Reducing the Information Scavenger Hunt to Improve Air Traffic Management Decision-Making

Catherine BOLCZAK[a] and Amanda M. STALEY[a]
[a]*The MITRE Corporation, 7515 Colshire Drive, McLean, Virginia, USA 22102*
cbolczak@mitre.org, astaley@mitre.org

ABSTRACT

Traffic managers (TMs) balance National Airspace System (NAS) capacity and air traffic demand in the face of daily variability and uncertainty. They construct a mental picture of the actual and predicted operational situations by combining observation of many different visual displays with data from multiple automated information systems. The MITRE Corporation's Center for Advanced Aviation System Development (MITRE CAASD) has developed a concept to address the TM's search through disparate information sources and the translation process required for air traffic management collaboration. A configurable portal has been prototyped with access to apps that replicate the mental integration currently performed by TMs and provide cues that alert them to potential problems, based on thresholds set by TMs. This paper describes the current air traffic management environment for the TM, the proposed concept, and the approach to the development of apps with an example of how an app integrates information for the TM.

KEYWORDS

Decision Making, Mental Model, Planning and Prediction, Aviation, Air Traffic Management.

INTRODUCTION

Obtaining common situation awareness has been repeatedly identified as an operational shortfall by Federal Aviation Administration (FAA) traffic managers (TMs).[1, 2] TMs balance National Airspace System (NAS) capacity and air traffic demand in the face of daily variability and uncertainty. They construct a mental picture of the actual and predicted operational situations by combining observation of many different visual displays (e.g., traffic, weather, airspace) with data from multiple automated information systems. The retrieval of relevant data to develop situation awareness can be a scavenger hunt through data fragmented across multiple systems. To coordinate potential solutions, TMs verbally communicate their mental picture of the operation to others who are impacted, who in turn have their own views and experience. Differences between these views must be reconciled to reach a decision.

The MITRE Corporation's Center for Advanced Aviation System Development (MITRE CAASD) is conducting research to address the TM's search through disparate information sources and the inefficient translation process required for air traffic management collaboration. Mental integration in and of itself is not necessarily a problem; however, it is by nature personalized. Since mental integration is currently a prerequisite to TM decision making, it leads to inconsistentcies in situation awareness formation, understanding the severity of issues, and eventual solution definition or coordination. The goal of the MITRE CAASD research described in this paper was to provide a quick reference portal of relevant operational information that replaces the scavenger hunt with a comprehensive, shareable, integrated system view. The configurable portal was intended to replicate the mental integration currently performed by TMs, provide cues that alert them to potential problems, based on thresholds set by TMs, and allow for a common view between TMs at non-colocated facilities to help air traffic management to operate in a cohesive manner.

This paper describes the current environment for the TM, the proposed concept – Traffic Flow Management Initiatives Performance Status (TIPS), an overview of the TIPS portal prototype, and the approach to the initial development of TIPS apps with an example of how an app integrates information for the TM.

THE AIR TRAFFIC MANAGER'S ENVIRONMENT

Air traffic management is distributed throughout all types of Air Traffic Control facilities, which have responsibilities as shown in Figure 1. While Air Traffic Control (ATC) is focused on tactical separation of individual aircraft, air traffic management is focused primarily strategically managing flows of aircraft. TMs balance air traffic demand with available system capacity to ensure air traffic controllers do not become overloaded. An overloaded situation, often referred to as congestion or a constraint, may be caused by either heavy traffic volume or by constraining factors, e.g. weather, navigation or surveillance equipment problems, or runway construction. TMs continually monitor predicted and current air traffic volume and constraining factors on several different systems. When there are capacity-demand imbalances, TMs may implement actions; for example, increasing the spacing between aircraft that are in an area of bad weather. This is because pilots frequently ask for deviations around the weather, which adds workload to the controller. TMs are located in some Air Traffic Control Towers (ATCTs), most Terminal Radar Approach Control (TRACONs), all Air Route Traffic Control Centers (ARTCCs), and at the ATC System Command Center (ATCSCC). The ATCSCC is a single facility that has overall responsibility for national air traffic management issues.

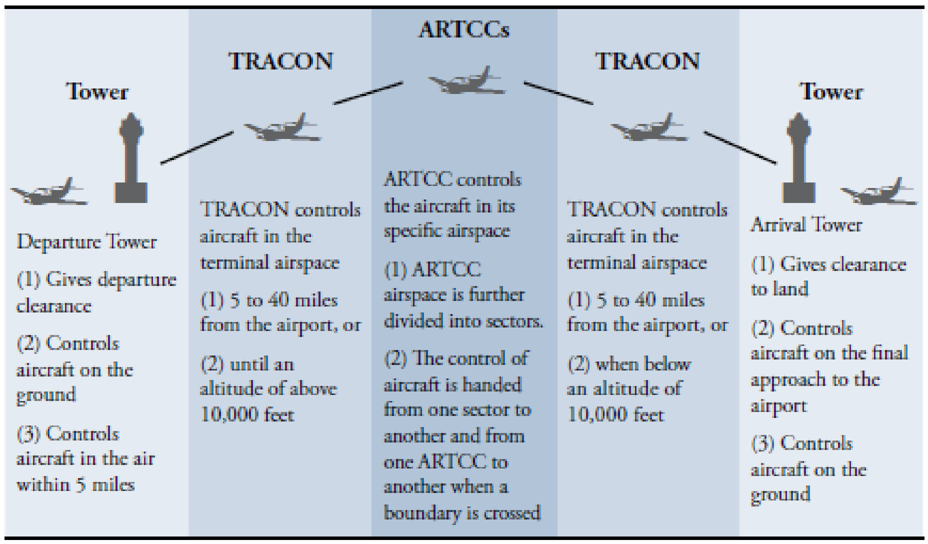
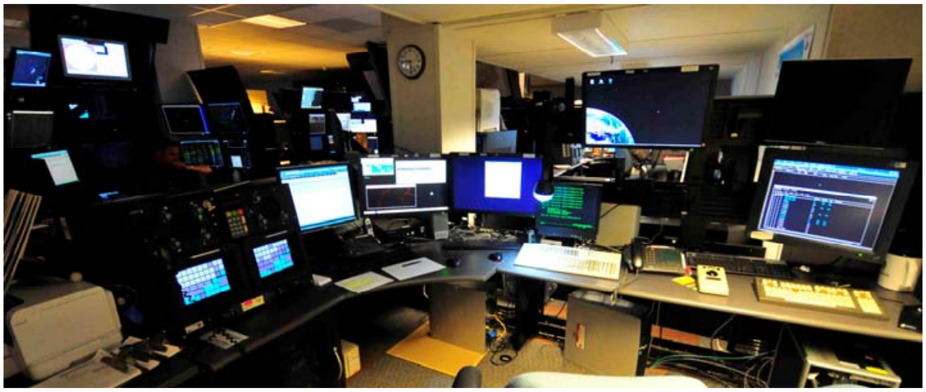


Figure 1. Air Traffic Facilities and Responsibilities[3]

TMs use a variety of systems, some of which are specific to the facility in which they are located. Most systems are in the NAS baseline, but there are also a number of "homegrown" tools developed to meet a particular facility's needs.[4, 5, 6] Predicted and current traffic volume is monitored on several systems, including the Traffic Flow Management System (TFMS), which includes the Traffic Situation Display (TSD) and Flight Schedule Monitor (FSM); Time Based Flow Management (TBFM) Timeline Graphical User Interface (TGUI) and geographical Plan-view Graphical User Interface (PGUI) displays; the Departure Spacing Program (DSP); the Airport Resource Management Tool (ARMT); and air traffic control displays. TMs also must glean predicted and current weather information from several systems, and then overlay their understanding of forecasts with the demand awareness to understand capacity impacts. Once actions, or Traffic Management Initiatives (TMIs), are proposed, analyzed, finalized, and coordinated, they are entered into another TFMS capability, the National Traffic Management Log (NTML), for issuance and dissemination.

Each of these systems offers functionality and data to help the TM do his or her job, but lack of integration among systems, and the need for the TM to consult multiple systems and displays, is challenging. Verbal coordination with other facilities is often required to ensure that all facilities are informed of a situation and working towards the same solution in complementary fashions. Figure 2 shows various complex TM positions with multiple displays.

(a) (b)



(c)

Figure 2. Various TM Positions in the NAS. (a) The Atlanta (ATL) Arrivals Position in the Atlanta ARTCC (ZTL), (b) The Supervisory Traffic Management Coordinator Position in the Washington ARTCC (ZDC), and (c) NAS Coordinator Position overlooking the Traffic Management Unit in ZTL *Photos: MITRE/CAASD*

THE TIPS CONCEPT

The TIPS concept envisons quick-reference access to relevant operational information that creates a comprehensive, shareable, integrated system view. The TIPS concept is intended to replicate and complement the mental integration currently performed by TMs and provide cues that alert them to potential problems, based on thresholds set by TMs. Earlier problem identification will enable TMs to implement problem resolutions that are more strategic and therefore more efficient than reactive solutions. Figure 3 is a high-level operational concept view of the TIPS concept.

The figure depicts the TM decision cycle – monitor NAS, identify constraint, analyze the constraint, plan a response, and act on a decision. The TM is scanning and querying multiple displays and systems, depicted in the picture of the workstation, building a mental picture of the current and future situation. TMs may become overwhelmed by numerous demands on his or her attention, such as phone calls, pending actions awaiting input, and walk-up requests. When a TM is focused on a high-priority task or urgent issue, he or she may lose sight of other system problems and actions requiring attention.

While it is extremely difficult for a human to maintain total situation awareness, there are some tasks that automation can do very easily; for example, processing multiple sources of data, computing and comparing values, and generating notifications and indications based on thresholds set by the TM. The TIPS concept is that automation works in the background constantly, freeing the TM to focus on activities that most require human experience and judgment, while providing a virtual "shoulder tap" to draw the TM's focus.

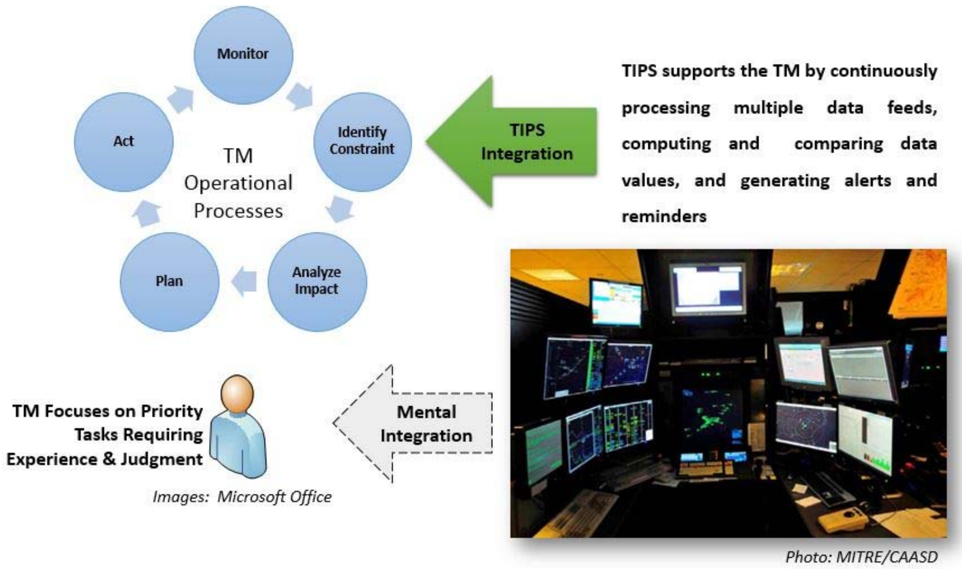


Figure 3. TIPS Operational Concept Overview

THE TIPS APP PORTAL

The technical approach to realizing the TIPS concept was to provide TMs with useful apps in a web-based portal. The apps were created by integrating existing and available data streams, based on data combinations and presentations prioritized by Subject Matter Experts (SMEs). In addition to meeting the operational needs and vision, this approach opened up possibilties for more agile capability acquisition to the FAA through small applications rather than expensive, proprietary platform-based systems, and innovative means of meeting user requirements through the use and flexibility of app stores.

The TIPS portal allows the TM to shift from scanning multiple displays as shown in Figure 2 to viewing a selectable set of performance indicators and other apps to assist with collaboration and decision-making. Alerting based on user-defined thresholds can be forced to notify the TM that attention is needed.

Figure 4 is a screenshot of the current TIPS portal prototype. The portal architecture is constructed with the Ozone Widget Framework, a government open-source software, which allows for app development with a variety of software technologies (e.g., Google Web Tools [GWT], Angular JS, Ruby on Rails) while still maintaining the ability to have cross-domain communication between different apps. The prototype illustrates access to apps developed under the MITRE CAASD research, as well as the ability to host other externally-defined apps and web pages that have published interfaces. The focus of the remainder of this paper is on the intial approach that was used to define and create apps that can replicate or complement TM mental integration.

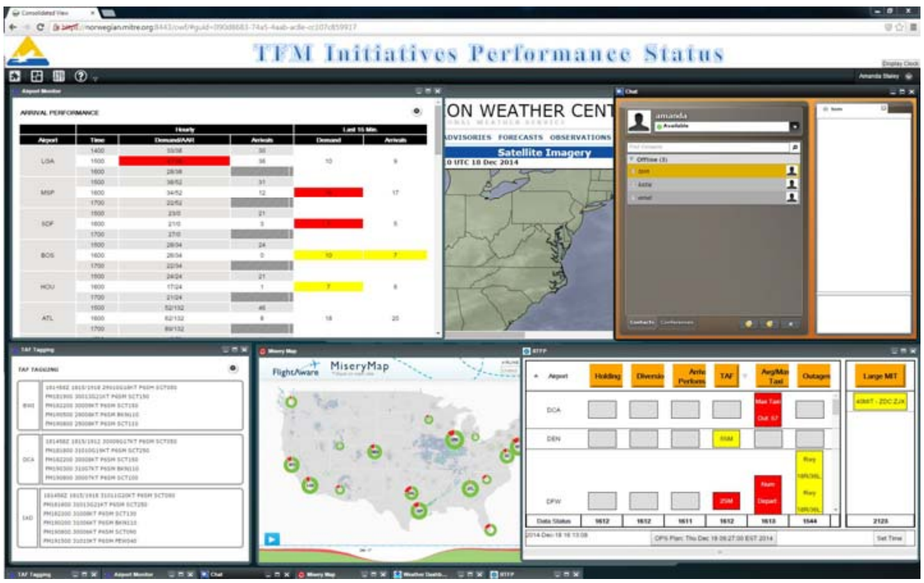


Figure 4. The Prototype TIPS Portal

APP DESIGN APPROACH

In order to build apps that replicate or complement mental integration and eventually reduce the need for it, MITRE CAASD developed a system engineering approach to capture how TMs gain situation awareness and make decisions.

It was crucial to formalize the design principles to ensure that app development moved data and information into focus for the TM, providing knowledge that would lead to understanding of impact. Following this model, initial efforts were focused on the decomposition of the air traffic flow management situation awareness challenge into information categories aligned with TM operational activities. An example of the methodology application is shown in Figure 5, depicting information integration required for Arrivals Management. Initially, an experiment was conducted with SMEs in which they were asked to prioritize information valuable to conducting their operational activities. During this experiment, the following types of questions were asked:

- What are the information gaps?
- What makes the job difficult?
- What is time-consuming?

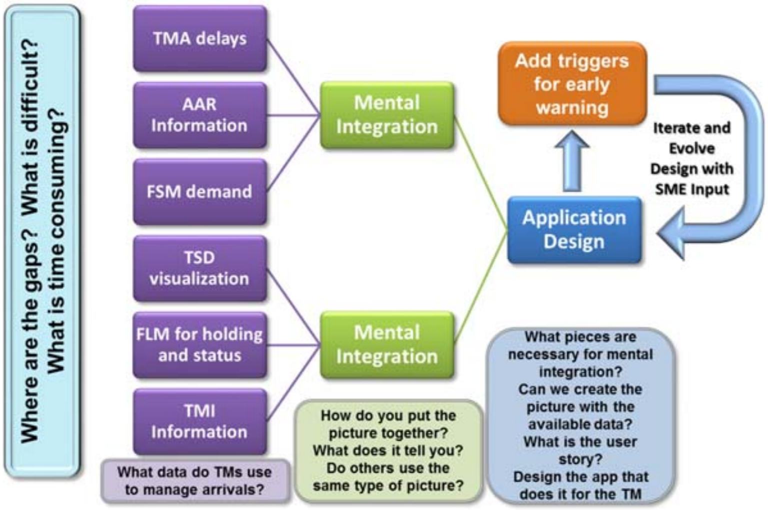


Figure 5. TIPS App Development Approach

Based on this discussion, a foundation set of information items was compiled. Subsequently, pair-wise combinations of information items were proposed and reviewed with the SMEs to ascertain which combinations would provide the greatest value. These combinations were used as the initial scope for identifying apps. In the experiment for the example illustrated above in Figure 5, the participant SMEs were asked to identify information that they needed to manage arrival flows of aircraft through their airspace of responsibility. Information identified included delay assignments, Airport Arrivals Rate information, and arrival demand from specific tools. The SMEs were prompted to further discuss how they put the picture together and how they use it. Once this information was collected, the next step was to determine how the mental integration described by the SMEs could be captured by integrating available data and presenting it in a meaningful way. The presentation included raw values and indicators of system performance, by, for example, color-coding numbers that exceed a particular threshold value.

This work led to preliminary design and development of the initial set apps, including:

- Airport arrival monitoring for advertised acceptance rates, actual arrival rates, demand information, and delay information,
- Airborne holding for coordination and awareness of impacted airspace sectors and elapsed durations,
- Terminal Airport Forecast (TAF) tagging for highlighting airport-specific weather constraints in forecasts, and
- Traffic Management Initiative (TMI) awareness for providing status and performance information of current TMIs.

Each of these apps was designed to provide useful information to the TM, in an easy to use manner, with selectable thresholds. They were designed to combine related data from multiple sources into a single location, to save keystrokes, to be a sharable resource, and to enable TMs to spend more time managing traffic, and less time searching automation systems.

EXAMPLE APP: AIRPORT ARRIVALS MONITOR

An example app developed was the Airport Arrivals Monitor app, a snapshot of which is shown in Figure 6. This app shows, for a user-selected set of airports, airport arrival demand versus Airport Acceptance Rates (AAR), and how many actual arrival aircraft landed. Information is continually updated as it is received from the data sources, providing users a rolling view of actual demand and actual arrivals over the last 15 minutes. This rolling update contrasts with the more static quarter-hour counts that TMs currently acquire through scanning displays. The color coding indicates potential demand-capacity imbalances; for example at Philadelphia International Airport (PHL), the app shows that the demand is 59 arrivals, while the airport says it can accept only 52. In addition, over the last 15 minutes, 21 aircraft were scheduled to arrive, but only 15 landed. If this trend continues and demand backs up, aircraft may be delayed in the air through holding or other measures that add workload to controllers and burn fuel for airlines. By identifying this trend early, the TM can proactively coordinate actions to avoid these undesirable measures. Thresholds for these performance indicators can be set by the user. Research is continuing into how thresholds should be set when there are multiple decision-makers from different facilities involved.

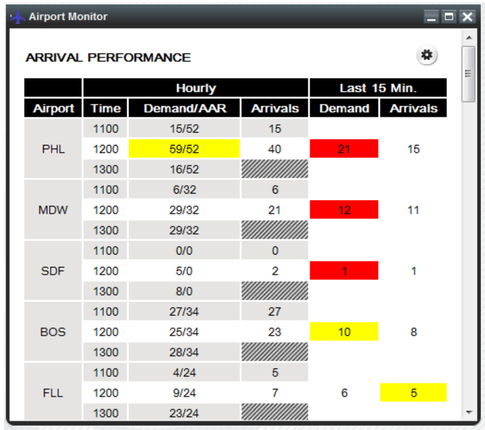


Figure 6. TIPS Airport Arrivals Monitor App

CONCLUSION

This paper described the development of a proposed concept to address the current inefficient and individualized method of obtaining situation awareness in the traffic flow management domain of aviation. An approach to defining operationally relevant information for concatenation, aggregation, and presentation has been illustrated through the use of facilitated SME discussions resulting in user situation awareness needs and requirements definition. Many of the systems available to traffic managers in today's operational environment provide an abundance of data and information, but it can be scattered and potentially buried amongst multiple displays or even multiple systems. This research has identified and applied simple, fundamental design principles requiring that developed apps must focus available data and information together appropriately to lead to TM knowledege allowing for them to have positive impact on the operations. With this perspective, the TIPS concept and portal prototype has been formulated to provide TMs access to system performance and other apps that provide useful information to the TM, in an easy to use manner, with selectable thresholds. The apps enable TMs to spend more time managing traffic, and less time seeking information from automation systems, which is crucial to realizing operational efficiencies and associated benefits.

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NOTICE

This work was produced for the U.S. Government under Contract DTFAWA-10-C-00080 and is subject to Federal Aviation Administration Acquisition Management System Clause 3.5-13, Rights In Data-General, Alt. III and Alt. IV (Oct. 1996).

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