finally, the controllers stated that the camera was not very useful in nighttime conditions without any infrared capability. Although we explored moving the camera view to different locations around the airport, the controllers did not believe that any of the alternate locations that we tested were better than the location used.

4.2 Simulation Issues

The controllers noted that traffic was too heavy at the start of Day 1. Due to the excessive volume, the controllers were too busy controlling traffic to interact with the camera. Therefore, we modified the scenarios to lower the levels of traffic to enable the controllers to devote more of their attention to the camera.

The initial configuration of the TIDS and the FDM was not optimized for camera use. Specifically, the monitors blocked the OTW view and the auxiliary camera view was initially on the left, which placed it in a location that was out of controllers' normal scan. Based on preliminary feedback from the controllers, we reconfigured the monitors on Day 2.

We also did not shut off the OTW view until the final day. Although this was not part of the initial set of test conditions, we believed that controllers would use the camera views more when the OTW view was unavailable. When we did shut off the OTW view on the last day of the part-task effort, we found that camera use increased substantially.

There were also some minor issues that were noted by the controllers during the simulation. They noted that the taxiway hold line, although visible on the PiP camera view, was too fuzzy, which reduced its usability. The aural alarms were not turned on during the simulation and this was somewhat distracting and did not support the controllers in detecting off-nominal events. Lastly, the off-nominals we selected for inclusion in this part-task evaluation were not equally optimal for encouraging camera use.

4.3 Final Debrief Results

Our final debrief provided the controllers with the opportunity to identify any additional issues that had not been identified elsewhere during the part-task evaluation. We first discussed, in more detail, possible uses for the camera in an SNT context. The controllers did believe that they might use camera views for some aspects of tower ATC. For example, the controllers stated that they might use camera views to observe the wheels up on departing aircraft to obtain more accurate timing information, to view aircraft on final approach, to view aircraft holding short of runways, to view aircraft stopped at spots, and to view some off-nominal events (e.g., zooming in on burning and smoking engines on an aircraft).

However, the controllers strongly believed that camera views would have limited usefulness for controllers, especially for viewing off-nominal events, without connectivity to a decision-support tool (DST). The DST could provide initial detection capability, which could then be used to move and focus the camera on the off-nominal event. In addition, any off-nominal event detected by the DST could then be presented in a dedicated camera inset window to draw the controller's attention to that event.

5. RECOMMENDATIONS

For the next evaluation, HITL 2.0, and for use in an SNT environment, we recommend providing both ground and local controllers with independent tracking cameras. The results showed that controllers are not willing to share control of a single camera and without independent camera views, the cameras become unusable. It is also essential for the SNT environment in future studies to include a panoramic stitched view, along with one or more fixed camera insets. The fixed views could be displayed in multiple inset windows, with different camera views (e.g., at spots, taxiway lines) tailored to specific positions. As stated previously, the controllers emphasized the need for higher resolution camera images to make them usable. Without a high-definition image, the controllers cannot see taxiway lines to detect runway incursions or see aircraft paint schemes to enable fast and reliable airline identifications.

For controllers to effectively use cameras for detecting off-nominal events in an SNT context, we believe that it is necessary to develop a DST that uses intelligent processing and alerting capabilities for detecting these events. This type of DST capability could be used to detect the off-nominal event, which could then trigger the display of that event in a fixed view displayed in an off-nominal camera inset window. The controllers also expressed a desire to explore how cameras could be used to auto-acquire and track aircraft on final and departure in a second dedicated camera-view inset. The controllers further recommended exploring whether there is any use for a camera view that shows two closely spaced aircraft or for having a fixed camera view of alleys and gate areas to help compensate for line of sight issues. Finally, we believe future SNT camera evaluations should include the use of eye-tracking technology to detect where a controller is looking immediately before and after off-nominal detection.

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Acronyms

ATC	Air Traffic Control
CARTS	Common Automated Radar Terminal System
CHI	Computer-Human Interaction
DESIREE	Distributed Environment for Simulation, Rapid Engineering, and Experimentation
DFW	Dallas Fort-Worth International Airport
DST	Decision Support Tool
FAA	Federal Aviation Administration
FDM	Flight Data Manager
HFE	Human Factors Engineer
HITL	Human-In-The Loop
MIT LL	Massachusetts Institute of Technology Lincoln Laboratory
NAS	National Airspace System
NextGen	Next Generation Air Transportation System
NIEC	NextGen Integration and Evaluation Capability
OTW	Out-The-Window
PiP	Picture-In-Picture
RACD	Remote ARTS Color Display
SME	Subject Matter Expert
SNT	Staffed NextGen Tower
STARS	Standard Terminal Automation Replacement System
TGF	Target Generation Facility
TIDS	Tower Information Display System
VESA	Video Electronics Standards Association
VFR	Visual Flight Rules
WJHTC	William J. Hughes Technical Center

Appendix A: Observer Off-Nominal Event Over-the-Shoulder Form

Observer Off-Nominal Event Over-the-Shoulder Form

OFF-NOMINAL EVENT: LOCAL 1 **TIME OF EVENT**__________

SCENARIO RUN ID ____

DESCRIPTION Aircraft Initiated Go-Around.

1 PLEASE CHECK ONE

- □ Completely unobserved
- □ Observed but no action taken
- □ Action taken at 1st opportunity…………….. □ succeeded □ failed
- □ Action taken at 2nd opportunity point…… □ succeeded □ failed

		PLEASE CIRCLE ONE			
2	RECOGNITION TIME The amount of time taken to recognize the event	1 Very inadequate	3 Neutral	5 Very adequate	N/A
3	APPROPRIATENESS OF ACTION The appropriateness of the actions taken to resolve the event	1 Very inappropriate	3 Neutral	5 Very appropriate	N/A
4	APPROPRIATENESS OF TIMING The appropriateness of the timing of the actions taken to resolve the event	1 Very inappropriate	3 Neutral	5 Very appropriate	N/A
5	ACCURACY OF COMMUNICATION - TRAFFIC The accuracy of communication with traffic regarding the event	1 Very unacceptable	3 Neural	5 Very acceptable	N/A
6	ACCURACY OF COMMUNICATION - ATC The accuracy of communication with other controllers regarding the event	1 Very unacceptable	3 Neural	5 Very acceptable	N/A
7	OVERALL RATING The overall adequacy of the response to the event	1 Very inadequate	3 Neural	5 Very adequate	N/A

*potential event and actual event used interchangeably

8 COMMENTS

____

____

____

____

Appendix B: Potential Camera Coverage Area

Potential Camera Coverage Area

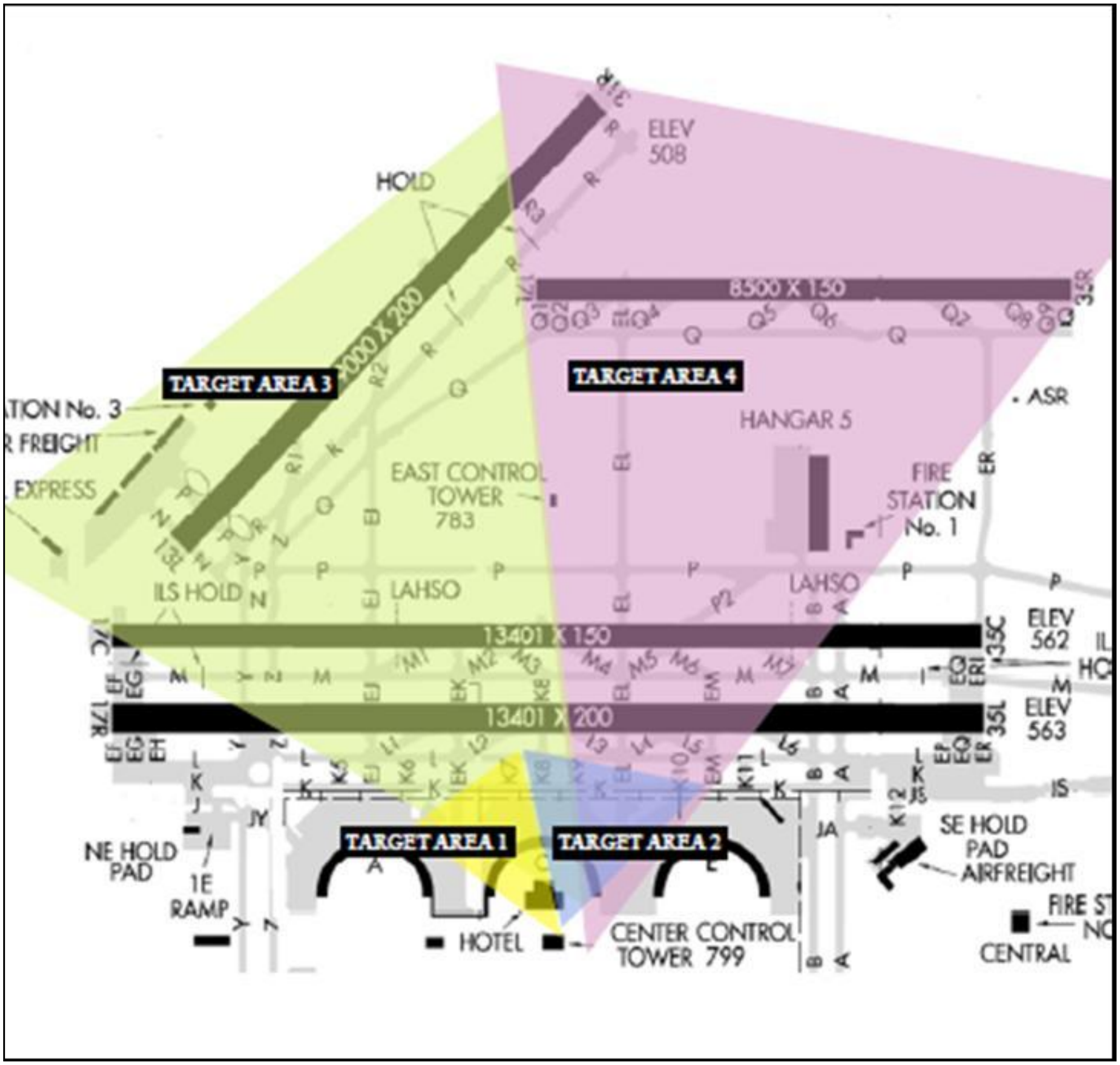

Figure. Potential coverage and viewing areas from Center Control Tower camera placement.

Appendix C: Informed Consent Form

Informed Consent Form

Individual's Consent to Voluntary Participation in a Research Project

I, ______________________________, understand that this study, Staffed NextGen Tower Camera Integration Computer Human Interface Evaluation, is sponsored by the Federal Aviation Administration (AJP-66, Concept Development and Validation) and is being directed by Ferne Friedman-Berg (AJP-6110).

Purpose

I have been recruited to volunteer as a controller in the project named above. As part of the Next Generation Air Transportation System (NextGen), the FAA envisions a ground-level facility that will be able to provide air traffic management (ATM) services to one or more remote airports. The purpose of this study is to investigate the effect that a NextGen Tower environment may have on air traffic control (ATC) operations.

Procedures

If I agree to participate, I, along with a second controller, will be asked to serve as a Ground or Local Controller and perform routine ATC operations in a simulation environment. Simulated air traffic will be presented on a virtual out-the-window (OTW) tower display, STARS, and an integrated certified surveillance display (TIDS). Additionally an electronic flight data management (FDM) display will be utilized. I will be trained on how to use any unfamiliar technologies/tools and given practice sessions to ensure I am comfortable with the systems. Once the practice sessions are completed, I will participate in nine experimental trials. I understand that data may be recorded (video, audio, and simulation metrics). Additionally, questionnaires will be employed to obtain subjective ratings on a variety of trial-related aspects. All activities will occur over three consecutive days (Tuesday-Thursday).

Discomfort and Risks

The only foreseeable risk could be fatigue from the simulations.

Benefits

I understand that there are no monetary benefits to my participation. The only benefit is the opportunity to help the FAA better design a Staffed NextGen Tower.

Controller Responsibilities

I attest that I am a Supervisor and have at least one year of experience as a CPC. During the research study, I will be at the WJHTC from 8:30am to 4:30pm each day.

Compensation and Injury

I will report any accident, injury, or illness immediately to Ferne Friedman-Berg at 609-485-7460. Medical assistance will be available, as needed, through the Atlantic County Emergency services via the Mainland Division of the Atlantic City Medical Center.

Controller's Assurances

I understand that my participation in this study is completely voluntary. I am participating because I want to. Dr. Friedman-Berg has adequately answered any and all questions I have about this study, my participation, and the procedures involved. I understand that Ms. Friedman-Berg will be available to answer any questions concerning procedures throughout this study. I understand that if new findings develop during the course of this research that may relate to my decision to continue participation, I will be informed.

I have not given up any of my legal rights or released any individual or institution from liability for negligence.

I understand that records of this study will be kept confidential and that I will not be identifiable by name or description in any reports or publications about this study. All audio and video recorded during the study will be used only for this study and will remain secure.

I understand that I may withdraw from this study at any time without penalty or loss of benefits to which I am otherwise entitled. I also understand that the researcher of this study may terminate my participation if she feels this to be in my best interest or best interest of the study.

If I have questions about this study or need to report any adverse effects from the research procedures, I will contact Ferne Friedman-Berg at 609-485-7460.

I have read this consent document. I understand its contents, and I freely consent to participate in this study under the conditions described. I have received a copy of this consent form.

*Research Controller:*____*Date:*________

*Investigator:*____*Date:*________

*Witness:*____*Date:*________

Appendix D: Biographical Questionnaire

Biographical Questionnaire

Controller # ____ Date _____

Instructions: This questionnaire is designed to obtain information about your background and experience as a certified professional controller (CPC). Researchers will only use this information to describe the controllers in this study as a group. Your identity will remain anonymous.

Demographic Information and Experience

1. Do you **wear corrective lenses**?	○ Yes	○ No
2. What is your **age**?	_______ years	
3. How long have you worked as a **Certified Professional Controller (including both FAA and military experience)**?	_______ years	_______ months
4. How long have you worked as a **CPC for the FAA**?	_______ years	_______ months
5. How long have you worked as a **Supervisor for the FAA?**		
6. How long have you **actively controlled traffic** in an airport traffic control tower?	_______ years	_______ months

7. Do you have operational experience with any electronic flight strip systems?		
		Years Exp
a. Advanced Electronic Flight Strip System (ORD)	○ Yes ○ No	
b. Electronic Flight Strip Transfer System (EFSTS)	○ Yes ○ No	
c. Other	○ Yes ○ No	

Appendix E: TIDS Quick-Action-Key Sheet

TIDS: How to use Quick Action Keys

- For entire display or independently in a PIP window
  - c - show/hide camera window
  - r - range rings on/off
  - t - change type of selected target
  - +/- - increase or decrease range ring size
  - m - change mile marker style
  - 5 - toggle hash marks at 5/10 miles (only applies to dash-style mile markers)
  - n - toggle mile marker numbers
  - p - change datablock position
  - b - show/hide datablocks for targets on ramp
  - u - show/hide datablocks for unknown targets
  - d - toggle shading on datablocks
  - l - change alarm window position
  - f - change airport configuration position
  - k - change icon for unknowns
  - w - toggle runway designators on/off
  - x - toggle taxiway designators on/off
  - s - toggle spots on/off
  - e - toggle area labels on/off
  - o - show/hide overflights
  - h - toggle track history on/off
  - v - toggle velocity vector on/off

MIT Lincoln Laboratory

DFW-1 TIDS ATC Training -12
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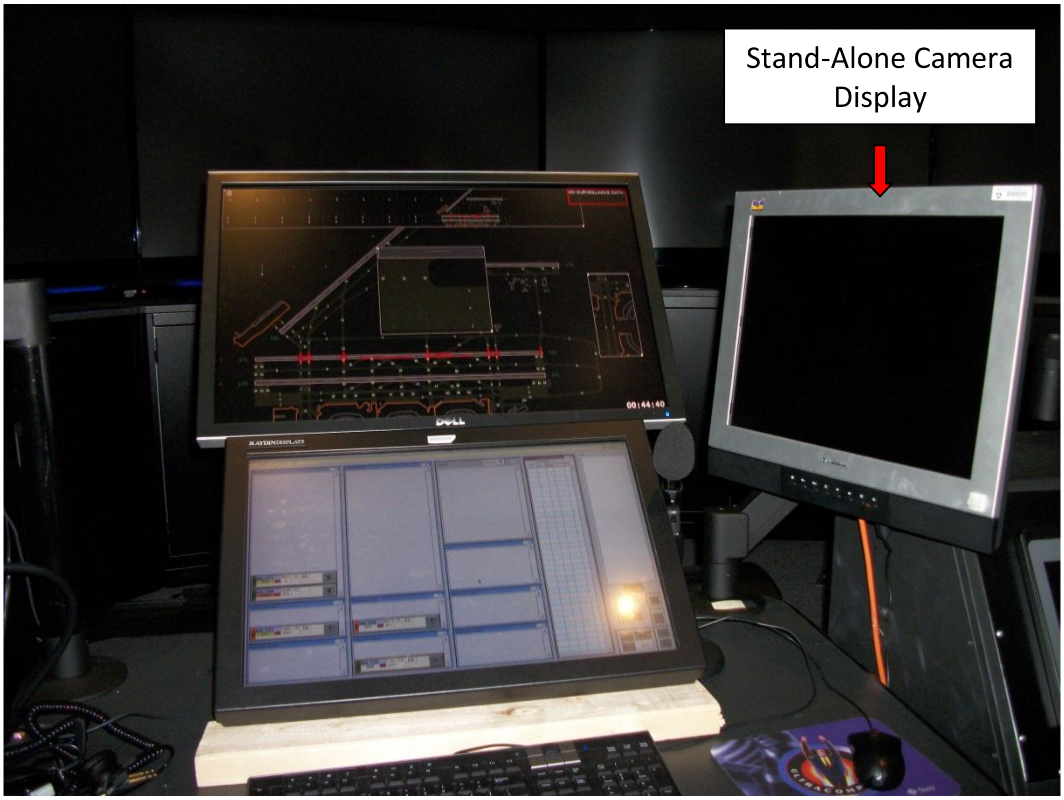
Appendix F: Camera Display Options

Potential Camera Display Options

CAMERA DISPLAY OPTION 1
Picture-in-Picture Display Capability

In Option 1, the controllers had the ability to manipulate a Camera View window and had control over the Camera Window location on the TIDS display. The controllers were able to select a target viewing area and move the Camera View, as needed, to view that target area.



CAMERA DISPLAY OPTION 2
Stand-Alone Display Capability

CAMERA DISPLAY OPTION 3
Picture-in-Picture Display Capability & Stand-Alone Display Capability

Note: The CAMERA DISPLAY OPTION 3 is a combination of CAMERA DISPLAY OPTION 1 and CAMERA DISPLAY OPTION 2.

Appendix G: Post-Run Questionnaire

Post-Run Questionnaire

Page One

1. Participant Number: *

2. Date: *

3. Run #

4. Scenario Number *

5. Please check all that apply for the three previous segments: *

	PIP Camera	Stand-alone Camera	PIP + Stand-alone Camera	Night Time
Segment 1 *	☐	☐	☐	☐
Segment 2 *	☐	☐	☐	☐
Segment 3 *	☐	☐	☐	☐

6. On a scale of 1 to 7, with 1 indicating Very Little and 7 indicating Very Much, please rate the degree to which the following displays or camera views helped you maintain awareness of aircraft identity: *

	1	2	3	4	5	6	7	N/A
Out-the-Window Display *	○	○	○	○	○	○	○	○
TIDS Display *	○	○	○	○	○	○	○	○
FDM Display *	○	○	○	○	○	○	○	○
PIP Camera View *	○	○	○	○	○	○	○	○
Stand-Alone Camera View *	○	○	○	○	○	○	○	○
PIP + Stand-Alone Camera View *	○	○	○	○	○	○	○	○

7. On a scale of 1 to 7, with 1 indicating Very Little and 7 indicating Very Much, please rate the degree to which the following displays or camera views helped you maintain awareness of traffic location: *

	1	2	3	4	5	6	7	N/A
Out-the-Window Display *	○	○	○	○	○	○	○	○
TIDS Display *	○	○	○	○	○	○	○	○
FDM Display *	○	○	○	○	○	○	○	○
PIP Camera View *	○	○	○	○	○	○	○	○
Stand-Alone Camera View *	○	○	○	○	○	○	○	○
PIP + Stand-Alone Camera View *	○	○	○	○	○	○	○	○

8. On a scale of 1 to 7, with 1 indicating Very Little and 7 indicating Very Much, please rate the degree to which the following displays or camera views helped you maintain efficient operations *

	1	2	3	4	5	6	7	N/A
Out-the-Window Display *	○	○	○	○	○	○	○	○
TIDS Display *	○	○	○	○	○	○	○	○
FDM Display *	○	○	○	○	○	○	○	○
PIP Camera View *	○	○	○	○	○	○	○	○
Stand-Alone Camera View *	○	○	○	○	○	○	○	○
PIP + Stand-Alone Camera View *	○	○	○	○	○	○	○	○

9. On a scale of 1 to 7, with 1 indicating Very Little and 7 indicating Very Much, please rate the degree to which the following displays or camera views helped you maintain safe operations: *

	1	2	3	4	5	6	7	N/A
Out-the-Window Display	○	○	○	○	○	○	○	○
TIDS Display	○	○	○	○	○	○	○	○
FDM Display	○	○	○	○	○	○	○	○
PIP Camera View	○	○	○	○	○	○	○	○
Stand-Alone Camera View	○	○	○	○	○	○	○	○
PIP + Stand-Alone Camera View	○	○	○	○	○	○	○	○

10. On a scale of 1 to 7, with 1 indicating Very Low and 7 indicating Very High, rate your awareness during the past scenario about potential runway incursions involving: *

	1	2	3	4	5	6	7	N/A
Arrivals on final	○	○	○	○	○	○	○	○
Aircraft on runways	○	○	○	○	○	○	○	○
Aircraft holding short on runways	○	○	○	○	○	○	○	○
Aircraft TIPH	○	○	○	○	○	○	○	○
Intersection departures	○	○	○	○	○	○	○	○
PIP + Stand-Alone Camera View	○	○	○	○	○	○	○	○

11. Did you notice any Computer-Human Interface (CHI) issues during this scenario? *

12. Do you have any additional comments or clarifications about your experience during this scenario? *

Appendix H: Post-Evaluation Questionnaire

Post-Evaluation Questionnaire

Page One

1. Participant Number *

2. 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 using the TIDS display: *

	1	2	3	4	5	6	7	N/A
Select a data block *	○	○	○	○	○	○	○	○
Deselect a data block *	○	○	○	○	○	○	○	○
Move a data block *	○	○	○	○	○	○	○	○
Maintain data block separation *	○	○	○	○	○	○	○	○
Detect aircraft location/position *	○	○	○	○	○	○	○	○
Determine aircraft type *	○	○	○	○	○	○	○	○
Determine aircraft weight class *	○	○	○	○	○	○	○	○
Determine aircraft airborne/ground status *	○	○	○	○	○	○	○	○
Find necessary flight information *	○	○	○	○	○	○	○	○
Maintain situational awareness *	○	○	○	○	○	○	○	○

3. On a scale of 1 to 7, with 1 indicating Very Inadequate and 7 indicating Very Adequate, please rate the adequacy of the following with regards to the TIDS display: *

	1	2	3	4	5	6	7	N/A
The size of the overall display *	○	○	○	○	○	○	○	○
The size of the icons/text/data blocks *	○	○	○	○	○	○	○	○
The picture-in-picture (PIP) capability *	○	○	○	○	○	○	○	○
The color schema of the icons and text *	○	○	○	○	○	○	○	○
The data block time sharing *	○	○	○	○	○	○	○	○
The data block presentation *	○	○	○	○	○	○	○	○

4. Please enter any additional comments regarding the TIDS display. Are there any features that you believe need to be added, modified, or removed? *

5. 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 using the FDM: *

	1	2	3	4	5	6	7	N/A
Select a flight strip *	○	○	○	○	○	○	○	○
Deselect a flight strip *	○	○	○	○	○	○	○	○
Undo an action/correct an error *	○	○	○	○	○	○	○	○
Determine aircraft location *	○	○	○	○	○	○	○	○
Transfer flight information *	○	○	○	○	○	○	○	○
Edit flight information *	○	○	○	○	○	○	○	○
Find flight information *	○	○	○	○	○	○	○	○
Manage flight strips *	○	○	○	○	○	○	○	○
Retrieve a flight strip *	○	○	○	○	○	○	○	○

6. On a scale of 1 to 7, with 1 indicating Very Inadequate and 7 indicating Very Adequate, please rate the adequacy of the following with regards to the FDM display: *

	1	2	3	4	5	6	7	N/A
The size of the display *	○	○	○	○	○	○	○	○
The readability/legibility of the text *	○	○	○	○	○	○	○	○
The strip bay configuration *	○	○	○	○	○	○	○	○
The information presentation *	○	○	○	○	○	○	○	○
The type of information presented *	○	○	○	○	○	○	○	○

7. Please enter any additional comments regarding the FDM display. Are there any features that you believe need to be added, modified, or removed, including any "memory aid" capabilities? *

8. 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 camera views (Stand-Alone and/or PIP) and their controls. *

	1	2	3	4	5	6	7	N/A
Create the PIP window on the TIDS display *	◯	◯	◯	◯	◯	◯	◯	◯
Resize the PIP window on the TIDS display *	◯	◯	◯	◯	◯	◯	◯	◯
Move the PIP window on the TIDS display *	◯	◯	◯	◯	◯	◯	◯	◯
Select a viewing area *	◯	◯	◯	◯	◯	◯	◯	◯
Resize a viewing area *	◯	◯	◯	◯	◯	◯	◯	◯
Select a target (i.e., aircraft or vehicle) *	◯	◯	◯	◯	◯	◯	◯	◯
Track a target *	◯	◯	◯	◯	◯	◯	◯	◯
Use the Zoom controls on the PIP view *	◯	◯	◯	◯	◯	◯	◯	◯
Use the Pan controls on the PIP view to *	◯	◯	◯	◯	◯	◯	◯	◯
Use the Tilt controls on the PIP view *	◯	◯	◯	◯	◯	◯	◯	◯
Use the Zoom controls on the Stand-Alone view *	◯	◯	◯	◯	◯	◯	◯	◯
Use the Pan controls on the Stand-Alone view to *	◯	◯	◯	◯	◯	◯	◯	◯
Use the Tilt controls on the Stand-Alone view *	◯	◯	◯	◯	◯	◯	◯	◯
Determine the location of an aircraft *	◯	◯	◯	◯	◯	◯	◯	◯
Determine the aircraft type/company *	◯	◯	◯	◯	◯	◯	◯	◯

9. On a scale of 1 to 7, with 1 indicating Very Inadequate and 7 indicating Very Adequate, please rate the adequacy of the following with regards to the Picture-in-Picture (PIP) view on the TIDS display and SNT operations: *

	1	2	3	4	5	6	7	N/A
The overall PIP presentation *	◯	◯	◯	◯	◯	◯	◯	◯
The overall functionality *	◯	◯	◯	◯	◯	◯	◯	◯
The PIP size *	◯	◯	◯	◯	◯	◯	◯	◯
The readability/legibility of the text *	◯	◯	◯	◯	◯	◯	◯	◯
The ease with which it allows you to locate a target *	◯	◯	◯	◯	◯	◯	◯	◯
The ease with which it allows you to determine the aircraft type/company *	◯	◯	◯	◯	◯	◯	◯	◯
The ease with which it allows you to track a target *	◯	◯	◯	◯	◯	◯	◯	◯
The overall automatic camera scanning functionality *	◯	◯	◯	◯	◯	◯	◯	◯
The ease with which it allows you to detect aircraft nonconformance *	◯	◯	◯	◯	◯	◯	◯	◯
Its ability to help you to maintain overall situational awareness *	◯	◯	◯	◯	◯	◯	◯	◯
The system responsiveness *	◯	◯	◯	◯	◯	◯	◯	◯
The system lag *	◯	◯	◯	◯	◯	◯	◯	◯

10. On a scale of 1 to 7, with 1 indicating Very Inadequate and 7 indicating Very Adequate, please rate the adequacy of the following with regards to the camera view on the Stand-Alone display and SNT operations: *

	1	2	3	4	5	6	7	N/A
The overall Stand-Alone presentation *	○	○	○	○	○	○	○	○
The overall functionality *	○	○	○	○	○	○	○	○
The size of the Stand-Alone display *	○	○	○	○	○	○	○	○
The readability/legibility of the text *	○	○	○	○	○	○	○	○
The ease with which it allows you to locate a target *	○	○	○	○	○	○	○	○
The ease with which it allows you to determine the aircraft type/company *	○	○	○	○	○	○	○	○
The ease with which it allows you to track a target *	○	○	○	○	○	○	○	○
The overall automatic camera scanning functionality *	○	○	○	○	○	○	○	○
The ease with which it allows you to detect aircraft nonconformance *	○	○	○	○	○	○	○	○
Its ability to help you to maintain overall situational awareness *	○	○	○	○	○	○	○	○
The system responsiveness *	○	○	○	○	○	○	○	○
The system lag *	○	○	○	○	○	○	○	○

11. On a scale of 1 to 7, with 1 indicating Completely Unnecessary and 7 indicating Completely Necessary, please rate the following with regards SNT operations: *

	1	2	3	4	5	6	7	N/A
The overall necessity of the picture-in-picture camera view on the TIDS *	○	○	○	○	○	○	○	○
The overall necessity of the camera view on the Stand-Alone display *	○	○	○	○	○	○	○	○

12. Please enter any additional comments regarding the camera views for either display. Are there any features that you believe need to be added, modified, or removed? *

Submit

0%