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# Factors Affecting the Communication of Status Information Between Technical Operations and Air Traffic Personnel

Vicki Ahlstrom, Human Factors Team – Atlantic City, ATO-P
Robert Muldoon, Northrop Grumman Information Technology
Henry Dorsey, Northrop Grumman Information Technology

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**16. Abstract**

The purpose of this study is to identify and assess ways to improve communication of system status between two key groups within the Federal Aviation Administration: Technical Operations and Air Traffic. To accomplish this goal, researchers employed qualitative measures to examine a number of elements related to how these two groups communicate system status, including information needs and methods of information transfer. Three major processes emerged that related to the communication of system status: coordination, information transfer, and logging. The information needs and methods used for each process are different. We present some common complications that may arise during communication of system status between the two groups as well as some conditions for successful communication. This study highlights the importance of a shared situational awareness for effective communication and identifies several potential strategies for facilitating effective communication between Technical Operations and Air Traffic personnel.

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## Executive Summary

Effective communication is critical to the NAS modernization effort. This report provides a starting point for improving Technical Operations and Air Traffic communication. In this report, we present the results of a study that examined communication between two key groups within the Federal Aviation Administration: Technical Operations (TO) and Air Traffic (AT) personnel. The purpose of this study was to identify and assess ways to improve communication of system status, including the identification of redundancies or inefficiencies in current methods of communication.

To accomplish this goal, we employed qualitative measures to examine a number of elements related to how these two groups communicate system status, including the identification of information needs, current methods of communication, perceived barriers to effective communication, and information flow. We conducted structured interviews with both TO and AT personnel at several key field site locations. Field site locations included both en route (Air Route Traffic Control Center) and terminal domains. We chose sites based on a number of factors, including potential impact on the National Airspace System (NAS), proximity, and the potential for interaction. This allowed a more comprehensive analysis of communication between organizational entities.

Three major categories emerged related to the communication of system status: coordination, information dissemination, and logging. The information needs and methods used for each of these categories of communication differed. Verbal communication in the form of telephone calls or face-to-face interaction was the primary and almost exclusive means of accomplishing *coordination* between the two groups. They accomplished *information dissemination* by the most diverse range of methods, including verbal face-to-face, verbal telephone, several different electronic systems, and hard copy. They completed *logging* through both hard copy and electronic means. An analysis of communication methods showed that there was very limited interaction or information sharing between the different sources of information. For information to get from one system to another, they often had to read or hear it and then manually type it into another system.

Both TO and AT have a strong commitment to the safety of the NAS, and they take that responsibility very seriously. Both the on-site TO and AT personnel expressed that their primary responsibility was to the facility, keeping the systems and equipment functioning so that the facility operates safely and smoothly. They emphasized that although the communication process is not always efficient, they manage to receive the information required to accomplish their primary task. However, with increasing traffic levels predicted for the future, the lack of efficient and effective communication could slow down the NAS or bring it to a standstill.

We identified several factors that contribute to effective communication, with a major emphasis on automation and an increase in shared awareness between TO and AT. Almost every person interviewed expressed that the coordination within the facility was very successful. They attributed this success primarily to an enhanced understanding of facility operations and constraints by on-site TO personnel rather than to the method of communication, which was primarily through face-to-face verbal exchange.

Participants identified barriers to effective communication. One major barrier was the lack of integration between communication systems. This was especially apparent in the information flow on the AT side. Participants described receiving information from one source and having to type the same information into another system. Participants also described breaks in the flow of information, such as when a hard copy message is misplaced or is not received by the intended recipient.

This study enabled a deeper understanding of the current barriers to effective communication. The analysis allowed us to go beyond what was previously known about TO and AT communication, revealing an understanding of the process by which communication disparities may arise. The understanding of the processes underlying effective communication, partnered with an understanding of informational needs and constraints, aids the development of more effective tools, processes, and procedures for TO and AT communication. An increase in communication effectiveness has the potential for decreasing NAS-related delays, decreasing workload, and increasing NAS safety.

This study highlights the importance of a shared situational awareness for facilitating effective communication and identifies several potential factors central to facilitating effective communication between TO and AT. By identifying the factors that influence the communication of status information between TO and AT, this study resulted in several suggestions for change. These suggestions could potentially streamline communications and reduce workload. We suggest the following recommendations for improvement:

1. Provide a shared system for accessing event status.
2. Allow automatic information transfer between systems.
3. Investigate the use of automation to reduce the duration of calls.
4. Provide a single point of contact at facilities.
5. Enhance the speed of coordination, overall, as well as with the Operations Control Center (OCCs).
6. Enhance local area knowledge by the OCCs.
7. Reduce calls for information by providing easy-to-use online lookup tools.
8. Tailor information to specific user needs.

We describe these recommendations in more detail in the body of the report. Anecdotal evidence, based on user responses, indicates that implementing the recommendations contained in this report could reduce the likelihood of errors, reduce workload, and increase efficiency of the NAS. For example, based on previous studies on communication and coordination in the Traffic Management environment, there is reason to believe that the use of automation to augment coordination could reduce the amount of time spent on telephone calls, by half, with the potential to save more than 1 million hours annually, allowing more time to focus on system maintenance. Further research is needed in which these suggestions are implemented either in a simulation or in a controlled field study to measure the benefit of the suggested interventions.

## 1. INTRODUCTION

### 1.1 Background

The National Airspace System (NAS) is a complex collection of thousands of systems and equipment located throughout the United States. These components comprise a virtual highway in the sky that allows aircraft to move safely and efficiently from one location to another. There are currently more than 30,000 Air Traffic Control (ATC) systems within the NAS, and this number continues to increase (Federal Aviation Administration [FAA], 1999). These systems are maintained by Technical Operations (TO). TO is the FAA organization responsible for managing and maintaining the NAS, including maintenance, performance checks, certification, and restoration of NAS services, systems, and equipment (FAA, 2004b).

ATC is a complex and dynamic environment. Different ATC entities are responsible as an aircraft moves from one location to another. Terminal Radar Approach Control (TRACON) facilities and Airport Traffic Control Towers (ATCTs) control the departure of aircraft from the airport and the arrival of aircraft at the destination. Some of these facilities have more of an impact on the overall NAS than others. Figure 1 shows these Operational Evolution Plan airports. Figure 2 shows Air Route Traffic Control Centers (ARTCCs), which are responsible for the aircraft between the departure and arrival phases of the flight. Many of the ARTCCs have TO Systems Operations Centers (SOCs) collocated with the ATC facility, as Figure 3 shows. Other facilities rely on a combination of local TO and regional Operations Control Centers (OCCs) (Figure 4).

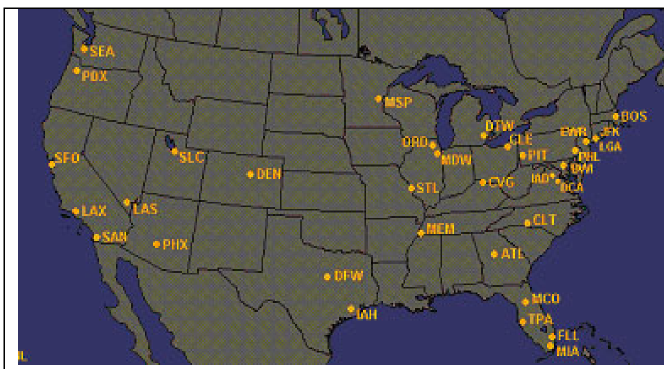


Figure 1. Major airports.

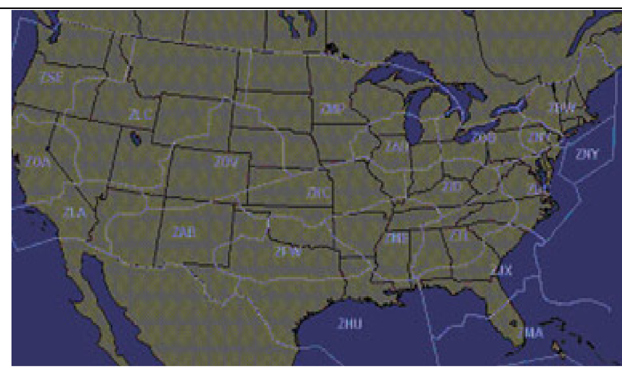

Figure 2. Air Route Traffic Control Centers.

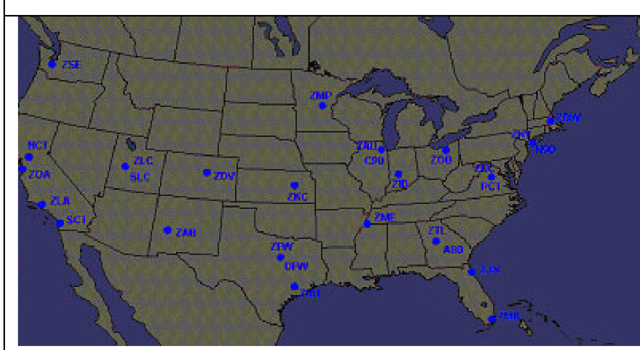

Figure 3. Service Operations Centers.

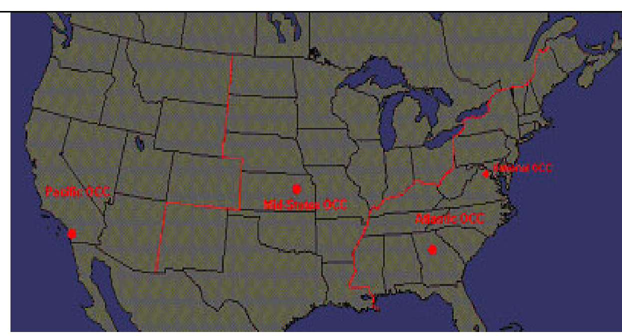

Figure 4. The three Operations Control Centers and the National Operations Control Center.

Source: technet.faa.gov

Air Traffic Controllers at ARTCCs, ATCTs, and TRACONs rely on thousands of pieces of equipment to move airplanes safely and efficiently through their airspace. If this equipment becomes unavailable, there can be severe impacts to the NAS. During the 2005 fiscal year, alone, there were 2,761 delays attributed to NAS equipment (FAA, 2005). At the beginning of the 2006 fiscal year (from October 2005 to February 2006), there were 991 equipment-related delays (see technet.faa.gov). Many of these delays lasted hours (or even days) before the service or equipment was restored. The longer that equipment is unavailable, the more aircraft are impacted, and the greater the overall effect on the flying public. Therefore, improving communication and coordination between Air Traffic (AT) and TO could enhance system efficiency and minimize delay duration.

### 1.2 Purpose

This study examines the communication structure and current practices between TO and AT personnel. The purpose of this study was to identify and assess ways to improve communication of system status, including the identification of redundancies or inefficiencies in current methods of communication. In order to reach this goal, we explored three separate questions:

1. *What are the current processes for the communication of equipment status for TO and AT personnel?*
2. *What are the information needs and constraints of the current system?*
3. *Are there unnecessary redundancies in the present system?*

The first question focuses on the "How" of information communication, whereas the second question focuses on the "What." Although each question touches on a slightly different aspect of information communication, they are inexorably linked. It may be that NAS personnel use one specific method to communicate certain types of information because it provides something that another method does not. In addition to examining the "How" and the "What" of information communication, we studied the efficiency of overall communication by identifying redundancies present in the current processes. Specifically, researchers investigated the potential for redundant communications when communicating NAS equipment and system status information. If communications are redundant, they will be costly in terms of unnecessary usage of resources. These resources may relate to the personnel (e.g., time consuming or workload intensive) or to the system.

## 2. METHOD

This section describes the methods used in this study. This was a qualitative study. Qualitative research methods are "valuable in providing rich descriptions of complex phenomena; tracking unique or unexpected events; illuminating the experience and interpretation of events by actors with widely differing stakes and roles…" (Shofaer, 1999, p. 1101). Qualitative research also allows the researcher to examine the extent to which something is actually happening in practice, help to clarify what is effective, and capture unintended consequences of policies and processes on real world operations (Spencer, Richie, Lewis, & Dillon, 2003).

The primary results of this study will be a description of the current state of affairs. Based on a thorough understanding of the current state of affairs, we can then make informed decisions on where interventions could be applied most appropriately. This type of inquiry is consistent with the structured interview evaluation strategy.

## 2.1 Participants

Although there are at least 17 operating position designators at ARTCCs and a similar number of different positions at terminal facilities, only a few AT positions regularly interact with TO (FAA, 2004a). The primary AT positions that interact with TO include the Facility Manager, Operations Managers (OM), Operations Supervisors (OS), Supervisory Traffic Management Coordinator-in-Charge (STMCIC), and Traffic Management Coordinator.

In all, we interviewed 29 participants. At one center, we interviewed 7 AT participants: two OMs, three OSs, one STMCIC, and one Air Traffic Control Staff Coordinator. At that same site, the researchers interviewed 4 participants from TO: three NAS Operations Managers (NOMs), and one automation manager. A fifth participant did not have time to complete the data collection but provided informal input and feedback.

At another en route center, we interviewed 5 AT participants: four OMs and one OS. At the same center, we interviewed 4 TO participants: three NOMs and a System Support Center (SSC) manager.

At one terminal facility, the researchers interviewed one AT Facility Manager and one TO Facility Support Manager. At a second terminal facility, the researchers interviewed two AT OMs. At the third terminal facility, the researchers interviewed a tower supervisor, an administrative OM, and an STMCIC. They also interviewed 2 TO participants: one automation/communications manager and one navigation/environmental manager.

## 2.2 Materials

### 2.2.1 Interview Protocol

Personnel at operational facilities are limited in the time that they have available to participate in research efforts. Therefore, the researchers developed short and highly focused questionnaires in an effort to minimize the impact on facility operations. The researchers developed two separate interview protocols to guide the structured interviews. One focused on communication of status from a TO perspective. There were seven questions on the TO structured interview.

1. *Please describe a typical interaction with AT.*
2. *What tasks do you need to contact or coordinate with AT to accomplish?*
3. *What problems/difficulties do you have in accomplishing tasks (including interruptions)?*
4. *What works well for you now in coordinating with AT?*
5. *What electronic systems do you use to communicate NAS status with AT?*
6. *What systems do you use to log NAS status?*
7. *My job would be so much easier if… (Please complete the statement).*

The other interview protocol focused on communication of status from an AT perspective. There were eight questions on the AT structured interview.

1. *Who do you contact when a piece of equipment is not functioning properly?*
2. *How do you contact that person?*
3. *Who gives you the information that a system is out or going to be out?*
4. *How do you know when a system is going to be returned to service?*
5. *Can you give a typical example of the information flow in your area?*
6. *Are there situations when you don't get the information you need? If yes, please explain.*
7. *Are your communications governed by any Letters of Agreement or Memorandums of Understanding? If yes, describe.*
8. *Do you have any suggestions for improving the communication between TO and AT?*

### 2.2.2 Questionnaires

As part of the structured interviews, the researchers asked the participants to provide information on tools that could be used to communicate system status. We gave participants an initial list of potential communication systems/methods (see Table 1). We informed them that not every person would use every system and that there may be some systems that were not on the list. In the case that the participant used a system not on the list, we asked them to name it and to provide some detailed information. We asked participants specifics about each of the systems, including who enters the information, who receives the information, and for what (specifically) each tool is used.

Table 1. Tools Used for Communication of NAS Status

| |
|---|
| National Traffic Management Log (NTML) |
| Information Display System (IDS)-4 or Systems Atlanta IDS (SAIDS) |
| Email or Lotus Notes |
| Traffic Management Unit (TMU) Log |
| Operational Information System (OIS) |
| Maintenance Management System (MMS) |
| Local/facility logs |
| General Notice of Information (GENOT) |
| Commercial telephone system |
| AM briefing/daily standup |
| Face-to-face communication |
| Event Manager |
| Outage sheet |
| Operations Network (OPSNET) |
| Fax |
| Enhanced Status Information System (ESIS) |
| General Information (GI) message through Keyboard Video Display Terminal (KVDT) |
| FAA Form 7230-4 |
| Mandatory Briefing Item (MBI) |
| Other (Describe) |

### 2.3 Procedures

Researchers used a face-to-face structured interview technique to collect data at operational field sites. We chose this technique based on the type of data we wished to collect. Structured interviews using open-ended questions are appropriate when the researchers want to explore information where the answers are not clearly known and may include both quantitative and qualitative data. Additionally, feedback from the SMEs in preliminary interviews indicated that the participants would provide better responses with this format of data collection.

A team of two to three researchers visited five operational sites to collect data. Two of the sites were ARTCCs and three were TRACONs. The facilities we visited included Cleveland ARTCC, TRACON, and ATCT; Covington TRACON and ATCT; Indianapolis ARTCC; and Philadelphia TRACON and ATCT. Due to temporal and financial constraints on the study, we did not interview personnel from small facilities such as towers that were not at a major airport. Often, large TRACONs are responsible for information dissemination to and from smaller towers; thus, we did receive some limited insight on communication with these smaller facilities.

We chose the facilities for their logistics and because they are representative of many facilities within the United States. We chose airports that were designated as potentially having great impact on the overall NAS (see Figure 1). We purposely chose facilities that were near each other to provide a broader perspective on the three processes of interest. The Cleveland and Indianapolis ARTCCs are adjacent to each other; the Covington TRACON and ATCT are in the area of the Indianapolis ARTCC; the Cleveland TRACON is proximal to Cleveland ARTCC; and the Philadelphia TRACON and ATCT are near enough to both Cleveland and Indianapolis ARTCC to potentially be impacted by either, but are not directly in the same airspace. Additionally, Covington and Philadelphia are in the Atlantic OCC area of responsibility, whereas the other facilities are in the Mid States OCC area of responsibility.

### 2.4 Data Collection

The research team had a designated point of contact (POC) at each site. This POC coordinated the research within their facility, including providing a location for data collection and organizing volunteer participants for the study. By using a local POC that was aware of facility constraints, we were able to minimize impact on the facility.

Upon arrival at the facility, the researchers met with the POC and provided a detailed description of the study. At each site, the POC coordinated the use of a location in which to conduct the interviews. The researchers interviewed one participant at a time in an effort to encourage the participants to speak freely. At the beginning of each session, the researchers provided each participant with an informed consent form, a brief description of the goals of the study, and contact information. The informed consent described the goals of the study, informed participants of their rights as a participant, and affirmed that any responses would be kept confidential. The participants signed the informed consent before participating in the data collection interview.

Each interview took approximately 30 minutes. Two researchers interviewed each participant. They alternated the duties of administering the questionnaire and note-taking. This procedure enabled one team member to direct the interview and the other to make detailed notes of the participant's responses, which a team member then transcribed. During the transcription process, all identifying information was removed from the responses.

### 2.4.1 Document Review

The first step in this study involved analyzing the results of recent data collection efforts. This includes previous studies and the results of a focus group in which TO personnel discussed their tasks related to the communication of status information (Ahlstrom, 2005; Ahlstrom, Koros, & Heiney, 2000; Ahlstrom & Muldoon, 2003). The analysis of these studies provided an initial framework for the data collection.

The FAA has several orders that describe procedures for communication. The researchers obtained and reviewed procedural documents used by both TO and AT. The Appendix lists the most relevant orders and data sources that we reviewed. Specifically, the researchers studied the procedures pertaining to the communication of equipment status between TO and AT. Examining these procedural documents allowed the researchers to understand the formal structure and processes surrounding TO and AT communication. These documents provided insight on where in the continuum TO and AT communications fell from very rigid and formal procedural-driven communication to informal communication. They also provided valuable information on what is communicated between the two groups and under what specific conditions communication occurs.

### 2.4.2 Preliminary Interviews

In preparation for data collection at operational field sites, researchers interviewed Subject Matter Experts (SMEs) who were available locally. Two of these SMEs worked in the Traffic Management Unit (TMU). One of the experts from the TMU worked at an en route center and one at a major TRACON. We also interviewed two former supervisors from the terminal environment and one current supervisor from the en route environment. These interviews provided important data and helped the researchers modify the data collection instrument and methodology. These SMEs responded to the interviews and provided feedback on the relevance of the questions, the ease at which they were able to answer the questions, and the length of the overall process. Additionally, the SMEs supplied input on the selection of participants for operational field site data collection. Based on the SME feedback, the researchers revised the questionnaires significantly to increase relevance, reduce response time, and improve the clarity of the wording.

## 3. RESULTS

Upon examining TO and AT procedural documents and analyzing participant responses, we found three major processes related to the communication of systems and equipment status. These three processes are coordination, information dissemination, and logging. Each of these three processes is somewhat different, but all are critical for effective TO and AT communication.

### 3.1 Coordination, Information Dissemination, and Logging Systems

As part of the structured interviews, the researchers asked the participants to provide information on a list of tools that could be used to communicate system status. We asked participants specifics about each of the systems, including who enters the information, who receives the information, and for what (specifically) each tool is used. In Table 2, we present descriptions of these systems along with a classification of whether they are used primarily for coordination, information dissemination, or logging and whether they are primarily verbal, electronic, or hard copy. Where possible, we included frequency of use, who is responsible for entering the data, who uses the data, and the purpose of the system.

Table 2. Systems Used for Communication of Status Information Between TO and AT

| Method | Description | Mode |
|---|---|---|
| **Coordination** | | |
| Commercial telephone system | Telephone and face-to-face are the primary means of coordination between TO and AT. Participants reported that this type of interaction occurs frequently. | Verbal |
| Face-to-face communication | Telephone and face-to-face communication are the primary means of coordination between TO and AT. Participants reported that this type of interaction occurs frequently. | Verbal |
| **Information Dissemination** | | |
| Commercial telephone system | If there is an outage on a system that is likely to have a major impact on operations, AT will be notified by telephone. Both TO and AT get calls providing or requesting information on specific events. For example, the Regional office staff could call AT requesting information. The OM also gets calls on future scheduled outages. | Verbal |
| AM briefing/daily standup | Although the primary purpose of the AM briefing is information dissemination, the AM briefing has components of both information dissemination and coordination, depending on the particular operational facility. At some facilities, TO and AT may discuss and coordinate matters at the AM briefing. At other facilities, TO disseminates information to AT. The AM briefing usually contains higher-level information. Usually attending are the facility manager, staff managers, TO, OM, plans & programs, and training and HR personnel. It occurs daily. | Verbal |
| Weekly meetings | Some facilities reported having weekly meetings with TO and AT supervisors, the OM, and support managers to discuss what is going on in the building (current and planned). | Verbal |
| Read & Initial book also known as Read & Sign book | This is a book that AT controllers must read and initial before signing on to position. It contains information that may impact traffic for that day. Information that goes onto this sheet comes from various sources that may be different depending on the facility. Information may include equipment outages (such as an Instrument Landing System outage). Sources may include plans and programs, training, and OM. Some facilities have a single focal point to put together this information and decide what should be included. | Paper |
| En Route Information Display System (ERIDS) | Prototype ERIDS exist at three ARTCCs at Salt Lake City, Jacksonville, and Boston. ERIDS will display graphic and text data products, including ATC documents, Notices to Airmen (NOTAMS), weather data, traffic management data, and general information. ERIDS will exchange information with other facilities via interfaces to the Weather and Radar Processor, the Weather Information Network Server, U.S. NOTAM System, the Enhanced Traffic Management System (ETMS), the National Airspace System Resources System, and the FAA Internet Protocol-Routed Multi-user Network (FIRMNet) – http://www.nas-architecture.faa.gov/nas5/ mechanism/mech_data.cfm?mid=6336 | Electronic |

| Method | Description | Mode |
|---|---|---|
| Email/Lotus Notes | Email/Lotus notes is sometimes used to transmit information to ATCTs that do not have other means for obtaining information. It is sometimes used to help resolve an issue if there is an extended problem that has not been resolved. | Electronic |
| Enhanced Status Information System (ESIS) | This is only present at ARTCCs. ESIS displays are currently used at ARTCCs for projecting ETMS and NTML information. Information that is displayed on ESIS includes runway configurations, runway status, NAVAID, and other equipment outages. | Electronic |
| Fax | Some facilities get faxes from airports when they close (for the midnight shift). The airport will fax the status, including outages, runway status, and any military operations. Contract towers may need to be contacted via FAX and telephone to make sure the FAX has been received. Some messages are lengthy and very precise. If a tower cannot accept messages electronically, all information has to be relayed verbally via telephone, which can be time consuming. | Hard copy |
| General Notice of Information (GENOT) | GENOTs are originated by FAA headquarters and appear on all teletype weather services. They carry general information of interest to airmen, forecasters, and others connected with aircraft operation and weather service. | Electronic |
| Planning sheets | The OMs have planning sheets that they disseminate with upcoming events for the week. The planning sheets are for a week at a time. Sometimes these are emailed (disseminated electronically). | Hard copy |
| General Information (GI) message through Keyboard Video Display Terminal (KVDT) | The KVDT communicates through the host computer. Often the OM takes the relevant information from the outage sheet and types it in. At some facilities, it is not the OM but a Systems Operations Specialist from the TMU who types in the information. It is sent out electronically to sectors and remote facilities. Information is then displayed on a KVDT and printed on flight strips. | Hard copy, Electronic |
| IDS-4 or Automated Surface Observing System (ASOS) Controller Equipment – Integrated Display System (ACE-IDS) | This is only present at terminal facilities. The IDS provides access to a variety of data including NOTAMs, Special Use airspace, temporary flight restrictions, documents and charts, and weather information. | Electronic |
| Internet | Each morning, area specific NOTAMs are accessed via the Internet. | Electronic |
| Mandatory Briefing Item (MBI) | MBIs include more than just equipment related information. This information often comes from the plans and programs office but is coordinated through TO. A hard copy is given to each supervisor and controller affected. | Hard copy |
| Operational Information System (OIS) | Contains information from the Air Traffic Control System Command Center (ATCSCC) on delays, ground delay programs, ground stops, delay information airport closing, runway/equipment information, icing information. | Electronic/ Internet |
| Operations Network (OPSNET) | OPSNET includes daily delay reporting as well as airport traffic counts, instrument operations, and instrument approaches. Data collection was expanded from the previous OPSNET to provide data entry currently submitted on FAA Forms 7230-1, Airport Traffic Record; 7230-12, Instrument Approaches Monthly Summary; and 7230-26, Instrument Operations, on a daily basis and from all Level III and higher Air Traffic Facilities. | Electronic |

| Method | Description | Mode |
|---|---|---|
| Outage sheet | The Outage sheet is primarily an information dissemination tool. It is created by TO and lists current and scheduled outages. A hard copy of the Outage Sheet is given to OMs and OSs. Occasionally, the OM or OS will say that they can't have two items listed on the sheet (usually radars) out at the same time. If that is the case, they either call TO or go to them face-to-face to coordinate a resolution. | Hard copy |
| Other forms | TO uses a form to request scheduled down time for equipment (this is a form that is initialed by each department involved, as it works its way to approval). | Hard copy |
| Aviation Information System (AIS) | Provides the operating status of the nation's largest airports and delay information in real-time from the ATCSCC. It does not provide information on equipment status. | Electronic |
| **Logging** | | |
| National Traffic Management Log (NTML) | The NTML is utilized to record Traffic Management activities in the facility. It does not replace the facility log; however it may be utilized as the facility log when documented in a facility directive. Facilities with the NTML are required to make data entries. It has the ability to send log data electronically to ESIS or to an NTML report. NTML can automate coordination by allowing facilities to electronically forward/receive/share log entries. It is used by AT in Traffic Management positions. | Electronic |
| Traffic Management Unit (TMU) Log | This is a daily log on events that impact the flow of air traffic in chronological order. It includes equipment status that may impact traffic movement. It is used by AT in Traffic Management positions. | Electronic |
| Equipment log | Some facilities keep a separate log for equipment related events. | Hard copy |
| FAA Form 7230-4 (Daily record of operations) | The FAA Form 7230-4 often exists in paper form. Although the data may be entered electronically, it is not usually transmitted electronically. Instead, the data are usually printed out at the end of the day. Supervisor and Watch Desk keep separate 7230-4 s for their areas. These data are compiled at the Operations office at the end of each shift used by AT. | Hard copy |
| Daily log | Equipment malfunction that impact NAS are always logged on 7230-4, but the daily log is for equipment that has low to no NAS impact. The daily log provides a history of the particular equipment. It is used by AT. | Hard copy |
| Radio Frequency log | Hard copy log on radio frequency issues distributed twice a day. | Hard copy |
| Yellow pad | One en route TO facility said that they have a yellow pad of paper, which they use to keep a chronological list of events. | Hard copy |
| Pass down log | One terminal facility TO specialist said that they have a "pass down log," which they use to identify unfinished tasks. The log is then "passed down" to the next shift. | Hard copy |
| Event Manager (EM) | This is used by TO specialists to create and update event tickets for the status of NAS events such as modification and certification. | Electronic |
| Maintenance Management System (MMS) | The MMS is the primary database used by TO supporting performance and parts monitoring for system operations to ensure systems are supporting the NAS as intended. | Electronic |
| Simplified Automated Logging (SAL) | This system is used by TO field technicians. | Electronic |

### 3.1.1 Coordination

In the context of TO and AT interaction, coordination implies a certain amount of collaboration. Coordination in the TO and AT context means that the affected parties are notified, are aware of the event, and are in some level of agreement about activities related to the event. TO may request that a system be released for maintenance at a specific time. If the time is not conducive to current operations, AT may deny the request. TO may then request a different time, which AT may approve. Coordination between TO and AT is a complex process that is influenced by current tasks, goals, and constraints.

Based on the responses to Question 2 of the structured interview (*How do you contact that person?),* coordination between TO and AT is primarily verbal, either face-to-face or telephone communication. The AT participants responded that they try to coordinate events with local TO first, then coordinate with OCCs. They reported adopting this strategy because it is faster than coordinating with the OCCs first.

According to the Airway Facilities (AF) Command Center Metrics database, there can be from 1 to 34 coordination points for a given event, with an average of 3 coordination points per event (FAA, 2005). During the preliminary research phase of this project, we viewed event related ticket data from Maintenance Management System (MMS) and Event Manager (EM). There was a nationwide total of 94,388 tickets created for all types of events entered into EM for the months of April, May, and June of 2005; equal to approximately 1,000 tickets daily. Approximately 70% of the events fell into the category of scheduled events.

Of the total number of events, OCC facilities generated 56,290 or 58% of these tickets. Data on the number of telephone calls from one OCC analyzed over a 4-day period show approximately 700 calls coming in and 1,000 calls going out daily. There is a 3 to 1 ratio of outgoing call duration to incoming call duration (99:17 total minutes vs. 31:29 total minutes, respectively). This could indicate increased communication complexity or information volume required by outgoing calls.

Participants reported that TO specialists spend a significant amount of time coordinating events with AT. This is consistent with the previously mentioned data and findings of an earlier study (Ahlstrom, 2005). TO specialists perform the majority of this coordination over the telephone or face-to-face. This coordination can be time consuming when it involves multiple individuals or groups of individuals.

Participants reported that there are times when an event is coordinated and scheduled weeks in advance; however, when the time approaches for the preventative maintenance to occur, circumstances change and the AT person in charge will not release the equipment for maintenance. When this occurs, the coordination process must start over again.

One thing we found is that there are differences between facilities in roles and responsibilities and how things work. For example, in one ARTCC, all of the communication with the OCC comes through local TO; the OCC does not communicate with AT. Participants at this facility maintain that this helps simplify coordination and makes the flow of information more efficient.

### 3.1.2 Information Dissemination

Information dissemination is different than coordination. Whereas coordination involves a two-way flow of information, information dissemination is often a one-way flow of information. The upward reporting of an event is an example of information dissemination. Depending on the circumstances and responsibilities surrounding an event, AT or TO may be the initiator or recipient of information dissemination.

Overall, the participants responded that scheduled outages are well coordinated for items that have a major impact on the NAS and for events that occurred frequently. They said that the items that are problematic tend to be infrequent or systems that were judged to have a lesser impact on the NAS. Also, the participants emphasized that, overall, the communication between TO and AT within a facility worked well. Based on the descriptions of information flow and the descriptions of systems, it appears that communication is generally effective, but not necessarily efficient. In other words, the users get the information that they need to complete their task, but it may take an exerted effort to get that information. One participant reported that he did not bother to disseminate information when they were under a "push" (i.e., when air traffic counts were high) because there were tasks that were higher on his priority list. This is consistent with the communications within teams under high workload or temporal stress (Ahlstrom et al., 2000; Salas, Dickinson, Converse, & Tannenbaum, 1992; Urban, Weaver, Bowers, & Rhodenizer, 1996). Team members who may otherwise communicate effectively may neglect to disperse information when faced with high workload or temporal stress.

Additionally, there is some selectiveness about what information is passed along, particularly within AT. For example, AT participants reported that for a radar outage, if there is redundancy, the information is not always passed to the AT floor. Sometimes, there is a breakdown in communication between the watch desk, the OS, and the controller.

The survey responses show that information dissemination can take many different forms. Information dissemination about equipment status among different AT entities is sometimes hard copy and sometimes electronic format. According to the participants interviewed, most of the data in electronic systems are not shared electronically between systems. Information is often collected by individuals, typed into forms, and disseminated as sheets of paper, which are hand carried from place to place. The majority of the information that is disseminated from TO and AT is in hard-copy format. Participants reported that there are times that these sheets of paper get lost or misplaced, resulting in additional communication or in some personnel not being informed of current equipment status. One participant stated, "*There are occasions when printed messages are missed and extensions of requests for down time go unnoticed.*"

Participants indicated that they would be in favor of a way to electronically link the different sources of information. AT participants suggested the use of the Enhanced Status Information System (ESIS) or IDS as a primary means of sharing information. Participants stated the following:

- *"We would totally embrace a system that provides sending GI messages to ESIS; however, ESIS is not at all tower locations."*

- *"Information should be sent out over the Net, and AF should be provided access to ESIS. AF should be able to enter critical items to ESIS as they receive them."*
- *"…some type of system status monitor was available to all. Access to this system should be in the sups area."*
- *"…communicate as much information as possible via the computer – Use the technology properly! We are still making hard copies for some information and hand delivering them to different departments and areas. If we could put all we do on ESIS and provide that ESIS display of information to SOC, everyone would embrace it."*
- *"It would be nice to have the -4* [FAA Form 7230-4, the Daily Record of Facility Operations] *go automatically to the IDS."*

3.1.3 Logging

Logging is the written (physical or electronic) documentation of maintenance and administrative activities. It provides an official means for documenting equipment performance, NAS events, and maintenance activities and provides an historical record of events. Steve Zaidman (Vice President for TO Services) stated, "Accurate, timely, and accessible information regarding activities and events that affect facilities is critical to the management of the NAS and is necessary to capture essential logging activities" (FAA, 2004c). Some activities that require log entries include

- Physical arrivals and departures at facilities without permanent maintenance staff.
- All system, subsystem, and service interruptions and related activities.
- Start and completion of periodic or corrective maintenance actions performed.
- Identification of failed or replaced equipment components.
- Start and completion of flight inspections if on-site personnel are involved or notified.
- Technical evaluations, inspections of any kind, and aircraft accident/incident investigations.
- Equipment changes, replacement, or adjustment of parameters.
- Modification, commissioning, or decommissioning activities.
- Pilferage, vandalism, or related events.
- Adverse weather effects, known commercial power failures, access road problems, or any other conditions that have specifically impacted a facility.
- Certification or decertification of systems, subsystems, or services.
- Visits of a technical nature by regional, headquarters, or non-FAA personnel.
- Coordination entries concerning facility transfer, intentional channel changes interruption, refusal of interruption request, or restoration.
- Supervisory log reviews.
- Start and completion of radio frequency interference investigation if system specialists are involved.
- Relevant statements from personnel who are cognizant of facility operations.

Both TO and AT have the responsibility for logging various events. According to participant responses, the primary means of logging events for AT is through FAA Form 7230-4 the Daily Record of Facility Operations. In the Traffic Management domain, the NTML is another means of logging. Both FAA Form 7230-4 and the NTML are used to document equipment-related events. For TO, events are documented in Simplified Automated Logging (SAL), EM, and MMS. All of these are electronic systems. We will describe these systems in more depth in the next section.

Participants had specific suggestions related to current methods of logging information. Participants stated the following:

- *"We need an accessible equipment log."*
- *"Communications need to show TO and us what status is simultaneously."*
- *"[Form] 7230-4 is used now. Data from it should be available as an electronic item automatically."*
- *"The -4, Equipment Log, and IDS all have to have information entered into them separately."*
- *"Right now, [Traffic Management Coordinators] TMCs or Sups have to manually copy information from the NTML to the IDS. It should be automatic."*
- *"Right now, we have an equipment log, a facility log, and a TMU log. They should be integrated but sortable. There are things that appear on one log but not on another."*

### 3.2 Information Flow

Both TO and AT emphasized that it is difficult to describe a typical information flow because the information flow was highly situation-specific; some examples follow. The words in brackets were added by a researcher for either explanation or clarification.

- **Equipment outages:**
  - "Generally, the flow for an equipment problem goes from the controller or supervisor to the operations manager, then to TO and the OCC. The AT sup[supervisor] used to fill out the –4, but now the OM does it. They only do that for major problems; not like replacing a keyboard or trackball."
  - "[Communication problem] The controller will tell the NOM, who tells the Comm. Tech [Communications Technician] and may also tell a remote Tech, who will then call the Comm. Tech, who will then call the NOM, who will then call the controller."
- **Scheduled outages or existing outages:**
  - "A list is generated by AF [i.e., Airway Facilities, the former name for Technical Operations] – given to the AT ops manager – then to the AT supervisor by the ops manager."

- "There is an AM briefing [refers to the morning briefing] to the supervisor; the supervisor enters it into ESIS and tells the controllers verbally. The OM also gets the AM briefing and enters it as a GI message. Then the GI message goes to controllers and remote towers who have the equipment."
- "Early morning, we receive a fax of major outages across country. They are not paid much attention to because the SOC notifies of items specific to us on a daily sheet. The sheets are distributed to the area supervisors. When I have to put out outages, I have to go through the additional information from TO in order to generate GI Messages. All we really need is whether the system/equipment is out or not. Outage Reports to each sector typed up into GI messages. It may take 10 to 20 minutes to decipher and send a message. The time has a lot to do with the variety of other things that are going on that have priority over sending the GI messages."
- "In the AM, TO hands a sheet to the TMU with scheduled outages. If this fluctuates, they verbally coordinate with the watch desk. In the en route environment, they always get a sheet from TO. They do not always pass this along to TRACONs."

All of the AT personnel reported that they try to coordinate with the local TO personnel before they contact the OCCs. They gave two reasons:

1. AT claimed that the OCCs slowed down the process.
2. AT reported that the local TO had a better understanding of the needs and constraints of the facilities, such as how critical the equipment was and when the busy time might be.

The TO personnel stated that if there is a significant event that causes delays, they will get telephone calls requesting additional information. These telephone calls can be a three-way call with the National Operations Control Center and OCC, or they may get calls from AT regional personnel. They reported that requests for additional information can impact the person on shift who is trying to resolve the problem.

### <u>3.3 Information Needs and Constraints</u>

TO and AT have different information needs related to NAS system status. TO specialists have a need for broader and more in-depth information about the systems than AT. At some facilities, TO has made an effort to provide AT with the complete information on an event through AM briefings or Outage sheets. At these facilities, AT indicated that having to sort through the information was detrimental and that they preferred to get only the basic information that they needed. This begs the question - *What are the information needs of TO and AT?*

According to the participants interviewed, the information needed depends on the task but may include some or all of the following. For AM briefings or Outage sheets, AT indicated that they would be mainly interested in the scheduled time out and the scheduled/predicted time of return. If the system is not a commonly known system but may have an impact on operations, they would want to know how the system outage could influence operations.

There are certain information items that AT reported using to guide decisions on whether to release a system for maintenance. Information that influenced these decisions included the system impact, current and predicted traffic loads, runway configurations, system interdependencies (especially related to who is using radar feeds), and weather information. AT personnel indicated that if TO had access to these items and were aware of the decision-making constraints related to these items, coordination time would be reduced because TO would be more likely to ask for an item at a time when AT would be more likely to approve the release. AT specialists indicated that on-site TO personnel often have this information, but they believed that off-site maintenance personnel did not.

Several other factors emerged as having an impact on TO and AT communication. AT participants reported that knowing who is responsible for maintaining each system is becoming an increasing concern because of the mix of contract and FAA-maintained systems. They reported that they do not always have accurate contact information for TO, including a lack of awareness of when on-site TO may be available if a facility is not staffed 24 hours each day.

Participants identified some constraints that could hinder effective communication between TO and AT. One of the major constraints that emerged was the lack of integration between systems. TO and AT have different systems, and they are not linked. Additionally, AT has several systems related to system status that are not integrated. AT reported having to manually re-enter information into multiple different systems. Both TO and AT participants reported that they have different acronyms and sometimes did not understand each other's logs. Both TO and AT participants said that there was a problem with timeliness of communication. Furthermore, they reported an unwillingness to go through the OCCs for coordination if it would add time to the equipment restoration process.

Communication about system status with entities other than TO emerged as a concern with AT. Some of the concerns that emerged included availability and accuracy of information related to the cost of an update or upgrade. In the terminal environment, they had many constraints related to their relationship with the city that owns the airport. This can also impact TO. Although both TO and AT are constrained by the city's schedule for maintenance, neither AT nor TO reported having a clear awareness of the city's schedule, and AT reported having technical difficulties in coordinating with the city on some issues. One specific example given was airport lighting. The city maintains runway lights, but the FAA maintains approach lights. For this situation, the city calls or faxes the watch desk for planned maintenance. This is not always coordinated with TO. This is especially problematic and complicated when responsibilities are shared. Terminal AT also reported that politics had a significant impact influencing decision making, particularly related to airport renovations.

Some AT operations are responsible for the communication of system status information to or from contract towers. This can be difficult because some contract towers do not have the equipment necessary to receive or transmit information except by telephone. This places additional workload on the terminal AT person who must relay or receive the information. If the information is not understood, this may require additional telephone calls for clarification.

Finally, AT participants reported that they sometimes question whether information that they have access to is correct. Participants specifically named the Operational Information System and TechNet in relation to this concern. They reported that information that they entered sometimes did not show up right away. This made them doubt the accuracy of the overall information.

### 3.4 Identifying Redundancies

Because of the complexity of the system, it is difficult to identify redundancies in communication. According to the participants, redundancy of communication (in the sense of duplication) was not a real problem for them. In fact, more than one person commented that having the same information exist in more than one location reduces the likelihood that they will miss it. However, they did consider redundancy of effort to be an issue. Redundancy of effort is best illustrated by the lack of communication between systems. Personnel enter information into one system and then have to enter the same information or portions of the same information into other systems. These concerns are evident in the suggestions made by personnel on ways to improve communication.

## 4. DISCUSSION AND SUMMARY

The research documented in this report investigates the factors that affect effective communication between TO and AT. A better understanding of these factors could help to reduce the potential for miscommunication and enhance communication efficiency. The results of this research demonstrate that communication of system status between TO and AT is not homogeneous, but instead tends to fall into three major categories: coordination, information dissemination, and logging. The underlying goals for each of these categories are different, and the tools and methods for each of these categories of communication are unique. For example, participant responses indicate a need for verbal confirmation when undertaking a task that requires coordination, but electronic or paper confirmations are adequate for information dissemination. Understanding the purpose behind the communication, whether to coordinate, disseminate information, or log events is important for the development of future communication tools.

Both TO and AT have a strong commitment to the safety of the NAS and take that responsibility very seriously. Both TO and AT said that their primary responsibility was to the facility, keeping the systems and equipment functioning so that it could run safely and smoothly. The most frequent example of this is the tendency for AT to coordinate items with the military or local TO before coordinating with the OCC. This finding underscores that there are some dysfunctional processes in TO and AT communication. Bringing this finding to the forefront allows decision makers to better align the processes with the purpose or goals.

We identified several factors as contributing to effective communication, with a major emphasis on an increase in shared awareness between TO and AT. Almost every person interviewed said that the coordination within a facility was very successful. They attributed this success primarily to an enhanced understanding of facility operations and constraints by on-site TO personnel and to a lesser extent, the method of communication, which was primarily face-to-face verbal communication.

Based on the results of this study, specific factors emerged that influence communication of system status between TO and AT. Some of these factors are interrelated; for example, an increase in shared information may lead to a decrease in calls requesting information. Decision makers can exploit these factors to improve communication efficiency within the NAS.

*1. Shared information*

Our results, based on the number of specific references to this topic, indicate that TO and AT lack a shared situational awareness on the overall NAS status. Both the TO and AT personnel indicated that a shared system for accessing event status would be beneficial. They made this suggestion with some caveats, however. AT personnel said that they would like such a system but only if it showed just the information they needed, primarily what the equipment was, what is the scheduled time for it to be out, what potential impact it had on NAS operations, and when it would be returned to service. They were concerned with being overwhelmed with information that was not necessary for their tasks. Additionally, we found that TO could benefit from enhanced knowledge about system impact, system interdependencies (such as who uses the equipment – especially radars), current and predicted traffic flows, current runway configurations, and weather.

*2. System integration*

We identified 19 individual systems used for information dissemination. Very few of these systems had any means for sharing or automatically transferring information. The result of having multiple systems that are not integrated is that someone has to manually transfer/enter the information from one system to another. Each time the data are transferred from one person or one system to another, there is additional workload and a possibility for errors.

Participants also specifically named the lack of integration between communication systems as a barrier to effective communication. This was especially apparent in the information flow on the AT side. Participants described receiving information from one source and having to type the same information into another system. Participants also described breaks in the flow of information when a hard copy of information is misplaced or does not go to the intended recipient.

*3. Use of automation to augment communication*

Data on the number of telephone calls from one OCC analyzed over a 4-day period show approximately 700 calls coming in and 1,000 calls going out daily. Outgoing telephone calls averaged 99:17 total minutes and incoming calls 31:29 total minutes. As there are three OCCs, this means that an estimated 297,000 minutes are spent on outgoing calls and 65,100 minutes are spent on incoming calls each day.

Yuditsky and Brickman (2006) conducted a study looking at the benefits of using an automated tool to augment the communication and coordination of information over the telephone. They found that transmitting the information by using an automated tool reduced time, workload and potential for user error. Specifically, time spent on coordination was decreased by more than half. Although the Yuditsky and Brickman study was conducted on Traffic Management Specialists and not TO Specialists, both Traffic Management Specialists and TO Specialists spend a significant amount of their time on coordination, logging and communication (referred to as information dissemination in this paper). Based on the results of the Yuditsky and Brickman study, there is reason to believe that the use of automation could reduce the amount of time spent on telephone calls, leading to reduced workload and increased efficiency. If an automated system could reduce the amount of time spent on the telephone by OCC specialists alone, by half, there is the potential to save more than 1 million hours each year, with even greater potential savings for TO as a whole. This time saved can allow the TO Specialists to focus their time and attention on critical maintenance tasks instead of coordination.

*4. Single point of contact*

One concern that emerged through the structured interviews was the impact of a many-to-many communication structure. For example, AT may contact TO about an event. A different person from TO may read the event ticket and want more information. That TO person may call AT, but it may be a different AT person that was originally contacted, and so on. One facility reported that multiple calls from an off-site TO facility to an AT facility became so problematic that it impacted AT operations. They resolved this problem by instituting a policy where there was a designated TO POC at the facility, and all requests for information went through this person.

*5. Enhanced speed of coordination with the OCCs*

The TO and AT personnel reported bypassing official formal coordination processes that required first coordinating with OCCs. There were two main reasons for adopting these procedures:

- **Time**. AT personnel reported that it usually takes less time to contact a local technician than it takes for the OCC to receive information, have that information routed to the appropriate OCC specialist, access the correct database of contacts for the specific equipment and location, and contact the appropriate technician.

  One participant described the information flow as follows: "[A system] goes out of service. AT calls the OCC. The OCC calls the local Tech. The local Tech calls AT to ask specific questions. The local Tech calls the OCC to explain the problem to them."

- **Local area knowledge/trust**. AT personnel reported that local TO personnel are more familiar with the needs of the facility. They also reported having a higher level of trust with local TO personnel based on relationships built over time. Specifically, they mentioned that
  - local personnel are more aware of the best times for preventative maintenance.
  - local TO personnel know which facilities rely on the same equipment and the degree of that dependence across those facilities.
  - OCCs were unaware of the importance of their equipment.
  - local personnel frequently found themselves speaking to someone at the OCC who was not certified to handle particular outages.

*6. Enhanced speed of coordination overall*

With the current number of event tickets estimated at approximately 1,000/day, and an average of three coordination points for each event, the time spent on coordination appears to have a significant impact on resources. Based on the structured interviews and OCC telephone records, the majority of the time spent on coordination is in relaying information over the telephone. The significant burden that coordinating events over the telephone causes for TO personnel indicates that it would be worthwhile to research ways to make coordination more efficient. We recommend that research be conducted on ways to expedite the coordination of events between TO and AT.

*7. Calls for information*

TO personnel specifically remarked that their work was impacted by multiple calls for information on an event. "We spend too much time updating people." They reported that these calls usually came from other TO personnel and that the information requested was already available electronically through MMS or EM. Further research is needed to determine specifically where these telephone calls originate and why they aren't using electronic information to answer their questions. This could be an indicator that the electronic system lacks usability, and people are unable to easily access the information that they need.

*8. Tailoring to specific information needs*

Information needs of TO are different than those of AT. This seems like an obvious statement, however, decisions that currently influence operations do not reflect an understanding of these differences. For example, at one facility, AT is given all of the information TO has on an event, increasing workload on both AT (who have to sift through the information for relevance) and TO (who are often asked to interpret the information for AT). We found that the primary information needs of AT from TO included what the equipment was, the scheduled time for it to be out, what potential impact it had on NAS operations, and when it would be returned to service. Providing AT with additional information not only did not benefit AT, it actually caused additional workload. TO has different needs, depending on whether the task at hand involves addressing an unscheduled outage or scheduling an outage. TO requires detailed information from AT about equipment and circumstances surrounding degradation or failure in order to diagnose or troubleshoot the problem. Additionally, participants reported that TO could benefit from enhanced knowledge about system impact, system interdependencies (Who uses the equipment - especially radars?), current and predicted traffic flows, current runway configurations, and weather. Participants said that these additional data could help TO plan requests for maintenance at times that would be more likely to be approved by AT.

This qualitative analysis of structured interview data enabled a deeper understanding of the current barriers to effective communication. Through these methods, we analyzed how communication existed in real operational environments. This is a critical perspective to take, as the NAS is a highly complex, dynamic environment. The analysis allowed us to go beyond what was previously known about TO and AT communication to reveal an understanding of the processes by which communication disparities may arise. The understanding of the processes underlying effective communication, partnered with an understanding of information needs and constraints, aids the development of more effective tools, processes, and procedures for TO and AT communication. An increase in communication effectiveness has the potential for decreasing NAS-related delays, decreasing workload, and increasing NAS safety.

## 5. CONCLUSION AND RECOMMENDATIONS

This study highlights the importance of a shared situational awareness on facilitating effective communication and identifies several potential factors central to facilitating effective communication between TO and AT. Researchers were able to extract high-level information needs and constraints key to effective communication based on participant responses. These conclusions cover the major themes that emerged from the interviews based on the number of participants whose responses aligned with the particular theme. Participants reported problems or difficulties they had with accomplishing tasks. Whereas the majority of the responses fit into the major themes, other concerns emerged but were expressed by fewer people. These concerns included decreased staffing, financial constraints, excessive administrative demands, and the nature of shift work–information transfer across shifts. We do not intend to diminish the importance of these concerns by not presenting them with the major themes.

By identifying the factors that influence the communication of status information between TO and AT, this study resulted in several suggestions for change. These suggestions could potentially streamline communications and reduce workload. Further research is needed in a simulation or in a controlled field study to quantify the benefit of the suggested interventions. Some recommendations for improvement that came out of this study include:

1. Provide a shared system for accessing event status.
2. Allow automatic information transfer between systems.
3. Investigate the use of automation to reduce the duration of calls.
4. Provide a single point of contact at facilities.
5. Enhance the speed of coordination, overall, as well as with the OCCs.
6. Enhance local area knowledge by the OCCs.
7. Reduce calls for information by providing easy-to-use online lookup tools.
8. Tailor information to specific user needs.

We describe these recommendations in more detail in the body of the report. Anecdotal evidence, based on user responses, indicates that implementing the recommendations contained in this report could reduce the likelihood of errors, reduce workload, and increase efficiency of the NAS. For example, based on previous studies on communication and coordination in the Traffic Management environment, there is reason to believe that the use of automation to augment coordination could reduce the amount of time spent on telephone calls, by half, with the potential to save more than 1 million hours annually, allowing more time to focus on system maintenance.

This study has several limitations which are worth noting. The recommendations in this study are derived from user input. Although the recommendations have a valid foundation, they may not all be applicable from a practical standpoint. That being said, effective communication is critical to NAS modernization. This report provides a starting point for improving communication.

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## Acronyms

| | |
|---|---|
| AF | Airway Facilities |
| AIS | Aviation Information System |
| ARTCC | Air Route Traffic Control Center |
| AT | Air Traffic |
| ATC | Air Traffic Control |
| ATCSCC | Air Traffic Control System Command Center |
| ATCT | Airport Traffic Control Tower |
| EM | Event Manager |
| ERIDS | En Route Information Display System |
| ESIS | Enhanced Status Information System |
| ETMS | Enhanced Traffic Management System |
| FAA | Federal Aviation Administration |
| GENOT | General Notice of Information |
| GI | General Information |
| IDS | Information Display System |
| KVDT | Keyboard Video Display Terminal |
| MBI | Mandatory Briefing Item |
| MMS | Maintenance Management System |
| NAS | National Airspace System |
| NOCC | National Operations Control Center |
| NOM | NAS Operations Manager |
| NOTAM | Notice to Airmen |
| NTML | National Traffic Management Log |
| OCC | Operations Control Center |
| OIS | Operational Information System |
| OM | Operations Manager |
| OPSNET | Operations Network |
| OS | Operations Supervisor |
| POC | Point of Contact |
| SAIDS | Systems Atlanta Information Display System |
| SAL | Simplified Automated Logging |

| | |
|---|---|
| SME | Subject Matter Expert |
| SOC | Service Operations Centers |
| SSC | System Support Center |
| STMCIC | Supervisory Traffic Management Coordinator-in-Charge |
| TMU | Traffic Management Unit |
| TO | Technical Operations |
| TRACON | Terminal Radar Approach Control |

# Appendix

# Reference Works

Reference Documents Including FAA Orders, Manuals, and Standard Operating Procedures

- 7210.3T (2004), Facility Operations and Administration
- 7210.55C (2004), Operational Data Reporting Requirements
- 7110.65N (2003), Air Traffic Control
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- Remote Periodic Maintenance and Certification SOP
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