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Transportation Systems Analysis and Assessment (TSAA)

Small Aircraft Transportation System (SATS) Demonstration

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16. Abstract

The SATS project is being conducted through a public-private partnership including NASA, the FAA, and the National Consortium for Aviation Mobility (NCAM). This proof of concept research and technology development phase has been an ongoing effort for the past five years. Several components of the SATS technology and SATS capable aircraft already exist. The demonstration effort described here focused on en route integration, in an attempt to identify system implementation and integration issues associated with SATS operations. This demonstration provided the first look into the controller perspective concerning the enroute integration of the SATS concept.

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EXECUTIVE SUMMARY

The National Aeronautics and Space Administration (NASA), in partnership with the Federal Aviation Administration (FAA), state, and local aviation and airport authorities, is conducting research to explore technologies needed for a small aircraft transportation system (SATS). The present research focuses on the current work of NASA's Transportation Systems Analysis and Assessment (TSAA) group. This document describes the most recent in a series of collaborative efforts involving the FAA William J. Hughes Technical Center and the NASA Langley Research Center (LaRC).

The SATS project is being conducted through a public-private partnership including NASA, the FAA, and the National Consortium for Aviation Mobility (NCAM). This proof of concept research and technology development phase has been an ongoing effort for the past five years. Several components of the SATS technology and SATS capable aircraft already exist. The demonstration effort described here focused on en route integration, in an attempt to identify system implementation and integration issues associated with SATS operations. In order to study these issues from a system perspective, we focused on two sectors within the New York Air Route Traffic Control Center (ZNY ARTCC) and two sectors of airspace within the Philadelphia Terminal Radar Approach Control (PHL TRACON). These facilities were selected due to their high levels of both traffic volume and airspace complexity. In the PHL TRACON, two SATS airports were created, one for each sector. Our goal was to identify whether the implementation of SATS had any effect on the adjacent en route ARTCC feeder sectors.

This demonstration provided the first look into the controller perspective concerning the enroute integration of the SATS concept. We used the lessons learned from the HVO study (Magyarits, Racine, & Hadley, 2005) as a model for our development of the transition procedures, airspace and SCA, and the SATS specific phraseology to effectively identify the impact of SATS operations on adjacent enroute sectors.

Overall, SATS was viewed favorably by all participants. For ZNY ARTCC controllers, SATS operations were not a factor in their operations as simulated in this demonstration. PHL participants responded that their operations into the two SATS airports were much more efficient when SATS procedures were in place as opposed to the baseline scenarios experienced. In addition, PHL controllers felt that the SATS procedures and phraseology (as prescribed for this study) were easy to adopt.

The research team recommends that future SATS simulations should be conducted with generic airspace (TRACON and ARTCC). Generic airspace sectors consist of easily remembered fix names and simplified operating procedures to facilitate learning. Using generic airspace would enable researchers to select a cross-section of participants from a variety of air traffic facilities. The feedback obtained (e.g. airspace redesign, SATS procedures, phraseology, and SCA construction) from this type of participant pool could be generalized across the NAS, and lead to a more robust SATS concept. Site-specific implementation issues could then be addressed in following simulations as necessary

1. Introduction

The National Aeronautics and Space Administration (NASA), in partnership with the Federal Aviation Administration (FAA), state, and local aviation and airport authorities, is conducting research to explore technologies needed for a small aircraft transportation system (SATS). The present research focuses on the current work of NASA's Transportation Systems Analysis and Assessment (TSAA) group. This document describes the most recent in a series of collaborative efforts involving the FAA William J. Hughes Technical Center and the NASA Langley Research Center (LaRC).

1.1 SATS Concept Overview

The SATS objective is to enable simultaneous operations by multiple aircraft in airspace where non-radar procedures are applied in and around small non-towered airports in near all-weather (Johnson, 2002). Today, there are minimal Air Traffic Control (ATC) services at these non-towered airports. During Visual Flight Rules (VFR) operations, pilots that use these airports use the Common Traffic Advisory Frequency (CTAF) for announcing position and intentions. To ensure safe operations, current day Instrument Flight Rules (IFR) procedures limit arrivals and departures at these airports to one-in, one-out under instrument meteorological conditions (IMC).

As described in the SATS Higher Volume Operations (HVO) Operational Concept: Nominal Operations document (Abbott, Jones, Consiglio, Williams, and Adams, 2004), the general philosophy underlying the SATS concept is "the establishment of a newly defined area of flight operations called a Self Controlled Area (SCA). During periods of IMC, a block of airspace would be established around SATS designated non-towered, non-radar airports. Aircraft flying en route to a SATS airport would be on a standard IFR flight plan with ATC providing separation services. Within the SCA, pilots would take responsibility for separation assurance between their aircraft and other similarly equipped aircraft. Using onboard equipment and procedures, they would then approach and land at the airport. Departures would be handled in a similar fashion

A key component of the SATS concept is a ground-based automation system, called an Airport Management Module (AMM) that provides sequencing information to pilots within the SCA (Abbott et al, 2004). The AMM is physically located at the SCA equipped airport and makes sequencing assignments based on calculations considering aircraft performance, position information, winds, missed approach requirements, and a set of predetermined operating rules for the SCA.

From the flight deck side, the SATS concept requires that aircraft have accurate position data (e.g., GPS-equipped), display information (e.g., Multi-Function Display), conflict detection and alerting avionics software, and be capable of transmitting and receiving data (e.g., ADS-B, data link).

The SATS project is focused on providing a compelling proof of concept demonstration and data adequate for FAA consideration, leading to further research and development of relevant operating capabilities, ATC and flight deck procedures and phraseology, and eventual application in the National Airspace System (NAS). As such, the concept emphasizes integration with the current and planned NAS with a design approach that is simple from both a procedural and system requirements standpoint (Abbott et al, 2004).

1.2 TSAA Project Background

The SATS Project is being conducted through a public-private partnership including NASA, the FAA, and the National Consortium for Aviation Mobility (NCAM). This proof of concept research and technology development phase has been an ongoing effort for the past five years. Several components of the SATS technology and SATS capable aircraft already exist. Within this five year period, SATS operational capability has been demonstrated in the following operating areas:

1. Higher volume operations (HVO) in non-radar airspace at non-towered airports.
2. Lower landing minimums at minimally equipped landing facilities.
3. Increased single-pilot crew safety mission reliability.
4. En Route Integration (ERI) of SATS in the NAS.

The demonstration effort described in this document focused on the fourth operating area, En Route Integration, in an attempt to identify system implementation and integration issues associated with SATS operations. In order to study these issues from a system perspective, we focused on two sectors within the New York Air Route Traffic Control Center (ARTCC) and two sectors of airspace within the Philadelphia Terminal Radar Approach Control (PHL TRACON). These facilities were selected due to their high levels of both traffic volume and airspace complexity. In the PHL TRACON, two SATS airports were created, one for each sector. Our goal was to identify whether the implementation of SATS had any effect on the adjacent en route ARTCC feeder sectors.

1.3 Simulation Objectives

The principle objective of this demonstration was to explore the impact of SATS operations on the surrounding National Airspace System (NAS). In order to accomplish this objective, we created SATS and Non-SATS scenarios with two different traffic loads. Current Certified Professional Controllers (CPCs) served as participants for this simulation. We examined differences in their ratings of subjective workload and their responses to post-scenario questionnaire items as a function of scenario type (SATS/Non-SATS) and traffic volume (90%/100%)[1]. In addition, we solicited feedback from participants regarding SATS procedures, phraseology and other potential issues concerning SATS implementation.

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[1] We asked our SMEs to give us their expert opinion on what traffic levels would provide us with moderate and high task load levels. The number of aircraft in a sector is but one of the variables that determine the task load. Others prefer to use sector complexity rather than task load (Mogford, Murphy, Roske-Hostrand, Yastrop, & Guttman, 1994). A measure of sector complexity considers not only volume of traffic, but also fleet mix, sector geometry, and other factors. In this demonstration, the number of aircraft combined with the number of crossing altitude profiles and the number of intersecting routes determined the classification of 90% or 100%.

2. Method

2.1 Participants

2.1.1 Certified Professional Controllers

Four full performance level (FPL) CPCs from ZNY ARTCC and two FPL CPCs from PHL TRACON participated in a three day demonstration focusing on the en route integration of SATS within the constraints of the current NAS. The ZNY participants worked the radar and data positions for sectors 26 and 92. The two PHL participants manned the North Arrival and Pottstown sectors.

Controller participation in this demonstration was strictly voluntary, and the standard protocols for preserving anonymity were observed. Strict adherence to all federal, union, and ethical guidelines was maintained throughout the demonstration. Appendix A contains the informed consent form which described the nature of the demonstration and the participant responsibilities.

2.1.2 Research Team

The research team consisted of one Research Psychologist from the Simulation and Analysis Group (ATO-P), one Operations Specialist from the Target Generation Facility Simulation Group (ATO-P), and two CPC Subject Matter Experts (SMEs), (1 from PHL TRACON, 1 from ZNY ARTCC). The field SMEs ensured that the traffic samples were realistic and accurately represented current operations within their respective facilities. In addition, the SMEs provided input on SATS procedures and phraseology which were incorporated into the demonstration. Support engineers from ATO-P ensured that the simulation labs functioned appropriately.

2.1.3 Simulation Pilots

Twenty-nine trained simulation pilots participated in this demonstration, one per workstation. Ten of these pilots were assigned to aircraft bound for the two SATs airports. Fifteen worked the other aircraft within the managed sectors, and the remaining 4 were responsible for other aircraft within the ghost sector (all areas outside of the controlled sectors). The pilots controlled generated aircraft targets via simulation pilot workstations, emulated pilot communications, and manipulated aircraft targets in response to ATC instructions through simple keyboard entries. Simulation pilots were not participants for evaluation.

2.2 Test Facility and Equipment

2.2.1 Target Generation Facility

The Target Generation Facility (TGF) provided the ATC environment for this demonstration which included the simulated radar sensors, airspace configuration, aircraft targets and associated aircraft performance characteristics. The digital radar messages for targets were adapted to mimic actual NAS characteristics by including the radar and environmental characteristics of the emulated airspace. Simulated primary and beacon radar data was then generated for each target. Flight datablocks contained flight identification, beacon code, and altitude information. Target positions were automatically updated at the same rate experienced in the respective facilities (TRACON, ARTCC).

2.2.2 Display System Facility 1

The WJHTC Display System Facility 1 (DSF1) included systems such as the Display System Replacement (DSR) controller workstations and the G3 Host mainframe with associated peripheral devices. Two sector positions, each with Radar and Data stations, were configured to emulate the current operating characteristics of the ZNY sectors simulated. Each included a thermal flight strip printer, strip bays, Voice Switching Control System (VSCS) equipment, maps, and the sector charts associated with the emulated airspace. A ghost controller occupied an additional controller position to mimic the interactions of adjacent sectors.

2.2.3 Standard Terminal Automation Replacement System (STARS) Facility

The WJHTC STARS laboratory included two STARS controller workstations and communications equipment typical of the current operational configuration of the PHL TRACON for the PHL North Arrival and Pottstown sectors. Controllers had the ability to coordinate traffic with ZNY participants via ground-to-ground communications, similar to their current capabilities at their respective facilities (See Figure 1).

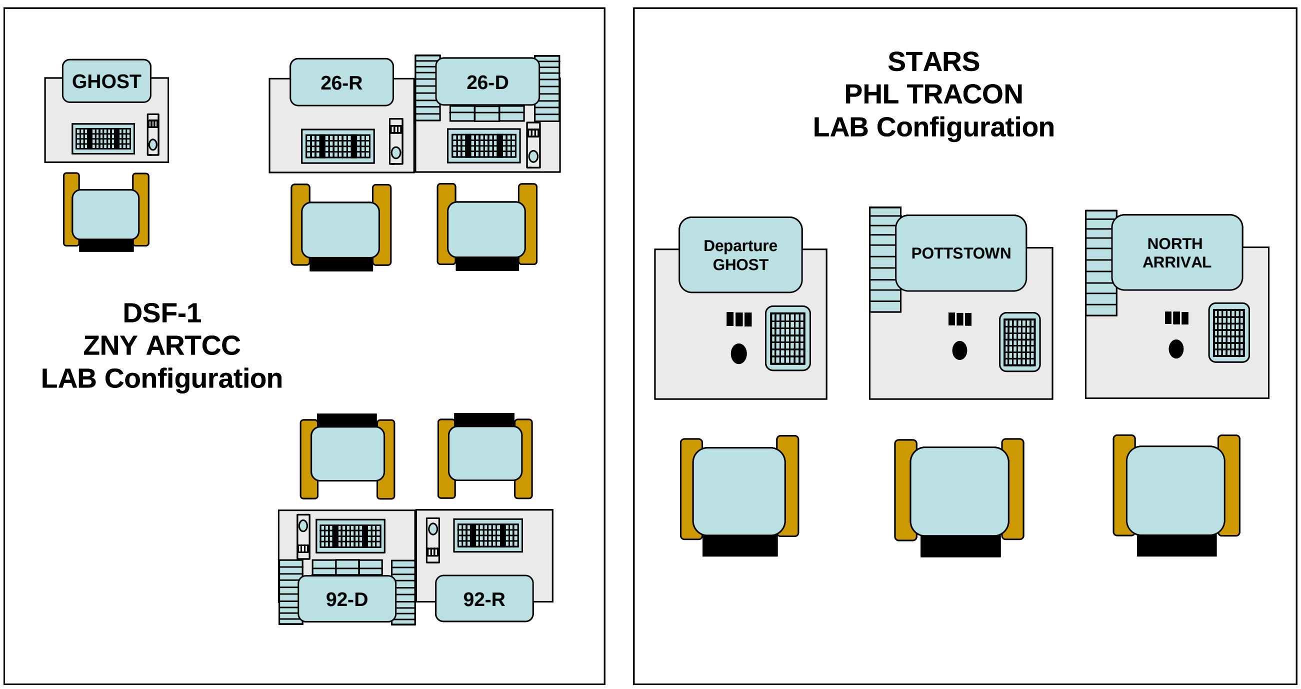

Figure 1. Laboratory configurations for ZNY and PHL.

2.3 Airspace

2.3.1 En Route Environment

The two sectors selected for ZNY ARTCC were sector 26 and sector 92. Sector 26 is a low altitude sector with no predominant traffic flow. Controllers working in this sector descend Philadelphia bound aircraft and also feed the North Arrival sector aircraft destined for Chester County Airport (40N). Sector 92 handles Philadelphia departures and Baltimore Metro traffic northbound from sector 26. In addition, some southbound arrivals into the Pottstown Airport (PTW) were fed to the PHL Pottstown sector.

2.3.2 Terminal Environment

The Chester County (40N) and Pottstown (PTW) airports were selected as SATS airports for this demonstration. Chester County Airport was contained within the North Arrival sector, and PTW was located within the Pottstown sector (see Figure 2). During the non-SATS runs, the current GPS approaches at those airports were used.

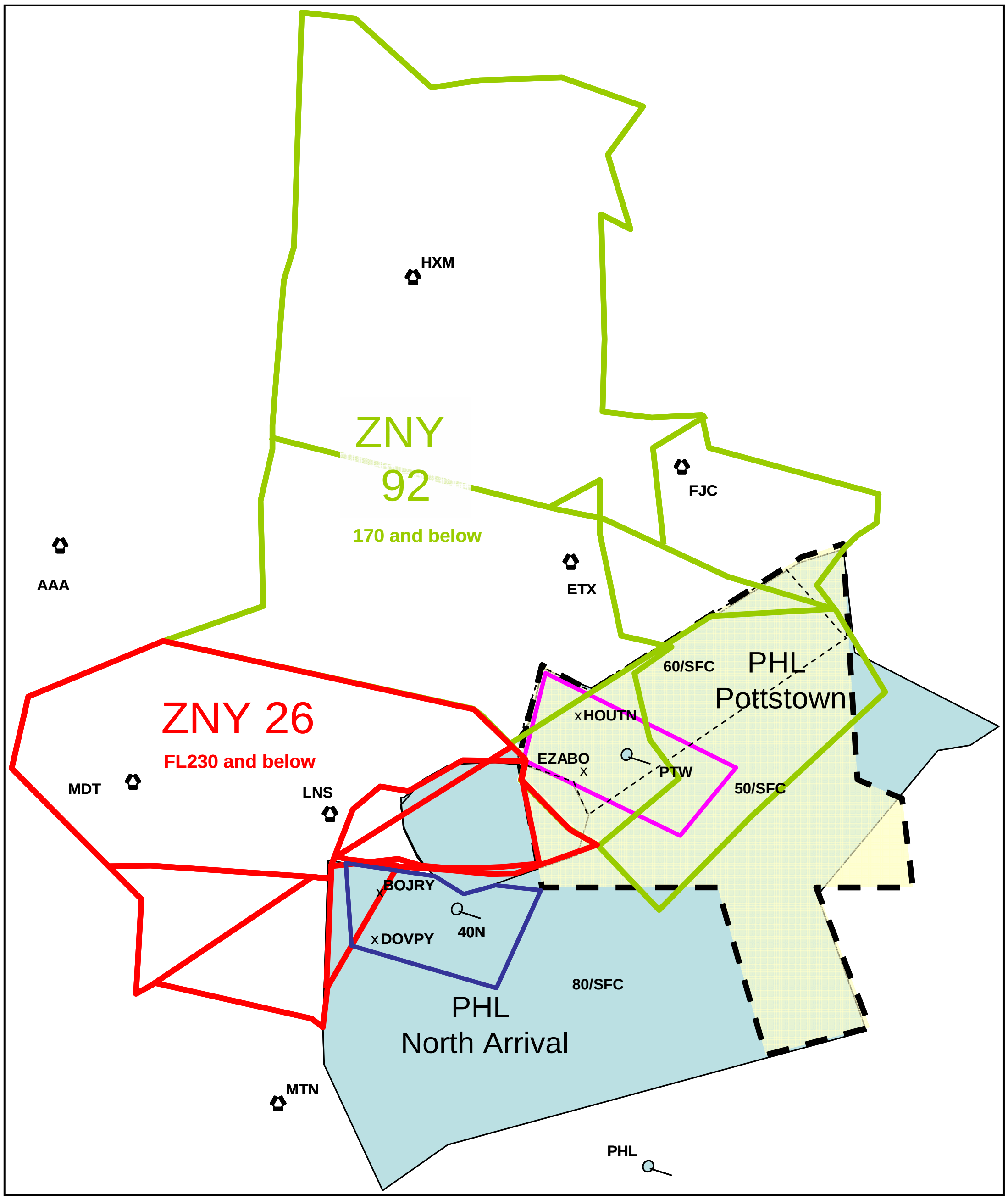

Figure 2. ZNY ARTCC and PHL TRACON simulated airspace.

2.4 Traffic Scenarios

The simulation consisted of six 50 minute scenarios. The scenarios varied on two dimensions: traffic level (90% or 100%) and airspace environment (SATS or Non-SATS, or Mixed). Planned arrivals and departures remained constant within each airspace environment in both traffic levels. When SATS operations were not in effect, the scenarios were considered baseline cases, representative of current day instrument meteorological conditions (IMC) operations at non-towered airports (i.e., one-in-one-out operation). Baseline arrivals and departures were ATC managed, whereas in SATS scenarios, SATS arrivals and departures were flight crew (in this case, simulation pilot) managed. Our SME research team members developed a set of procedures to handle the mixed equipage scenarios. They felt that for safety considerations that the non-equipped aircraft would hold above the SCA until the SATS equipped aircraft had landed. After the last SATS equipped aircrafts' IFR had been cancelled, the controller would then assume traditional operations and permit the non-equipped to descend. Table 1 depicts the six traffic scenarios.

Weather conditions were IMC for all scenarios, requiring IFR operations to the airports. Only normal traffic and SATS traffic was emulated; no off-nominal situations were included in this demonstration.

Table 1. Scenario descriptions and aircraft counts

Scenarios	**90%** Over Flights	**100%** Over Flights	**40N Arrivals / Departures**	**PTW Arrivals / Departures**	**90% TOTAL A/C***	**100% TOTAL A/C***
Baseline	139	146	+ 7 Arrivals / 5 Departures	+ 9 Arrivals / 5 Departures	**165**	**172**
SATS	139	146	+ 7 Arrivals / 5 Departures	+ 9 Arrivals / 5 Departures	**165**	**172**
Mixed	139	146	+ 7Arrivals** /5 Departures; **(**2 were non-SATS)**	+9Arrivals** /5 Departures **(**2 were non-SATS)**	**165**	**172**

*number of aircraft distributed among the 4 sectors simulated during the 50 minute scenarios

2.5 Procedure

Sections 2.5.1 through 2.5.4 describe the daily schedule of events, participant training and familiarization, controller procedures, and simulation pilot training and procedures for the demonstration.

2.5.1 Daily Schedule of Events

The demonstration spanned three full days consisting of training, simulation, and debriefing. Table 2 delineates the schedule of events.

Table 2. Daily Schedule of Events

	Day One		**Day Two**		**Day Three**
Time	**Event**	**Time**	**Event**	**Time**	**Event**
Hour 1	Introduction	Hour 1	Test Scenario 2 (100% Baseline) Post scenario questionnaire	Hour 1	Test Scenario 5 (100% Mixed) Post scenario questionnaire
Hour 2	Airspace Briefing	Hour 2		Hour 2	
Hour 3	Break	Hour 3	Test Scenario 3 (90% Mixed) Post scenario questionnaire	Hour 3	Break
Hour 4	Familiarization /training	Hour 4		Hour 4	Test Scenario 6 (90% Baseline) Post scenario questionnaire
Hour 5	Break	Hour 5	Break	Hour 5	
Hour 6	Test Scenario 1 (90% SATS) Post scenario questionnaire	Hour 6	Test Scenario 4 (100% SATS) Post scenario questionnaire	Hour 6	Post Simulation Debriefing
Hour 7		Hour 7		Hour 7	Buffer

2.5.2 Participant Training

The CPC's received briefings on the objectives of the simulation prior to participation which highlighted the SATS concept, the impact on current procedures and phraseology, and the roles and responsibilities associated with their participation. They received hands-on familiarization training by performing a practice scenario in their respective positions with SATS operations in effect.

2.5.3 Controller Procedures

Sections 2.5.3.1 through 2.5.3.3 highlight the SATS related controller procedures that were implemented in the demonstration. These pertained to the TRACON participants however all participants were briefed on the new procedures.

2.5.3.1 Responsibility

Outside SCA. The CPC was responsible for all aircraft outside the SCA, whether they were SATS-equipped or not. CPC's were instructed to apply normal current day ATC procedures. Inside the SCA, pilots were responsible for their own separation. If SCA capacity was reached, pilots received a "standby" message from the AMM upon requesting an arrival fix. The CPC was either informed by the pilot of a "standby" or the CPC queried the pilot of his/her SCA entry status. Participants were instructed to practice normal holding procedures (above the SCA) when this type of action became necessary.

Transitioning into SCA-SATS Arrivals. As SATS-equipped aircraft approached the SCA with intent to enter, pilots were required to inform controllers when they received sequence information from the AMM to enter the SCA prior to crossing into the SCA. For vertical entries, the pilot informed the CPC that he/she had clearance to enter the SCA, the controller was instructed to issue a "descend at pilots discretion" clearance, issue a "change to the common traffic advisory frequency (CTAF)," and finally, terminated radar service. For lateral entries, the procedures were similar, with the exception of the descend clearance. The CTAF instruction and termination of radar services was given once the aircraft penetrated the SCA.

Transitioning out of SCA - SATS Departures. Pilots of SATS-equipped aircraft intending to depart a non-controlled airport during SATS operations had to request a release from the CPC to depart. Once the CPC acknowledged and granted the departure release, he/she expected the aircraft to exit the SCA into his/her controlled airspace sometime thereafter. Other than issuing the release, the CPC had no responsibility to the aircraft while it was inside the SCA.

2.5.3.2 Phraseology

The implementation of an SCA or SCA's in the case of the current demonstration, into the current airspace system represents a fundamental change in the roles and responsibilities of pilots and controllers. In order to address aspects of the SATS concept that do not exist in today's environment, new procedures and phraseology were developed for this effort (see Appendix B for sample phraseology). These phraseology and procedure changes were drafted specifically for our demonstration, and are not to be considered as a finished product.

2.5.3.3 SCA Airports

Chester County Airport (40N) This airport is located within the lateral confines of PHL airspace, specifically, underlying the North Arrival sector, which owns the surface to 8,000 ft Mean Sea Level (MSL) over most of the sector. The North Arrival sector configuration was applied for this demonstration. Sector airspace video maps currently used for the North Arrival sector were displayed on the controller consoles. Additional information on the maps included airport runway, GPS approach, departure fixes, and the SCA boundary. Rather than use a generic representation of an SCA (Magyarits, Racine, & Hadley, 2005), the research team developed a site specific SCA that was tailored to minimize the impact on current operations within the PHL TRACON. The SCA was displayed during the SATS and Mixed equipage scenarios only. SATS arrivals flew to the Initial Approach Fix (IAF) DOVPY, contained within the SCA on the GPS runway 11 approach. Aircraft entering vertically (i.e., above the SCA) entered the SCA at 4,000 ft. Within the SCA, the DOVPY IAF accommodated aircraft holding at 3,000 ft and 4,000 ft. Aircraft that were held at DOVPY above 4,000 ft remained under positive control. Figure 3 contains a graphical depiction of the Chester County Airport/SCA in North Arrival sector airspace as simulated.

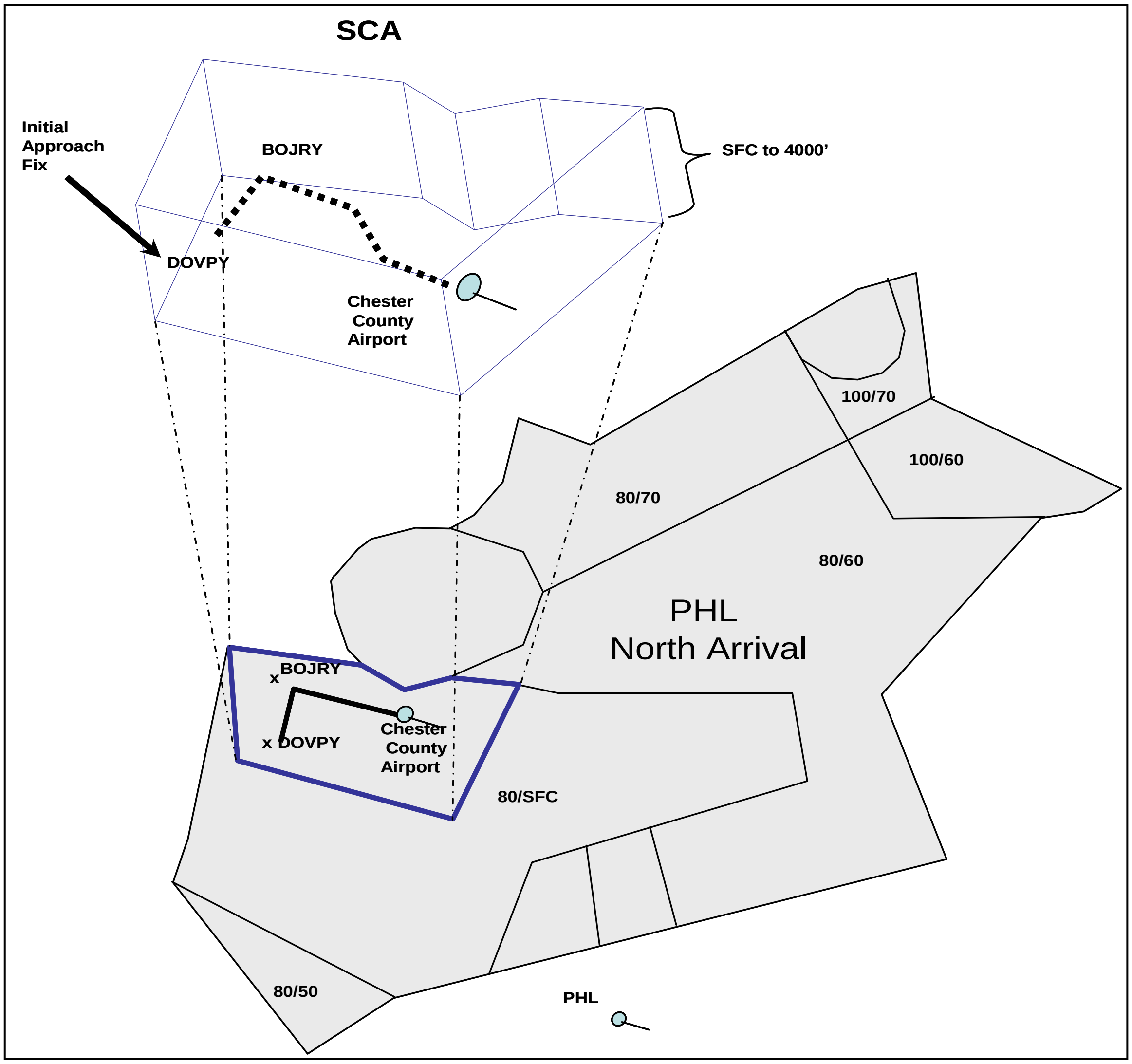

Figure 3. Chester County Airport/SCA in PHL North Arrival airspace.

Pottstown/Limerick Airport (PTW) This airport is also located within the lateral confines of PHL airspace, specifically underlying the Pottstown sector which owns from the surface to 5000 ft and 6000 ft in some areas. Portions of the Pottstown sector are situated beneath North Arrival airspace. Sector airspace video maps currently used for the Pottstown sector were displayed on the controller consoles. Additional information on the maps included airport runway, GPS approach, departure fixes, and the SCA boundary. A site specific SCA was tailored to minimize the impact on current operations within the PHL TRACON. The SCA was displayed during the SATS and Mixed equipage scenarios only. SATS arrivals flew to the Initial Approach Fix (IAF) HOUTN, contained within the SCA on the GPS runway 10 approach. Aircraft entering vertically (i.e., above the SCA) entered the SCA at 4,000 ft. Within the SCA, the HOUTN IAF accommodated aircraft holding at 3,000 ft and 4,000 ft. Aircraft that were held at HOUTN above 4,000 ft remained under positive control. Figure 4 contains a graphical depiction of the Pottstown/Limerick Airport/SCA in the Pottstown sector airspace as simulated.

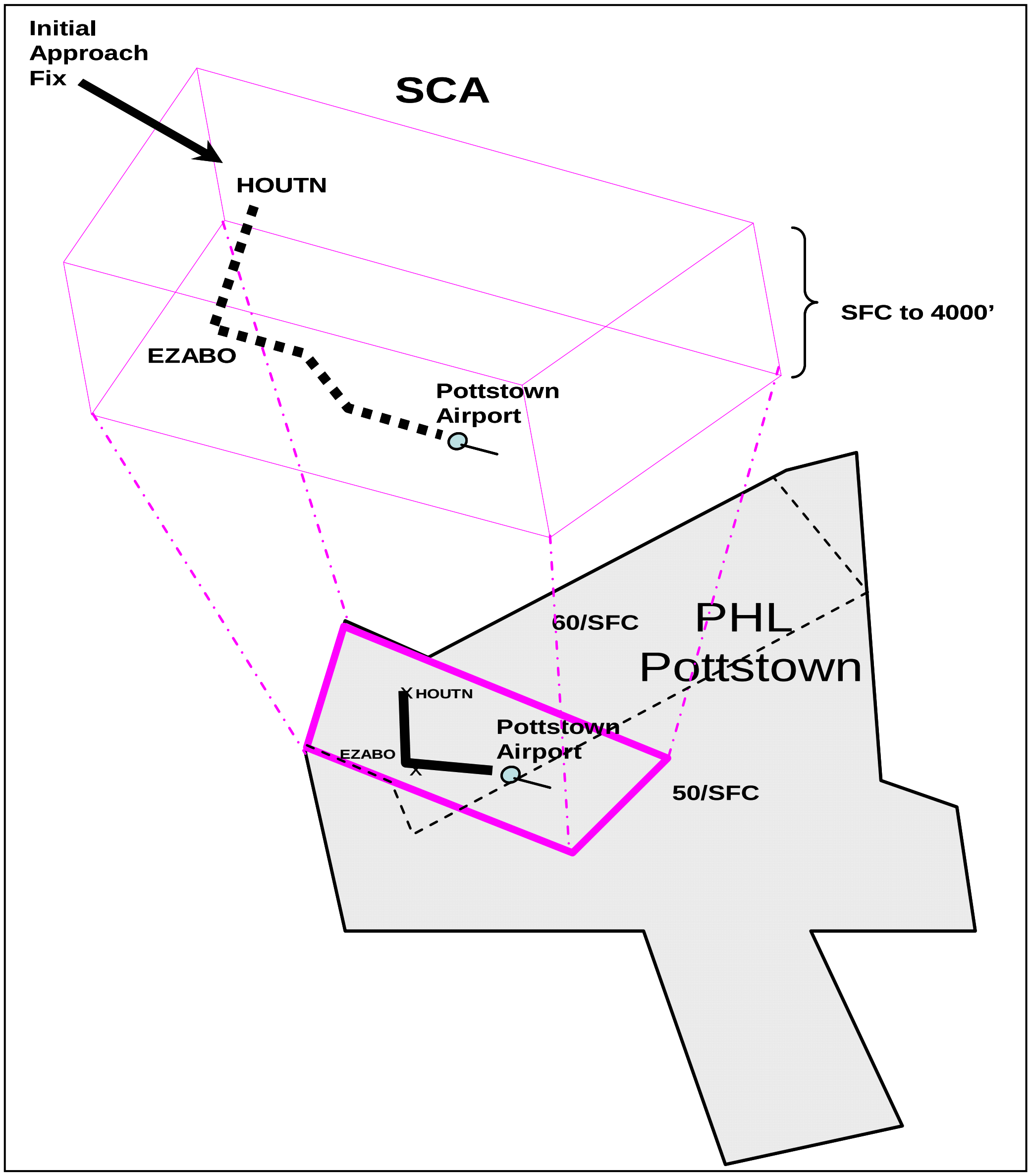

Figure 4. Pottstown Airport/SCA in PHL Pottstown airspace.

2.5.4 Simulation Pilot Training

Twenty-nine simulation pilots were trained on SATS procedures for this demonstration. Their training consisted of managing aircraft and responding to ATC instructions in SATS traffic scenarios for several weeks prior to the formal runs. Each simulation pilot operated one workstation and was responsible for a maximum of 7 aircraft at any given time during the scenarios. A ghost sector position handled inbound and outbound aircraft from the four sectors simulated. There were 10 pilots assigned to aircraft destined for or originating from the two SATS airports.

2.5.4.1 Simulation Pilot Procedures

The TGF system designates the SCA as a "sector" for logistical purposes. At a predetermined distance from the SCA, all SATS aircraft initiated an automated command to the AMM requesting entrance into the SCA. The pilot then received a prompt modeling the AMM's reply. The AMM message contained information necessary for the pilot to begin approach into the SCA, and where to go in the event of a missed approach. The pilot was instructed to immediately report this reply (whether entry approved or standby) to the controller.

If the AMM approved vertical entry, the pilot informed the controller that he/she had approval for the SCA. The controller then issued a descent at pilot's discretion, change to CTAF instruction, and then termination of radar services. Aircraft granted lateral entries by the AMM could enter through the side of the SCA by requesting descent, flying to the IAF, and then beginning the approach. The controller terminated radar services and issued the CTAF instruction once the aircraft penetrated the side of the SCA (via the SCA display on the sector video map). Aircraft not granted entries by the AMM were instructed to go to the IAF and hold (above the SCA, 5000' and above) at the altitude directed by the controller, until aircraft already within the SCA descended and initiated their approach. Once space was available within the SCA, the AMM granted a vertical entry and the pilot was instructed to follow his/her sequence to the airport while maintaining separation.

If the AMM issued a "stand-by" reply, the pilot informed the controller and followed the controller's holding instructions. Upon receipt of approval to enter the SCA, the pilot informed the controller, and conducted operations accordingly

Departures were conducted as in today's environment. The pilot called for clearance delivery on the appropriate sector frequency and requested a release. When given clearance, the pilot was free to take-off when the runway was available. The pilot reported "rolling" and informed the controller that he or she was exiting the SCA.

2.6 Simulation Assumptions and Limitations

Previous SATS research using FPL CPC's here at the Technical Center was limited to TRACON specific and ARTCC specific issues. This demonstration was an initial examination of a system implementation (aircraft traveling through ARTCC airspace descending into SATS airports within TRACON airspace) for the SATS initiative through the use of ATC human-in-the-loop simulation. Our goal was to solicit feedback from CPC participants on the SATS concept, and identify any potential "downstream" impacts on the adjacent ARTCC relative to a SATS implementation in the neighboring TRACON.

We developed our initial traffic samples with NASA's Demand Model, and the Future Demand Generator to simulate the predicted growth in traffic volume for the years 2010 and 2022. Unfortunately, our subject matter experts from PHL and ZNY both agreed that the volume of this future traffic would dictate significant airspace changes and therefore would be unrealistic to simulate within current airspace configurations. The air/ground communications alone would be severely limited by the frequency congestion created by attempting to communicate with such an extensive number of aircraft. Instead of using current versus future traffic samples, we compromised and developed 90% volume and 100% volume traffic samples to address/identify proposed system implementation issues. It was our assumption that with both 100% and 90% traffic samples and SATS operations would see reduce the TRACON controllers' workload relative to that same traffic volume under baseline (or current day) operations, respectively. Furthermore, it was anticipated that under baseline conditions, the TRACON participants may have had to issue holding instructions to aircraft destined for the SATS airports due to the current "one-in-one-out" procedures at non-towered airports in IMC conditions. In those instances it was expected that workload may increase for the adjacent ARTCC as holding tends to have a cumulative impact on traffic flows. Outside of the normal holding procedures above the two airports, TRACON participants did not feel the need to "shut the door" on the ARTCC. Philadelphia bound traffic in the same arrival stream as those destined for the Chester County or Pottstown airports were not impacted as there were several altitudes available for TRACON participants to route traffic into PHL.

In addition, the mixed equipage scenarios required a flight plan cancellation capability of the AMM that does not currently exist. The procedures developed for the mixed equipage scenarios essentially gave arrival priority to SATS equipped aircraft. In other words, in the event of two aircraft (1 SATS, the other Non-SATS) converging on the SCA, the Non-SATS would hold above the SCA until the SATS aircraft had landed. Currently, there is no mechanism that would notify the controller that the SATS aircraft was safely on the ground and off the runway in order to safely initiate descent of the Non-SATS aircraft. We simulated an AMM cancellation of the SATS flight plan to address this issue.

Finally, the reader should take into account that this demonstration represents the subjective feedback gathered from only one group of participants. Future research, building on the controller feedback solicited in this study, with a larger participant pool is necessary to provide data on the feasibility of SATS en route integration beyond the scope of these assumptions and limitations.

3. Results

Data collection consisted of various questionnaires designed to provide information on controller background experience, as well as a range of subjective data relative to the SATS concept. Since the main focus of this demonstration was on controller feedback, a great deal of questionnaire ratings and open-ended responses were collected and summarized.

3.1 Background Experience

CPC participants completed Background Questionnaires (see Appendix C) at the beginning of the simulation to provide the researchers with demographic information and depth of experience. Summary background experience is shown in Table 3.

Table 3. CPC Background Experience

Facility	Mean Age (yrs)	Total ATC Experience	Experience in Terminal or En Route Environment (yrs)	Experience at Current Facility
PHL TRACON	47.5	20.4	11	11.5
ZNY ARTCC	38	12.6	12.6	12

3.2 Subjective Feedback

Research personnel collected subjective data from participants using online workload assessment techniques, questionnaires, and debriefing sessions. Table 4 summarizes the data collection method objectives and their frequency of use. The data collected included workload, situation awareness assessments, and written and verbal responses pertaining to the SATS concept and issues associated with its implementation.

Table 4. Subjective Data Collection Methods

Method	Frequency	Objective	Additional Information
Workload Assessment Keypad	Five-minute intervals	Gather data on controller perceived workload over the course of each traffic scenario	Section 3.2.1
Post-Scenario Questionnaire	Every run	Collect assessment of workload situation awareness ,procedures/phraseology, and scenario difficulty	Appendix D
Post-Simulation Questionnaire	Once	Collect ratings and open-ended data on simulation-specific issues, including, • SATS concept • Procedures/phraseology • Workload • Simulation realism	Appendix E
Post-Simulation Debriefing	Once	Allow for open discussion of additional issues of interest to participants	Verbal discussion

3.2.1 Workload

On Post-Simulation Questionnaires, controllers provided ratings of the overall effects of SATS on workload as compared to today's conventional non-radar procedures. Table 5 shows the results by facility (PHL and ZNY). The consensus among participants was that SATS had no impact at all on workload.

Table 5. Post-Simulation Workload Ratings

	PHL TRACON		**ZNY ARTCC**			
Workload	CPC-1	CPC-2	CPC-1	CPC-2	CPC-3	CPC-4
Effect of SATS on workload compared to current day operations ① ② ③ ④ ⑤ ⑥ ⑦ Decreased Greatly ... Increased Greatly	**4**	**6**	**4**	**4**	**4**	**4**
Effect mixed equipage on workload compared to current day operations ① ② ③ ④ ⑤ ⑥ ⑦ Decreased Greatly ... Increased Greatly	**4**	**4**	**4**	**4**	**4**	**4**

Participants also provided workload assessments during test scenarios and following their participation in the simulation in the form of open-ended written and verbal feedback. During the traffic scenarios, CPCs provided real-time ratings of workload using electronic keypads [I.e., Workload Assessment Keypads (WAKs)]. The keypads contained number scales from 1 to 7 that illuminated and sounded a brief tone at 5-minute intervals, prompting the participants to select a rating that corresponded to their workload level at that moment in time. A rating of 1 corresponded to the lowest workload rating and 7 corresponded to the highest workload rating. If the participant did not enter a rating within 20 seconds of the prompt, the keypad lights extinguished and the highest rating was automatically entered. Sections 3.2.1.1 and 3.2.1.2 present more details of the during-the-run workload assessments by respective ATC facility.

3.2.1.1 PHL TRACON

During the Run Workload. The sector assignment for the TRACON appeared to have an influence on subjective ratings of workload. For the North Arrival sector, workload ratings stayed constant regardless of scenario type. In the Pottstown sector, the lowest ratings of workload were given during the SATS scenarios. In addition, the mixed equipage scenarios elicited the highest ratings of workload (see Figure 5).

Overall Workload.

Participants commented that, of the two sectors, the North Arrival Sector was significantly busier because of the large numbers of Philadelphia bound arrival traffic. However, with SATS the workload was about the same between the 90% and 100% scenarios, it was their efficiency that improved (as they were able to run higher traffic levels into the smaller airports).

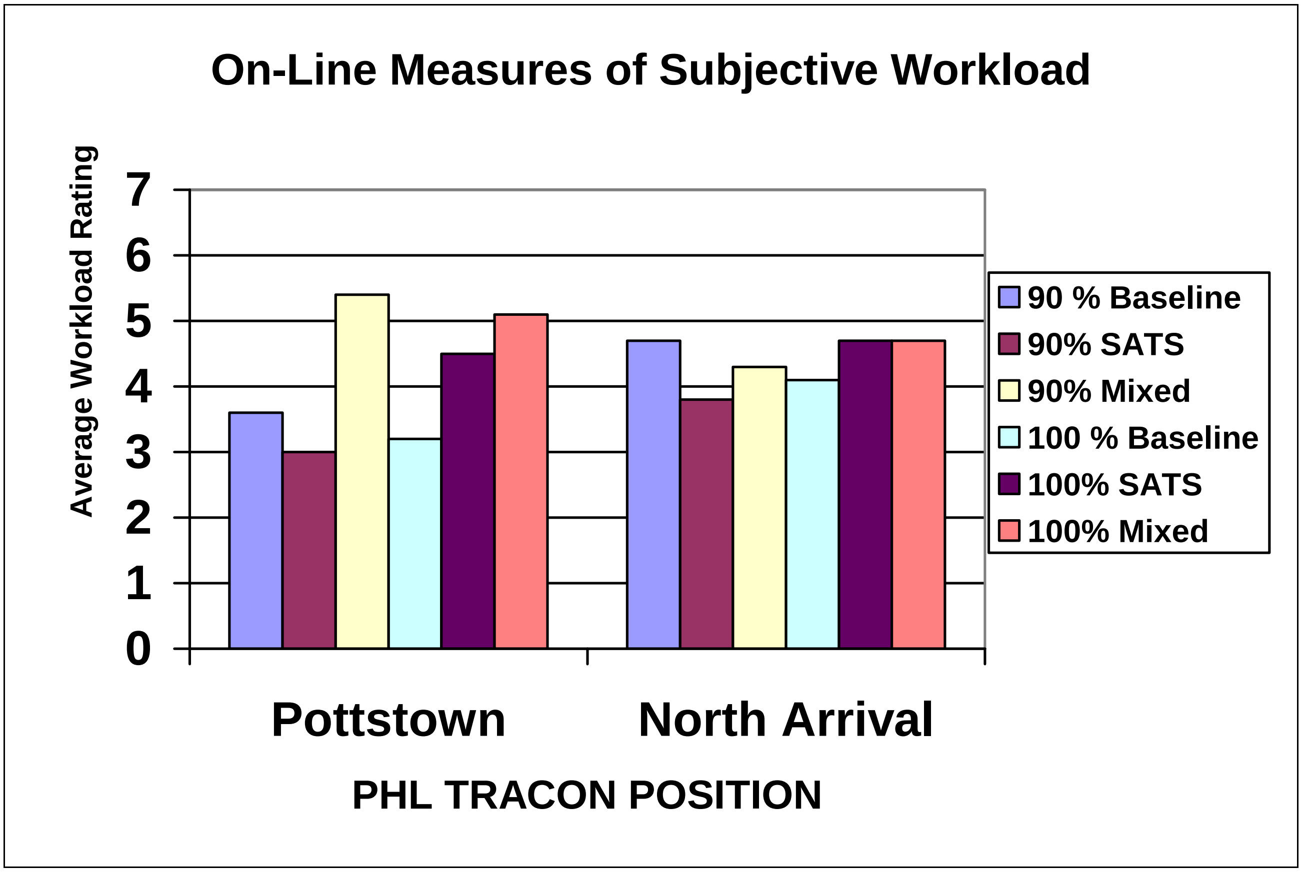

Figure 5. Mean workload ratings for the TRACON participants

3.2.1.2 ZNY ARTCC

During the Run Workload. Workload ratings across both sectors of the ZNY airspace simulated did not vary considerably. Sector 92 participants reported low workload across all scenarios. Sector 26 participants did have some mild differences among scenarios. The lowest ratings, however, were under SATS conditions (see Figure 6).

Overall Workload. Participants working sector 92 airspace commented that while there was more traffic than they were used to seeing, there was little complexity regardless of scenario type. Sector 26 was "considerably busier," and this preliminary data hints that the mixed equipage scenarios impacted the radar and data-side workload ratings.

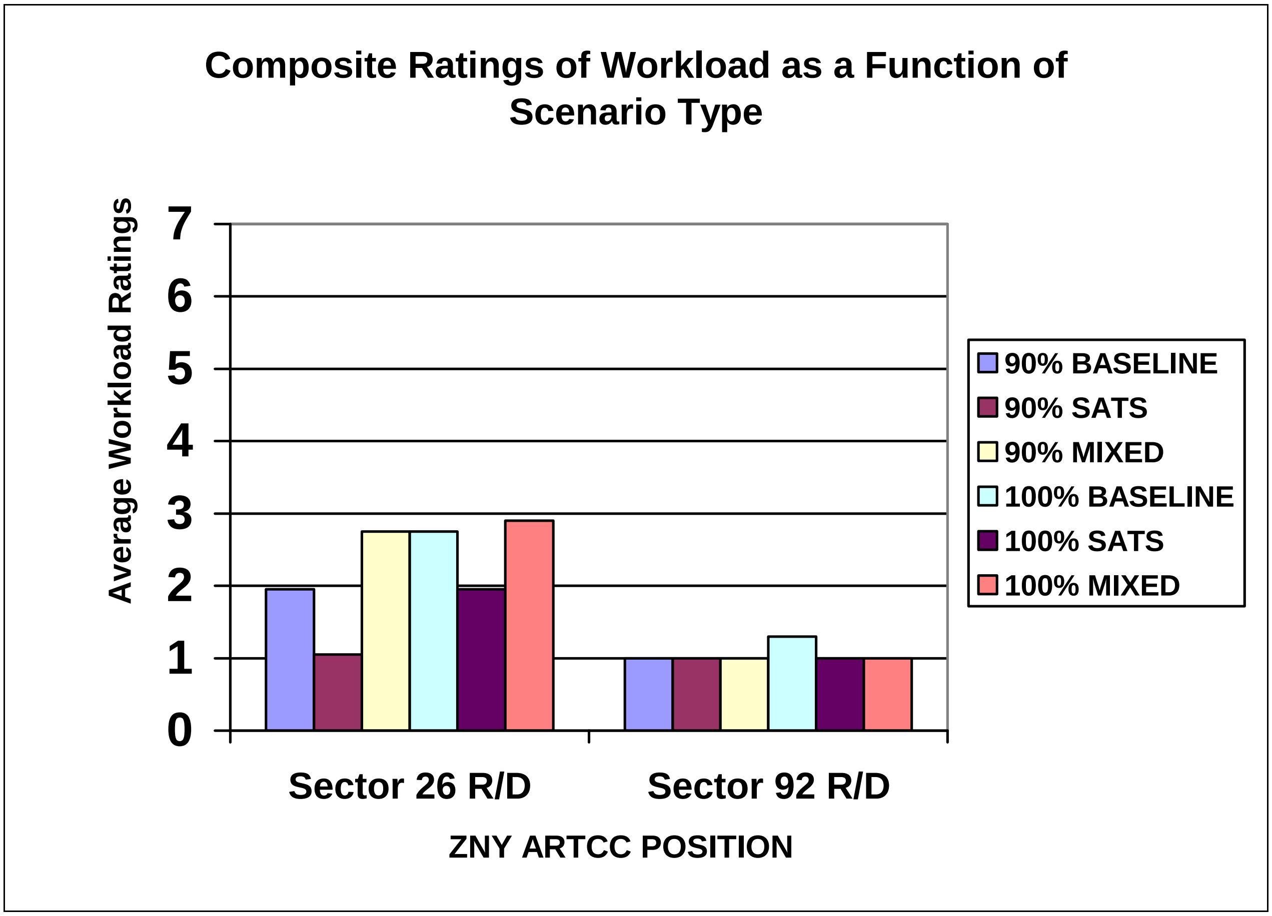

Figure 6. Mean workload ratings for the ZNY participants (workload ratings for R/D within each sector were averaged)

3.2.2 Concept Feasibility

The researchers asked the controllers to provide feedback on the feasibility of integrating SATS in the en route environment from several different perspectives. Controllers provided ratings and comments on the overall feasibility of implementing SATS, the SCA size, the impact of mixed equipage, and the impact of SATS on the ability to control traffic. Table 6 shows individual ratings

Table 6. Individual Ratings on the Feasibility of the SATS Concept

	PHL TRACON		ZNY ARTCC			
Concept Feasibility	CPC-1	CPC-2	CPC-1	CPC-2	CPC-3	CPC-4
Feasibility of implementing SATS in other airspace within the NAS **Not Feasible ① ② ③ ④ ⑤ ⑥ ⑦ Very Feasible**	**3**	**5**	**4**	**5**	**7**	**4**
Effect of SATS on ability to control traffic **Negative Effect① ② ③ ④ ⑤ ⑥ ⑦ Positive Effect**	**6**	**6**	**4**	**4**	**4**	**4**
SATS beneficial? **Not Beneficial ① ② ③ ④ ⑤ ⑥ ⑦ Very Beneficial**	**4**	**4**	**5**	**4**	**4**	**7**

3.2.2.1 Concept Feasibility

Participants were queried on how feasible the SATS operations would be in both the simulated and other airspace within the current NAS.

Overall Concept Feasibility

PHL- Both PHL participants agreed that the SATS concept, as simulated, could be feasible depending upon the geographical location. Even though the SCAs in this current demonstration were modified to meld into the existing PHL airspace structure, controllers felt that the high volume of operations for PHL INTL would outweigh the airspace needs for the smaller airports. They felt that the airspace was much too important for PHL operations than those of the two satellites.

ZNY-The consensus among ZNY participants was that for the small airports SATS would offer more efficient operating procedures.

SCA Size.

PHL-For PHL controllers the size of the SCA was a concern. They questioned whether or not the SCA would "flip" in the same fashion that runway assignments change due to prevailing winds.

ZNY-ZNY participants did not have an opinion on this item.

Impact on Ability to Control Traffic.

PHL- PHL controllers agreed that SATS procedures were easy to adopt. They felt there was a "large decrease in babysitting" aircraft destined for the SATS airports. SATS was thought to improve the ability to control traffic for those airports, but they felt SATS negatively affected other aircraft in the area.

ZNY- ZNY controllers felt that SATS had no effect at all on their ability to control traffic. SATS operations were transparent to them.

Impact of Mixed Equipage.

PHL- Both participants felt that the IFR cancellation procedures, as simulated, for both sides of the frequency. The operation was "cumbersome" at times. One suggested that instead of SATS priority, time slots could be given to the non-equipped much like the way PHL runs their Precision Runway Monitor (PRM) program.

ZNY- Mixed equipage was not a factor for the en route controllers.

3.2.3 Procedures and Phraseology

The researchers asked the TRACON controllers to provide feedback on the simulated SATS procedures and phraseology, including the following: ability to adapt to SATS procedures, effectiveness of SATS transition procedures, frequency of communications and the acceptability of SATS phraseology as simulated. Table 7 shows individual rating results on these issues.

Table 7. Ratings on SATS Procedures and Phraseology

	PHL	
Procedures and Phraseology	***CPC 1***	***CPC 2***
Ability to adapt to SATS procedures **Not Easily ① ② ③ ④ ⑤ ⑥ ⑦ Very Easily**	**6**	**7**
Effectiveness of transition procedures into SATS airspace (arrivals) **Not Effective ① ② ③ ④ ⑤ ⑥ ⑦ Very Effective**	**6**	**4**
Effect of SATS on frequency of communications **Decreased Greatly ① ② ③ ④ ⑤ ⑥ ⑦ Increased Greatly**	**3**	**4**
Acceptability of SATS phraseology as prescribed in simulation **Not Acceptable ① ② ③ ④ ⑤ ⑥ ⑦ Very Acceptable**	**2**	**6**

4. Discussion

This demonstration provided the first look into the controller perspective concerning the enroute integration of the SATS concept. We used the lessons learned from the HVO study (Magyarits, et al, 2005) as a model for our development of the transition procedures, airspace and SCA, and the SATS specific phraseology to effectively identify the impact of SATS operations on adjacent enroute sectors. The results reported in this document are bound by the assumptions and limitations highlighted in Section 2.6. Although quantitative data (e.g., frequency of communications, separation losses, arrival rates) is captured through the simulator data reduction and analysis tool suite, the small sample size (N=1) negates meaningful data derived comparisons, and therefore were not part of the experimental design. Rather, the research team focused on the subjective feedback from the participants based upon their experience in this demonstration.

Overall, SATS was viewed favorably by all six participants. For ZNY ARTCC controllers, SATS operations were not a factor in their operations as simulated in this demonstration. The two PHL participants responded that their operations into the two SATS airports were much more efficient when SATS procedures were in place as opposed to the baseline scenarios experienced. In addition, PHL controllers felt that the SATS procedures and phraseology (as prescribed for this study) were easy to adopt.

As with the HVO study (Magyarits, et al., 2005), participants agreed that considerable airspace redesign would have be accomplished in order to facilitate the evolution of the SATS concept. With the projected increase in demand for smaller aircraft, airspace redesign is likely to occur. The research team recommends that future SATS simulations should be conducted with generic airspace (TRACON and ARTCC). Generic airspace sectors consist of easily remembered fix names and simplified operating procedures to facilitate learning. Using generic airspace would enable researchers to select a cross-section of participants from a variety of air traffic facilities. The feedback obtained (e.g. airspace redesign, SATS procedures, phraseology, and SCA construction) from this type of participant pool could be generalized across the NAS, and lead to a more robust SATS concept. Site-specific implementation issues could then be addressed in following simulations as necessary.

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Acronyms

40N	Coatsville/Chester County G.O.Carlson Airport
AMM	Airport Management Module
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
CPC	Certified Professional Controller
CTAF	Common Traffic Advisory Frequency
EFC	Expect Further Clearance
FAA	Federal Aviation Administration
FPL	Full Performance Level
GPS	Global Positioning System
HVO	Higher Volume Operations
IAF	Initial Approach Fix
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
MSL	Mean Sea Level
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
PHL	Philadelphia Air Traffic Control Facility
PTW	Pottstown/Limerick Airport
SATS	Small Aircraft Transportation System
TSAA	Transportation Systems Analysis and Assessment
ZNY	New York Air Route Traffic Control Center

APPENDIX – A

Participant Consent Form

Participant Consent Form

I, ____________________________, understand that National Aeronautics Space Administration (NASA) Langley Research Center and the Federal Aviation Administration (FAA) William J. Hughes Technical Center sponsor and direct this study, entitled *Transportation System Analysis and Assessment Demonstration.*

4.1.1.1 Nature and Purpose:

I agree to volunteer as a participant in the demonstration cited above. I understand the purpose of *Transportation System Analysis and Assessment Demonstration* is to assess controller workload and acceptability of the Small Aircraft Transportation System (SATS) transition procedures. If the procedure is determined to not be feasible within the existing airspace, I will make recommendations/ suggestions with respect to airspace, procedural, phraseology, route changes, or other relevant feedback that could enable a successful SATS operation. I will also identify potential impacts of such changes on surrounding airspace.

4.1.1.2 Participant Responsibilities:

The study will emulate operational air traffic conditions in Sector 26 and 92 of New York Air Route Traffic Control Center (ARTCC) and Pottstown and North Arrival of Philadelphia Terminal Radar Approach Control. I will monitor and control aircraft as I would in the field. I will provide workload ratings when prompted and complete questionnaires after each scenario and at the completion of the simulation.

4.1.1.3 Discomforts and Risks:

There are no expected discomforts or risks associated with this demonstration.

4.1.1.4 Participant Assurances:

I understand that my participation in this demonstration is completely voluntary. I understand that if new findings develop during the course of this research that may relate to my decision to continue to participation, I will be informed. I understand that I can withdraw from the demonstration at any time without penalty or loss of benefits to which I may be entitled. I also understand that the researcher of this demonstration may terminate my participation if he/she feels this to be in my best interest.

I understand that records of this demonstration are strictly confidential, and that I will not be identifiable by name or description in any reports or publications about this study. Video and audio recordings are for use within NASA and the WJHTC only. Any of the materials that may identify me as a participant cannot be used for purposes other than internal to NASA or the WJHTC without my written permission.

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 Participant: ______________________________Date: ______________

APPENDIX - B

Proposed Phraseology and Procedures

Procedures and Phraseology for SATS TSAA Simulation

SATS Arrivals

Event:	**Vertical entry into SATS airspace.** **Aircraft enters the ATC facility Terminal area in which the destination SATS airport is located, proceeding to the IAF an "L" approach requested by the pilot and delay is anticipated at the clearance limit prior to aircraft being able to enter the SCA**
Pilot:	"(Approach), (A/C ID), AT or DESCENDING TO (altitude), WITH (airport) WEATHER, INITIAL APPROACH FIX (fix)."
ATC:	"(A/C ID), (Approach), CLEARED TO (fix), HOLD (direction), AS PUBLISHED, MAINTAIN (altitude)." If necessary: "EXPECT FURTHER CLEARANCE (time)."
Note:	The assigned altitude will be the first available holding altitude above the SCA. If necessary, issue detailed holding instructions)
Event:	**Aircraft is at an altitude immediately above the SCA**
ATC:	"(A/C ID) (Approach), ADVISE WHEN YOU RECEIVE APPROVAL TO ENTER THE SCA."
Pilot:	"(A/C ID) HAS APPROVAL TO ENTER THE SCA."
ATC:	"(A/C ID) DESCEND AT PILOT'S DISCRETION. "A/C ID) RADAR SERVICES TERMINATED. CHANGE TO ADVISORY FREQUENCY APPROVED. "(Pilot assumes separation responsibility)

SATS Arrivals (cont'd)

Event:	**Horizontal entry into SATS airspace.** **SATS equipped aircraft is inbound to the IAF on the "L" approach for the destination SATS airport, below the upper limit of the SCA. Aircraft enters the ATC facility Terminal area in which the SATS airport is located and requests entry into the SCA at an altitude below the vertical limit of the airspace):**

Pilot: "(Approach), (A/C ID), WE ARE LEVEL AT (altitude), WITH (airport) WEATHER, INITIAL APPROACH FIX (fix)."

ATC: "(A/C ID), (Approach), ADVISE WHEN YOU RECEIVE APPROVAL TO ENTER THE SCA. MAINTAIN (altitude) UNTIL ENTERING THE SCA."

Pilot: **"(**A/C ID) HAS APPROVAL TO ENTER THE SCA."

ATC: "(A/C ID), RADAR SERVICE TERMINATED. CHANGE TO ADVISORY FREQUENCY APPROVED." ***(Pilot assumes separation responsibility).***

SATS Departures

Event: **Aircraft requests release**

Pilot: Initiates departure request to Clearance Delivery position via hand held radio.

Clearance Delivery: Presents ATC with flight strip of aircraft requesting departure

Clearance Delivery: : "(A/C ID), RELEASED FOR DEPARTURE." Or "(A/C ID), HOLD FOR RELEASE, EXPECT (time in hours and/or minutes) DEPARTURE DELAY."

Note: ATC would advise of any delays or relay any pertinent information at this time.

Optional: If ground communications capability exists: Pilot takes runway, advises ATC "(A/C ID) rolling."

Event: **Pilot contacts ATC climbing out on departure**

Pilot: "(Approach), (A/C ID), AIRBORNE, LEAVING (altitude) FOR (assigned altitude)."

Note: This may be an altitude above the SCA, if so assigned in pre-departure clearance.

ATC: *"(*A/C ID), (Approach), REPORT LEAVING THE SCA."

Pilot: "(A/C ID), LEAVING THE SCA."

ATC: "(A/C ID), RADAR CONTACT."

APPENDIX - C

Background Questionnaires

Background Questionnaire (ZNY)

Participant Code_____

Date ______________

Instructions:

This questionnaire is designed to obtain information about your background and experience as a certified professional controller. The information will be used to describe the participants in this study as a group. Your identity will remain anonymous.

Demographic Information and Experience

1. What is your **gender**?	♂ **Male**	♀ **Female**

2. What is your **age**?	_____ years
3. What is your **total experience as a controller** (in any control position and geographic location)?	_____ years _____ months
4. What is your **total experience as a ZNY** controller?	_____ years _____ months
5. Are you currently **certified on Sector 26 (Lancaster) and Sector 92 (Pottstown)** operations?	_____ Yes _____ No
6. How long have you **actively controlled traffic** in the en route environment?	_____ years _____ months
7. How many of the **past 12 months** have you actively controlled traffic?	_____ months

Background Questionnaire (PHL)

Participant Code_____

Date ______________

Instructions:

This questionnaire is designed to obtain information about your background and experience as a certified professional controller. The information will be used to describe the participants in this study as a group. Your identity will remain anonymous.

Demographic Information and Experience

1. What is your **gender**?	♂ **Male**	♀ **Female**

2. What is your **age**?	_____ years
3. What is your **total experience as a controller** (in any control position and geographic location)?	_____ years _____ months
4. What is your **total experience as a PHL** terminal controller?	_____ years _____ months
5. Are you currently **certified on Pottstown and/or North Arrival** operations?	_____ Yes _____ No
6. How long have you **actively controlled traffic** in the en route environment?	_____ years _____ months
7. How many of the **past 12 months** have you actively controlled traffic?	_____ months

APPENDIX - D

Post Scenario Questionnaire

Post Scenario Questionnaire

Instructions:

Please answer the following questions based upon your experience in the run just completed. Your identity will remain anonymous.

1. Rate your **overall level of ATC performance** during this scenario.	Extremely Poor	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Good

2. Rate your **ability to move aircraft through the sector** during this scenario.	Extremely Poor	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Good

The term ***situation awareness*** refers to how well you were able to perceive the elements in the environment, to comprehend their meaning, and to project their status.

3. Rate your **overall level of situation awareness** during this scenario.	Extremely Poor	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Good

4. Rate your **situation awareness for current aircraft locations** during this scenario.	Extremely Poor	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Good

5. Rate your **situation awareness for projected aircraft locations** during this scenario.	Extremely Poor	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Good

6. Rate your **situation awareness for potential loss-of-separation** during this scenario.	Extremely Poor	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Good

7. Rate the **difficulty** of this scenario.	Extremely Easy	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Difficult

8. How would you rate the **overall level of efficiency** of this operation?	Extremely Low	① ② ③ ④ ⑤ ⑥ ⑦	Extremely High

9. Rate the **performance of the simulation pilots** in terms of their responding to your control instructions and providing readbacks.	Extremely Poor	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Good

The term ***workload*** refers to both the cognitive and physical demands imposed by your tasks.

10. Rate your **overall mental workload** during this run. (Mental workload refers to planning, coordination, etc.).	Very low	① ② ③ ④ ⑤ ⑥ ⑦	Very high

A. Were there any tasks that you would normally perform when controlling traffic that you were unable to perform during this particular scenario? (Check one) Yes □ No □

B. If you answered "Yes" to part A, please list the tasks you were unable to complete.

____

____

11. Rate the workload you experienced with **ground-to-air communications** during this run.	Very low	① ② ③ ④ ⑤ ⑥ ⑦	Very high

12. Rate the workload you experienced with **controlling aircraft into and out of the airport.**	Very low	① ② ③ ④ ⑤ ⑥ ⑦	Very high

The following questions refer to situational awareness in three dimensions: 1) Demand on attentional resources, 2) Supply of attentional resources and 3) Understanding.

13	**Demand of attention** How demanding was the scenario on your attention?	Low	① ② ③ ④ ⑤ ⑥ ⑦	High

14	**Instability of situation** How likely to change was the scenario?	Low	① ② ③ ④ ⑤ ⑥ ⑦	High

15	**Complexity of situation** How complicated was the scenario?	Low	① ② ③ ④ ⑤ ⑥ ⑦	High

16	**Variability of situation** How variable were the factors in the scenario?	Low	① ② ③ ④ ⑤ ⑥ ⑦	High

17	**Supply of attention resources** How much attention did you have available to devote to the scenario?	Low	① ② ③ ④ ⑤ ⑥ ⑦	High
18	**Arousal** How alert and ready for action did you feel throughout the scenario?	Low	① ② ③ ④ ⑤ ⑥ ⑦	High
19	**Concentration of attention** How concentrated were you on the scenario?	Low	① ② ③ ④ ⑤ ⑥ ⑦	High
20	**Division of attention** How divided was your attention among the elements in the scenario?	Low	① ② ③ ④ ⑤ ⑥ ⑦	High
21	**Spare mental capacity** How much attention did you have left over to deal with new events, should they happen?	Low	① ② ③ ④ ⑤ ⑥ ⑦	High
22	**Understanding of the situation** How well did you understand the situation as it was in this scenario?	Low	① ② ③ ④ ⑤ ⑥ ⑦	High
23	**Information quantity** How much information were you able to obtain throughout the scenario?	Low	① ② ③ ④ ⑤ ⑥ ⑦	High
24	**Information quality** How good or valuable was the information that you obtained throughout the scenario?	Low	① ② ③ ④ ⑤ ⑥ ⑦	High
25	**Familiarity** How knowledgeable and familiar were you with the events and elements in the scenario?	Low	① ② ③ ④ ⑤ ⑥ ⑦	High

APPENDIX - E

ATC Post Simulation Questionnaire

ATC Post Simulation Questionnaire

Participant Code_____

Instructions:

Please answer the following questions based upon your experience in the demonstration. Your identity will remain anonymous.

Concept

1. Please fill in the number that best describes **the feasibility of implementing** the Small Aircraft Transportation System (SATS) in the National Airspace System (NAS).	Not At All Feasible	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Feasible

2. What effect, if any, did the SATS operation have on your **ability to control traffic**?	Negative Effect	① ② ③ ④ ⑤ ⑥ ⑦	Positive Effect

A. Explain how the SATS operation **affected your ability to control traffic**, if at all.

____

____

____

____

____

3. Based upon your experience in the demonstration, do you feel that **implementing the SATS** would be beneficial?	Not At All	① ② ③ ④ ⑤ ⑥ ⑦	A Great Deal

A. What are the **advantages and disadvantages** of the SATS as you see them?

____

____

____

____

____

Procedures/Phraseology

4. Were you able to **adapt to the SATS procedures**?	Not At All	① ② ③ ④ ⑤ ⑥ ⑦	A Great Deal

A. **Explain how you adapted** to the SATS operation, if at all.

____

____

____

____

5. How **effective were the SATS transition procedures** (e.g. timeliness of aircraft reporting Self Controlled Area (SCA) entry approval, efficiency of aircraft arrival operations)?	Not At All Effective	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Effective

A. Please explain.

____

____

____

____

6. What effect, if any, did the SATS operation have on the **frequency of communications**?	Decreased Greatly	① ② ③ ④ ⑤ ⑥ ⑦	Increased Greatly

7. How **acceptable were the roles and responsibilities** imposed on **ATC** in the simulation?	Not Acceptable	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Acceptable

A. Explain how the **SATS roles and responsibilities were unacceptable**, if at all.

____

____

____

____

____

8. Was the **phraseology** adopted to support the Small Aircraft Transportation System operations **during the simulation acceptable**?	Not At All	① ② ③ ④ ⑤ ⑥ ⑦	A Great Deal

A. Explain how the **SATS phraseology affected operations**, if at all.

____

____

____

Workload

The term ***workload*** refers to both the cognitive and physical demands imposed by your tasks.

9. What **effect**, if any, did the SATS operation have **on your workload** in comparison to today's conventional non-radar procedures?	Decreased Greatly	① ② ③ ④ ⑤ ⑥ ⑦	Increased Greatly

A. Explain how the **SATS affected your workload**, if at all.

____

____

____

____

10. What **effect**, if any, did the mixed equipage scenarios have **on your workload** in comparison to the SATS and NonSATS runs?	Decreased Greatly	① ② ③ ④ ⑤ ⑥ ⑦	Increased Greatly

A. Explain how the presence of **mixed equipage affected your workload**, if at all.

____

____

____

____

B. Instead of a "SATS priority" implementation, would you have preferred a "first come, first served" procedure for the mixed equipped scenarios? Do you have any other recommendations on how to address the impact of mixed equipment in a SATS environment?

____

____

____

____

Realism

11. In general, how **realistic was the simulation**?	Extremely Unrealistic	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Realistic

12. Rate the **realism of the simulated hardware/software** compared to actual equipment.	Extremely Unrealistic	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Realistic

13. Rate the **realism of the simulation traffic** compared to actual NAS traffic.	Extremely Unrealistic	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Realistic

14. Rate the **realism of the simulation airspace** compared to actual NAS airspace.	Extremely Unrealistic	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Realistic

15. Please fill in the number that best describes overall **how well the simulation-pilots performed** during this simulation.	Extremely Poor	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Well

16. To what extent did the **WAK (workload assessment keypad) interfere with your performance**?	Not At All	① ② ③ ④ ⑤ ⑥ ⑦	A Great Deal

17. Please rate the **adequacy of the training** you received for the simulation.	Extremely Poor	① ② ③ ④ ⑤ ⑥ ⑦	Extremely Well

18. Is there anything about the study that we should have asked or that you would like to comment about?

____

____

____

____

____