Traffic Flow Management Concept of Operations for Flow Management Data and Services (FMDS) for Investment Analysis Readiness Decision (IARD)

February 2022

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1 Introduction

The National Airspace System (NAS) is a dynamic system that must respond to variability in weather, system constraints, and traffic demand. The fundamental goal of Traffic Flow Management (TFM) is to promote a safe, orderly, and expeditious flow of traffic that minimizes delays. This is achieved through coordination, utilization, and analysis of Traffic Management Initiatives (TMIs) that modify demand to account for changes in capacity.

Today, the Traffic Flow Management System (TFMS) provides tools for users to develop, coordinate, issue, and manage TMIs that balance flight demand and NAS capacity. However, those tools have reached end of life and are exhibiting accuracy and latency issues, as well as shortfalls in reliability, maintainability, and availability (RMA). The core functions that TFMS supports are summarized in Figure 1-1.

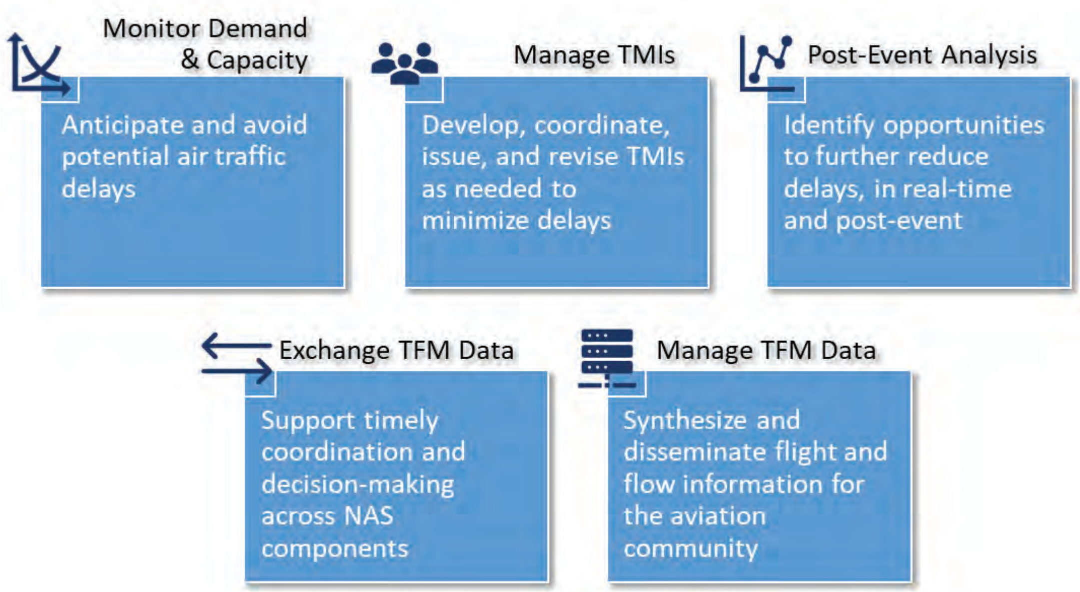

Figure 1-1. TFM Functions

This Concept of Operations provides a vision for the initial deployment of Flow Management Data and Services (FMDS), a new incarnation of TFMS that will meet the operational, RMA, and performance needs of its users. FMDS is expected to be deployed in 2027. Although FMDS is not anticipated to make significant changes to TFM roles and responsibilities relative to the current system, it is a key step in realizing the future TFM vision and maturing the transition to Trajectory Based Operations (TBO) [1].

FMDS is envisioned to leverage new technologies and a new approach to software development and deployment to accelerate the delivery of TFM automation capabilities. FMDS will employ a new software architecture that will align with evolutions in the FAA Enterprise Architecture and infrastructure. The new architecture and infrastructure will allow TFM activities to scale to projected air traffic growth. With an architecture designed for flexibility and extensibility, FMDS will provide a foundation for future TFM capabilities that can leverage new technologies and operate in a more interconnected operational and technical environment. In meeting this vision, FMDS will address shortfalls in TFMS related to the inability of its architecture and hardware to support long-desired features and functions.

FMDS will provide a streamlined user experience for a broad array of users within and external to the Federal Aviation Administration (FAA). FMDS will also provide a foundation for efforts to achieve future FAA goals such as [2, 3, 1]:

- Quickly identify lessons learned to better support continuous TFM planning processes.
- Gate-to-gate integration of flight and flow data.
- Standardize operational metrics across TMIs and planning timeframes.
- Integrate new entrants into the NAS.
- Improve response of NAS operations to uncertainty.
- Improve underlying TFM algorithms to better support predicting and managing demand and capacity.

1.1 Background

TFMS is the result of modernization of the Enhanced Traffic Management System (ETMS). ETMS was a prototype developed organically from the late 1980s through the early 2000s to support TFM functions conducted by traffic managers at Air Route Traffic Control Centers (ARTCCs) and the Air Traffic Control System Command Center (ATCSCC). It evolved into the framework for conducting Collaborative Decision Making (CDM) and therefore expanded its user base to include Terminal Radar Approach Controls (TRACONs), Air Traffic Control Towers (ATCTs), NAS users, and international air traffic control (ATC) organizations. The data produced by ETMS and, later, TFMS, became crucial to NAS users, other external organizations, and the flying public to maintain awareness of NAS operations and status.

In recent years, TFMS users' operational needs for availability, accuracy, and system response times have increased to a point that exceeds the current system capability. A recent technical refresh at the TFMS Remote Sites (TRSs) was unable to address all the performance issues, and obsolescence of the current software may preclude another technical refresh. The TFMS Program Office investigated the root causes of TFMS outages, identified system shortfalls, and developed recommendations for improving RMA and performance [4, 5]. The FAA is pursuing many of these recommendations as part of the FMDS program.

1.2 Definition of Key Terms

This section defines terms used in this document that may be interpreted differently by different readers. The descriptions provided here define the terms *as they are used in* *this document*. This is not intended to be a complete glossary for FMDS, nor is it intended to provide definitions for all terms relevant to traffic flow management.[1]

Traffic Flow Management (TFM) is defined on the FAA website [6] as follows:

> "A 'system approach' to managing traffic that considers the impact of individual actions on the whole. Managing disruptions in airspace capacity (caused for example by bad weather, traffic [volume], or emergencies) requires consideration of who or what may be impacted by events, and a coordinated mitigation effort to ensure safety, efficiency and equity in the delivery of air traffic services. Without a coordinated response, local flight delays due to small disruptions can quickly ripple across the entire U.S., causing large scale rerouting, flight cancellations, and significant widespread delays."

TFM in the NAS is overseen by the ATCSCC. Traffic management also takes place in the ARTCCs, TRACONs, and ATCTs, and in collaboration with other NAS stakeholders, including the airlines, general aviation (GA), and the military.

The term ***TFM automation system*** is used in statements that are equally applicable to TFMS or FMDS. If the statement is applicable to only one, the specific automation system name (i.e., TFMS or FMDS) is used.

NAS resources include the airports, airways, fixes, ATC sectors, and other features of the NAS that TFM personnel can use in TMI definitions.

Traffic management initiatives (TMIs) are techniques used to balance demand with capacity, including Ground Delay Programs (GDPs), Airspace Flow Programs (AFPs), Collaborative Trajectory Options Programs (CTOPs), Miles-in-Trail (MIT), Minutes-in-Trail (MINIT), reroutes, and other techniques defined in procedures [7].

The term ***traffic managers*** includes Traffic Management Specialists (TMSs), Traffic Management Coordinators (TMCs), National Operations Managers (NOMs), and other FAA personnel from different types of facilities that today use TFMS to support TFM functions. There are multiple personnel within many facilities with a variety of job titles that perform similar TFM functions. At some facilities or during certain time periods, even ATC personnel act in a TFM role. For brevity, this document collectively refers to these users as traffic managers.

NAS users are individuals and organizations who operate aircraft in the NAS, and who currently use TFMS applications and data to maintain awareness of TMIs and other constraints.

The term ***user***, with no qualifier, refers to any TFM automation system user, including FAA users, NAS users, and others. A complete list of users is provided in Section 2.1.

Collaborative Decision Making (CDM) "is a joint [FAA] and aviation industry endeavor aimed at improving [TFM] through increased data and information exchange among aviation community stakeholders. … CDM is an operating paradigm where TFM

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[1] For detailed discussions of TFM concepts, see the TFM Learning website: https://tfmlearning.faa.gov/

decisions are based on a shared, common view of the NAS and an awareness of the consequences these decisions may have on the system and its stakeholders" [8]. CDM is both: 1) the philosophy that stakeholders should share "operational information, ideologies and preferences" to build a common view of the NAS; and 2) the tools and procedures that support this information sharing to produce TFM decisions and actions that are best for the NAS. "Participation in CDM is limited to qualified aviation and aerospace related entities that support the specific data-sharing criteria defined in a CDM Agreement" [8].

A ***CDM member*** is a NAS user organization that: "(1) provides raw CDM data to the FAA, (2) receives processed CDM data from the FAA, and (3) collaboratively works with the FAA [TFM] function in responding to NAS demand-capacity imbalances and other system constraints" [9]. The FAA aggregates the data provided by all CDM members, uses it to support the CDM process, and distributes it to all CDM members.

A ***software service*** is a software functionality or set of functionalities that different software clients can use for different purposes, along with the rules that should control its usage. One such rule might control the data available from the service based on the identity of the client requesting the service. An example service might support retrieval of specified information or the execution of a set of operations [10]. FMDS is envisioned to leverage shared services to avoid duplication of functionality within the system.

The software service is the primary component for implementing functionality in a ***microservices architecture.*** In a microservices environment, services are self-contained and loosely coupled, such that they "can be individually designed, developed, tested, and deployed with little or no dependency on other components or services in the application" [11]. FMDS is envisioned to leverage a microservices architecture, in alignment with the NAS Automation Evolution Strategy [25].

1.3 Problem Statement

TFMS does not meet its RMA and response time requirements and is expected to become untenable within the next few years. The system has become a patchwork of disparate applications that traffic managers must employ individually at various stages of a single TFM activity. This disjointed process leads to inefficient TFM and complicates post-event analysis. Furthermore, evolution of TFMS capabilities has slowed due to the cost of adding modern functionality to an archaic system architecture and the need to expend an increasing portion of development resources to address reported system problems.

The TFMS shortfalls and needed FMDS capabilities, as documented in the Shortfall Analysis Report [12], are summarized in Table 1-1.

Table 1-1. TFMS Shortfalls and FMDS Capabilities

TFMS Shortfall Category	TFMS Shortfall Description	Shortfall Example(s)/Measure(s)	FMDS Capabilities
SF-1: Unacceptable performance and a lack of expandability and scalability prevent TFMS from meeting evolving needs.	SF-1.1: TFMS no longer meets the necessary availability and reliability for effective TFM operations.	Examples of workarounds traffic managers employ to account for TFMS performance limitations. Accumulated length of outages due to maintenance actions to prevent system or component performance degradation. Count of problem tickets associated with system response time. Count of TRS support incidents and affected hardware.	FMDS will provide a standards-based microservices architecture that will meet system RMA requirements to address operational needs.
	SF-1.2: Key TFMS components cannot meet peak operational performance needs and can be inefficient during routine operations.	Operational workload values that exceed TFMS design thresholds for number of active flights, Flow Evaluation Areas (FEAs) and Flow Constrained Areas (FCAs), FEA/FCA-related actions, flight list requests, and Monitor Alert reports.	A modernized architecture and infrastructure will allow FMDS to meet operational requirements for performance, reliability, and availability.
	SF-1.3: TFMS cannot support planned future enhancements and updates.	Examples of enhancements approved for TFMS acquisition that were delayed, deferred, and/or rescoped due to TFMS limitations.	The FMDS architecture will support future enhancements.

TFMS Shortfall Category	TFMS Shortfall Description	Shortfall Example(s)/Measure(s)	FMDS Capabilities
	SF-1.4: TFMS includes multiple types of data interfaces that are unintegrated and difficult to maintain and update.	Count of problem tickets related to data interface problems.	FMDS will modernize and standardize data interfaces and leverage NAS enterprise data services to reduce the footprint and complexity of deployed software and hardware.
SF-2: Lack of a comprehensive failover strategy prevents continuity of operations.	SF-2.1: TFMS lacks a comprehensive failover strategy for loss of service.	Outage durations for TFMS patch installations.	FMDS will employ a comprehensive failover strategy to maintain high levels of reliability and availability.
	SF-2.2: TFMS lacks a comprehensive, timely response to major disaster failures.	Documentation of TFMS capabilities not provided by the Disaster Recovery Center (DRC). Complexity and length of DRC activation process.	FMDS will provide a comprehensive disaster recovery plan to ensure availability of capabilities when a failure occurs.
SF-3: Lack of integrated capabilities inhibits consistent operational system-wide views, operational decision-making, and usability of the system.	SF-3.1: TFM operational decision-making requires manual assimilation of data from a variety of sources due to piecemeal operational information, decision-making, and tools.	Amount of time wasted by traffic managers entering information in multiple applications for MIT restrictions.	FMDS will provide a streamlined application suite that supports TFM workflows and eliminates redundant manual data entry.
	SF-3.2: TFMS user interfaces are graphically and functionally inconsistent and complex.	Examples of user interface inconsistencies that inhibit usability of TFMS capabilities.	The FMDS user application suite will provide a consistent look and feel with a modernized user interface (UI) that will improve usability, increase efficiency, and reduce opportunities for user error.

TFMS Shortfall Category	TFMS Shortfall Description	Shortfall Example(s)/Measure(s)	FMDS Capabilities
	SF-3.3: TFMS applications are not integrated and provide duplicative functionality.	Examples of data inconsistencies and duplication of functionality across applications that increase system complexity.	The streamlined FMDS user application suite will integrate functionality to support TFM workflows.

1.4 Concept Overview

FMDS will provide a reliable TFM automation system with a modernized architecture that will increase reliability and reduce response time. A microservices architecture will provide flexibility to the FAA for implementing capabilities and leveraging enterprise services. A modernized architecture will also support future enhancements. As much as possible, FMDS will leverage enterprise services. Functions needed by multiple applications (and automation systems) will be implemented as shared services. This will avoid duplication of functions and data across services, applications, and automation systems, which will simplify development and maintenance. A modernized architecture will also improve the processes for providing system support, from reducing the need for synchronizing data on the backend to providing visibility into system and component performance to prevent system failures.

TFM automation system functions will be implemented in a streamlined interface that will improve the user experience. The consolidated application suite and improved performance of FMDS will allow traffic managers to view all traffic, TMIs, and weather in one integrated application, allowing for more proactive and efficient execution of TFM actions. Today, traffic managers collect information electronically but manually log it. FMDS will support automated logging of common information, reducing traffic manager workload associated with entering duplicate data across applications. Automated logging will also make it easier for traffic managers to share information with multiple facilities, improving electronic coordination.

NAS users will access information about NAS operations and collaborate with traffic managers in new ways. The various TFMS web applications that NAS users must currently monitor separately will be streamlined and accessible via a centralized portal. NAS users will be able to subscribe to notifications of changes in TMIs, operations plans, and other information, relieving them from the need to poll or scrape[2] several websites. CDM members will transition away from the use of local instances of the Flight Schedule Monitor (FSM) application, as its functionality will be included in the integrated situation awareness display application. To support this transition, FMDS may provide application programming interfaces (APIs) that will allow CDM members to access data and services they can use to model the impact of TMIs on their flights. Alternatively, or in addition, FMDS may provide CDM members access to a web-based version of the integrated situation awareness display that will allow them to perform similar tasks as they can do today via FSM and the remote desktop version of the Traffic Situation Display (TSD) application.

Post-event analysis will be supported by a searchable store of the data FMDS presents to users, data exchanged among FMDS users/facilities, and data exchanged among the underlying software services and automation systems. The data store will support better understanding of series of events and their impacts on NAS operations and will provide improved replay capabilities.

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[2] Web scraping is an automated process for periodically downloading and extracting data from a web page.

FMDS will use NAS enterprise services and standard industry data formats when appropriate to minimize the number of different data structures utilized and duplicate functionality across systems. This will allow for simplified internal maintenance and updates and will ease data sharing across NAS automation systems.

1.5 Alignment

FMDS is a solution-level concept, as illustrated in Table 1-2.

Table 1-2. FMDS Concept Alignment

Level	Layer	Concept
0	Global	ICAO Doc 9971: Manual on Collaborative Air Traffic Flow Management
1	Enterprise	Charting Aviation's Future – Operating in an Info-Centric NAS Enterprise Information Management
2	Service	Performance Based Flow Management (PBFM) FFM: The Corporate Plan for Future TFM Collaborative Air Traffic Management System Wide Information Management (SWIM)
3	Sub-Service	N/A
4	Solution	Flow Management Data and Services (FMDS)

FMDS aligns to Business and Technology Improvement (BTI) number 508120, Improved Automation Infrastructure, described in Table 1-3.

Table 1-3. FMDS Alignment to BTI

BTI Number	BTI Description
508120	Improved Automation Infrastructure

FMDS aligns to the Next Generation Air Transportation System (NextGen) Operational Improvement (OI) Increments summarized in Table 1-4.

Table 1-4. FMDS Alignment to OI Increments

ID	Number	OI Increment Description
1	105210-01	Improve Demand Predictions
2	105210-02	Integrate TMI Modeling
3	105210-03	Improved Integration of Traffic Flow Management Operations
4	105210-04	Aircraft Equipage Eligibility During TMIs

ID	Number	OI Increment Description
5	105211-01	Integrated Departure Route Planning
6	105303-24	Enhanced Post Operations

The BTI and OI Increments align to the FMDS opportunities as shown in Table 1-5.

Table 1-5. FMDS Capabilities Mapped to BTI and OI Increments

FMDS Capability	BTI	OI 1	OI 2	OI 3	OI 4	OI 5	OI 6
FMDS will provide a standards-based microservices architecture that will meet system RMA requirements to address operational needs.	X	X	X	X			
A modernized architecture and infrastructure will allow FMDS to meet operational requirements for performance, reliability, and availability.	X	X	X	X	X	X	X
The FMDS architecture will reduce the footprint and complexity of deployed software and hardware, leverage NAS enterprise data services, and support future enhancements.	X	X	X	X	X	X	X
FMDS will employ a comprehensive failover strategy to maintain high levels of reliability and availability.	X						
FMDS will provide a comprehensive disaster recovery plan to ensure availability of capabilities when a failure occurs.	X						
FMDS will provide a streamlined application suite that supports TFM workflows and eliminates redundant manual data entry. The user application suite will provide a consistent look and feel with a modernized user interface (UI) that will improve usability, increase efficiency, and reduce opportunities for user error.	X	X	X	X		X	X

2 “As is” Operations

TFMS primarily supports traffic managers and NAS users in monitoring demand relative to capacity, assessing the impact of constraints such as weather on NAS operations, and coordinating TMIs to address demand-capacity imbalances, as shown in Figure 2-1.

Figure 2-1. Current Operational Environment

The following subsections introduce the TFMS users, their relative organization and use of TFMS, the TFMS applications, and illustrate how the TFMS shortfalls impact their work.

2.1 TFM Automation System Users

TFM automation system users include internal FAA users and users external to the FAA, as shown in Table 2-1. FMDS will continue to support the system users identified in Table 2-1.

Table 2-1. TFM Automation System Users

Internal FAA Users	External Users

• Traffic managers at different facilities, including ATCSCC, ARTCCs, TRACONs, and ATCTs
• Air traffic control personnel, including:
  o Operations Supervisors
  o Operations Managers
  o Air traffic controllers
• Quality control (QC) personnel
• System analysts
• Training personnel
• System administration and support:
  o System specialists
  o System administrators
  o Software engineering support
	• NAS users:
	  o Domestic and international air carriers
	  o Commercial operators
	  o General aviation
	  o Flight Plan Service Providers[3]
	  o Military
	• Flying public
	• International ATC organizations
	• External users of TFM automation system data

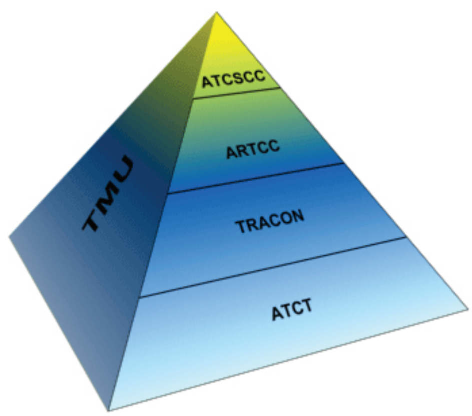

Figure 2-2. Relative Organization of ATC Facilities

The core group of internal FAA users includes traffic managers at different facilities, including the ATCSCC, ARTCCs, TRACONs, and ATCTs (see Figure 2-2). Each type of facility has a different area of focus within the NAS, and therefore a different scope of TFM decision-making. Their access to TFMS capabilities reflects that scope. For example, "the ATCSCC monitors and manages the flow of air traffic throughout the NAS, producing a safe, orderly, and expeditious flow of traffic while minimizing delays" [7, pp. 18-1-1]. ATCSCC traffic managers, including a NOM, multiple National Traffic Management Officers (NTMOs), and multiple National Traffic Management Specialists (NTMSs) "direct the operation" of TFM in the NAS [7, pp. 18-2-3], interacting with facilities where there are authorized traffic management personnel (see Figure 2-3). The ATCSCC is the focal point for traffic management in the NAS and is the final approving authority for TMIs that impact multiple ARTCCs. ATCSCC traffic

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[3] Flight plan service providers access TFM data on behalf of their customers to support flight planning and replanning.

managers coordinate with ARTCC, TRACON, and ATCT traffic managers and NAS users as appropriate to [7]:

- Monitor NAS components and weather to determine when capacity is likely to be reduced and TMIs will be required.
- Reroute flows of traffic as needed.
- Implement national TMIs including time-based metering (TBM), GDPs, AFPs, and CTOPs.
- Evaluate proposed TMIs throughout the NAS for appropriateness.
- Monitor TMIs issued throughout the NAS for effectiveness.
- Manage airspace relevant to space launch and reentry operations.

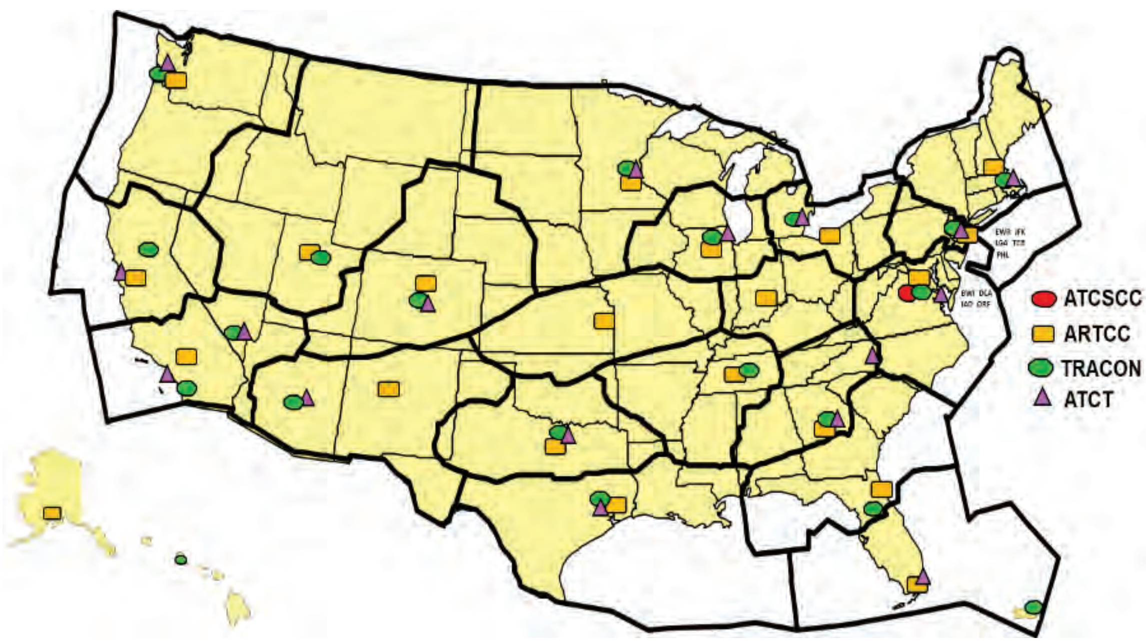

Figure 2-3. TFM Facilities Across the NAS

Meanwhile, ARTCC traffic managers, including a Supervisory Traffic Management Coordinator (STMC), multiple TMCs, and the Center Weather Service Unit (CWSU), “monitor and balance traffic flows within their areas of responsibility in accordance with [TFM] directives” [7, pp. 18-1-4]. Their responsibilities include [7]:

- Implementing TMIs “in conjunction with, or as directed by the ATCSCC” [7, pp. 18-2-4].
- Ensuring that the ATCSCC is advised of all changes within their area of responsibility that could significantly impact the system and all agreements with other facilities related to TMIs.
- Coordinating TFM actions with adjacent facilities through the ATCSCC.
- Implementing TMIs to manage traffic within their area of responsibility.

- Logging all TMIs and TFM actions.
- Coordinating with TRACON traffic managers to develop strategies to manage arrivals and maintain airport arrival capacity.
- Reporting delays according to FAA policy.
- Managing civil aviation traffic in the vicinity of active Special Activity Airspace (SAA).

Large TRACONs have traffic management units (TMUs) that are organized similarly to those at ARTCCs, whereas small TRACONs and ATCTs have at least one staff member responsible for acting as a TMC for their facility. They coordinate with relevant ARTCCs (typically the ARTCC overlying their facility), neighboring TRACONs, and the local ATCT(s) to balance traffic flows with capacity. They coordinate with ATCTs to manage airport and airspace configurations. TRACON traffic managers may participate in teleconferences with ARTCC and ATCSCC traffic managers, but it is rare for a TRACON to coordinate directly with the ATCSCC without the participation of the ARTCC.

Multiple additional FAA users interact with TFMS and/or the data it produces. In addition to viewing TMI information from TFMS, air traffic controllers interact with TFMS via Airborne Reroute (ABRR) and Pre-Departure Reroute (PDRR). TFMS sends reroutes issued via ABRR/PDRR to En Route Automation Modernization (ERAM), and the controller either applies or rejects the route amendment. ERAM then returns this controller response to TFMS.

QC personnel and system analysts use TFMS applications and data for post-event analysis. Training personnel use TFMS to support TFM training activities. In the context of this document, TFMS users also include system administration and support personnel responsible for maintaining TFMS software, hardware, and communication infrastructure.

Other FAA automation systems use the data that TFMS produces. For example, ERAM receives route amendments from TFMS for controllers to issue to aircraft, as noted above. Other NAS systems receive TFMS information about TMIs and their impact on flights via the TFMData SWIM service. TFMData includes both a flight information service that provides flight plans and track data, and a flow information service that provides TMI data. TFMS also exchanges flight and traffic management data with international ATC automation systems to support operations planning.

External user groups that leverage TFMS data include NAS users that receive information about NAS operations, constraints, and initiatives from various TFMS applications. CDM members are a subset of NAS users that have an explicit role in TFM decision-making and have access to certain TFMS capabilities that are not available to other NAS users (although some TFMS features are available only to traffic managers).

Other external users leverage flight and flow data from TFMData to participate in flight tracking, planning, post-event analysis, maintenance, engineering, and research and development activities, as well as third party commercial organizations that provide access to NAS data for a variety of customers.

2.2 TFMS Applications

TFMS capabilities are provided via a collection of applications that have evolved over the last 20+ years. Some of the applications run locally on a TRS workstation, while others are web-based. Both TRS desktop and web applications use data provided by the TFM Production Center (TPC), which is a centralized site for receiving, processing, and synchronizing data from external sources and the TFMS applications. The web applications are hosted at the TPC but in the Auxiliary Subsystem, which includes three separate zones allowing varying access controls to users. The exchange of data between TRS applications and the TPC is accomplished via a patchwork of technologies – many of which are proprietary and outdated – that duplicate functionality, introduce latency into the display of data to users, and hinder implementation of desired capabilities. This section introduces several TFMS applications that are frequently named in this document.

The desktop applications, listed below, are used for monitoring the NAS, modeling and issuing TMIs, and logging and communicating the TMIs across facilities. FMDS will ensure TFM system users have access to functionality like that provided by these applications. Traffic managers also routinely use TMIs developed in and issued from Time Based Flow Management (TBFM) as part of their TFM strategy and decision making. However, as TBFM is a separate automation system from TFMS, it will not be addressed in this document except in relation to TFMS.

The following are the most frequently used desktop applications:

- **Traffic Situation Display (TSD):** Displays geospatial, flight, and weather data on a map. It also provides text reports, alerts (e.g., NAS Monitor), and FEA/FCA timelines and bar charts. The TSD is used by traffic managers to model and issue FEAs, FCAs, Reroutes, and CTOPs. CDM members can access a web-based, read-only version of the TSD (referred to as the “thin-client”).
- **Flight Schedule Monitor (FSM):** Shows demand and capacity at airports and FEAs/FCAs and is used by traffic managers to model and issue GDPs, Ground Stops, and AFPs. Many CDM members have locally installed versions of FSM they can use to model the impact of proposed and issued TMIs on their operations.
- **National Traffic Management Log (NTML):** Used by traffic managers to issue TMIs such as MIT restrictions and to log alerts and events. NTML automatically collects certain data and distributes NAS operational data among TFMS users to support electronic coordination. Some data from NTML is passed to the Operational Information System (OIS),[4] where NAS users can access information about NAS operations.
- **Enhanced Status Information System (ESIS):** Used by traffic managers to communicate TFM-related NAS status information to air traffic controllers and

[4] The public-facing website for the OIS has been redesigned and renamed to be the NAS Status page, but the data provided on that site is still driven by the OIS. FAA facilities and authorized NAS users still access OIS. This document generally refers to this information sharing capability as OIS.

other operational personnel within a facility. Limited integration with NTML allows some restrictions and edits to be posted to the ESIS display from NTML. However, a TFMS workstation is only allowed to send or edit a locally created TMI to ESIS if it was created at that workstation.

- **Route Management Tool (RMT):** Provides three separate sets of capabilities for different groups of users:
    - Adaptation specialists can create, edit, and coordinate changes to all stored traffic management routes, such as Coded Departure Routes (CDRs) and Playbook Routes (not in real-time with the operation).
    - Traffic managers can search for and display specific routes in real-time with the operation, along with determining which routes avoid weather.
    - NAS users and FAA users can export specific data for use in adaptation data sets for other systems, such as the Reroute Manager (listed below).
- **Surface Viewer (SV):** Displays aircraft locations on the ground at select airports,[5] providing traffic managers in ARTCCs and other traffic management facilities access to information from the Terminal Flight Data Manager (TFDM).

These six primary desktop applications are supported by ancillary applications available on the TFMS workstation, including:

- **Preference (Pref) Set Manager:** Enables users to save and recall customized TSD configurations across workspaces on a single workstation. Pref sets cannot be shared across workstations.
- **Reroute Manager (RRMGR):** Used to query adaptation data to aid in constructing reroutes. It provides static information on airport/Navigational Aid (NAVAID)/fix identifiers, preferred routes, major traffic flows, and parsed routes. It also displays whether filed routes are compliant or non-compliant with published route advisories.
- **TFMS Messaging Application:** Used by traffic managers to create advisories or general messages. Advisories publish information about TMIs to other TFMS applications and users. General messages are like email messages that traffic managers can send to other TFMS users.
- **TFMS Reports:** Allows users, including traffic managers, to create reports that provide information about TMI performance and other aspects of NAS operations, in addition to the hard-coded reports available through the TSD command line. Some of the reports support real-time TFM decision-making, whereas others support end-of-day reporting and/or post-event analysis.
- **Pop-Notify:** Provides users with notifications of various messages, such as advisories or receipt of reports.

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[5] The Surface Viewer application was deployed as part of TFMS R14 in October 2021, but not activated. At the time of writing, a date for activation of the SV application has not been published.

- **Global Secure Desktop (GSD):** Allows sites that are not TRSs to access the TSD and FSM applications through a remote desktop. CDM members use GSD to access the TSD, reducing the complexity of deploying FSM and TSD locally to CDM members.[6]

In addition to these applications, traffic managers use an external utility to capture a screenshot, take a video, or capture slides of a desired area of the workstation display at a specified interval. System support and QC personnel may use an external spreadsheet application for testing, troubleshooting, and performing post-operations analysis based on data exported from FSM.

An additional set of web-based applications, some of which are available to external users as well as internal users, is listed in Appendix B. Many of the web applications are accessible via the OIS, which is a key conduit of information between the ATCSCC and other facilities and NAS users.

2.3 Traffic Flow Management Collaboration and Decision-making

A core TFM function is collaborative decision-making among FAA traffic managers and NAS users. The key TFM functions supported by TFMS today and a high-level view of the TFM decision-making process are shown in Figure 2-4. Each of the main tasks is discussed in the following subsections.

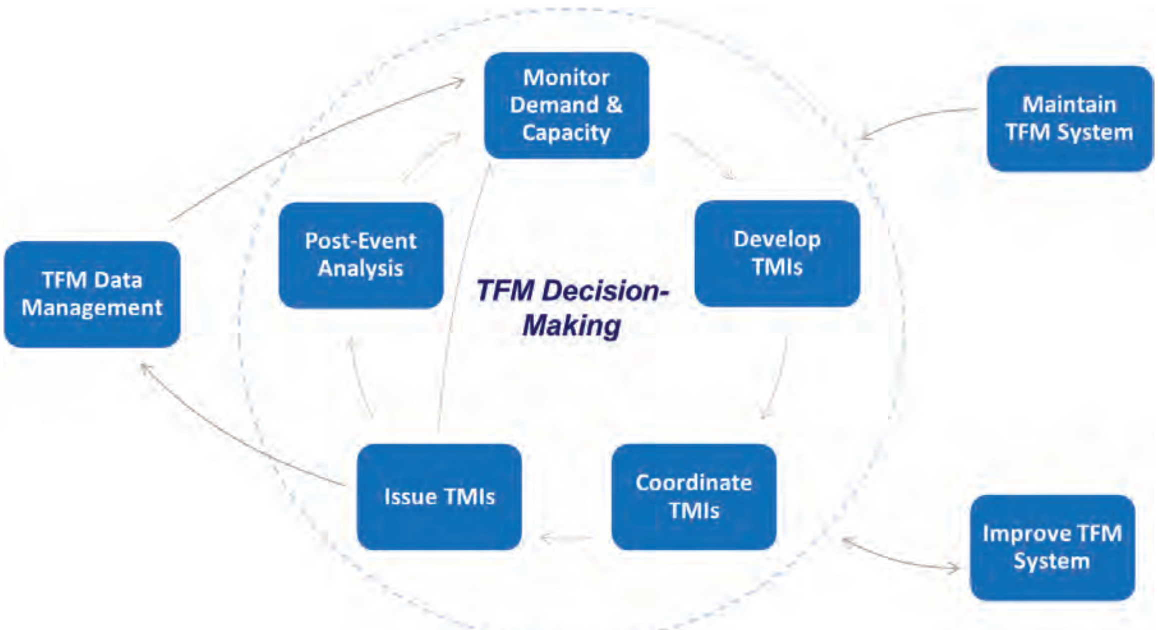

Figure 2-4. Overview of TFM Decision-making Process

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[6] CDM members may choose a local installation of FSM, but they are not provided a local installation of the TSD.

2.3.1 *TFM Data Management*

TFMS receives information about air traffic demand and capacity constraints to inform the TFM decision-making process. The automated systems that exchange this data with TFMS are summarized in Figure 2-5.

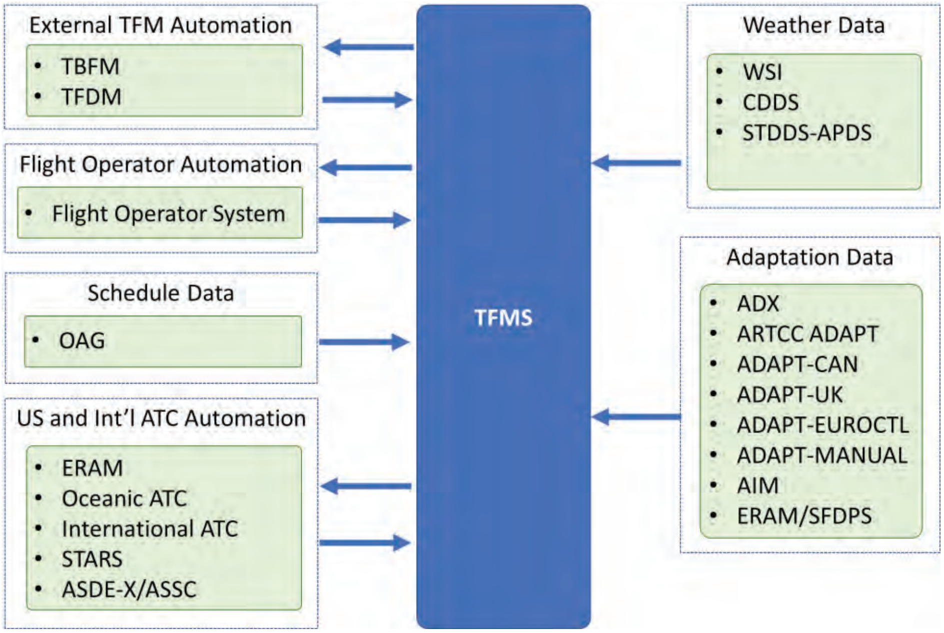


Figure 2-5. Automated Systems that Exchange Data with TFMS

TFMS processes weather data from a variety of sources and in a variety of formats, and transforms that data as needed for display and to incorporate into certain decision support functions. Traffic managers use weather forecasts to manually estimate capacity for NAS resources.

TFMS receives adaptation data from a variety of US and international sources, including NAS users. TFMS has some automated processes for transforming the adaptation data as needed to ensure airspaces, routes, and aircraft are represented appropriately. However, some of the data is very difficult to process automatically and adaptation specialists must process some of it manually. Furthermore, different data is provided on different time scales and adaptation specialists must manually incorporate it into the adaptation update process. Once they have assembled the data, adaptation specialists build and test the adaptation update with limited automation support from TFMS.

The TFMS tools and information accessible to NAS users depends on the type of user. For example, all authorized NAS users have access to the web applications available through the OIS (see Appendix B), whereas CDM members have access to applications and data that are not available to non-CDM members, such as FSM and a web-based version of the TSD.

The TFMData SWIM service supports data exchange between TFMS and NAS users, including CDM members. NAS users may subscribe to TFMS data published via TFMData and incorporate it into their own flight planning capabilities.[7]

One of the many uses of data published by the TFMData SWIM service is to support real-time TFM operations. For example, ATCSCC traffic managers have access to a TFM Efficiency Toolbox, a web-based suite of tools external to TFMS, that allows personnel to drill into TFMS data to answer pertinent questions. For example, if a facility loses its ability to provide ATC services ("ATC-zero"), these tools allow ATCSCC traffic managers to determine the schedule and volume of flights for that facility to inform their strategy development. In addition, Plan, Execute, Review, Train and Improve (PERTI) teams have built tools using data from TFMS that allows planning to focus on the future time periods during which constraints are expected to impact NAS traffic, as shown in Figure 2-6 (from [13]).

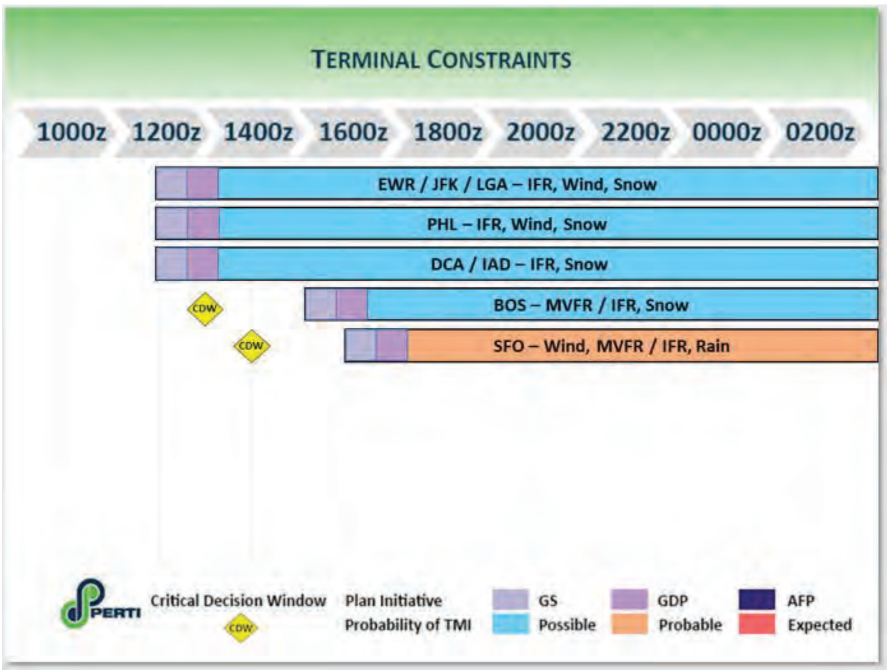


Figure 2-6. Example PERTI Planning Timeline

Thus, TFMS not only ingests data from multiple sources for use within TFMS, but it also processes and provides data externally to support various aspects of NAS operations.

2.3.2 Support TFM Decision-making

TFMS supports TFM decision-making at multiple time scales, ranging from the PERTI planning process that seeks to identify constraints over the next several days, to managing demand and capacity imbalances over the next several hours. TFMS also supports its users in evaluating the performance of TMIs, both in real-time and as part

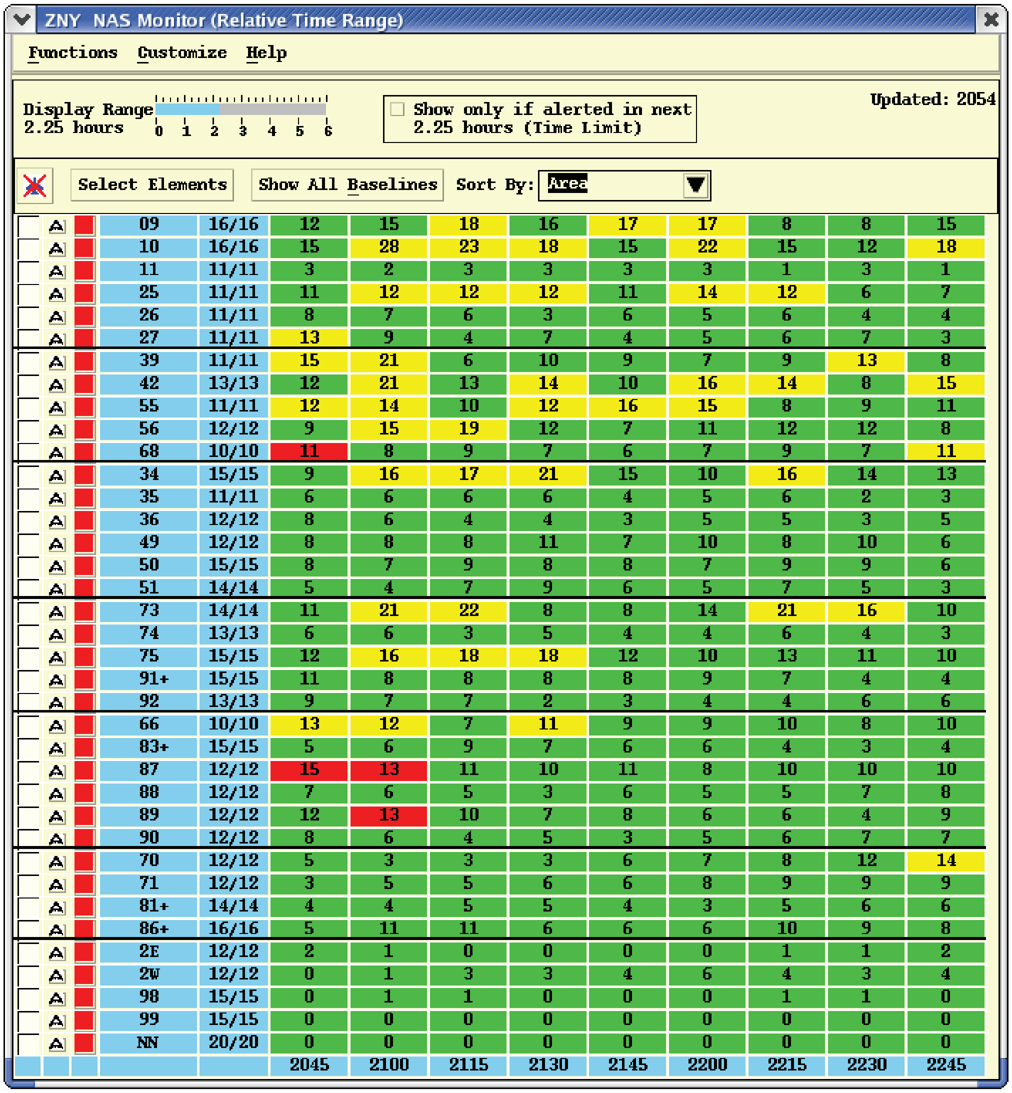
[7] Note that all external users may subscribe to the non-sensitive TFMData feed and incorporate the data into their proprietary capabilities; however, only NAS users are relevant to the discussion of TFM collaboration and decision-making.

of post-event analysis. This section describes the support TFMS provides to traffic managers and NAS users as they carry out TFM coordination and decision-making. The large breadth of TFMS users and features gives rise to multiple workflows and interactions between TFMS and its users; the description here summarizes common uses of TFMS across multiple users.

2.3.2.1 Monitor Demand and Capacity

Identifying time periods when demand is likely to exceed capacity for NAS resources is a key input to developing effective TFM strategies. This requires information about both demand for, and capacity of, NAS resources. Different TFMS users monitor demand and capacity at different time scales; PERTI teams monitor for constraints such as weather and SAA that are likely to impact NAS traffic over the next several days, whereas most traffic managers and NAS users are focused on constraints that will impact NAS traffic over the next several hours.

The Monitor Alert Parameter (MAP) for each ATC sector, fix, and airport is the level of traffic demand that triggers the TSD to notify traffic managers "that sector/airport efficiency may be degraded during specific periods of time" [7]. If demand for a given NAS resource is expected to exceed the MAP value at any point during a given 15-minute time period, TFMS provides a notification to the relevant traffic management workstation via both the TSD map display and a color-coded grid in the NAS Monitor (see Figure 2-7, from [14]). The traffic manager is required to examine the sector in the TSD/NAS Monitor and determine if any action is needed. Then, the traffic manager must make a NTML entry detailing the action(s) taken to resolve the alert, as the data is not automatically shared across applications. Since NTML is a standalone application with its own supporting infrastructure that was built using different technology than TSD and FSM, it is difficult for NTML to exchange data with these applications [12].



		2045	2100	2115	2130	2145	2200	2215	2230	2245
09	16/16	12	15	18	16	17	17	8	8	15
10	16/16	15	28	23	18	15	22	15	12	18
11	11/11	3	2	3	3	3	3	1	3	1
25	11/11	11	12	12	12	11	14	12	6	7
26	11/11	8	7	6	3	6	5	6	4	4
27	11/11	13	9	4	7	4	5	6	7	3
39	11/11	15	21	6	10	9	7	9	13	8
42	13/13	12	21	13	14	10	16	14	8	15
55	11/11	12	14	10	12	16	15	8	9	11
56	12/12	9	15	19	12	7	11	12	12	8
68	10/10	11	8	9	7	6	7	9	7	11
34	15/15	9	16	17	21	15	10	16	14	13
35	11/11	6	6	6	6	4	5	6	2	3
36	12/12	8	6	4	4	3	5	5	3	5
49	12/12	8	8	8	11	7	10	8	10	6
50	15/15	8	7	9	8	8	7	9	9	6
51	14/14	5	4	7	9	6	5	7	5	3
73	14/14	11	21	22	8	8	14	21	16	10
74	13/13	6	6	3	5	4	4	6	4	3
75	15/15	12	16	18	18	12	10	13	11	10
91+	15/15	11	8	8	8	8	9	7	4	4
92	13/13	9	7	7	2	3	4	4	6	6
66	10/10	13	12	7	11	9	9	10	8	10
83+	15/15	5	6	9	7	6	6	4	3	4
87	12/12	15	13	11	10	11	8	10	10	10
88	12/12	7	6	5	3	6	5	5	7	8
89	12/12	12	13	10	7	8	6	6	4	9
90	12/12	8	6	4	5	3	5	6	7	7
70	12/12	5	3	3	3	6	7	8	12	14
71	12/12	3	5	5	6	6	8	9	9	9
81+	14/14	4	4	5	5	4	3	5	6	6
86+	16/16	5	11	11	6	6	6	10	9	8
2E	12/12	2	1	0	0	0	0	1	1	2
2W	12/12	0	1	3	3	4	6	4	3	4
98	15/15	0	1	1	0	0	0	1	1	0
99	15/15	0	0	0	0	0	0	0	0	0
NN	20/20	0	0	0	0	0	0	0	0	0

Figure 2-7. NAS Monitor

Traffic managers use the Departure Viewer feature of the TSD to monitor departures, grouped by airports or departure fixes, as shown in Figure 2-8 (from [14]). They can use this information to determine whether demand exceeds capacity for departure fixes or how well demand is balanced across departure fixes. Improvements to this information have been in the development and deployment pipeline for more than 10 years but have not yet been fielded [12].

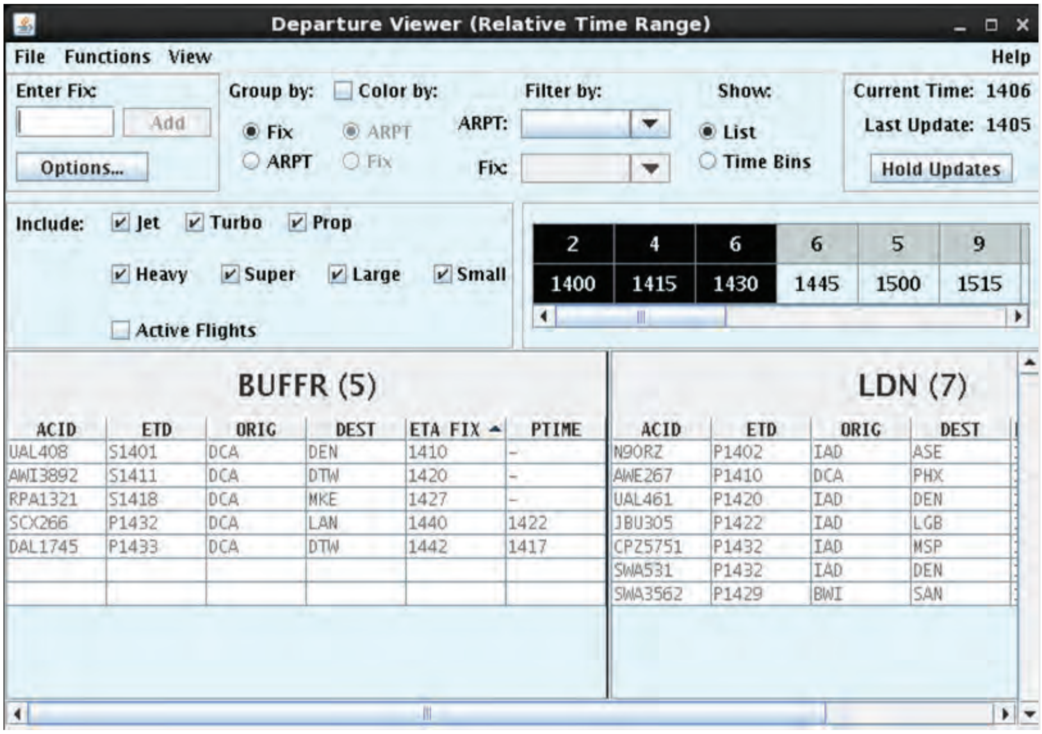


Figure 2-8. Departure Viewer

FEAs and FCAs allow traffic managers to determine demand for a given NAS resource or region of airspace. Only ATCSCC users can create and publish FCAs, which identify flights subject to a constraint. Users at other sites can only create and share FEAs, which identify flights in the defined region of airspace and time interval that satisfy given flight filters [7].

Traffic managers draw one or more FEAs/FCAs on the TSD, set the valid time period based on their expectation of when a demand-capacity imbalance may occur, and filter only the specific flights of interest to the FEA/FCA (e.g., departures from a given airport). Then, they can view the number of flights meeting the filter criteria expected to intersect the FEA/FCA over time and the list of flights in each time period, as shown in Figure 2-9 (from [14]). Note that this provides demand information, but not demand *relative to expected capacity*. Furthermore, if a traffic manager requests a flight list, the TFMS response time may be so slow that the traffic manager re-submits the request, creating additional load on the system and further bogging down system response [12].

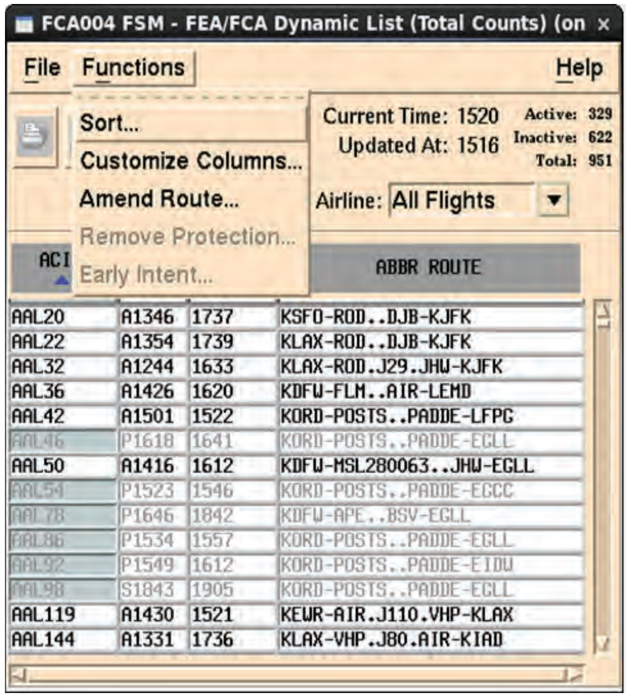


Figure 2-9. FCA Dynamic Flight List

In some instances, traffic managers may need to identify demand associated with GA traffic. For example, some AFPs schedule GA aircraft separately from scheduled carriers, and some airports have ramp space for scheduled carriers but not GA aircraft. TFMS allows traffic managers to create an FEA and specify they are interested in "GA" and/or "Air Taxi" flights. However, TFMS is unable to accurately identify all such aircraft. As a result, TFMS displays an inaccurate flight list for the FEA and provides inaccurate demand information to the traffic manager. One work-around is to create an FEA to generate a list of the scheduled air carriers and then exempt those aircraft from a separate FEA in order to capture GA traffic only. This work-around is time consuming and inefficient.

Whereas traffic managers use FEA/FCAs displayed on the TSD to monitor demand for regions of airspace, they use FSM to monitor demand and capacity for airports. It is common for ARTCC traffic managers to use multiple FSM windows to monitor demand for all of the airports within their area of interest.

When traffic managers perceive that forecast weather or other constraints will impact capacity, they must estimate the projected capacity based on their experience and existing guidelines. To support estimations of airport arrival and departure capacity, TRACON and ATCT traffic managers enter airport configuration, rates, and arrival and departure counts into NTML (if they have access) or the Airport Metrics web page (if they do not have access to NTML). The duplicated functionality between NTML and the Airport Metrics web application requires backend synchronization of the separate databases [5]. Additionally, if the entry in NTML is formatted incorrectly, the data must be manually entered in the Airport Metrics web page by the ATCSCC traffic manager. This is in addition to setting airport arrival and/or departure rates in FSM for the purpose of communicating rates to all FSM users and managing TMIs.

In addition to the flight list associated with an FEA/FCA, TFMS provides a Diverted Flight List, which monitors the flight plans of airborne flights, identifying in real time those that divert from the original destination and to where they divert. It also monitors the demand for alternate airports and provides alerts as alternate airports fill up. The Diverted Flight List provides situation awareness early in a diversion event to help prevent alternate airports from being overloaded and to ensure diverted flights can continue to their destinations when conditions allow.

NAS users also monitor demand and capacity via TFMS capabilities. All NAS users (and the general public) can view demand and advisories about TMIs and the constraints the TMIs are intended to address through the OIS. For example, the Airport Arrival Demand Chart (AADC)[8] is a publicly accessible view of the FSM-modeled demand for many NAS airports (and some Canadian airports); see Figure 2-10.

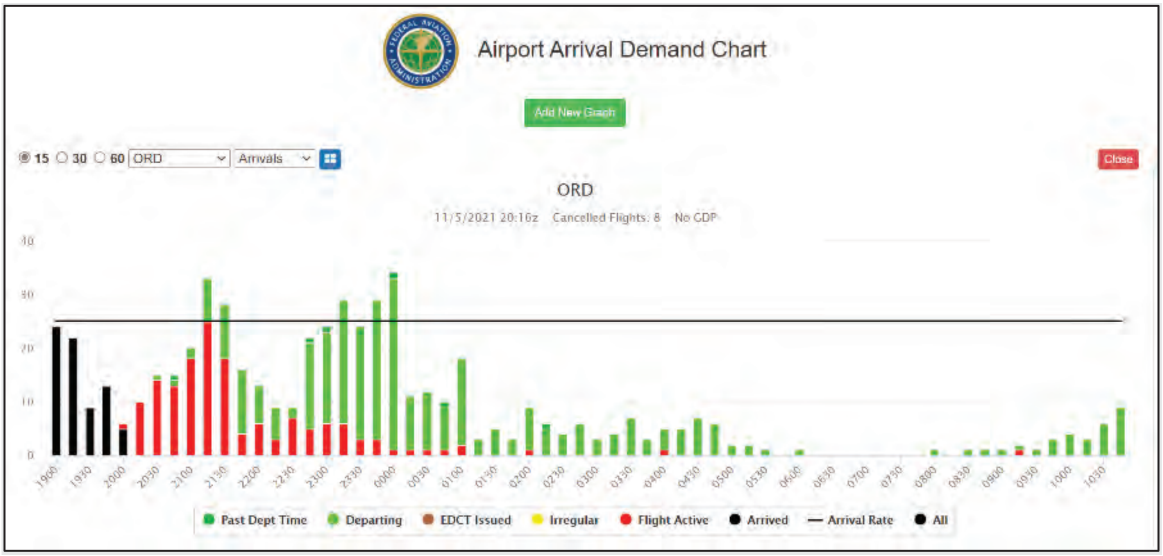


Figure 2-10. AADC view of Chicago O'Hare International Airport (ORD)

As NAS users update their flight plans and schedules in response to TMIs and other potential capacity problems, TFMS updates its demand predictions and displays the results via the TSD and FSM. This constant adjustment of operations (and TMIs) contributes to the highly dynamic operations in the NAS, and lack of integration among the various TFMS applications requires near-constant re-synchronization of data across applications. Any delay to this synchronization, due to factors like high data loads, can cause mismatches in data shown by the different applications. Furthermore, many restrictions are entered into NTML in free text and recorded in a format that is not machine-readable. This means that NTML restrictions, including MIT, are unavailable to the demand models that provide information to the TSD and FSM. This can cause NAS Monitor alerts to be unreliable and, in some cases, lead traffic managers to issue unnecessary TMIs [5].

[8] https://www.fly.faa.gov/aadc/

2.3.2.2 Develop TMIs

Once a traffic manager determines that a demand-capacity imbalance is likely to exist over the next several hours, they develop an initial TFM strategy to coordinate with other facilities. A TFM strategy typically involves one or more TMIs and a plan for when traffic managers will re-evaluate the planned TMIs to determine if the TMIs should be implemented, modified, or cancelled. In addition to TMIs issued via TFMS, traffic managers may consider TBM or restrictions such as MIT. However, the TFMS demand information does not account for the effects of TBM or restrictions. Furthermore, TFMS modeling cannot tell the traffic manager whether TBM or MIT will resolve the issue. Improved support for integrated modeling, along with other improvements in TMI modeling capabilities, have been identified as desirable enhancements that the current TFMS infrastructure is unable to adequately support [12].

To model a TMI, the TFMS user may associate an airport or FEA/FCA (or multiple FCAs in the case of a CTOP) with the TMI and then set the flow rate for the TMI in 15-minute or hourly intervals. Depending on the type of TMI, FSM or TSD will then calculate the number of flights affected by the TMI, and the average and maximum delay that the TMI would impose on those flights. To effectively create, model, implement, and monitor the effectiveness of several TMIs, like AFPs, TFMS users must switch back and forth between the TSD and FSM [4].

To manage traffic flows, TMUs build monitoring FEAs that use pre-defined filters to isolate each flow. Figure 2-11 shows a series of FEAs created by the Minneapolis ARTCC (ZMP) TMU to manage the flow of arrivals into the Minneapolis-St. Paul International Airport (MSP). ZMP TMU submits these FEAs to the ATCSCC and surrounding facilities via NTML for all MIT and fix balancing reroute requests. The FEAs and flights are color coded by traffic flow, with a chart for each FEA showing demand over time. If the FEA volume exceeds a predetermined threshold and the traffic manager determines that they will need to pass back a restriction of 25 MIT or greater to an adjacent facility, they must first share an FEA with that facility and the ATCSCC. The upstream facility will then use their own FEAs to determine if they will need to pass additional restrictions further upstream to help them meet the MIT restriction.

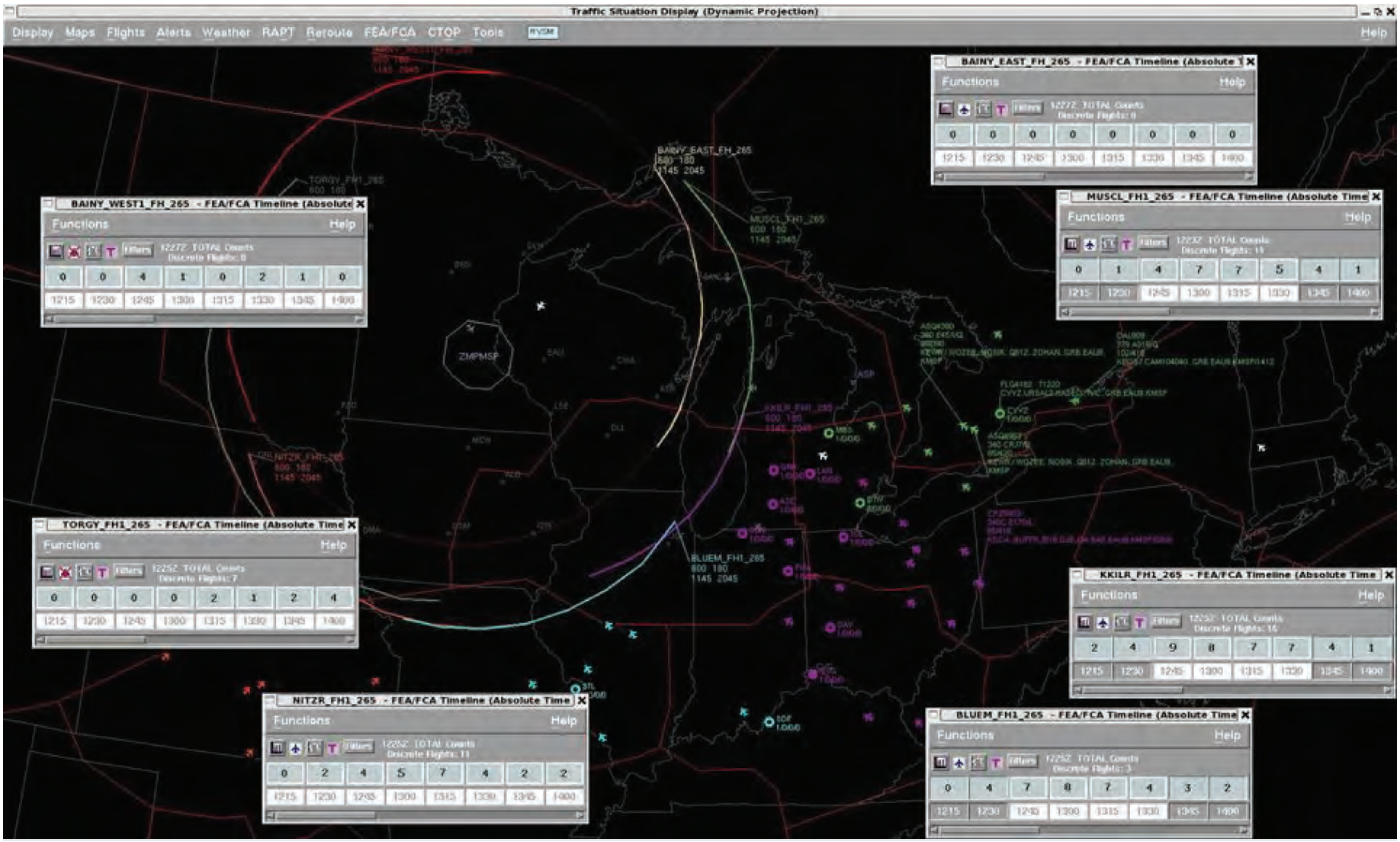


Figure 2-11. Example of FEAs to Justify Flow Restrictions

Traffic managers use FSM and TSD to model the impact that TMIs will have on air traffic, including the list of flights impacted and the delays imposed. When airport arrival demand exceeds capacity, traffic managers can use FSM to model the impact that either a ground stop or a GDP will have on a select set of flights (see Figure 2-12 for an example, from [15]). When airspace demand is predicted to exceed capacity, traffic managers can model an AFP that will reduce the flow rate through an FCA.

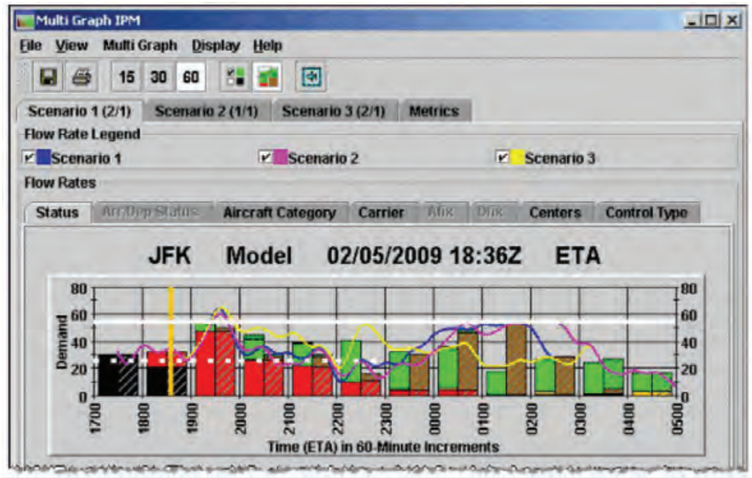


Figure 2-12. Sample Modeling Results in FSM

Traffic managers can use RMT to search for pre-coordinated routes that avoid constraints, such as those shown in Figure 2-13 (from [16]). RMT also allows users to view affected flights and identify reroutes for them. RMT receives an updated flight list every 5 minutes, which may cause RMT to show different flight information than that viewed in other TFMS applications. Furthermore, the process for querying flights and routes is cumbersome and difficult to ensure consistent results for similar queries.

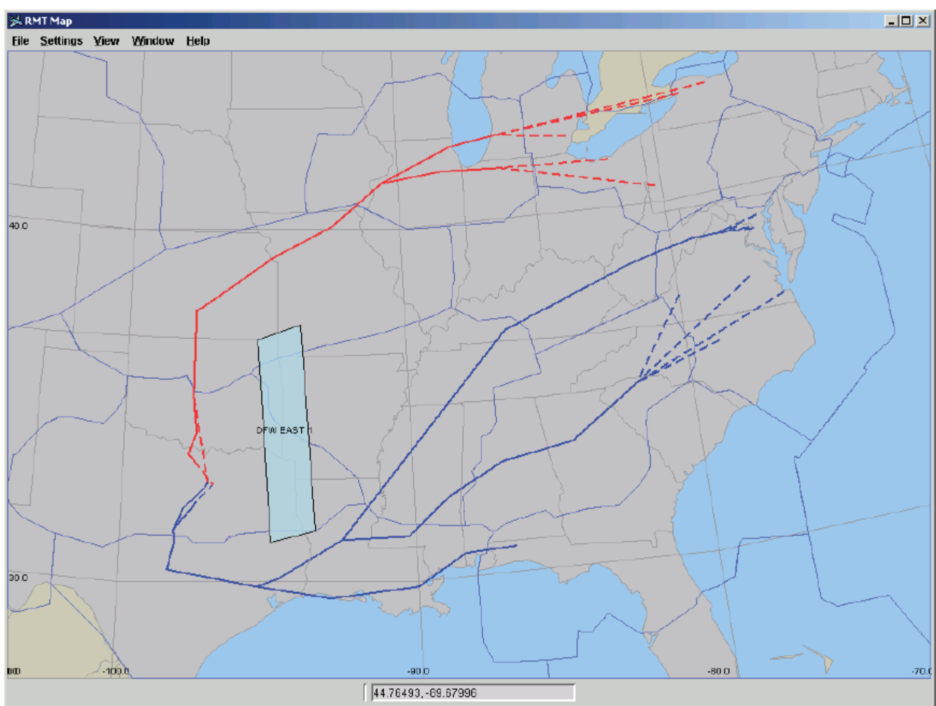


Figure 2-13. RMT Display of Playbook Routes Avoiding a Constraint

Traffic managers can also use the Reroute Impact Assessment (RRIA) tool on the TSD to model the impact that large-scale reroutes and, if desired, associated MIT restrictions will have on sectors along the proposed route, as shown in Figure 2-14 (from [14]). However, it is difficult for TFMS to forecast the impact of MIT restrictions until flights are slowed to achieve the appropriate spacing. In addition, the RRIA modeling capability has been plagued with performance issues due to the underlying legacy architecture.

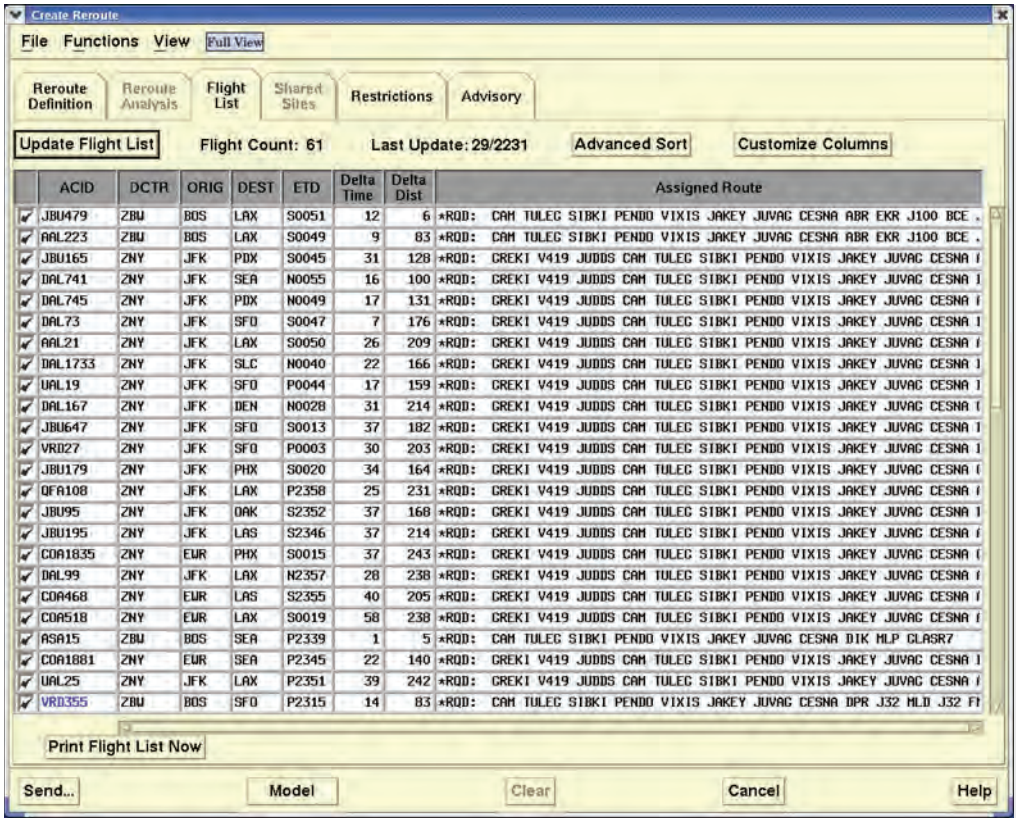


Figure 2-14. RRIA Model Results Showing Affected Flights and Change in Flight Time and Distance due to the Modeled Reroute

Overall, the modeling capability provided by each of these applications produces a wide array of delay data that is used to predict impact and effectiveness of TMIs under consideration; however, this data requires a certain amount of subjective interpretation. Is the amount of delay too much or too little, and will the proposed TMI resolve the traffic management issue at hand? Traffic managers have requested a TMI modeling capability that would consolidate all TMIs and allow them to fast-forward into the future – so they can better evaluate the effectiveness of a TMI or set of TMIs – but that functionality exceeds the current capabilities of the TFMS architecture and infrastructure.

2.3.2.3 Coordinate TMIs

The TMI coordination process starts with the PERTI team's long-range planning. The PERTI team anticipates the effects of capacity-reducing constraints over a 24+ hour range (e.g., adverse weather, equipment outages, and space vehicle launch/reentry operations). During the once-daily PERTI advanced planning webinar, the team collaborates with TMUs and NAS users regarding these constraints and predicted capacity and demand to anticipate potential TMIs. The result of this collaboration is the advanced plan that eventually becomes the day-of Operations Plan.

Traffic managers at all ARTCCs and many TRACONs and ATCTs, along with Airline Operations Centers (AOCs) and representatives for GA and international air carriers, start their day by attending the Strategic Planning Webinar conducted by the ATCSCC. During the webinar, the ATCSCC shares information and analysis about active TMIs and collaborates with attendees regarding strategies to address excess demand predicted to occur over the next several hours.

During these planning webinars, held every two hours throughout the day and evening, revisions are made to the previous Operations Plan based on updated demand, constraint, and capacity forecasts. Unless there is a need to resolve an urgent, unexpected issue (e.g., pop-up weather, aircraft incident), initial conversations about potential TMIs first occur on a separate voice call with ATCSCC NTMSs.

Before implementing a GDP or AFP, an ATCSCC NTMS will collaborate with stakeholders, model the program in FSM, and send the parameters of that model in a Proposed TMI advisory. This information sharing promotes productive collaboration prior to implementing the TMI. NAS users can model the impact of a proposed GDP or AFP using FSM and adjust flight plans prior to the TMI being issued; NAS users do not have this modeling capability for TMIs like CTOPs that are managed in the TSD.

Restrictions, such as MITs, are more tactical in nature and are usually not discussed on the Planning webinars. Before a restriction of 25 MIT or greater is published, the requesting field facility TMU must first submit their request to the ATCSCC and impacted facilities via NTML, accompanied by an FEA that shows the demand-capacity imbalance. If all recipients approve the restriction, then it goes forward. However, if the ATCSCC or one of the impacted facilities has an objection or comment, the ATCSCC will facilitate a phone call to negotiate and/or modify the request. Once approved, the receiving facility may require additional passback restrictions, which are also coordinated via NTML. This entire coordination process needs to be completed in a timely manner, so the receiving facilities have enough time to review, respond, coordinate, and implement passback restrictions.

FSM does allow ARTCC traffic managers to model GDPs and ground stops and share the proposed TMI parameters – but not the modeled results – with the ATCSCC and neighboring ARTCCs. Neighboring ARTCC traffic managers can then model the impact of that TMI on their airspace and provide feedback by phone. ATCSCC traffic managers can then issue an advisory for the proposed TMI, as shown in Figure 2-15 as number 030.[9] Note that only the ATCSCC can issue advisories, and therefore it is rare for ARTCC traffic managers to exercise this FSM capability for modeling and sharing GDPs and ground stops.

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9 https://www.fly.faa.gov/adv/adv_list.jsp?WhichAdvisories=ATCSCC&AdvisoryCategory=NotAll&dates=Friday%2C+12-04-2020&Gdelay=Gdelay

GROUND DELAY PROGRAMS				
NUMBER	CONTROL ELEMENT	DATE	BRIEF TITLE	SEND TIME
040	PBI/ZMA	12/04/20	CDM GROUND DELAY PROGRAM CNX	12/04/20 17:50
036	PBI/ZMA	12/04/20	CDM GROUND DELAY PROGRAM	12/04/20 15:25
031	PBI/ZMA	12/04/20	CDM GROUND DELAY PROGRAM	12/04/20 14:12
030	PBI/ZMA	12/04/20	CDM PROPOSED GROUND DELAY PROGRAM	12/04/20 14:01
010	PBI/ZMA	12/04/20	CDM GROUND DELAY PROGRAM CNX	12/04/20 02:50

Figure 2-15. Example Advisories, including Proposed Advisory

Alternatively, traffic managers can model reroutes using RRIA in the TSD and share the parameters and model results with other facilities for evaluation and negotiation. Impacted facilities can provide a counter proposal in RRIA, allowing the negotiation to occur electronically rather than solely by phone. However, RRIA involves a cumbersome workflow and is not used as often as it could be [2].

Traffic managers at TRACONs and ATCTs provide input to ARTCC TMI planning, typically by phone. TRACON and ATCT traffic managers also coordinate with each other internally (as needed) to ensure that, for example, departure spacing is appropriate to meet the MIT required for handoff to the ARTCC airspace.

2.3.2.4 Issue TMIs

Once a set of initiatives has been agreed to, traffic managers implement the TMI(s) using FSM, TSD, NTML, or TBFM, depending on the TMI type. For each TMI, traffic managers provide the causal factor in the application used to issue the TMI. Each application employs its own semantics for parameters like causal factor, complicating efforts to relate TMIs to each other and measure their combined effects in post-event analysis. Each application also uses a unique, proprietary communication functionality, which can increase network loads and may contribute to lags in performance [12].

TFMS applications provide some automated support for issuing advisories to implement TMIs. For TMIs issued via FSM, FSM gathers the TMI parameters into a "coversheet" that allows the traffic manager to issue the advisory describing the TMI. Other FSM users can see the program on their FSM display. Similarly, TSD collects the parameters needed for sharing the TMI information, either as an advisory or as a general message via the TFMS Messaging capability. TFMS Messaging also supports sharing of information like Severe Weather Avoidance Plan (SWAP) statements and ad hoc advisories.

The information disseminated for each initiative can be specific to each facility, but generally includes the start and end time of the initiative, the flights affected, and any suggested flight plan modifications. To share TMIs with NAS users, TFMS posts advisories to the OIS. Advisories are provided to CDM members via the CDM data feed and are provided to all NAS users via Teletype (TTY). Some advisories, but not all, are also distributed via SWIM. Once a TMI has been approved, it is logged (mostly manually) in NTML.

Traffic managers use ESIS, a separate TFMS application, to display the relevant information to controllers. Traffic managers configure NTML to send an advisory to ESIS.

Each operational supervisor can then select the information to be displayed and configure the ESIS display for their operational area. Controllers can view the restrictions relevant to the traffic they manage.

If the TFM strategy involves a GDP, AFP, or CTOP, TFMS applies the Ration By Schedule (RBS) algorithm to allocate arrival slots for the constrained resource to NAS users, and computes Expect Departure Clearance Times (EDCTs) for all included flights. CDM members receive arrival slots and EDCTs for GDPs and AFPs directly through FSM and use FSM along with proprietary capabilities to determine which flights to substitute (i.e., swap slots). All airlines receive their EDCTs directly from TFMS via Teletype, including those that are not CDM members. TFMS provides EDCTs to ERAM so that ERAM can include the EDCT in the flight plan. GA pilots receive their EDCTs when they call for their departure clearance, or they may look up their EDCTs through the NAS System Status web page.[10]

Once a TMI has been implemented, the traffic manager monitors its effectiveness using similar processes and capabilities as those discussed in Section 2.3.2.1 and can modify or terminate the TMI as needed using the application they used to issue the TMI (FSM/TSD/NTML/TBFM). They can also monitor the effectiveness of current GDPs and AFPs using reports produced by Real-Time Flight Schedule Analyzer (RT-FSA).[11] For GDPs, traffic managers must manually record the actual traffic counts at the end of each hour to support post-event analysis of TMI performance.

If the TMI is modified or terminated, FSM/TSD allow the traffic manager to disseminate the updated information to other FAA users via NTML. Traffic managers must separately report delays in NTML, ESIS, and the Information Display System (IDS) in terminal facilities, and ATCSCC traffic managers must manually enter delays into the GDP coversheet.

If the TFM strategy involves a ground stop implemented during an active GDP, traffic managers cannot end the ground stop and purge it from FSM without also purging the active GDP. As a result, traffic managers call individual ARTCCs to communicate that the ground stopped flights can be released without canceling the ground stop within FSM. As a result, FSM continues to show flights as included in the ground stop when there are no longer any stopped flights. This creates confusion among NAS users, who often call traffic managers to ask for clarification, thereby increasing traffic manager workload.

In addition to running the algorithms to manage the allocation of slots associated with GDPs and AFPs, FSM provides several reports, including flight counts, departure times relative to program EDCTs, and delays. FSM monitors whether flights adhere to their EDCTs and can inform ATCSCC traffic managers of flights that do not depart within an allowable time after the EDCT. However, it is common for the field facility to call the ATCSCC to request a new EDCT for a flight that will not depart on time. FSM allows ATCSCC traffic managers to give a flight a new EDCT that will minimize impact to other

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[10] https://www.fly.faa.gov/edct/jsp/edctLookUp.jsp

[11] RT-FSA is a component of the Flight Schedule Analyzer (FSA), which produces reports on performance and status of TMIs issued via FSM (GDPs, AFPs, and ground stops) based on Aggregate Demand List (ADL) data. RT-FSA is limited to current-day TMIs, whereas FSA provides an archive of past days' TMIs.

flights by searching for open arrival slots. Alternatively, the ATCSCC or ARTCC traffic manager can manually adjust the flight’s EDCT, and FSM recalculates EDCTs for later flights as needed to smooth predicted demand.

Traffic managers use several TSD features to identify and manage flights that are not in compliance with a reroute, including Reroute Monitor, FEA filters, and the Route Amendment Dialog (RAD). Reroute Monitor enables traffic managers to monitor for flight plans whose routes traverse the identified airspace. ARTCC traffic managers submit route amendments through the RAD [14] to ensure those flights are rerouted correctly. The RAD allows them to apply the same amendment to several flights. The PDRR and ABRR capabilities then provide the amendments to ERAM. ERAM then provides the amendments to the ATCTs or sector controllers to issue to pre-departure or airborne flights, respectively. To balance demand across departure fixes, traffic managers can use the Departure Viewer to identify eligible flights and import them into the RAD to amend the route and send it to the ATCT (via PDRR) to be issued [14].

The ATCSCC also opens the Tactical Customer Advocate (TCA) position each day to help NAS users manage flights that are severely impacted by TMI(s) and need to be prioritized. When this position is activated, NAS users can submit requests via the TCA web page (for CDM members) or a phone call (for NAS users that are not CDM members). The ATCSCC traffic manager working the position reviews the request and works to address the issue.

NAS users monitor several different TFMS applications for information about constraints and TFM strategies by reviewing and repeatedly refreshing the different web pages on the OIS and/or NAS System Status website. For example, they may monitor the:

- OIS or NAS System Status web pages to view high level information about active TMIs and delays.
- Advisory Database web page to make sure they have the latest information on TMIs and other operations, such as new advisories or cancelled TMIs, frequently “polling” the website to look for new additions.
- AADC to monitor FSM-predicted arrival demand for airports of interest to anticipate future TMIs.
- Current Reroutes Application to ensure they file flight plans that comply with the latest reroute TMIs.
- Current Restrictions Application to view restrictions entered via NTML.
- Airport Status Information web page to view delay and other status information for specific airports; and
- Runway Visual Range (RVR) information for NAS airports.[12]

[12] Note that the RVR data is provided by the SWIM Terminal Data Distribution System (STDDS) service and not TFMS. See Appendix B for more information.

They also may subscribe to email updates from the Aviation Information System (AIS) to receive delay information for the largest airports in the NAS.

The inconsistent design across these different web applications makes them overly complex to use, requiring users to navigate multiple menus and/or provide numerous data inputs to obtain the data they need. For example, a GA operator of a small fleet of aircraft may want to retrieve information about the current TMIs and the EDCTs for their flights. To do this, they would first query the Current Advisories web page and search through the resulting list for the impacted airspace/airports where they will be operating flights (there is no way to filter the list by airport or other criteria). After identifying the TMIs and determining which of their flights could be impacted, the user queries the EDCT Lookup web application for each flight. In addition, the user would need to access the Current Restrictions web page to review the restrictions that are in effect, and somehow determine which restrictions may be applicable to each of their flights [5].

Note that the Current Restrictions posted to the OIS are free text, lacking consistent semantics across facilities, and may use coded language that is only clear to personnel with significant experience with a particular facility. Furthermore, the OIS requires traffic managers to clear out some programs manually, which may or may not happen in a timely manner. As a result, the current set of TMIs shown on the OIS may not always be accurate. Although NTML and the OIS have an automated interface, the OIS can only interpret NTML delay data when it is entered in a specific format. Often the data is not formatted correctly because most NTML entries are free text. If it is not formatted correctly, ATCSCC traffic managers must re-enter information from NTML into the OIS, further complicating NAS users' efforts to maintain situation awareness and hindering post-event analysis [12].

2.3.2.5 Post-Event Analysis

The goal of post-event analysis is to evaluate NAS operations and the performance of TFM strategies for a given day or event. Analysis results are key to PERTI products and support post-event discussions between traffic managers and NAS users to develop "lessons learned" for future operations.

The daily National System Review (NSR) is a post-event analysis product that is a key element of the PERTI process. The NSR informs FAA and NAS users of performance of the TFM strategies used on the previous day relative to a standard set of metrics and provides a forecast of future constraints such as weather and SAA. Analysts supporting the NSR create, annotate, and edit video playbacks using the TSD Replay capability and gather data from Flight Schedule Analyzer (FSA) and other sources to report on delays and other key performance indicators.

Facilities also are required to carry out several analyses as specified in JO 7210.634 [17]. For example, periodic traffic management reviews (TMRs) require facilities to "assess whether those initiatives that were implemented were thorough, performed as intended, and implemented following FAA orders," and to "assess whether those triggers used to initiate any TMIs were appropriate, coordinated, and communicated to the appropriate end user." The post-event analysis team uses several different tools to carry out their duties, collecting data from multiple NAS automation systems and external data sources. TFMS data and reporting capabilities represent a *subset* of those tools, which are discussed here to provide a sense of how TFMS currently supports post-event analysis. Post-event analysts' use of tools external to TFMS is discussed here where the data underlying the analysis is from TFMS and/or the information analysts glean from the external analysis capability is also available in TFMS but not in a useful way.

Post-event analyses answer questions related to topics such as:

- Compliance to program parameters including controlled departure times, assigned routes, and MIT spacing.
- Delay and holding metrics, including equitability of delay across NAS users.
- Flights included in multiple TMIs.
- Periods of over- and under-delivery relative to TMI parameters.
- Individual flight route amendments.
- Diversions.
- Complaints received from NAS users related to the TFM strategy and its execution.

Performing these analyses often involves diving into questions about what information was available, to whom, and at what time, to understand the decision-making processes that drove TFM performance during a given day or event. Data to support post-event analysis is available in various databases, TFMS reporting applications, and data stores for other NAS automation systems. However, these data sources are application- or system-specific, and the lack of integration of data across applications and systems makes deriving the entire "picture" of historical events very difficult.

The TFMS tools that analysts at the ATCSCC use to support post-event analysis include:

- Advisory database
- NTML log
- Facility log
- FSM (historical mode)
- TSD (Replay command)
- FSA

They also maintain their own archives of the data exchanged via some of these TFMS tools, including communications received through the TCA Portal and other means (email, phone, etc.) and information posted to the OIS. They have built several web scraping, analysis, and reporting capabilities on top of the existing data and reporting tools[13] and use flight history information (including route changes) from other third-party websites. TFMS also provides reporting and analysis tools that analysts typically do not use, such as FSA Morning Brief.

Post-event analysis processes also apply to quality assurance-related service and aircraft accident event reviews as defined in JO7210.634 [17]. Analysts are directed to "use all available tools," including TFMS, replay, voice recordings, and discussions with affected personnel to consider issues such as training, metrics affecting efficiency (e.g., TMIs, delays, traffic volume/complexity), airspace/airport issues, applicable procedures and directives, technical operations (e.g., equipment configuration, performance, outages), customer feedback, resource management (e.g., position relief management), and actions of involved personnel. Findings may point to issues affecting a specific time period, or systemic issues that need to be addressed within the facility or across the NAS.

The lack of integration across TFMS applications creates difficulties in gathering the necessary metrics for these reviews. For example, FSM provides reports with statistics like the number of each carrier's flights affected and delays absorbed. However, these reports are only available for an FCA if the traffic manager who created it designated it as FSM-eligible.

One data source that can drive TFM decision-making is the sector demand predictions provided by NAS Monitor; NAS Monitor predictions are displayed to traffic managers but not archived. As a result, post-event analysts have difficulty recreating the context surrounding decisions driven by these predictions. Note that Monitor Alert alerts are archived, but that only provides context for TFM decisions taken after an alert as opposed to decisions taken proactively (or not taken) based on predicted demand.

Analysts (and traffic managers) also use RT-FSA to monitor the effectiveness of the programs used on the current day, both while they are in place and after they are cancelled. RT-FSA is somewhat inconvenient to use because it is a different application from FSM (where TMIs are modeled, issued, and monitored), and because it only allows analysis of the current day's programs, and not any previous day.

Analysts need to be able to see a flight history display (like that in RT-FSA) that shows all the actions affecting a flight, including route amendments, but this is difficult to access after the event. Because this capability is not in FSA, analysts must use the advisories and correlate them with flight history data from other external sources to help figure out a past flight's history of route amendments. This ability was supported in the past; current tools do not provide this capability and therefore analysts must access it via external websites.

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[13] Some examples include:
http://www.atcscc.faa.gov/QA/gdly/logbrowser/testLog2.html
http://www.atcscc.faa.gov/QA/gdly/logbrowser/yuilog.html
http://www.atcscc.faa.gov/QA/gdly/logbrowser/restrictions/curr_rstn_ajax.html
http://www.atcscc.faa.gov/Operations/DTO_Recap_Report/DTO_Recap.html

How well flights comply with restrictions is an important metric. The post-event analysis team uses RT-FSA to generate reports measuring flights' deviation from restrictions for the current day; if compliance information is needed for previous days, analysts must generate compliance histories for individual flights.

Analysts may replay archived TFMS data to better understand the decision-making process carried out during a given event. This typically needs to include the weather information that was available to the traffic manager at the time the TMI modeling decisions were made. FSM Historical Mode allows them to view the data that was available at the time, although analysts sometimes would rather look at different points in time on different panels in the display. Analysts also use the TSD Replay command to view data archived by TSD. However, only a subset of the data is available, and analysts are unable to interact with the archived data, which inhibits their ability to evaluate alternative TFM strategies. Furthermore, data is only maintained locally for 24 hours. After that, analysts must call to request the data and then wait for the data to be provided. Lastly, the TSD Replay mode overlays historical traffic data on current adaptation and sectorization data [14]. For example, if sectors were combined or de-combined differently during the event of interest, the replay will not show that. Legacy methods for archiving and accessing data make it hard to store sufficient data onsite, or provide access to data archived at the TPC, impeding effective support of the post-event analysis process.

In addition to being used to issue advisories, NTML is intended to log NAS events to support post-event analysis. As noted above, some information is gathered automatically into NTML to support issuing TMI advisories. However, traffic managers need to enter some data manually but do not always know what NTML collects automatically versus what they need to enter manually. For example, traffic managers are expected to enter TBFM metering sessions into NTML, but they often do not do so in a timely manner (if at all), or they enter the information inconsistently across facilities, which makes searching for the entries difficult. As a result, the record in NTML is often incomplete regarding what TMIs were implemented, when, and for what purpose. This complicates post-event analysis.

2.4 Maintaining the TFM Automation System

TFMS was designated as an efficiency-critical FAA capability in 2013 [12], requiring a System Support function to ensure its performance and integrity in a near real-time environment. To that end, TFMS requires both first- and second-level system support.

First-level support is provided mainly by the TFM Consolidated Service Desk (TCSD), along with on-site support at the ATCSCC and limited on-site support at most other sites. Detailed administrative and technical procedures guide TCSD personnel in operating, monitoring, troubleshooting, and maintaining TFMS hardware and software. "TCSD personnel record problems, track the progress of fixes, escalate incidents through final resolution and create a knowledge base of operational and incident response solutions" [4]. They use local capabilities to generate detailed reports on TFMS maintenance and availability issues. They use several legacy tools (e.g., Watchdog, NetMail, various scripts) to perform monitor and control (M&C) functions, including monitoring TFMS components for outages and service degradations and responding to those situations using actions such as remotely restarting affected components [5]. This is in addition to periodically restarting system components according to detailed software maintenance procedures to prevent performance degradation issues.

Software maintenance procedures are documented in daily checklists and very detailed multistep descriptions of how to carry out the M&C functions for the TRS resources and applications. These documents are long, static, and difficult to maintain. For example, the System Computer Operator Manual (SCOM) is a document spanning five separate files, with an overview provided in Volume 1; an evaluation found the overview to be out of sync with the sections actually provided in the manuals [5].

TCSD personnel also manage user accounts and ensure each account has access to the appropriate system components (and only the appropriate system components). This is chiefly managed by locating capabilities on servers that are accessible by certain user roles, requiring the TFMS applications to be replicated across servers (in addition to requiring accounts to be synchronized across the servers).

When software updates have been prepared and tested, TCSD personnel are responsible for deployment. To install these software updates, the entire TFMS system needs to be taken down for approximately six hours. Although these shutdowns are timed to minimize the impact on operations, they can still disrupt late-night and west coast operations [4].

TCSD personnel also are responsible for weekly updates of TFMS adaptation data, such as updates provided by CDM members that identify the carrier names and flight numbers to associate with that CDM member's EDCTs.

When TCSD personnel are unable to address a user issue, it is escalated to Second-Level Engineering (SLE), which is responsible for troubleshooting and addressing user application issues through software engineering and field support [18]. SLE is also responsible for testing system patches and updates. However, they are unable to perform regression testing on TFMS applications, in which they would run through a historical scenario multiple times and analyze the data/logs for differences. This limitation makes it especially difficult to troubleshoot a reported issue. SLE is also responsible for compiling reports on TFMS performance, including availability of system components.

SLE maintains and manages the TFMS infrastructure and hardware, including repair of hardware when necessary. Some of the TFMS hardware (and software) is obsolete and no longer supported by its providers, making the SLE task very difficult [5]. SLE provides logistical support for remote sites, including replacing hardware as needed. They perform site surveys to prepare for new TRS hardware/capability installations. SLE maintains the numerous connections that allow the various components of TFMS to exchange data with each other and with external systems (data sources, TFMData, CDM, etc.), which is complicated by the complex architecture.

The TFMS architecture also includes the Disaster Recovery Center (DRC), whose intent is to provide a "slightly reduced TFM operational capability" [4] in the event of a disaster, outage, or failure. The DRC, however, omits several web applications, like the OIS, that are key to maintaining common situation awareness between traffic managers and NAS users. It also omits ABRR and PDRR [12].

Furthermore, when a transition to the DRC is needed, the process is complex, manual, time-consuming, and largely untested [19]. Transition of core processes should take 15 minutes, but it could be up to 6 hours before remote sites can access those core processes. Manual processes for DRC maintenance and TPC synchronization further increase risk if the decision is made to transition to the DRC. The legacy architecture inhibits the ability to modernize and automate processes for restoring complete system function when failures occur.

2.5 Training Users for TFM Automation System Improvements

Ideally, TFM automation training reinforces the importance of managing traffic using a systemic approach that considers the impact of individual flight actions on NAS operations. Effective TFM training extends this system-wide philosophy to the user community, requiring the training infrastructure to reach TFMS users represented in each type of FAA facility as well as NAS users and flight plan service providers. The TFMS training infrastructure falls short of meeting its users' training needs.

TFMS provides a centralized training infrastructure. The only TFMS workstations available for training are located at the ATCSCC, TPC, and Mike Monroney Aeronautical Center (MMAC), and these are limited in number. To set up workstations for training requires a cumbersome process involving individually configuring at least one workstation to mimic a TPC instance, and individually configuring workstations to mimic TRS instances receiving data from the TPC instance. It is infeasible for most TFMS users to travel to the TPC or ATCSCC for hands-on training for each new release, and so most training consists of briefings on new capabilities and their use in a select set of representative scenarios. As a result, the first hands-on experience most TFMS users get with a new capability is live in operation. This creates a situation in which a traffic manager may execute a new function without fully understanding the likely impact on controllers or other aspects of NAS operations, creating potential safety hazards in addition to TFM inefficiencies as traffic managers gain experience with the impacts of a new feature.

Additionally, TFMS provides minimal training for those responsible for system hardware maintenance. System maintenance personnel have access to an overview to show them how to add/remove hardware, but their training does not cover other information that would be useful, such as interfaces between TFMS and other systems like ERAM.

3 Justification and Description of Changes

The Shortfall Analysis Report (SAR) [12] groups the operational shortfalls associated with TFMS into the following three categories:

1. Shortfall Category SF-1: Unacceptable performance and lack of expandability and scalability prevent TFMS from meeting evolving needs.
2. Shortfall Category SF-2: Lack of a comprehensive failover strategy prevents continuity of operations.

3. Shortfall Category SF-3: Lack of integrated capabilities inhibits consistent operational system-wide views, operational decision-making, and usability of the system.

The shortfalls associated with each category are briefly described in the sections that follow.

3.1 Shortfall Category SF-1: Unacceptable performance and lack of expandability and scalability prevent TFMS from meeting evolving needs

The shortfalls in Category SF-1 are associated with the challenges of using the current system, which does not fully provide the performance required for effective and efficient TFM operations and has not allowed the scalability or extensibility necessary to meet the needs of evolving NAS operations.

3.1.1 Shortfall SF-1.1: TFMS no longer meets the necessary availability and reliability for effective TFM operations

3.1.1.1 Shortfall

TFMS was designed for the projected system load on the TFMS Core at the time it was implemented. However, user expectations have changed since its inception and system loads have exceeded the projections made 20 years ago, with significant increases in the number of flights for which TFMS must process data, as well as the number of users requesting information about those flights. As a result, users are experiencing increased system response times and outages, particularly during times of high system demand. Users often take several different courses of action to avoid these issues:

- Turn off capabilities or limit their use.
- Pre-emptively restart the system or system components to minimize outages [5].
- Revert to manual processes to communicate and gather operational data.

The inability for TFMS to meet users' needs, and the actions users take to prevent the system from failing completely, impede effective TFM service delivery.

3.1.1.2 Opportunity

Upgrading TFM automation system components will allow the system to meet its users' current and future reliability and availability needs. This will, in turn, allow users to focus more of their efforts on TFM service delivery rather than dealing with system deficiencies.

3.1.2 Shortfall SF-1.2: TFMS components cannot meet peak operational performance needs and can be inefficient during routine operations

3.1.2.1 Shortfall

While some aspects of TFMS' service-oriented architecture are scalable, in general the TFMS infrastructure cannot dynamically scale in real-time, particularly during periods of planned outages or unexpected increases in user demand. This shortcoming can result in longer system response times and decreased reliability when traffic managers need it most. On the other hand, during periods when the system experiences loads that are reduced relative to the design reference, the lack of dynamic scalability in the architecture causes hardware over-provisioning, where more resources are available than are needed. During these periods, the program pays to operate resources that are not needed to support operations.

3.1.2.2 Opportunity

Updating the TFM automation system to use modern hardware and software architecture methods will enable the infrastructure to dynamically scale with NAS traffic and user demand. This will better balance the available computational resources with demand, without overprovisioning.

3.1.3 Shortfall SF-1.3: TFMS cannot support planned future enhancements and updates

3.1.3.1 Shortfall

Limitations of the current TFMS infrastructure have resulted in delaying, deferring, or rescoping system enhancements, including security upgrades and enhancements to support emerging users. System enhancements often require more resources, such as processing power and bandwidth, than what TFMS can provide. For example, Corridor Integrated Weather System (CIWS) is a key source of high-resolution weather forecast data. However, TFMS is unable to display the full suite of CIWS data at the update rate that CIWS provides without severely hampering system response time. To combat this, the CIWS data visible on the TSD is purposefully degraded, which has caused many traffic managers to choose not to display it on their TSD at all. To compensate, traffic managers often display CIWS data in a web browser on a separate workstation, reducing the benefit derived from the effort to introduce CIWS weather to TFMS.

The aging TRS hardware and infrastructure has resulted in the delay or deferment of system enhancements that could provide operational improvements; in 2018, both Advanced Flight-Specific Trajectories (AFST) and Enhanced NAS Impact Modeling (ENIM) were indefinitely postponed due to concerns that TFMS did not provide a good foundation for the enhancements. In fact, no new functionality was implemented in TFMS between April 2016 (Release 13) and October 2021 (Release 14) due to infrastructure concerns, particularly TRS infrastructure [12].

When enhancements are applied, the length of time to get them from concept development to operational deployment delays the realization of the benefits those enhancements are expected to provide. By the time the enhancements are finally deployed, NAS operations may have changed, with TFMS users developing new operational workflows that reduce the effectiveness of the new capabilities. Furthermore, the lack of operational feedback during the concept development and implementation stages of various system enhancements have resulted in the capabilities not being used as intended (or at all).

3.1.3.2 Opportunity

Modernizing the TFM automation system architecture and infrastructure will provide a foundation on which future enhancements can be built. This will allow the TFM automation system to provide its users access to the capabilities they need to maintain safe and expeditious traffic flows while accommodating emergent users and will support efforts to achieve future FAA goals.

3.1.4 Shortfall SF-1.4: TFMS includes multiple types of data interfaces which are costly, unintegrated, and difficult to maintain and update

3.1.4.1 Shortfall

TFMS uses an overly complicated set of external and internal interfaces for data exchange.

- External – There are currently 45 external interfaces maintained by TFMS, using a mix of point-to-point and SWIM interfaces. Each interface operates in accordance with its own published Interface Control Document (ICD), meaning that each interface has unique protocols for maintenance and updates.
- Internal – Data exchange between the modernized TPC core and the TRSs is provided in four unique formats and countless schemas using an inefficient string of 16 legacy message adapters and legacy communication components.

The number of external interfaces and the complexity of the internal interfaces create challenges for supporting and upgrading TFMS.

3.1.4.2 Opportunity

Consolidating and modernizing data interfaces to streamline data exchanges will improve TFM automation system supportability.

3.2 Shortfall Category SF-2: Lack of a comprehensive failover strategy prevents continuity of operations

The shortfalls in this category point to the inability to maintain system availability in the event of a component failure/outage or a major disaster failure.

3.2.1 Shortfall SF-2.1: TFMS lacks a comprehensive failover strategy for loss of service

3.2.1.1 Shortfall

TFMS currently does not provide a redundant failover architecture. As a result, TFMS cannot provide failover functionality in the event of a failure that is not considered a disaster,[14] and the whole system must be taken offline for hours at a time for many required maintenance activities. This lack of redundancy leads to TFMS users resorting

[14] In this context, "disaster" includes fire, flood, terrorist act, or a major system or network failure that renders the TPC incapable of sustaining operations.

to manual methods of TFM, including manual communication of situational data, manual coordination of capacity and demand, and manual resolution of capacity and demand issues. These manual methods impact TFM operations and overall NAS efficiency.

3.2.1.2 Opportunity

Modernizing the TFM automation system infrastructure will create an opportunity to design the new system with a failover strategy in mind. Modern software and architecture technologies better support monitoring of system components and can provide feedback to users indicating the availability of application data and system functions. Modern architectures also make it easier to failover to a backup if/when necessary.

3.2.2 Shortfall SF-2.2: TFMS lacks a comprehensive, timely response to major disaster failures

3.2.2.1 Shortfall

The current switchover process for TFMS to move its operations from the TPC to the DRC is excessively time-consuming, resulting in extended TFMS downtime and reduced TFM service delivery beyond the precipitating disaster. Furthermore, the DRC was designed to operate a smaller set of capabilities than the TPC to maintain basic continuity of operations. The lack of full capability when operating through the DRC inhibits the ability to deliver TFM service.

3.2.2.2 Opportunity

Modernizing the TFM automation system architecture and infrastructure provides an opportunity to design comprehensive disaster recovery strategies into the system, allowing users to maintain TFM service delivery in the event of a disaster.

3.3 Shortfall Category SF-3: Lack of integrated capabilities inhibits consistent operational system-wide views, operational decision-making, and usability of the system

The shortfalls in this category highlight some of the issues arising from the lack of integration across TFMS applications.

3.3.1 Shortfall SF-3.1: TFM operational decision-making requires manual assimilation of data from a variety of sources due to piecemeal operational information, decision-making, and tools

3.3.1.1 Shortfall

The lack of capabilities to support a shared system-wide view of NAS operations can result in an incomplete or delayed understanding of what is happening, which impacts collaborative TFM strategy development. Currently, the information needed to obtain a comprehensive understanding of NAS operations is spread across multiple systems. For example, traffic managers in a single ARTCC use up to 10 monitors when managing en route traffic and up to 21 monitors for arrival traffic to carry out their specific tasks and responsibilities [12]. As a result, traffic managers spend a considerable amount time and effort to develop a complete mental view of their operation. An incomplete operational picture may lead to incorrect conclusions and ineffective (or counterproductive) actions that impose excess delay on the NAS.

3.3.1.2 Opportunity

Redesigning the TFM automation system provides an opportunity to provide its functionality in a streamlined user application suite that shares data across functions, reducing the need for mental assimilation of data.

3.3.2 Shortfall SF-3.2: TFMS user interfaces are graphically and functionally inconsistent and complex

3.3.2.1 Shortfall

Inconsistent and complex user interfaces and functions impede ease of use and understanding. Operational personnel have voiced issues with functionality being spread across multiple applications, inconsistent semantics, and lack of common look and feel across applications. Such issues exist with the TFMS interface and have gotten worse as capabilities have been added.

3.3.2.2 Opportunity

Redesigning the TFM automation system will provide an opportunity to create a consistent design and semantics across the user interface and TFM functions. A functionally consistent and streamlined user application suite will improve usability, increase efficiency, and reduce opportunities for user error.

3.3.3 Shortfall SF-3.3: TFMS applications are not integrated and provide duplicative functionality

3.3.3.1 Shortfall

Inefficient and limited capabilities for conducting TFM require traffic managers to use multiple applications to carry out individual tasks. Several TFMS applications have overlapping and duplicative capabilities because the architecture does not support the use of shared services for common functional needs. For example, both the TSD and FSM have functions for modeling and issuing TMIs that do not account for all the TMIs that are currently active. Furthermore, the two applications have different mechanisms for receiving flight data, causing them to sometimes show disparate flight lists. Similarly, traffic managers evaluate MIT restrictions in the TSD (which does not support modeling) and then coordinate them via the NTML. With no integrated TMI modeling capability, traffic managers are unable to tell the true impact of the choices they make and may over-constrain the system because of unexpected interactions.

3.3.3.2 Opportunity

Modernizing the TFM automation system will support the use of shared services, including databases, to provide functions commonly needed across applications. This will reduce duplication of code, streamlining the architecture and improving system maintainability. The architecture will also improve data quality and provide a common and consistent view across all FMDS displays and NAS automation systems.

4 "To Be" Operations

This section describes the vision for replacing the functionality provided by TFMS with FMDS. The following subsections describe the FMDS concept, including:

- The assumptions underlying the FMDS concept description.
- Constraints on the FMDS concept and implementation.
- The expected operational environment for FMDS deployment
- A description of the FMDS vision for TFM activities, system support, and training for system enhancements.
- Infrastructure required to support FMDS, including services.
- Expected benefits of FMDS.

All aspects of the FMDS concept support BTI 508120, Improved Automation Infrastructure, as they are all focused on this overarching objective. Alignment of specific elements of the Concept of Operations to the OI Increments are noted in Section 4 as applicable.

4.1 Assumptions

This document includes assumptions about the FMDS operational and technical environment as well as the baseline FMDS capabilities.

4.1.1 Operational and Technical Environment Assumptions

- FMDS will be implemented in an environment in which bandwidth is not necessarily a primary constraint on the system architecture.
- FMDS will be deployed in a NAS automation environment that is evolving to embrace new processes and technologies such as enterprise services; Cloud computing; continuous testing and continuous integration practices; and Agile acquisition, software development, and deployment processes [20, 21].[15]
- FMDS will be implemented in an operational environment characterized by the increased use of TBM, arrival pre-conditioning, and other flow management

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[15] The FAA is in the process of "implementing agile practices in FAA acquisitions," according to the Federal Acquisition Systems Toolbox. https://fast.faa.gov/AMSBB_AMS_Building_Blocks.cfm.

improvements deployed by NAS-wide initiatives such as TBO and the FAA Metroplex Program.

- FMDS will leverage new and existing SWIM services for receiving relevant data as appropriate.
- FMDS components will be certified if needed according to FAA Order 6000.15.
- NAS users will continue to be active participants in TFM by providing the necessary data to FMDS in a timely and effective manner and participating in planning webinars as they do today.
- NAS users will transition away from legacy data exchange interfaces (ARINC, AOCNet), to use SWIM data exchange interfaces (TFMData Request/Reply). Note that advisories and EDCTs will continue to be disseminated via teletype in addition to modern data exchange methods to support a broad range of NAS users.

4.1.2 Baseline FMDS Capabilities

FMDS will provide all capabilities currently provided by TFMS, with the following exceptions:

- Capabilities currently provided by TFMS that other programs will provide in the future. For example, Common Support Services-Weather (CSS-Wx) will perform some of the weather processing functions performed by TFMS today.
- Capabilities currently provided by TFMS that are unused in the current environment and no longer necessary. At the time of writing, these capabilities have not been identified, but an analysis involving multiple stakeholders will make this determination.

FMDS will provide all capabilities that were baselined as part of TFMS Enhancement 4 and/or requirements levied on TFMS by the Terminal Flight Data Manager (TFDM) Program [22]. The capabilities related to Enhancement 4 and TFDM that are not available in TFMS at the time of writing but will be deployed with FMDS are summarized below, roughly grouped according to capability area.

4.1.2.1 Traffic Management Visibility into Surface Operations

- Ability for traffic managers to view status of airport/runway line-ups at all airports feeding shared Metroplex departure fixes (existing Departure Spacing Program [DSP] capability) for selected Metroplexes.
- Capability for ATCT and ARTCC/TRACON traffic managers to tactically coordinate departures to manage departure flows more efficiently (existing DSP capability).
- Airport Resource Management Tool (ARMT) departure efficiency analysis and reporting to replace the standalone ARMT tool currently deployed at 30+ ATC facilities.

4.1.2.2 TMI Modeling and Performance

- Updates to RRIA, including modeling of a Reroute that includes a MIT restriction.

- Improving Demand Prediction (IDP), which produces more accurate demand predictions by using new data sources, considering implemented TMIs, adjusting TFMS demand prediction algorithms, and smoothing aggregate demand [23] (OI Increment 105210-01).

- Integrated Departure Route Planning (IDRP) (OI Increment 105211-01) for selected major metroplexes, which supports:
    - Traffic manager identification of route options for departures on a flight list, including eligible routes for user-selected flights and future demand for specific departure fixes.
    - Quick access to a simplified RAD for departures to be rerouted.
    - Improved departure trajectory predictions based on requirements from the Improved Demand Prediction (IDP) baseline.
    - IDRP departure fix combine/de-combine and open/closure status will automatically be logged in NTML.
- International Civil Aviation Organization (ICAO) Equipment Code Processing that allows checking of route eligibility based on Area Navigation (RNAV) equipage for aircraft being rerouted via TFMS and identification of flights eligible for selected Automatic Dependent Surveillance-Broadcast (ADS-B)-dependent spacing procedures (OI Increment 105210-04).

4.1.2.3 Data Exchange

- Data exchanges between TFMS and TFDM.

- Addition to TFMData to publish airport arrival and departure delay to support cloud migration of the web applications.

4.2 Constraints

The following constraints impact the technical and operational environment for the FMDS concept:

- Implementing FMDS will not impose changes on other NAS systems that have not already been specified in baselined requirements documents.
- FMDS will be designed and implemented in a manner consistent with existing agreements with the CDM community. This includes data and functionality provided to CDM members.
- Deployment of FMDS should be coordinated with deployment or maintenance of other critical NAS systems to avoid interference.
- Implementation of FMDS should not complicate traffic managers' working environment or require additional floor space in the field facilities.
- FMDS user interfaces will be designed with an emphasis on maximizing usability as well as transferability of TFMS users' knowledge to the new system.
- Current Acquisition Management System (AMS) processes constrain the possibilities for implementing new development and deployment processes.
- FMDS requirements based on criticality of the system to the NAS may constrain the options for FMDS architecture and hosting.

- If FMDS needs to maintain legacy interfaces between NAS automation systems, that may constrain options for data exchange standards.

4.3 Operational Environment

Figure 4-1 summarizes the FMDS operational environment. As with TFMS, FMDS will support TFM activities at the ATCSCC as well as ARTCCs, TRACONs, and ATCTs across the NAS, and the automation systems in use at those facilities. The allocation of roles and responsibilities of operational users will remain the same as today. FMDS will support development and coordination of TMIs affecting all phases of flight to manage demand relative to capacity, as is the case for TFMS today.

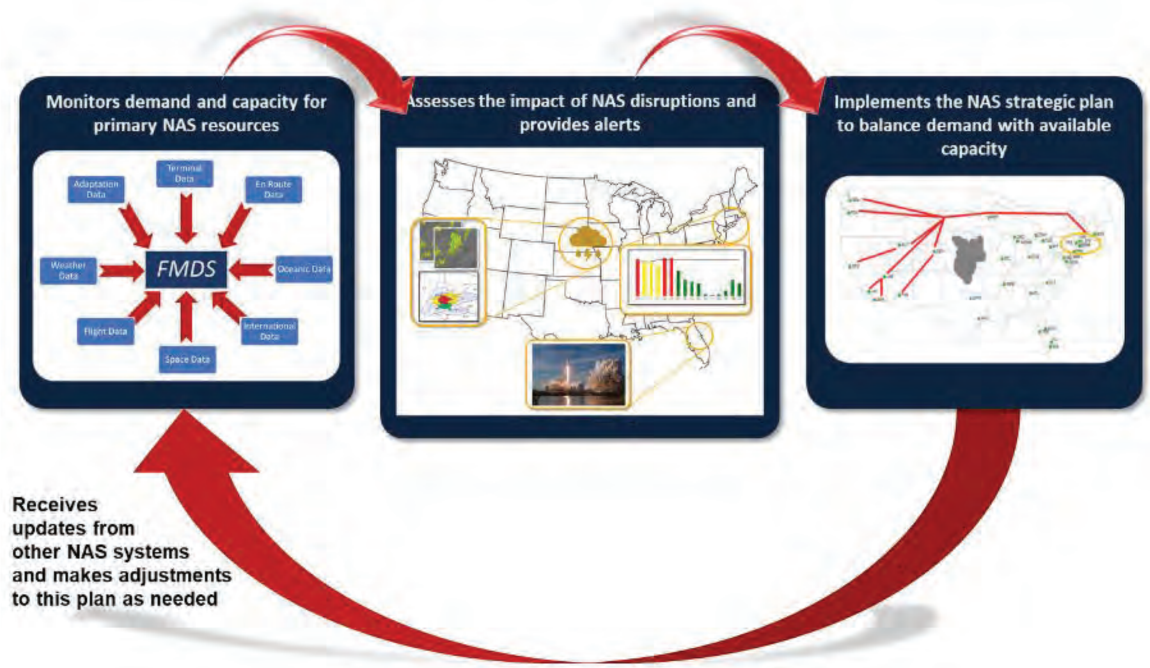


Figure 4-1. FMDS Operational Environment

The FMDS operational environment is expected to include increasingly diverse NAS users, including space launch and reentry vehicles, aircraft using cooperative separation, aircraft that maintain separation via detect and avoid capabilities (considered alternatives to traditional ATC), aircraft traveling at speeds incompatible with legacy operations (super- and hypersonic), and concepts such as Upper Class E Traffic Management (ETM). FMDS and the infrastructure for data exchange with NAS users will support such diversity in operations.

The deployment of TFDM to airports across the NAS will significantly impact the operational environment for ATCT and TRACON traffic managers. TFDM will provide some information to its users that today is only available from TFMS and will complement TFMS capabilities that are expected to be part of the FMDS baseline (e.g., IDRP). TFDM will also support data exchange between ATCTs, TRACONs, and ARTCCs that will streamline implementation and management of surface based TMIs.

The FMDS operational environment will also include new and expanded capabilities associated with TBO. Chiefly, the FAA continues to expand the use of TBM and other

TMIs modeled, coordinated, and issued through TBFM, which will impact the traffic management decision-making process. The continued transition to TBO will encourage stakeholders to increase their ability to share information that will enable more accurate planning of flights and flows and a common understanding of where a flight will be and when. More accurate planning will increase predictability for NAS users and promises to increase flexibility and efficiency of airspace, airports, and flights throughout the NAS [24].

The transition to TBO places increased emphasis on strategic planning such as that associated with the PERTI process. PERTI envisions strategic planning that is web-based with adjustments to the plan occurring in real-time as new information and/or constraints become available. All stakeholders will have access to accurate planning information and the ability to provide input to the plan electronically.

To further support the transition to TBO, NAS users will ensure their aircraft are able to fly precise flight paths and cross key points of interest at assigned times.

The increasing adoption of enterprise services within the FAA represents another significant change in the FMDS operational environment. Multiple FAA efforts are underway to define and deploy enterprise services to support data management and exchange. The transition to enterprise services will both shape the operating environment for FMDS and create new infrastructure that FMDS can leverage, as discussed in Section 4.5.2 below.

4.4 Concept of Operations

Figure 4-2 provides an overview of the FMDS concept. FMDS users internal to the FAA will access most of the information they need to perform the key TFM collaboration and decision-making functions (see Section 4.4.1) through an integrated situation awareness display. FMDS users external to the FAA (e.g., NAS users) will access the TFM information they need through a streamlined suite of FMDS applications and data. Access to these applications will be configurable based on individual users and their role(s). The FMDS applications will exchange data with an underlying suite of common services using APIs designed according to approved industry standards. To the extent practicable, these services will be common across the

System enhancements will be provided through applications and services developed and deployed using a set of practices that automates processes between development, security, and operations teams to build, test, and release incremental software improvements rapidly and reliably [25]. This process is envisioned to be one of continuous exploration of enhancements that, once tested, are deployed via automated processes that ensure continuous synchronization between operational and test environments. New features will be released into the operational environment on-demand as opposed to solely as part of large, scheduled system updates.

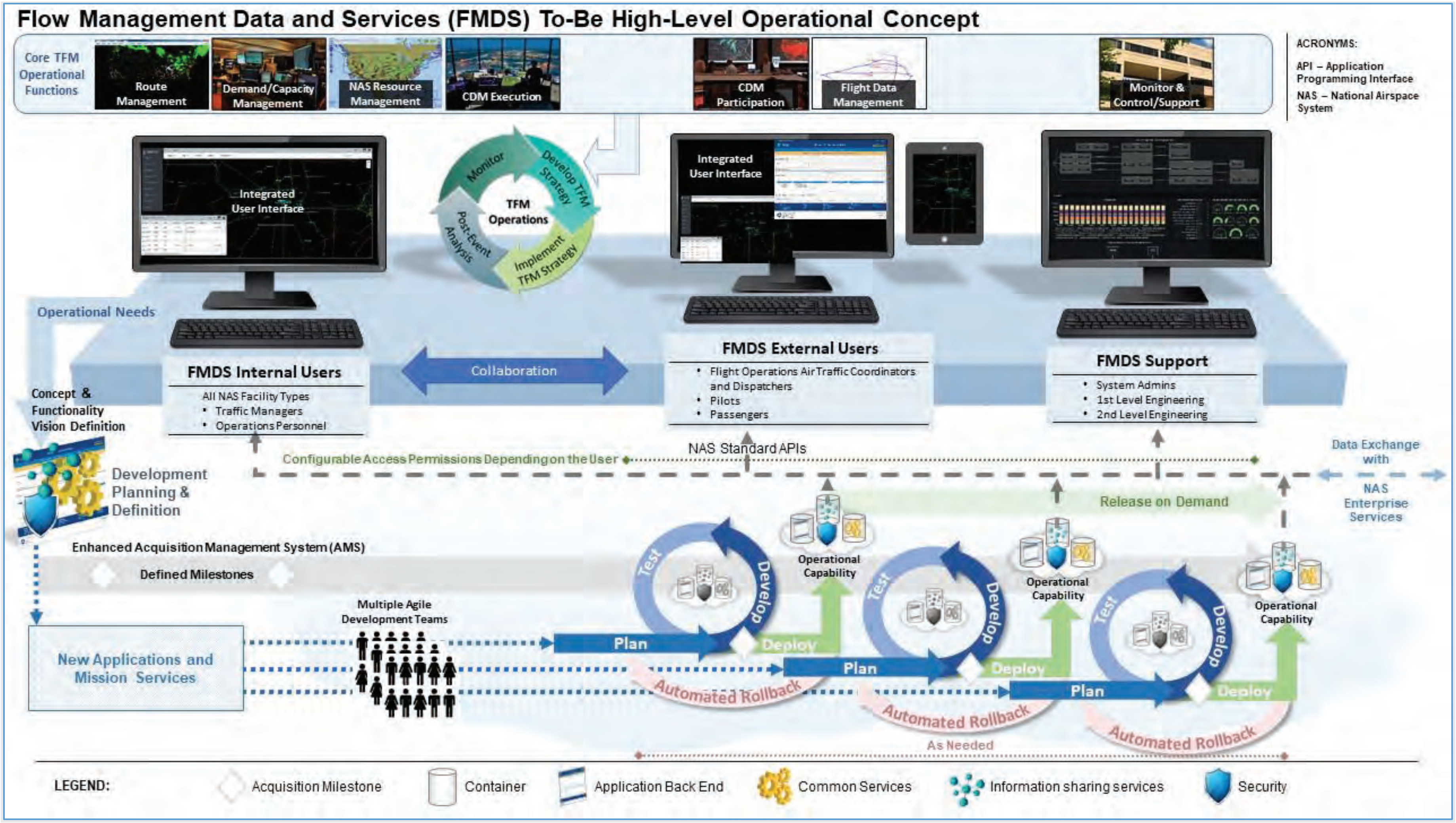


Figure 4-2. FMDS Concept Overview

4.4.1 Traffic Flow Management Collaboration and Decision-making

This section describes how FMDS will support the TFM collaboration and decision-making functions discussed in Section 2.3 above.

4.4.1.1 TFM Data Management

FMDS will be able to receive the same information that TFMS ingests to support TFM collaboration and decision-making. FMDS will also be able to interface with newly created enterprise services such as CSS-Wx as they become available to replace legacy data exchange interfaces. However, FMDS users will access that information differently. For example, the modernized FMDS architecture will allow users to view CIWS weather data directly on the situation awareness display, integrated with the flight, TMI, and other traffic management data that TFMS currently provides separately through the TSD, FSM, and NTML.

CDM members will continue to provide their inputs, including early intent messages, Trajectory Options Sets (TOSs), and substitutions. Note that this includes the ability for CDM members to submit a TOS whether or not a CTOP is in place. They will receive EDCTs for their flights included in TFM programs via existing mechanisms (e.g., SWIM, TTY). NAS users will be able to access the TFM information they need to plan their operations and coordinate with traffic managers, in accordance with CDM data sharing agreements. For example, in addition to the SWIM data distribution provided by TFMS today, FMDS may provide APIs that allow CDM members to access FMDS data and services. Alternatively, CDM members could access certain FMDS displays to support their role in TFM decision-making. In all cases, existing processes and agreements for data sharing between FAA and NAS users will be preserved, and FMDS will allow users to control what information they share, when, and with whom.

4.4.1.2 Support TFM Decision-making

A key feature of FMDS will be the integrated situation awareness display, which will integrate the functionality today provided by disparate TFMS applications. The integrated display will streamline TFM workflows, allowing traffic managers to spend more of their time developing solutions to traffic flow problems rather than entering data into separate applications. It also will support TFM functions as described in the following sections.

4.4.1.2.1 Monitor Demand and Capacity

FMDS will allow traffic managers to assess demand relative to capacity and weather, and model TMIs, without switching between applications. Traffic managers will create FEA/FCAs on the integrated situation awareness display to monitor demand for the indicated airspace, and the integrated situation awareness display will allow them to view all TMIs. Traffic managers will be able to see MIT restrictions together with GDPs, allowing them to better tailor MIT restrictions to meet the airport arrival capacity associated with the GDP (or decide the MIT restriction is not needed). Allowing traffic managers to view MIT restrictions implemented in upstream and/or downstream facilities, together with the demand for their airspace, may allow them to better tailor the MIT restrictions they issue for their airspace. Alternatively, they may decide that another MIT restriction for their airspace is not needed. This is in addition to the ability for FMDS to model the impact of TBM and MIT restrictions on flight demand [23] (OI Increment 105210-01).

When the integrated situation awareness display provides a notification to a traffic manager, such as a notification that demand for a sector will exceed capacity, the traffic manager will address the alert without needing to switch applications. To the extent possible, FMDS will automatically log the action taken; when automatic logging is not possible (e.g., the traffic manager addressed the alert via manual coordination), the traffic manager will be able to log the action directly in the integrated situation awareness display and easily relate the action to the alert. Today, they must log the action manually in a separate application (i.e., NTML).

For TFDM airports and other NAS resources for which capacity and constraint information is published, FMDS will automatically ingest the information as it is received, without the need for separate manual input. This is in contrast to the current requirement for traffic managers to enter this data manually into NTML after viewing it in another application. For NAS resources that do not have automated means to publish capacity and constraint information, FMDS will ensure access to a single portal for manually entering this data. For example, traffic managers at non-TFDM airports will have a single portal to enter airport configuration, rates, arrival and departure delays, and flight counts, as opposed to splitting these entries between NTML and OIS as is done today.

NAS users will be able to access demand, capacity, and constraint information via a centralized portal that allows them to subscribe to the data of interest to them and to receive notifications related to that data, such as TMIs and NAS resources of interest. Today, NAS users must monitor and repeatedly refresh several different websites to ensure they have the most up to date information.

4.4.1.2.2 Develop TMIs

The integrated situation awareness display will provide the interface for all TMI modeling, implementation, and management. In the near term, modeling will be limited to those TMIs that can be modeled in TFMS, with the addition of Reroutes with associated MIT restrictions. TFMS demand predictions will also include the effects of TMIs issued via other NAS automation systems such as TBFM and TFDM [23] (OI Increment 105210-01). Modeling for all TMIs will utilize the same flight data, eliminating the need for users to double check that flight data has been synchronized across applications. FMDS will streamline and automate maintenance of the adapted route libraries that support most restrictions, including aspects of adapted Playbook routes such as protected segments. Where feasible, FMDS will synchronize adapted route libraries with other NAS automation systems (e.g., ERAM) to reduce mismatches.

The modernized FMDS architecture will improve speed and responsiveness of the modeling capabilities and prevent user modeling errors from causing system outages.

4.4.1.2.3 Coordinate TMIs

FMDS will facilitate coordination through the integrated situation awareness display and a centralized portal for TFM coordination with NAS users. ATCSCC traffic managers will provide information ahead of the Planning Webinar according to the continuous PERTI plan that authorized personnel engage in today. ATCSCC users will be able to use a web-based version of the integrated situation awareness display during Planning Webinars and other stakeholder collaboration interactions to review and discuss with participants. For example, they could display a current GDP along with the current airport demand.

The integrated situation awareness display will support all data sharing that is provided today via NTML, TSD, and FSM. For example, traffic managers will be able to share proposed program parameters, RRIA modeling results, and proposed restrictions – all through the integrated situation awareness display. Note that traffic managers will decide when they are ready to share an FEA/FCA or TMI, and with whom, as they are able to do with TFMS today. This ensures traffic managers can fully evaluate a TFM strategy before sharing it with other users.

Streamlining and integrating TFM functionality will make it easier for traffic managers to monitor the strategies proposed and implemented by other facilities, supplementing Planning Webinars and phone calls. The integrated situation awareness display will notify traffic managers of TMIs proposed and issued by other facilities that affect flights in their airspace and/or are related to TMIs issued in their facility. They will be able to view FEA/FCAs and TMIs proposed and implemented by any facility. Traffic managers will be able to view information about proposed TMIs, view the modeled impact of the TMI, and take action as needed using the integrated situation awareness display and a streamlined workflow. Furthermore, the integrated situation awareness display will allow traffic managers to connect a given TMI, such as a passback restriction, to an existing TMI that it is intended to support, such as an AFP.

FSM will be retired with the introduction of FMDS, including those instances of FSM that are installed at CDM member sites. As a result, CDM members will require an alternate means to access the TMI information they need to monitor programs and model effects on their operations. Note that most, if not all, CDM members already have alternate applications to manage the impact of TMIs on their operations. For this purpose, FMDS may provide an API for a TMI modeling service that will allow CDM members to access the same algorithms used by traffic managers to model TMIs. To facilitate adoption, API documentation would include detailed information about how to make use of the API to accomplish common tasks. Alternatively, or in addition, FMDS may provide CDM members access to a web-based version of the integrated situation awareness display that will allow them to perform similar modeling and EDCT management tasks as they can do today via FSM. This will support common situation awareness between FAA traffic managers and NAS users.

4.4.1.2.4 Issue TMIs

Traffic managers will use FMDS to more easily implement the TFM strategies developed and coordinated via the integrated situation awareness display and webinars. Regardless of the TMI, the traffic manager will create, review, select with whom it should be shared and when, and issue it directly from the integrated situation awareness display. Issuing all TMIs directly from the same application used to model them will allow advisories to have access to all the information in the model, including TMI parameters, flight lists, and model/analysis results. By creating the advisory directly in the integrated situation awareness display, traffic managers will not have to enter information into multiple applications to complete its distribution as is done today. Furthermore, FMDS will support logging of TMI parameters and model/analysis results that are not available today, such as pop-up and reserve rates, as well as flight list analysis results for reroutes (e.g., number of flights captured, from where, how many additional miles flown for each).

The integrated situation awareness display will have one advisory form for all applicable TMIs and will pre-populate as many fields in the form as possible to minimize manual data entry. For example, a constraint for an airport in the Washington, DC, region could require passback restrictions as far away as Denver ARTCC (ZDV). At that long range, the passback restriction may affect only a small number of aircraft. FMDS will allow ZDV and other ARTCCs in the western US to link these passback restrictions to the TMI issued in the eastern US. This will improve the ability for the ATCSCC to maintain awareness of TFM strategies across the NAS. Having all the TMIs in one streamlined display will improve their situation awareness and enable them to more directly determine the necessary restrictions to pass back to upstream facilities. Today, the ATCSCC traffic manager responsible for operations in the eastern US does not receive notification of restrictions proposed by ARTCCs in the western US. Conversely, when the original restriction is canceled, FMDS will notify relevant users so they can evaluate whether any related passback restrictions are still needed.

FMDS will automate processes for displaying TMI information on facility ESIS boards and IDS (or the Enterprise Information Display System [E-IDS]), and for providing TMI information to NAS users (e.g., posting information to the consolidated web portal). Templates for advisories and other TMI information sharing tools will be stored centrally so they will be available to all appropriate users. NAS users will subscribe to receive TFM information in their desired industry-standard format. CDM members may also have access to a version of the integrated situation awareness display that allows them to see information about proposed and active programs, along with demand and delay information. All advisories will be issued via SWIM (and TTY), consistently formatted, and correlated with TMIs as appropriate. Consistent formatting of TMI information will make it easier for NAS users to build an understanding of the TMIs and the impact on their operations.

Other FMDS users will receive notifications of new advisories. They will be able to view the information about the TMI directly on the integrated situation awareness display – including textual, graphical, and geospatial information. This will make it easier for users to view the impact of TMIs proposed and implemented by the ATCSCC and other facilities on their local operations, promoting common situation awareness. This will improve the ability for traffic managers to fine tune their TFM strategies to improve balancing traffic demand with available capacity.

Additionally, traffic managers may configure parameters for alerts to demand and capacity imbalances to support monitoring the effectiveness of the issued TMIs. The integrated situation awareness display will show TMI performance metrics, including delays and flight compliance with TMI controls like EDCTs and required routes. If a flight needs its control time modified, ATCSCC traffic managers will use the integrated situation awareness display to make the change. FMDS will recalculate flights' EDCTs as needed to smooth demand, consistent with CDM procedures and algorithms. If a flight's route is not in compliance with a required route, the integrated situation awareness display will incorporate the capabilities provided via the RAD today to notify the traffic manager and allow them to submit route amendments as needed. Flight history will be available wherever a user can select a flight, integrating capabilities currently split between the TSD and RT-FSA.

If a facility needs to revise or cancel a TMI, they will use the integrated situation awareness display to select that TMI and modify or cancel it as needed, following appropriate processes for coordinating TMI revisions and cancellations. The integrated situation awareness display will allow them to issue an advisory with the amendment and will automatically maintain a log of changes to the TMI. This will support common situation awareness during the event and facilitate post-event analysis. Other FMDS users will be able to view the modified TMI and consider the follow-on effects on their own locally developed TMIs and other aspects of their operations. TMI history will be available wherever a user can select a proposed or issued TMI.

A centralized web portal will allow NAS users to access information about all active TMIs in one place. When a TMI is modified or replaced, information about that TMI will be automatically updated accordingly to support NAS users in easily discerning the current state of the NAS. ATCSCC and NAS users will use a centralized portal to manage slot reservation programs as well as individual flight needs through TCA requests and diversions. ATCSCC traffic managers will monitor the NAS users' requests on this centralized portal and address each request as needed.

4.4.1.2.5 Post-Event Analysis

Personnel responsible for post-event analysis will have access to a searchable, downloadable store of FMDS data that is aligned with FAA enterprise data management services. The data store will include information presented to users, data exchanged among users/facilities (including log entries), and data exchanged among the underlying software services. This will include actual and forecasted airport and airspace demand, actual and forecast weather, assessment of demand and capacity accuracy predictions, compliance, and overall effectiveness, and will allow analysts to identify flow management actions taken for similar past events and their impact (OI Increment 105210-04). The lessons learned will support future evaluation of alternative strategies and construction of better TMIs.

Post-event analysts will be able to use their tools – external to FMDS – to conduct dynamic queries. FMDS will not provide the analysts' tools, but rather will ensure data is available and accessible to analysts using external tools.

Analysts will be able to search for and download FMDS data on historical (and current) TMIs by type, keyword, or other relevant characteristics. This will make it much easier for post-event analysts to understand a series of events and their impacts, and to replay them in the integrated situation awareness display. The FMDS replay capability will make it just as easy for users to interact with stored data (e.g., modeling TMIs) as with live data (except for issuing TMIs).

A carefully selected set of commonly used reports on FMDS data will be easily accessible and editable from the data store (e.g., the Deputy Director of System Operations [DDSO] Recap Report that is produced daily). However, the emphasis will be on leveraging enterprise services that process data from multiple NAS automation systems, and ensuring the stored data is searchable and downloadable so that analysts can build their desired analysis products.

The store of FMDS data will support synchronization of time across displays of multiple airports in viewing historical events. It will also allow analysts to reconstruct flight histories, including reroutes and other amendments, as well as events associated with groups of flights, such as those going over a specific fix or between a given airport pair. In contrast, each TFMS application separately archives the data used by, and actions taken in, that application. This makes it difficult to access information about different TMIs associated with a given NAS resource. Making the data accessible will eliminate the need for analysts to scrape TFMS websites to create their own archives for post-event analysis.

4.4.2 Maintaining the TFM Automation System

The modernized FMDS architecture will facilitate system support that satisfies users' expectations for RMA and performance while enabling more effective TFM collaboration and decision-making. The new architecture will modify the processes and technologies used to perform first- and second-level engineering and support a streamlined set of applications and processes for M&C. FMDS will employ a more editable and maintainable approach for system support documentation (e.g., a wiki), improving maintainability of the documentation and reducing reliance on individual knowledge. FMDS also will support more streamlined and automated processes for managing and validating adaptation updates.

Modernized technologies will support self-monitoring processes and comprehensive M&C displays to inform operational and support personnel about the status, performance, and availability of FMDS capabilities and data sources. This visibility will extend to all system components and will support maintenance personnel in identifying and addressing developing issues before they cascade into system failures at a position or facility. FMDS will alert appropriate personnel to emerging issues. These notifications will avoid an excessive number of nuisance alerts while providing enough information to ensure personnel are aware of emerging issues. For example, support personnel could receive an indication that a particular process is taking longer than usual, such as the preview function of a tool for creating reroutes or the process for generating a flight list from an FEA/FCA.

The modernized architecture, streamlined user application suite, and reduced duplication of functionality within the system will simplify processes for troubleshooting and resolving issues. The use of modern technologies will increase the pool of support personnel with the requisite knowledge to diagnose and resolve issues. Modernized technologies will support remote logging where feasible to further streamline troubleshooting of user issues. Modernized, standards-based data connections among FMDS components will simplify the processes for maintaining those data connections.

FMDS will support configuration management practices that provide visibility into the system baseline, component versions, and system changes throughout its life cycle. The modernized architecture will implement a comprehensive failover strategy that will minimize the effects of performance issues or a loss of service in one component on other system components. This philosophy applies to component failure, routine maintenance, and deployment of a new version of a given component. In the event of a failure of any component or components, either physical or virtual, the FMDS architecture and failover strategy will support a seamless switchover to the redundant infrastructure. This should occur with minimal to no interruption to end users and the flying public.

In the event of a complete failure of both operational and backup systems for technical or non-technical reasons, FMDS will follow a disaster recovery plan that includes a system that can quickly become operational and provide the full complement of FMDS functionality, in contrast to the limited set of functions provided by the TFMS DRC today.

Updated hardware will reduce the need for in-house repair in the near term. The modernized FMDS architecture may reduce the hardware footprint at remote sites, simplifying site deployments and remote site logistics support for the long term.

FMDS will provide processes, applications, and tools to aid FMDS support personnel in the validation, certification, troubleshooting, and analysis of the FMDS system and services. FMDS should also provide data analytics to help identify trends and potential issues long before they become systemic issues or failures. FMDS architecture and tools will provide key system support functions such as automated monitoring of availability and performance of system components and data connections, ensuring the integrity of hardware, as well as maintaining performance such as load balancing across servers. FMDS will also support improvements in processes for deploying software releases, troubleshooting system issues, and building and deploying adaptation updates.

FMDS will employ a centralized user authentication service, so that user accounts will no longer be managed in multiple places as they are for TFMS. This will simplify the processes for managing user accounts and eliminate the need for synchronizing application data across servers. It may also reduce the hardware required to support the web applications, since each application will not have to be hosted separately in all three domains that exist today to manage user access. Note that access processes and requirements may differ for traffic managers as opposed to other FMDS users. For example, at FAA operational facilities traffic managers always need to be able to access TMU positions. On the other hand, individual NAS user representatives may have personal access credentials that will allow them to access the FMDS capabilities for which they are authorized.

Users will be able to configure their instance(s) of the integrated situation awareness display using preference settings (pref sets). Individual users will be able to create multiple pref sets to reflect how their information needs differ in different operational conditions, and they will be able to access their pref sets from different workstations and share them with other users. For each user role, the integrated situation awareness display will provide “template” pref sets, and facilities will be able to customize those templates as needed.

The microservices FMDS architecture will allow new and updated services to be tested via connections to the same data used to support operational capabilities, simplifying the process for developing test data sets and allowing new capabilities to be exercised more completely in the test environment. It also will allow individual services to be updated without taking full applications offline for long periods of time.

4.4.3 Training Personnel for TFM Automation System Improvements

FMDS will provide a robust training environment not only at the ATCSCC, MMAC, and TPC, but also at field facilities. This training environment will allow both operational users and system support personnel to gain experience with all features – including those already deployed and those nearing implementation. Trainees will be able to explore new functionality in the context of live or simulated data in an environment that is sufficiently isolated from the operational environment to prevent training activities from influencing traffic operations. As part of developing a training course, a training developer might use FMDS to identify a past operational period of interest (e.g., a day), edit features of the operational data for that period, and allow students to manage the simulated traffic using the FMDS capabilities of interest for the training session. This will allow users to interact with new features before they are called upon to use these features in an operational setting. Trainees will be able to operate in a simulated environment such that their actions will influence simulated flights, but they will not influence live NAS operations. It is important to note that this training environment will support both initial FMDS deployment as well as enhancements to the baseline FMDS system. It will support the introduction of new features and will refresh the users’ knowledge of infrequently used features. The FMDS architecture will support a future integrated simulation training environment that includes interaction with other NAS automation systems’ training environments.

In addition to traffic managers and other operational users, FMDS will provide a robust training environment for system support personnel, including those responsible for FMDS software and hardware support and those providing support at the enterprise level. Those responsible for maintaining the system need to have training on all aspects of the system, including its architecture, hardware, software, logistics, and the enterprise services with which FMDS will exchange data. This will include training on the technical system specifications as well as the tools FMDS will provide to support M&C and other system support functions. As needed, training will include information about technologies and processes envisioned for FMDS architecture and support that are very different from those technologies used in TFMS. The training – and personnel with the requisite knowledge – will be available where they are needed, including the local facility level and where SLE is provided.

4.5 Supporting Infrastructure

This section describes the infrastructure required to support FMDS, both internal to and external to FMDS.

4.5.1 Infrastructure Internal to FMDS

FMDS envisions an infrastructure that is markedly different from the current TFMS infrastructure. Chiefly, FMDS envisions a microservices architecture, in which each function is encapsulated in a service, in alignment with the NAS Automation Evolution Strategy [25]. For example, one microservice might model CTOPs, whereas another microservice might model GDPs. Both services would interface with shared services for common functions like accessing flight data. These services will use standards-based data exchange protocols to facilitate interoperability. The architecture will be centralized to the extent possible, minimizing the footprint of locally installed hardware and software at the remote sites, streamlining maintenance and logistics.

4.5.2 Infrastructure External to FMDS

The infrastructure components required to support FMDS include:

- Existing systems that exchange data with TFMS, including ERAM, TBFM, TFDM, Advanced Technologies and Oceanic Procedures (ATOP), Standard Terminal Automation Replacement System (STARS), and NAS users, including the following enhancements:
    - TBFM Sustainment 1 and Enhancement 1
    - ERAM Enhancement 2
    - STARS Sustainment 2 and Enhancement 2
    - ATOP Sustainment 2
- TFDM, including satisfaction of the requirements allocated to TFDM associated with Surface Movement Advisor (SMA), Advanced Electronic Flight Strips (AEFS), DSP, and ARMT.
- SWIM services capable of supporting data exchanges with FMDS applications and services, including those associated with ERAM, TBFM, TFDM, CSS-Wx, Aeronautical Common Services (ACS), and others as they are developed.
- FAA Enterprise Network Services (FENS) to support internal FAA communication.
- An enterprise hardware platform (such as FAA Cloud Services or Integrated Enterprise Services Platform) that supports virtualization, containerization, and mission support to host FMDS services.

4.6 Benefits

FMDS will address the identified shortfalls [12] and provide benefits in the following categories:

- Replacing obsolete capabilities

- Administrative benefits
- Supportability benefits
- Infrastructure improvements
- Productivity benefits

The benefits associated with each of these categories are discussed further below. These benefits are tied to the shortfall measures described in the FMDS Shortfall Analysis Report [12].

4.6.1 Replacing Obsolete Capabilities

By replacing the obsolete TFMS capabilities, FMDS will improve operational availability and system reliability, system response times, and remote site equipment maintenance and support. Benefits include:

- Reducing the need for maintenance reboots to prevent system or system component performance degradation. As a result, FMDS will be more capable to meet the availability requirements established for it.
- Improving system performance will reduce the number of problem tickets created by users related to latency.
- Improving system reliability, availability, and performance, and reducing the hardware footprint at remote sites, will reduce the number of remote site support incidents and the number of pieces of hardware affected by each incident.

4.6.2 Administrative Benefits

The modernized and streamlined FMDS architecture will reduce the length of time it takes to develop, test, and deploy system enhancements. Modernized components and a standards-based architecture will make it easier for developers to understand the relationships and dependencies between proposed system enhancements and existing system components. Continuous integration and testing will improve the development and deployment processes, reducing surprises and delays in delivering new capabilities.

Integration, testing, and deployment processes that provide users earlier delivery of new capabilities will initiate benefits accrual sooner, improving the return on investment.

4.6.3 Supportability Benefits

The modernized FMDS architecture will streamline and standardize the data exchange interfaces within the TFM automation system as well as the external interfaces between the TFM automation system and other NAS automation systems. Interface improvements will increase data quality and reduce the number of problem tickets associated with data interface issues.

4.6.4 Infrastructure Benefits

Implementing failover strategies that maintain a full suite of FMDS services during system upgrades and provide better management of outages, component failures, and major disaster failures, will increase the availability of the TFM automation system. For example, enhanced failover will reduce FMDS downtime due to maintenance. Disaster recovery will more quickly restore FMDS operations after a major disaster.

4.6.5 Productivity Benefits

The integrated situation awareness display will improve traffic manager productivity. Specifically, FMDS will reduce the amount of time traffic managers spend manually entering data into multiple applications to support common functions like coordinating, logging, and communicating MIT restrictions to controllers for implementation. FMDS will also create a consistent user experience across system features, including data, semantics, and look and feel, which will improve system usability. These usability improvements will complement productivity as they reduce user confusion, increase situation awareness, decrease workload, and reduce the number of user errors [26].

Integrated functionality in FMDS will reduce the time traffic managers spend searching for data in one function after already selecting that data in another function (e.g., searching for a flight in the Departure Viewer that is already selected in the Surface Viewer).

An improved training environment will allow traffic managers to learn how to interact with a new feature in an offline environment, requiring less training to occur on the job. An offline training environment provides a more viable space for mastering new TFM capabilities and prevents counter-productive training actions from impacting real-time traffic flows.

5 Operational Scenarios

The operational scenarios in this section illustrate how the key features of FMDS will improve the experience of its users relative to the current environment.

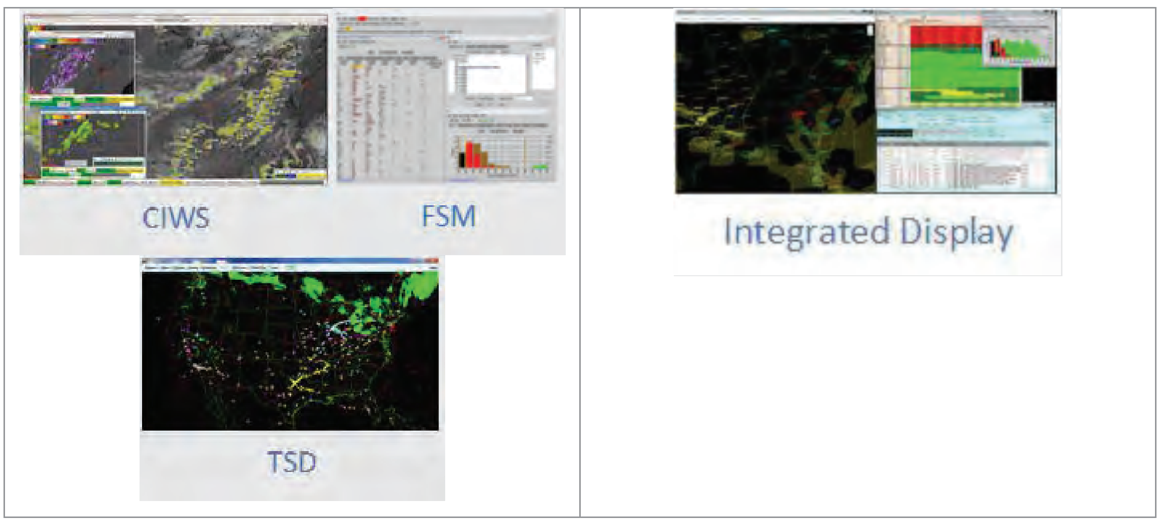
5.1 FMDS Support for a Large-Scale Weather Event

This weather scenario depicts a large-scale weather event impacting the eastern third of the NAS, including the Ohio Valley and New York Metroplex, where multiple AFPs, GDPs, required routes, and route-out options through Canada are planned and negotiated. It illustrates how FMDS will support TFM coordination and decision-making that involves numerous FAA facilities, NAS users, and NAVCANADA. As noted above, FMDS will not change the roles, responsibilities, and processes for carrying out TFM activities relative to the current environment. Rather, FMDS will significantly streamline the user experience.

5.1.1 AFP Event Planning

AFP planning usually starts with the PERTI process on the day prior. The PERTI planning team monitors long-range weather forecasts and documents TMIs that could address the potential demand/capacity imbalances created by the weather constraint(s). This information is discussed twice daily with NAS stakeholders during the PERTI Advanced Planning Webinars. The resulting collaboration between FAA TMUs, NAVCANADA, and NAS users creates the PERTI plan, which includes the expected TFM strategies for the next day's operations.

The following morning, the ATCSCC Severe Weather Unit and the Northeast Terminal Area review the PERTI plan and determine that, in addition to GDPs for the New York airports, two AFPs plus Playbook routes need to be discussed on the first Strategic Planning Webinar. To help facilitate those discussions the ATCSCC traffic managers use the FMDS integrated situation awareness display to view traffic, weather, and the latest information about SAA schedule and status. The traffic managers display the two FCAs (OB1 and A05) and discuss the start/stop times, altitudes, and proposed hourly throughput rates. Figure 5-1 provides a comparison of this process with the displays used to execute this task today.



TFMS Applications to Support AFP Planning | *FMDS Integrated Situation Awareness Display Supports AFP Planning*

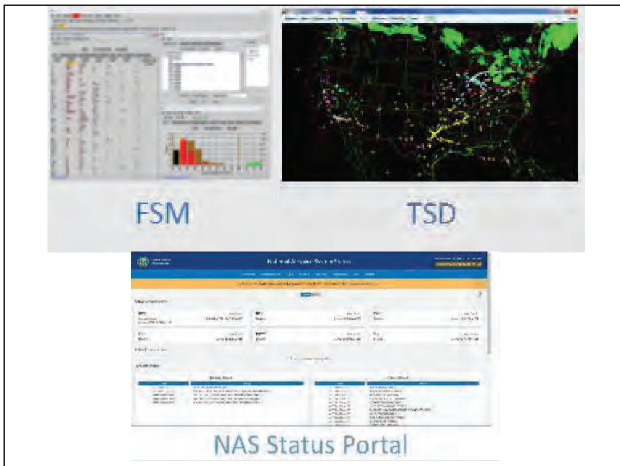
Figure 5-1. Multiple TFMS Applications for AFP Planning (Left) versus FMDS Integrated Situation Awareness Display (Right)

When the ATCSCC traffic managers agree on a strategy that will manage the weather situation, they share the proposal with affected facilities. The message includes all the proposed TMIs and their parameters such that other users can easily import them into their integrated situation awareness display for modeling. The ATCSCC and traffic managers from affected facilities coordinate the parameters for the AFPs, and the ATCSCC briefs the strategy during each of the planning webinars, held every two hours. The traffic manager displays the weather and explains the modeled results to webinar participants, allowing them to see the constraints driving the traffic manager's plan and to provide feedback.

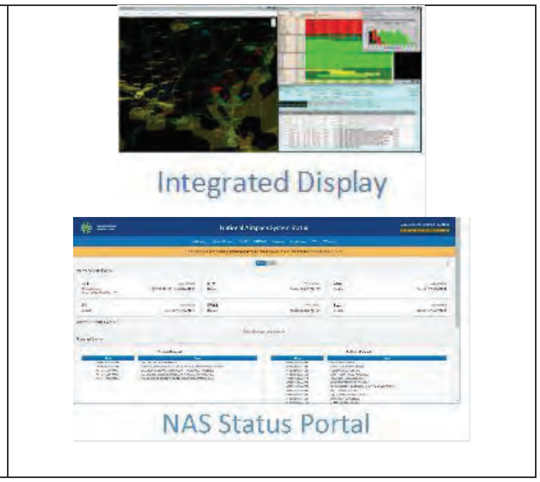
5.1.2 AFP Strategy Execution

After the planning webinar, the ATCSCC issues advisories for the AFPs and supporting Playbook routes, which automatically shares all AFP parameters, as well as the Playbook routes, with all integrated situation awareness display users. FMDS allows traffic managers to ensure that the advisories are posted to the centralized portal and logged for post-event analysis.

In addition to viewing both AFPs on the integrated situation awareness display, CDM members receive and review their airline's EDCTs, prioritize their flights, and submit substitution requests using the existing SWIM framework for exchanging CDM data. They set up alerts in the centralized web portal so they will be notified of changes of interest to their operations. Conversely, with TFMS, they would need to monitor the AFPs via FSM, monitor traffic demand via the TSD, and monitor multiple OIS pages to maintain awareness of TMIs and delays (see Figure 5-2). Furthermore, FMDS will provide APIs allowing CDM members' internal systems to leverage TMI modeling and other related algorithms to improve their management of EDCTs compared to what they can achieve with FSM today.



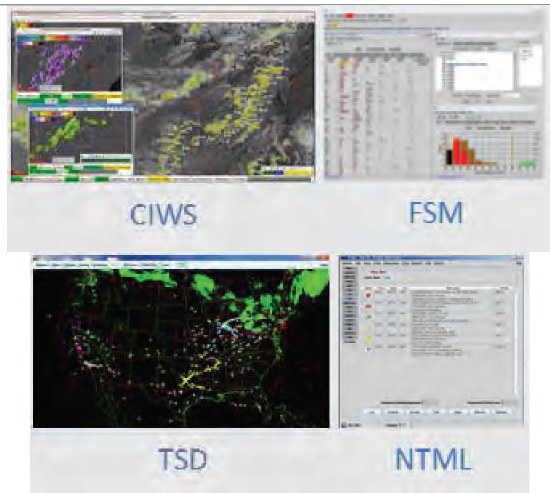
TFMS Applications to Support CDM Members in Managing EDCTs



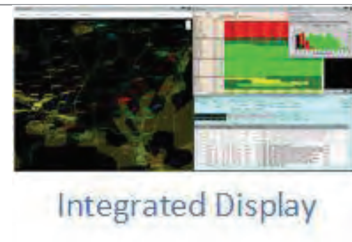
Streamlined FMDS Applications to Support CDM Members in Managing EDCTs

Figure 5-2. Applications for CDM Members to Manage EDCTs in TFMS (Left) vs FMDS (Right)

Field facilities use the integrated situation awareness display to view AFPs, build FEAs, review traffic volume, and coordinate additional TMIs (e.g., MIT, TBM) to ensure appropriate spacing at the FCAs to support the AFPs. The integrated situation awareness display supports seamless, automated collection of the necessary data to log the event and display the TMIs to the ESIS board in each operational area (see Figure 5-3). With TFMS, field facilities would have to use FSM to monitor the AFPs, the TSD to build FEAs and monitor traffic flows, and NTML to coordinate additional TMIs. They would need to separately designate data for ESIS to display and manually log events not already coordinated in NTML.



TFMS Applications to Support AFP Execution



Integrated Situation Awareness Display Integrates ARTCC Support for AFP Execution

Figure 5-3. Multiple TFMS Applications (Left) vs Integrated Situation Awareness Display Support (Right) for AFP Execution

As an example of how a field facility TMU might use the integrated situation awareness display to coordinate a restriction, a traffic manager at Chicago ARTCC (ZAU) uses the integrated display to create or recall a set of stored FEAs to assess demand for regions of their airspace. Seeing that demand is expected to exceed capacity over the next couple of hours, the traffic manager uses the integrated situation awareness display to create and model a MIT restriction.[16] Once they have selected the parameters for the MIT restriction, the traffic manager uses the integrated situation awareness display to send the proposed MIT restriction to providing facilities and the ATCSCC for coordination and approval. With TFMS, the traffic manager would have to use the TSD to assess airspace demand and separately create the MIT restriction in NTML.

FMDS users at each impacted facility receive a notification of the new restriction in the integrated situation awareness display. Each TMC clicks on the notification to review it; they are able to see not only the restriction but also the FEAs used to create it and other pertinent information that helps them understand the reasons underlying the restriction. With TFMS, these users would receive the notification via NTML and need to assess the impact of the MIT restriction separately on their TSD.

For example, traffic managers at ATCSCC and ZMP TMU receive notification that ZAU has requested a passback MIT restriction for eastbound traffic to the NY Metro area. The ATCSCC and ZMP traffic managers open the restriction on the integrated situation awareness display and examine the FEA the ZAU traffic manager submitted. Since ZMP has localized weather in central Iowa that is causing aircraft deviations, the ZMP TMC does not approve the request but instead requests a conference call. During the call

[16] Continued maturation of TBO capabilities may support future use of a more precise TMI than MIT, such as TBM. However, TBM is not expected to support metering to a point in the en route airspace as would be required to use TBM in place of this MIT restriction.

with ZAU and ZMP, the ATCSCC traffic manager uses all the data displayed on the integrated situation awareness display to discuss ZMP's concerns and develop an alternate strategy. ZDV TMU is brought into the discussion and after reviewing the same data, they agree to help ZMP provide the MIT that ZAU is requesting. After this negotiation is completed, ZAU sends an amended proposal that all parties accept. With FMDS, all this functionality is available from the integrated situation awareness display, whereas in TFMS the traffic managers would have to use the TSD to evaluate demand and separately enter data into NTML to support electronic coordination.

5.1.3 AFP Monitoring

Throughout the AFP event, traffic managers at the ATCSCC and the field facility TMUs use the integrated situation awareness display to monitor the weather forecast, as well as traffic volume through both AFPs. They resolve excess traffic demand by adding and modifying TMIs as necessary. Traffic managers use the integrated situation awareness display to share the information needed to coordinate these TMIs and log all the data needed for post-event analysis. With TFMS, AFP demand must be monitored in FSM, while sector demand is monitored using the NAS Monitor function in TSD and MIT restrictions are coordinated separately using NTML. This is in addition to monitoring the weather forecast on a separate CIWS display.

As an example, ZMP TMU creates an FEA along their eastern boundary to monitor demand-capacity imbalances and route compliance. Using the integrated situation awareness display, they are alerted to several flights that are not on the required routes. They select the flights, amend the routes, and send the amendments via ABRR to the correct sectors for controllers to issue. TFMS currently supports this PDRR/ABRR workflow; however, these Reroute Monitor and RAD features are not usually displayed on the same TSD.

The processes described above are continually reviewed and updated throughout the severe weather event. The ATCSCC has the responsibility for monitoring the overall AFP "big picture." Each field facility TMU continually monitors their own traffic flows feeding the AFP, along with the associated Playbook routes and MIT restrictions affecting their airspace.

5.1.4 AFP Conclusion

Near the end of the AFP event, the ATCSCC traffic manager monitors the diminishing weather and traffic volume, while receiving updates from the field facilities indicating that the weather that was impacting air traffic has diminished enough to cancel the program. Traffic managers observe fewer large cells of heavy precipitation on the weather display, echo tops are lower, and aircraft are not deviating quite as much to avoid the weather.

The traffic manager models the cancellation of each TMI one by one to ensure canceling will not overload sectors with airborne flights that may be given shortcuts, or by the backlog of flights that are still waiting to depart.

When the traffic manager cancels the AFPs, FMDS suspends any remaining EDCTs and publishes the updated flight information. NAS users receive the cancellation advisories and file flight plan amendments as desired that return flights to their original routes.

ZAU receives notifications of the cancellation via the integrated situation awareness display. The traffic manager keeps the local TMIs in place, then slowly reduces them to control the flows during this cancellation process. They model each TMI reduction before issuing it, similar to the process used by the ATCSCC. Since FMDS issues all TMIs via the integrated situation awareness display, it is the only application traffic managers need to facilitate the process of winding down the TMIs.

5.1.5 Post-event Analysis

The following morning, ATCSCC analysts use FMDS' simplified reporting application to generate reports describing the operation from the day before. The report generation process is streamlined because data is consolidated in the FMDS data store, and all TMIs and advisories use a consistent nomenclature. The report generation process is also more automated than today because FMDS automatically captures the necessary data throughout the day, including the TMIs, advisories, and other events. This contrasts with the several TFMS applications required to accomplish the same goal as shown in Figure 5-4.

TFMS Applications to Support Post-Event Analysis

FMDS Applications to Support Post-Event Analysis

Figure 5-4. TFMS Applications (Left) vs FMDS Applications (Right) to Support Post-Event Analysis

Suppose that a NAS user commented on the daily shift summary that, during the previous day's AFP event, they experienced an exceptionally long ground delay on a flight from Detroit Metro Airport (DTW) to Newark Liberty International Airport (EWR). Analysts use the Replay feature to find the time period in question. They can view, in one place, the information the TMU used to guide their decision-making and provide a report that the TMU can discuss in the morning operations webinar. With TFMS, the analysts would need to synchronize replay times in the TSD, FSM, the Surface Viewer, and the weather and correlate with the data recorded in the logs to be able to discuss.

Similarly, the TMU/analyst at each field facility generates reports for the local facility post-event analysis. The consistent nomenclature across TMIs and advisories makes it straightforward for the field facilities, regional traffic management, and service areas to generate reports that complement those generated by the ATCSCC analysts.

5.2 FMDS Support for a Large-Scale Weather Event Using CTOP

This scenario illustrates how FMDS will support the use of a CTOP to manage the large-scale weather event in the previous scenario.

Based on the planning information from the PERTI team, the ATCSCC creates the two FCAs, along with start/stop times and proposed throughput rates using the integrated situation awareness display. Controlling multiple FCAs with one CTOP minimizes the number of flights that FMDS treats as "pop-ups" if they route out of one FCA and into another. Supporting multiple route options and reducing the number of pop-ups in turn reduces the number of flights that need to be manually coordinated via the TCA position.

ATCSCC shares the proposal with affected facilities, including the proposed CTOP and all its parameters. The ATCSCC and traffic managers from affected facilities coordinate the parameters for the CTOP and the ATCSCC briefs the strategy during each of the planning webinars. The traffic manager displays the weather and explains the modeled results to webinar participants, allowing them to provide feedback.

NAS users receive advisories for the CTOP and any related TMIs. They evaluate their route options and submit TOSs that list the trajectory options they are prepared to fly, and their preferences related to tradeoffs between ground delay and alternate routes. FMDS uses the CTOP algorithm to account for the demand and the available capacity and to assign the most preferred option possible to each flight.

FMDS provides NAS users the CTOP trajectory assignment for each of their flights, including cruising altitude, speed, and EDCT if a delay is incurred.

5.3 Using the TOS with PDRR

This departure reroute scenario uses a Washington ARTCC (ZDC) convective weather scenario, resulting in departure congestion and subsequent reroutes, to demonstrate how the integrated display simplifies the process of submitting reroutes using TOS queries with PDRR.

In this scenario, thunderstorms have built to the west of Dulles International Airport (IAD), causing the ZDC TMU to impose restrictions on IAD and Potomac Consolidated TRACON (PCT) for departures over the RAMAY departure fix. This results in back-ups and departure delays on the surface at IAD. Figure 5-5 shows how the weather situation is interfering with departures over RAMAY, and how rerouting those flights over COLIN will help resolve this flow issue.

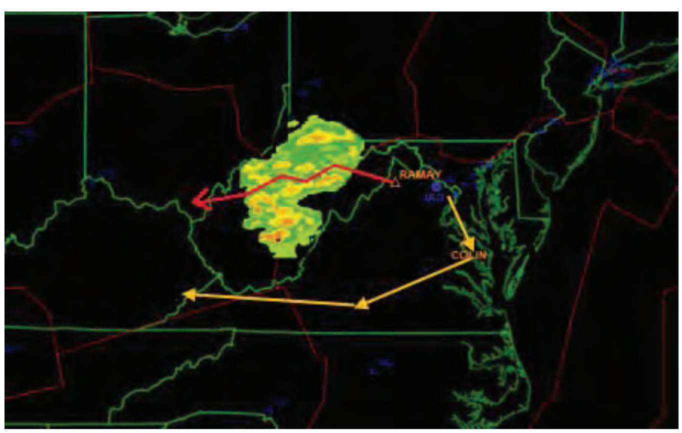


Figure 5-5. Thunderstorms Building West of IAD Affecting Departures Over RAMAY

Using today's displays and applications, traffic managers must filter the Reroute Monitor to display departures from Dulles International Airport (IAD) filed over the fix in question, then manually select flights to reroute over a more favorable fix as part of a Severe Weather Avoidance Plan (SWAP). With FMDS, the ZDC Traffic Management Coordinator (TMC) simply queries the integrated situation awareness display for departures over RAMAY that have filed TOSs that contain routes over the COLIN departure fix.

It is important to note that in this scenario it is assumed that: 1) The flights that have filed a TOS have adequate fuel and can accept those reroutes, and 2) The use of CDRs has been coordinated with PCT, IAD, and Indianapolis ARTCC (ZID) through the ATCSCC. With all flights containing the desired alternate departure fix in a trajectory option identified, the TMC can use the integrated situation awareness display to easily select the optimal candidates to reroute over COLIN based on their placement in the departure queue. For example, they may view the lineup of flights awaiting departure and surgically select those that are near the front of the departure queue. The selected flights are then rerouted and the new flight plan amendments are sent to IAD via PDRR.

5.4 Using the TOS to Find a Pathfinder

This airborne reroute scenario further illustrates how the integrated situation awareness display will allow traffic managers to perform TFM actions with fewer manual steps and less mental consolidation of information than is needed with TFMS.

Continuing from the previous departure reroute scenario, the thunderstorms to the west of IAD appear to be dissipating. Traffic managers are now in need of a Pathfinder flight to fly through the area to ensure its readiness for regular traffic. Figure 5-6 shows the severe weather system exiting the previously afflicted area around RAMAY, indicating the opportunity to coordinate a Pathfinder flight over RAMAY.

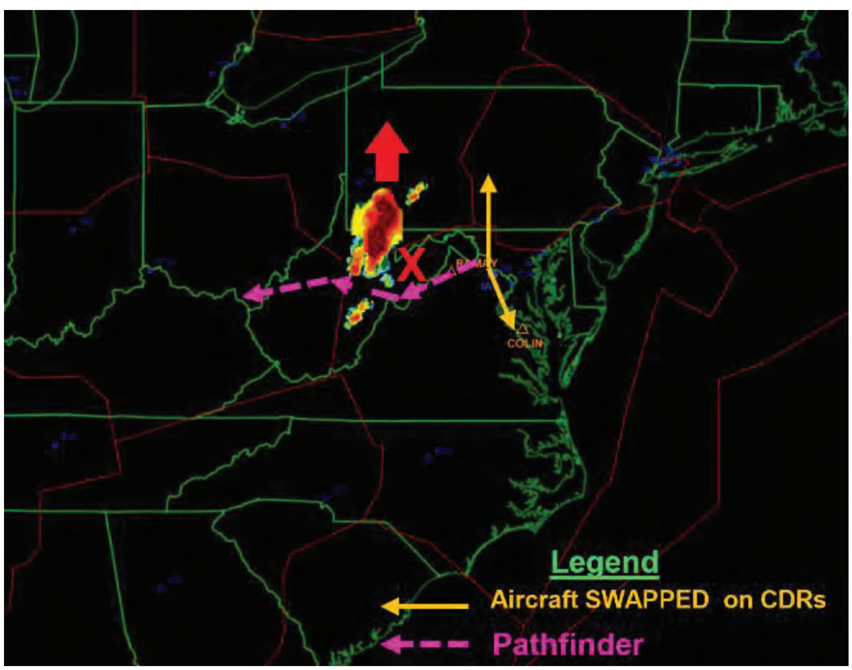
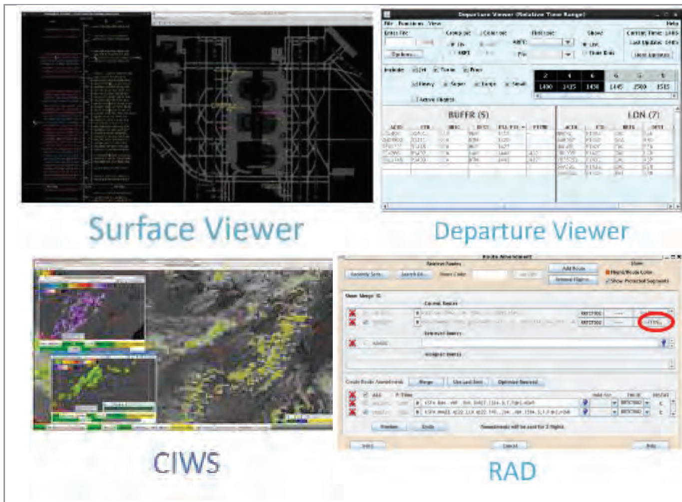


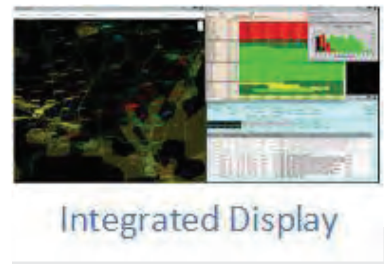
Figure 5-6. Thunderstorm Dissipation Indicates Option for a Pathfinder Flight

In TFMS, there is no easy method of identifying flights that were originally filed for a specific route. There are manual methods to recall a flight's route before a SWAP event, but those are inconvenient and inefficient.

In FMDS, the TMC simply uses the integrated situation awareness display to query all IAD departures for TOSs for which the highest priority route was originally filed over RAMAY. The TMC then selects a Pathfinder flight from this list and coordinates the reroute over RAMAY.



TFMS Applications to Support TOS Querying and Reroute Selection and Implementation



FMDS Integrated Situation Awareness Display Supports TOS Querying and Reroute Selection and Implementation

Figure 5-7. Multiple TFMS Applications to Support TOS Querying, and Reroute Selection and Implementation (Left) versus Integrated Situation Awareness Display in FMDS (Right)

5.5 Managing a Partial System Outage

This weather outage scenario highlights the improved ability for FMDS to notify users and system support personnel of a partial system outage, and how the modernized FMDS architecture supports restoring service. Examples of a partial system outage include a missing data feed, or a failure in one or more software or hardware components.

A TFMS user may only realize that the weather data feed is unavailable after the display fails to update as expected, or if the user notices via the "Times" display that the last update time for a weather product is significantly in the past. A FMDS user sees a notification via the integrated situation awareness display that the weather data feed is unavailable. The display of weather data then changes to indicate that it might be stale, allowing the traffic manager to use this information to inform their use of the weather display.

FMDS automatically alerts maintenance personnel to the outage. They use the system monitoring capabilities that provide visibility into component performance and status, along with updated, web-based, and easily navigable FMDS documentation, to begin the troubleshooting process, in contrast to navigating the several thousand pages of static TFMS documentation (see Figure 5-8).

Figure 5-8. Static TFMS Documentation (Left) vs Editable, Maintainable, Navigable FMDS System Documentation (Right)

The modernized FMDS architecture and components, along with system support tools that provide visibility into component status and performance, support maintenance personnel in troubleshooting and resolving the issue more quickly than would be possible with the complex TFMS data exchanges. Once the issue has been resolved and the weather data restored, the displayed weather data is updated and FMDS reverts the display to normal.

5.6 CDM Member Creates a Slot Credit Substitution Capability

This scenario illustrates the process for an organization external to the FAA, in this case a CDM member air carrier, to develop an application using FMDS services and data. Note that the process is the same whether the airline develops the capability in-house or contracts a vendor to develop the capability for them. A similar process could be followed by a commercial entity developing the capability with the intent to offer it to multiple airlines.

Some airlines today use a commercial application called Enhanced Substitution Module (ESM) for conducting slot substitutions during GDPs and AFPs. ESM relies on the Aggregate Demand List (ADL) data that feeds the FSM application as its source of flight data. With the retirement of FSM, these CDM members will need a new capability for managing their slots assigned during AFPs and GDPs. The FMDS architecture allows the FAA to provide the needed data and modeling functionality through services that enable the airline to develop their own capability more easily. Whereas CDM members can develop applications today that exchange data with TFMS via the TFMData Request/Reply SWIM service, they are unable to access TFMS modeling algorithms to ensure they accurately model the impact of a TMI on their operation.

Our exemplar airline reviews the FMDS documentation intended for external application developers to identify the needed data and services. They determine that they need access to APIs for the Flight Information Service and the RBS algorithm, accessed via the TMI Modeling Services. Then, they coordinate access to those data and to APIs for those services via an established FMDS on-ramping process.

The airline develops the application and conducts integration testing with connections to an FMDS test environment. The application is required to adhere to FMDS security requirements. As part of this process, the FMDS test team assesses the impact of the application on the existing FMDS services to determine whether the existing configuration can support the new application. Once testing is complete and the application is approved for operational use, the airline reconfigures their application to connect to the operational FMDS environment, with appropriate safeguards in place to ensure data integrity.

The process outlined here extends to other services beyond replicating existing capabilities. For example, airlines could use the same process to develop capabilities to better develop and manage TOSs.

6 Summary of Impacts

The FMDS concept will impact different stakeholders in different ways, as discussed in this section.

Traffic managers will experience increased productivity in conducting their TFM activities. They will be relieved from manual entry of data from one TFMS application into another, as FMDS will automate these processes. They will access TFM information and capabilities from a single integrated situation awareness display rather than having to switch back and forth between applications. Furthermore, the FMDS system will be more responsive. However, the new user experience will require comprehensive training, and traffic managers should expect multiple opportunities to provide their input into the design, development, and deployment of the streamlined user application suite.

NAS users will have access to improved situation awareness of NAS status and operations through the centralized portal for NAS status information. NAS users will be able to exchange data with FMDS using the same capabilities they use today, except for CDM members who use FSM and the web based TSD Thin Client. FMDS will provide alternative means for CDM members to access this information, such as access to a version of the integrated situation awareness display and/or APIs that will allow NAS users to develop their own applications to meet their needs.

System support personnel will be able to deliver improved RMA with a reduced hardware and logistics footprint. It is important to note that the modernization envisioned by FMDS will change the technologies employed and therefore the skills needed for system support. However, these technologies will enable FMDS to provide better tools for system support personnel, including capabilities to provide visibility into status and performance of system components and information, automation, and improved processes for managing component failures and major disaster failures.

Analysts supporting the post-event, quality control, and quality assurance processes will have improved access to the data they need to build an understanding of NAS operations.

System developers will have an improved ability to develop and deploy new capabilities in a timely and efficient manner.

FMDS Program Office will benefit from improved return on investments in system development and maintenance. The modernized FMDS architecture and envisioned development and deployment strategy may require new approaches for contract management and configuration management. Furthermore, implementation of FMDS will impact future TFM automation system capabilities. It will be important to ensure that FMDS provides a strong foundation to support future implementation of those capabilities.

FMDS will deliver gravely needed updates to today's TFM environment that will benefit all stakeholders, and will facilitate future enhancements in TFM decision support that cannot be accommodated with today's infrastructure.

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Appendix A Acronyms

Acronym	Definition
AADC	Airport Arrival Demand Chart
ABRR	Airborne Reroute
ACS	Aeronautical Common Services
ADL	Aggregate Demand List
ADS-B	Automatic Dependent Surveillance-Broadcast
AEFS	Advanced Electronic Flight Strips
AFP	Airspace Flow Program
AFST	Advanced Flight-Specific Trajectories
AIS	Aviation Information System
AJM	FAA Program Management Office
AJV	FAA Mission Support Services (FAA Service Unit)
AMS	Acquisition Management System
ANG	FAA Office of NextGen
AOC	Aeronautical Operations Center
AOCNet	Airline Operation Center Network
API	Application Programming Interface
APREQ	Approval Request
ARMT	Airport Resource Management Tool
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATCSCC	Air Traffic Control System Command Center
ATCT	Airport Traffic Control Tower
ATOP	Advanced Technologies and Oceanic Procedures
BTI	Business and Technology Information
CDM	Collaborative Decision Making
CDR	Coded Departure Route
CIWS	Corridor Integrated Weather System

Acronym	Definition
CSS-Wx	Common Support Services – Weather
CTOP	Collaborative Trajectory Options Program
CVRS	Computerized Voice Reservation System
CWSU	Center Weather Service Unit
DDSO	Deputy Director of System Operations
DRC	Disaster Recovery Center
DSP	Departure Spacing Program
DTO	Director of Tactical Operations
DTW	Detroit Metro Airport
EDCT	Expect Departure Clearance Time
E-IDS	Enterprise Information Display System
ENIM	Enhanced NAS Impact Modeling
ERAM	En Route Automation Modernization
ESIS	Enhanced Status Information System
ESM	Enhanced Substitution Module
ETM	Upper Class E Traffic Management
ETMS	Enhanced Traffic Management System
EWR	Newark Liberty International Airport
FAA	Federal Aviation Administration
FCA	Flow Constrained Area
FEA	Flow Evaluation Area
FENS	FAA Enterprise Network Services
FMDS	Flow Management Data and Services
FSA	Flight Schedule Analyzer
FSM	Flight Schedule Monitor
FTI	FAA Telecommunications Infrastructure
GA	General Aviation
GDP	Ground Delay Program

Acronym	Definition
GSD	Global Secure Desktop
GUI	Graphical User Interface
HTML	Hypertext Markup Language
IAD	Washington Dulles International Airport
IARD	Investment Analysis Readiness Decision
ICAO	International Civil Aviation Organization
ICD	Interface Control Document
IDP	Improved Demand Prediction
IDRP	Integrated Departure Route Planning
IDS	Information Display System
M&C	Monitor and Control
MAP	Monitor Alert Parameter
MINIT	Minutes-In-Trail
MIT	Miles-In-Trail
MMAC	Mike Monroney Aeronautical Center
MSP	Minneapolis-St. Paul International Airport
MTO	Manager of Tactical Operations
NAS	National Airspace System
NAVAID	Navigational Aid
NESG	NAS Enterprise Security Gateway
NFDC	National Flight Data Center
NextGen	Next Generation Air Transportation System
NOM	National Operations Manager
NSR	NAS System Review
NTML	National Traffic Management Log
NTMO	National Traffic Management Officer
NTMS	National Traffic Management Specialist
OI	Operational Improvement

Acronym	Definition
OIS	Operational Information System
OJT	On-the-Job-Training
OPS-IP	Operational Internet Protocol
OPSNET	Operations Network
ORD	Chicago O'Hare International Airport
PCT	Potomac TRACON
PDF	Portable Document Format
PDRR	Pre-Departure ReRoute
PERTI	Plan, Execute, Review, Train and Improve
Pref Set	Preference Set
PRMU	Precision Runway Monitor Utilization
QC	Quality Control
RAD	Route Amendment Dialog
RBS	Ration By Schedule
RMA	Reliability, Maintainability, and Availability
RMT	Route Management Tool
RNAV	Area Navigation
RRIA	Reroute Impact Assessment
RRMGR	Reroute Manager
RT-FSA	Real-Time Flight Schedule Analyzer
RVR	Runway Visual Range
SAA	Special Activity Airspace
SAR	Shortfall Analysis Report
SCOM	System Computer Operator Manual
SLE	Second Level Engineering
SMA	Surface Movement Advisor
STARS	Standard Terminal Automation Replacement System

Acronym	Definition
STDDS	SWIM Terminal Data Distribution Service - Terminal Aviation Information Service
STMC	Supervisory Traffic Management Coordinator
STMP	Special Traffic Management Program
SV	Surface Viewer
SWAP	Severe Weather Avoidance Plan
SWIM	System Wide Information Management
TBFM	Time Based Flow Management
TBM	Time Based Metering
TBO	Trajectory Based Operations
TCA	Tactical Customer Advocate
TCSD	TFM Consolidated Service Desk
TFDM	Terminal Flight Data Manager
TFM	Traffic Flow Management
TFMS	Traffic Flow Management System
TMC	Traffic Management Coordinator
TMI	Traffic Management Initiative
TMR	Traffic Management Review
TMS	Traffic Management Specialist
TMU	Traffic Management Unit
TOS	Trajectory Options Set
TPC	TFM Production Center
TRACON	Terminal Radar Approach Control
TRS	TFMS Remote Site
TSD	Traffic Situation Display
TSS	TFMS Support Subsystem
TTY	Teletype
UI	User Interface

Acronym	Definition
VACAPES	Virginia Capes Operating Area
XML	eXtensible Markup Language
ZAU	Chicago ARTCC
ZDC	Washington ARTCC
ZDV	Denver ARTCC
ZID	Indianapolis ARTCC
ZMP	Minneapolis ARTCC

Appendix B TFMS Web Applications

This appendix provides a list of current TFMS web applications, along with a brief description of each.

Application	Description
Advisory Database Web Page	Search and view advisories from the last 14 days.
Airport Arrival Demand Chart (AADC)	Display FSM bar graph data for user-selected airports. Background cron jobs on the TFMS Support Subsystem (TSS) FSM server at the TPC retrieve the flight demand data from the FSM server at specific intervals.
Airport Metrics Web Application	Displays data provided by NTML, including date, arrival runway(s), airport arrival rate, departure runway(s), and airport departure rate. An FAA user can choose a specific date and airport to add, modify or delete flight counts.
Aviation Information System (AIS)	E-mail subscription service that allows a user to receive delay information and changes in operating status for the largest NAS airports.
Collaborative Decision Making	An Akamai hosted public website (cdm.fly.faa.gov) used by the FAA, NAV CANADA, and all CDM members to disseminate and access CDM-related information.
Computerized Voice Reservation System (CVRS)	Allows users to register, reserve time slots, and update and cancel time slot reservations at an airport designated as a high-density traffic airport. This application replaced the touch tone telephone interface, which was decommissioned in August 2018. Note that design/functionality is the same as the electronic Special Traffic Management Program (e-STMP) application, so they share backend code/database. Subsystems: • eCVRS (Intranet) • eCVRS (Internet) • CVRS Administration tool • CVRS Airport Reservation Office Tool • CVRS/STMP Database • CVRS Reports
Current Reroutes Application	Displays all currently active reroutes. Each reroute has a link to the associated advisory link that will open the full advisory text in a separate window. For FAA users, a link is provided that displays the route maps and the affected Flights list. Only the advisory-related data with links to the full advisory text are provided to Internet users (no flight lists or route maps).

Application	Description
Current Reroutes Application	Query capability for restrictions entered via NTML.
Data Quality	Website that provides data quality metrics, restricted for specific CDM/QA/QC personnel. It is a legacy product that is not currently built/compiled with the TFMS web application code. A related website, Data Gate, has been decommissioned.
Diversion Recovery Web Page	Allows NAS users to enter information regarding a diverted flight, and it provides some basic reporting capabilities.
DTO/MTO Recap Report	Generates and displays the Director of Tactical Operations (DTO) Recap Report, which summarizes NAS Traffic Management programs for a particular day. The main page of the application contains a table with links to the individual DTO Recap Reports for each of the past 14 days. The Manager of Tactical Operations (MTO) Recap Report is run from the command line and contains no Graphical User Interface (GUI).
Flight Schedule Analyzer (FSA)	Generates a collection of dynamic reports for evaluating performance of TMIs issued via FSM (GDPs, AFPs, and ground stops) based on ADL data. Interactive drill-down and querying available. Sub-components include: • Real time FSA (RT-FSA) for current-day TMIs • ADL Parser • Auto Operations Network (OPSNET) Delay Processor • FSA Morning Brief (covered separately) • FSA Database
Flight Schedule Analyzer (FSA) Morning Brief	Provides various reports on the previous day's TMIs
Airport Status Web page – XML	Provides flight delay information by airport in a machine-readable format.
EDCT Lookup	Allows individual aircraft operators to determine if an EDCT has been issued for their specific flight.
ATCSCC Logs (Internet - Private)	Gathers the ATCSCC NTML logs from 12 positions and presents them for viewing via a link under the Current Products list and/or the Operations Tab on the ATCSCC Intranet web page. The application also maintains and displays the past 14 days' versions of NTML ATCSCC Logs, NAS Summary Reports, and NAS Shift Summary Reports (retrieved from the NTML database).
East West Directory	Provides static information on runway configurations and procedures for each airport, organized by ARTCC

Application	Description
OIS/NAS Status	Displays current information on the following topics: • Active airport events (e.g., GDPs, closures, deicing) • Active en route events (e.g., AFPs, Playbooks) • Forecast events • ATCSCC announcements ATCSCC users can add/edit/delete, while others can only view. Provides links to several of the other web applications.
System Impact Reports	Displays a table of outages/projects/events with their date range, ARTCC, Facility Identifier, and last update time.
Tactical Customer Advocate (TCA) Tool	Supports the TCA Hotline function to resolve pressing NAS user issues during busy periods (such as during severe weather events or national emergencies). Authorized NAS users report issues and ATCSCC TCA specialists resolve them. Also allows authorized users to review current and past issues and resolutions.
TFMS Status Web Page	Provides CDM users with three types of information: the status of FAA systems, planned events, and issues of interest to the CDM community. Only authorized users can add/edit the data.
OPSNET	FAA's official system for recording traffic counts and traffic delays. Departure and overall facility delays of 15 minutes or more are recorded by air traffic controllers. Note that OPSNET is being modernized by a different program (OPSNET-R) and therefore is out of scope for FMDS.
OPSNET Reports	Provides links to 18 types of daily OPSNET reports and 10 types of monthly OPSNET reports.
Playbook Web Application (Includes Contingency Routes)	Used as a starting point to plan, define, and establish reroutes. Can be viewed in either Hypertext Markup Language (HTML) or Portable Document Format (PDF).
Route Management Tool (RMT) Web	Allows users to view the Operational CDR database, as well as the National Flight Data Center (NFDC) preferred route, location identifier and airway intersection information. The Intranet and Internet versions of RMT-Web are identical to each other.
Runway Visual Range Web Page (RVR)	Provides situational awareness of RVR data that is received by the TPC via the SWIM Terminal Data Distribution System (STDDS) service. Note that the public website redirects users to the STDDS web page for RVR data. The NAS Enterprise Security Gateway (NESG) and FAA Telecommunications Infrastructure (FTI) Operational Internet Protocol (OPS-IP) network service still use the TFMS display. Since this data is provided by STDDS, this capability is out of scope for FMDS.

Application	Description
STMP Web Application	The e-STMP web application allows users to request, confirm, update, and cancel a reservation online for a specific special event. It also lists the current special events and summary information about them. STMP reports are also available.