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MITRE PRODUCT

A Concept of Use for an Initial Integrated Impact Assessment Capability

August 2001

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MITRE
Center for Advanced Aviation System Development
McLean, Virginia

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Section 1

Introduction

This document describes a concept of use for an automated capability that can assess the impact on the National Airspace System (NAS) of multiple, interacting traffic management initiatives (TMIs). A prototype of an Integrated Impact Assessment (IIA) capability is being developed at The MITRE Corporation's Center for Advanced Aviation System Development (CAASD). Today the IIA prototype models the effects of three specific types of TMIs: rerouting, miles in trail (MIT) restrictions, and altitude restrictions (whether dynamic or static, as in such documents as Standard Operating Procedures [SOPs]). Furthermore, it measures the impact of the proposed TMIs using primarily the metrics, sector volume and flight delay. In future builds, the IIA prototype is planned to model other TMIs, such as Ground Delay Programs (GDPs), and to incorporate other metrics as well.

The concept described in this document explores the operational uses of the features currently modeled by CAASD's IIA prototype. It is expected that the initial IIA capability described herein would be implemented in the operational environment in the 2003–2005 time period. Issues involved in using an initial IIA capability are also discussed in this document.

1.1 Purpose

This document is intended to serve three purposes:

- To promote discussion on requirements for an initial IIA capability among its stakeholders, those most interested in how the capability will be used. Stakeholders are expected to include traffic managers at Federal Aviation Administration (FAA) operational facilities and air carrier personnel at Aeronautical Operational Control (AOC) facilities.
- To help those developing an initial IIA capability understand the environment in which the capability will be used, how traffic managers will interface with the capability, and the kinds of questions the capability will help traffic managers answer.
- To illustrate how the components of an initial IIA capability would work together and with other functions of the Traffic Flow Management (TFM) automation system.

1.2 Background

The role of TFM is to balance the capacity of resources against demand by airspace users for those resources. Charged with this responsibility are two distinct groups of traffic managers: 1. Traffic management specialists at the Air Traffic Control System Command Center (ATCSCC) (also referred to as "Command Center"), the national operational facility of the FAA that maintains a system-wide perspective on NAS traffic flows; and 2. Traffic management coordinators (TMCs) in local FAA operational facilities. Local FAA operational facilities include Air Route Traffic Control Centers (ARTCCs), Terminal Radar Approach Control (TRACON) facilities, and Airport Traffic Control Towers (ATCTs).

Traffic managers use a variety of initiatives to manage traffic flows. TMIs include the following:

- GDPs
- MIT restrictions along a route, at a boundary, or to a fix
- Ground stops for departures
- Rerouting
- Speed and altitude restrictions

While traffic managers today have a limited number of automation tools to assist them in managing traffic flows, the tools thus far have been single-purpose—solving a single problem in a specific part of the NAS or applying a single TMI. None of these tools analyze the cumulative effect of one or more TMIs or help the traffic manager understand the interactions among TMIs. For example, what would be the result when an MIT restriction is imposed on traffic heading north to Chicago Center when, concurrently, east-west flows are being routed around a thunderstorm in Kansas City Center? Today traffic managers make educated guesses at such questions, or, because they are busy attending to the details related to managing to the event, they might not have the opportunity to even consider the question. A capability that can quickly predict the effects of multiple TMIs would help reduce the unintended interactions arising from individually developing and implementing the TMIs.

Furthermore, few of these tools adequately model the effect of the proposed strategies on the NAS as a whole or enable the traffic manager to do “what if” analyses—that is, experiment with different parameters to evaluate TFM strategies and identify the strategy that best meets the traffic manager’s objectives—and do so in a timely manner.

There is a clear need to understand the synergistic effects of multiple TFM actions.

1.2.1 The Initial IIA Prototype

In the mid-1990s, CAASD began work on a research platform, now called the Collaborative Routing Coordination Tools (CRCT), on which TFM operational concepts and automation functions could be developed for research purposes and, later, evaluated by TFM personnel in their operations facilities. To date, three specific CRCT automation functions have been integrated into the initial prototype for the IIA capability. These three automation functions are the following:

- Rerouting – enables the traffic manager to quickly design routes around a defined airspace and assess the impact of the new routes on sector volume or flight delay.
- MIT restriction – enables the traffic manager to quickly apply MIT restrictions along a defined traffic flow, whether a typical flow or a proposed new route, to identify the impact of the MIT restrictions on sector volume or flight delay.
- Altitude restriction – enables the traffic manager to quickly apply altitude restrictions along a defined traffic flow (for example, all departures from Minneapolis Center to Detroit), to identify the impact of the altitude restrictions on sector volume.

Though this document describes how these initial functions of the IIA capability will be used, other functions are planned for integration into a mature IIA prototype. Candidate functions include GDP, ground stop, and techniques for direct volume management. Furthermore, metrics other than sector volume and flight delay are being explored for inclusion in the future.

1.2.2 Relationship to Other TFM Tools

It is intended that the IIA capability be integrated into the NAS TFM automation system, which is currently based on the Enhanced Traffic Management System (ETMS).

1.2.3 Relationship to Other TFM Research

The concept of use described in this document is related to the following CAASD work:

- Field evaluations of capabilities assessing the impact of individual initiatives are currently underway.
- A description of the functions of the initial IIA capability described herein is being prepared as a separate document.

1.3 Scope

The concept of use described in this document focuses on “what if” capabilities for rerouting, MIT restrictions, and altitude restrictions. The ability to model and provide “what if” analysis of other TMIs will be included in future work, as discussed in Section 5. This concept contains scenarios that illustrate the use of an initial IIA capability for en route and departure traffic flow management. Application to arrival flow management is left for future work.

The architectural implications of implementing an IIA capability within the TFM automation infrastructure are being studied. That work is in progress and outside the scope of this document.

1.4 Organization of This Document

Section 2 describes characteristics of the operating environment that are assumed in this document. Section 3 outlines the major functions of an initial IIA capability. In Section 4, two scenarios suggest how an initial IIA capability might be used as part of en route traffic flow management and of departure flow management. Section 5 captures issues related to the use of an IIA capability, as well as possible next steps toward developing an enhanced IIA capability.

Section 2

Assumptions

Several assumptions have been made in developing the concept of use for an initial IIA capability. This document assumes that implementation and operational use of the initial IIA capabilities described in this document will occur during the 2003–2005 period.

2.1 Assumptions about TFM Automation System Capabilities

The TFM automation system in the future is expected to integrate multiple TFM-related functions:

- The functions of today's TFM automation system.
- Tools that currently aid in TFM decision making and are not yet integrated into today's TFM automation system.
- The functions of the initial IIA capability described in this document.

In addition, the TFM automation system is assumed to perform the following functions:

- The TFM automation system accepts *early intent information*—any information provided by the airspace user in advance of the departure that is used by the TFM automation system in predicting demand.
- The TFM automation system is aware of when a TFM designated route[1] is proposed, activated, or de-activated.
- When a flight plan is not in accordance with the requirement for TFM designated routes, then the TFM automation system notifies the en route center TMC and the flight's AOC.

The TFM automation system is assumed to communicate with the AOC—whether this is to the AOC automation system, by fax, or through some other means beyond what is used today is not specified. While the TFM automation may become more integrated with the air traffic control (ATC) automation system, forming a single Air Traffic Management (ATM) automation system, this need not be assumed for this concept of use.

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1 As used in this document, a *TFM designated route* is a route specified by a traffic manager on which traffic meeting certain criteria (for example, traveling between a specific city pair) are required to fly.

2.2 Assumptions about Roles and Responsibilities

The responsibilities of national versus local TFM are assumed to remain about the same as they are today. In particular:

- The Command Center communicates information about capacity and aggregate demand via the Command Center webpage.
- The Command Center conducts regularly scheduled telephone conferences with appropriate FAA facilities and airspace users.

2.3 Assumptions about Procedures

It is assumed that airspace users can and do submit demand updates throughout the day, as part of the effort to provide early intent information. How the information is submitted and at what point the information is included in TFM demand predictions are to be studied and not within the scope of this document. The relationship between submitting early intent information and filing a flight plan still needs to be explored. Airspace users have expressed concern that the best guesses they submit for the purposes of early intent could somehow be used against them—for example, that they would be held to flying the route or departing at the stated time contained in the early intent information.

Whenever a change is made to the route or altitude filed in a flight plan, it is assumed that change is recorded electronically in the flight plan (for example, by the airspace user via replanning or by controller or traffic manager via the ATC automation system). As used in this document, *replan* means that the user makes changes in flight route, altitude, time of departure or time of arrival to an airport or fix. This information could already have been included in a flight plan filed by the user or in early intent information.

2.4 Assumptions about Access to an Initial IIA Capability

All FAA operational facilities are assumed to have access to the IIA capability. It is assumed that airspace users do not have access to the IIA capability, but could obtain the IIA capability's impact assessment results that are specific for their carrier—for example, the list of flights affected by a TFM initiative—via such methods as today's Common Constraint Situation Display (CCSD).

Section 3

Major Functions of an Initial IIA Capability

The initial IIA capability performs the following functions:

- Accepts and processes demand information, including information from filed flight plans and information about airspace users' early intent.
- Allows the traffic manager to draw the lateral bounds of any airspace, called a Flow Constrained Area (FCA), and choose its altitude range and effective time period. Speed, heading, and growth/decay (when the FCA is for weather) may also be specified to examine the projected movement and size of the airspace in conjunction with affected traffic.
- Identifies flights expected to be rerouted or on which an MIT or altitude restriction will be applied, through the use of an FCA.
- Identifies the time a flight will intersect an FCA.
- Electronically shares graphical information among FAA facilities and with the appropriate airspace users.
- Identifies the flights in a flow specified by the traffic manager.
- Allows the traffic manager to quickly define proposed routes, and to decide which specific flights or traffic flows will fly the route.
- Models aircraft flying as filed or on the routes suggested by the traffic manager. It models aircraft or traffic flows on which MIT restrictions or altitude restrictions are imposed.
- Allows the traffic manager to quickly experiment with different strategies involving rerouting, MIT restrictions, and altitude restrictions.
- Allows the traffic manager to apply MIT restrictions that vary over time on a route or traffic flow.

- Quickly identifies impact as a result of a strategy involving rerouting, MIT restrictions, or altitude restrictions. Impact is measured by the following:
    1. Prediction of sector loading for several hours into the future
    2. Prediction of delay per flight
        - In particular, when MIT restrictions are involved, the delay per flight is further delineated into:
            (a) Delay due to the MIT restriction alone
            (b) Delay due to the combination of rerouting and the MIT restriction
    3. Prediction of average and maximum delay of all flights affected by the strategy
    4. Prediction of the difference in the distance flown between the as-filed route versus the proposed reroute
- Provides information, on flights to be affected by a strategy, that can be forwarded to airspace users; this information can include delay for each of the airspace user's flights as well as difference in distance flown.
- Identifies the sectors that a route intersects.
- Identifies flights that are expected to be in a sector in a given time period. It predicts the peak instantaneous traffic count for each sector during a given time period and identifies which sectors are predicted to exceed their thresholds.
- Identifies those flights whose total flight time or distance is less than a parameter value specified by the traffic manager.

It is anticipated that the initial IIA capability will be part of the overall TFM automation system and will not be a standalone system. As such, the functions of the initial IIA capability will operate on a set of data shared with the other functions of the TFM automation system, including a common understanding of flight trajectories and sector loading.

Section 4

Scenarios to Illustrate Potential Uses of an Initial IIA Capability

The potential uses of the initial functions of the IIA capability are illustrated in two scenarios, en route traffic flow management and departure flow management. These scenarios should not be viewed as the prescribed role of an IIA capability. Rather, these scenarios are intended both to highlight how an initial IIA capability might be used in the operational environment, and to raise questions among stakeholders about topics such as the following:

- Procedures
- Roles and responsibilities
- Timing of the use of an IIA capability
- Role of the airspace user in "what if" strategy analysis
- How else an IIA capability could be used for TFM
- What data an IIA capability could produce that are needed by traffic managers or airspace users
- What additional functions of an IIA capability would be useful
- Human factors concerns
- Architectural implications

4.1 En Route Traffic Flow Management Scenario

Use of rerouting coupled with MIT restrictions is a common strategy for traffic managers today. In the following scenario, which takes place on June 18, 2003, TMCs from several neighboring en route centers and the traffic management specialist from the Command Center work together to develop a strategy to move traffic around a predicted disruptive weather system. The IIA capability is first used to estimate the magnitude of the traffic affected, then to help develop candidate strategies, and evaluate how well each candidate strategy is expected to work. After studying the IIA capability's results, traffic managers decide which strategy to implement. Airspace users are kept informed throughout the day and have access to appropriate flight-specific information, produced by the IIA capability, which is used to assess their business objectives.

1500Z (11:00 a.m. EDT) Initial planning for predicted weather
(t-4.0)[2]

Severe weather forecast four hours from now

Highly likely thunderstorms are predicted over the airspace of Chicago Center (ZAU), Indianapolis Center (ZID), and Memphis Center (ZME) for the 1900Z–2300Z time period, building up to about 2000Z–2100Z, then decaying over time so that just a few cells will affect ZME traffic after 2300Z. The line of thunderstorms is typical of the kind of weather experienced in this region in the summer months.

The en route centers' TMCs use the IIA capability to obtain a rough estimate of the number of flights that are planned to fly through their centers' airspace in the 1900Z–2300Z timeframe.

In their next regularly scheduled FAA-airspace user telephone conference, the Command Center specialist and TMCs from these en route centers agree that a reroute strategy will be necessary to manage the anticipated volume of traffic. The traffic managers have encountered similar weather situations in past seasons and hypothesize that route N1 will be used to the north of the storm and route S1 to the south. This is a familiar reroute strategy (similar to today's National Playbook routes) to the traffic managers. They agree to keep watch on the situation.

The specialist enters a message on the Command Center webpage that rerouting to the north and south of the thunderstorm on N1 and S1 is likely.

1600Z IIA capability is used to plan a reroute strategy
(t-3.0)

IIA capability identifies flights predicted to fly through impacted airspace

The weather forecast remains the same. The Command Center specialist facilitates a collaboration session with TMCs from ZAU, ZID, and ZME and their neighboring en route centers to the north and south (Minneapolis [ZMP], Cleveland [ZOB], Fort Worth [ZFW], Houston [ZHU] and Atlanta [ZTL]). The specialist uses the IIA capability's feature of electronically sharing graphical information. With this feature, facilities can participate in drawing or modifying an object (such as a weather outline or a proposed route). All

2 In the scenarios, "t" represents the forecast start of severe weather, with "(t-4.0)" indicating that severe weather is expected to begin in four hours.

participants can see and comment on the object, thus providing a "common view" of the situation and enabling collaborative strategy development.

The traffic managers want to see which flights have filed or are likely to file for the airspace in which the severe weather is expected to materialize. First, the specialist draws a series of FCAs for 1900Z–2300Z, following the movement of the storm and the growth and decay pattern predicted by the meteorologists. Each FCA represents the predicted weather for a given time period, in this case, 1900Z–1959Z (FCA1), 2000Z–2059Z (FCA2), 2100Z–2159Z (FCA3), and 2200Z–2159Z (FCA4). After some discussion, the TMCs agree that the resulting series of FCAs, as seen in Figure 4-1, reflects the situation.

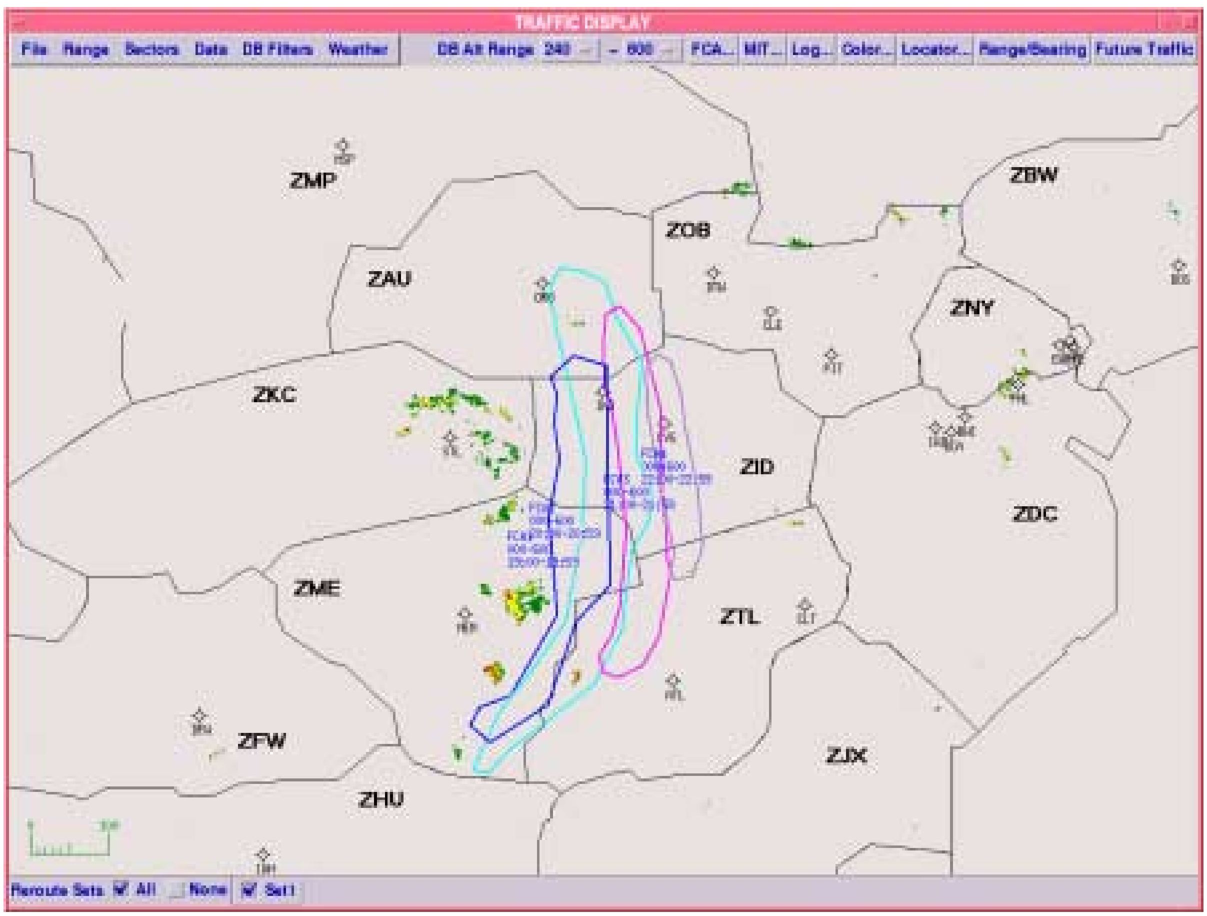

Figure 4-1. A Series of FCAs Represents Storm Movement and Size

Next, the specialist uses the IIA capability to identify the flights expected to fly into the impacted airspace—that is, intersect the FCAs—using the following data: information from flight plans already filed for today, early intent information, and an estimate based on recently published schedules for scheduled flights that have not submitted early intent information. Figure 4-2 illustrates the path for each flight planned for the impacted airspace (with other traffic suppressed). The route information for each such flight is contained in the FCA List, a portion of which is shown in Figure 4-3. In the right-most column of the FCA List, the IIA capability indicates the amount of time (hours: minutes: seconds) until the flight is predicted to intersect the FCAs. In the upper right corner of the FCA List, the IIA capability indicates that 162 flights are planned through the FCAs, of which 161 have yet to depart.

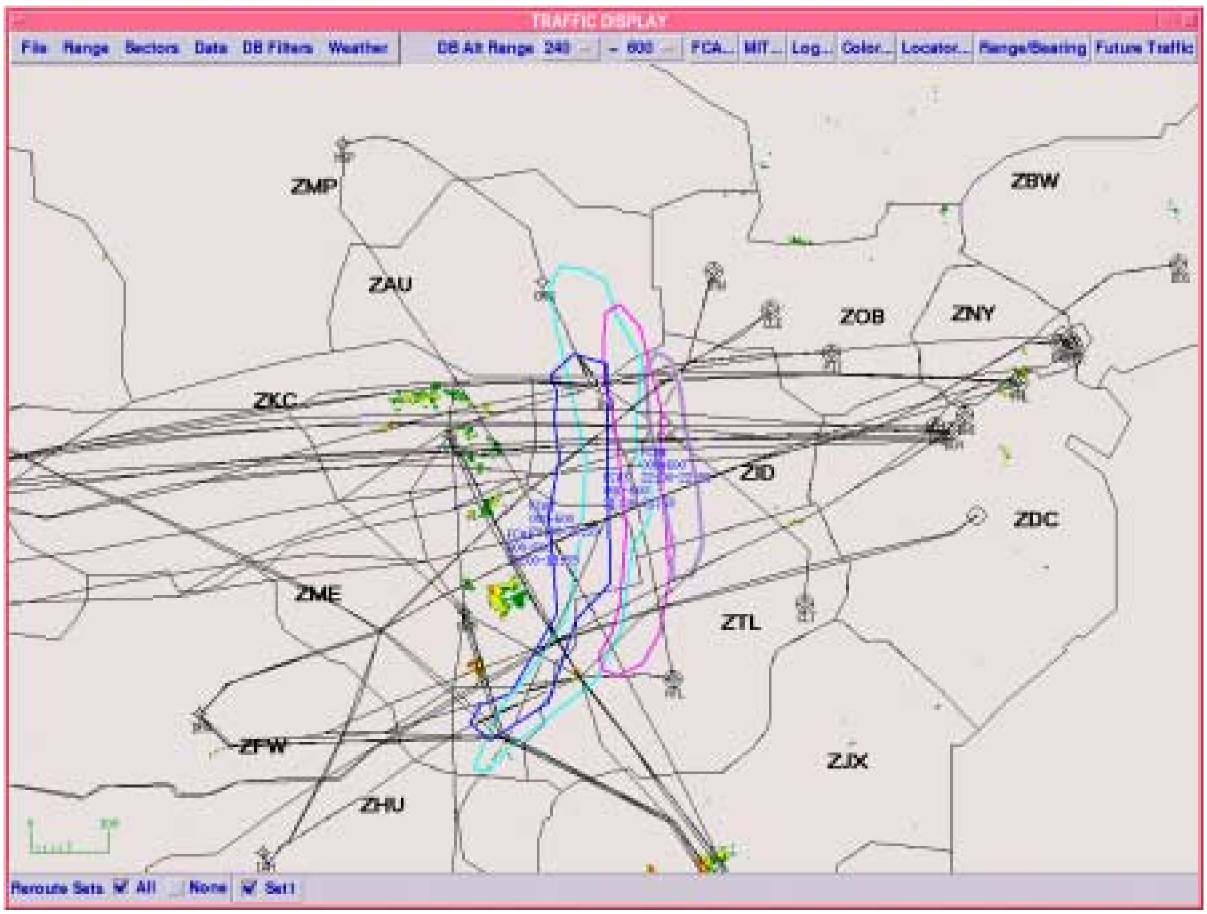

Figure 4-2. Projected Paths of Flights Intersecting the FCAs

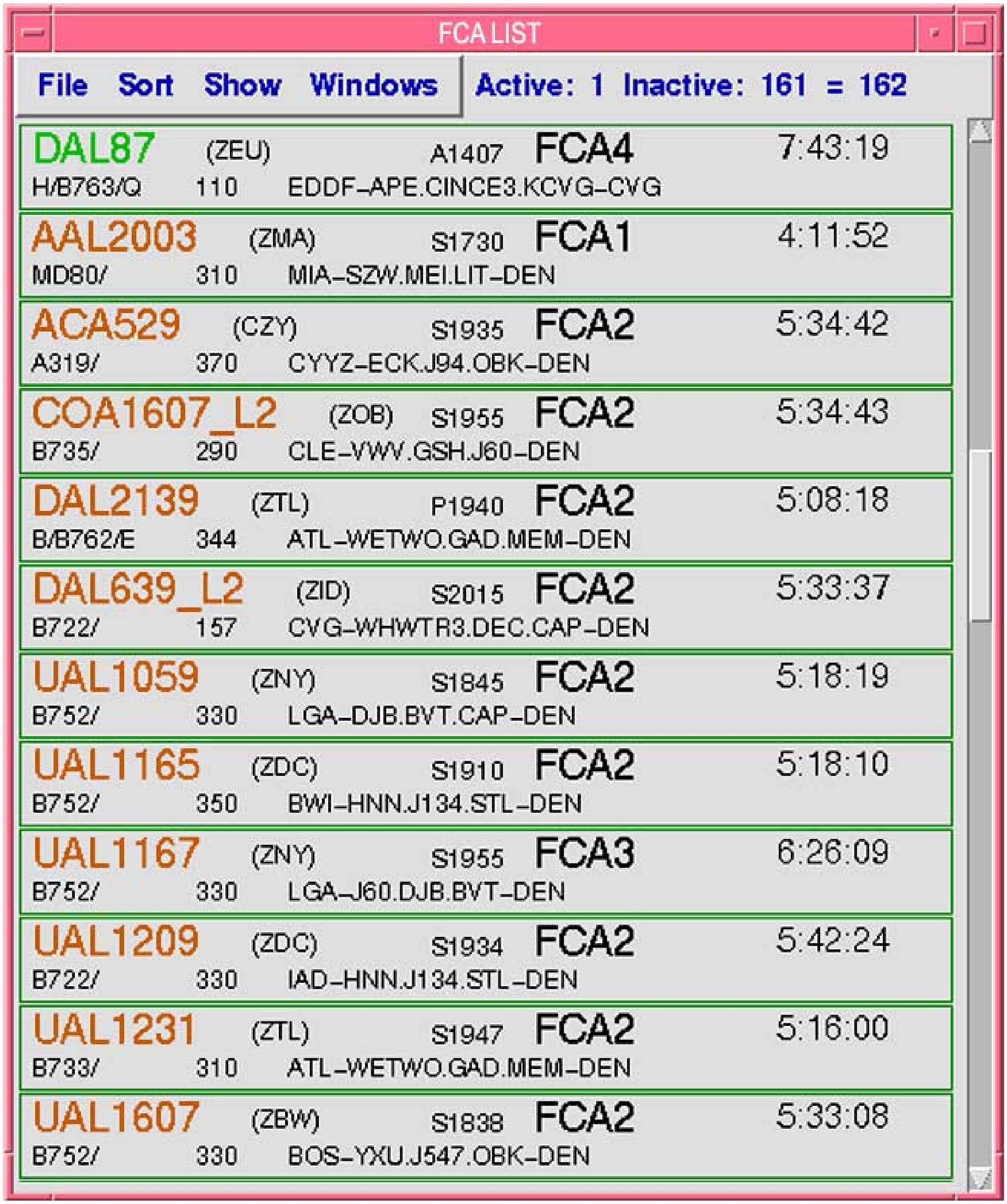

Figure 4-3. FCA List: Flights Currently Planned for Impacted Airspace

Used together, the graphical depiction of the flight paths (Figure 4-2) and the textual flight route information (Figure 4-3) help the traffic manager attain a better understanding of the magnitude of the situation in these several hours before the onset of the severe weather.

IIA capability is used to develop and evaluate reroute strategies

Traffic managers are also interested in the characteristics of the flows, including how the flights are distributed and aggregated into the flows. For example, they may want to see how heavy the traffic flow is from Washington to Fort Worth Center or how heavy the traffic flow is crossing the western boundary of ZOB since these flows will be affected by the weather system. To understand the size of certain flows, the Command Center specialist specifies the name of the flows for the IIA capability. The IIA capability then calculates the number of flights per flow specified. The result is shown in Table 4-1.

Table 4-1. Count of Flights in TMC-Specified Flows

Flow Specified by Traffic Manager	1900Z–1959Z	2000Z–2059Z	2100Z–2159Z	2200Z–2259Z
FlowA	16	24	29	14
FlowB	16	15	7	3
FlowC	13	11	11	9
FlowD	5	9	7	3
Miscellaneous	2	4	3	2

Continuing in this collaboration session, the participants discuss their concerns. The TMC from ZOB, for example, comments that the higher than usual FlowA demand would likely overwhelm ZOB. All concerns are considered in developing the reroute strategy. The specialist uses the IIA capability to draw one route, N1, to the north of the FCAs to carry the traffic from FlowA and FlowB; and one route, S1, to the south of the FCAs for traffic from FlowC and FlowD. Since the weather forecast describes a storm system that is typical in this region and since N1 and S1 are often-used routes to manage around similar weather events, then with little further discussion, the TMCs agree to the route definition. The routes, N1 and S1, are illustrated in Figure 4-4. Furthermore, the IIA capability graphically depicts the new paths (the dashed green lines of Figure 4-4) of flights to be rerouted onto N1 and S1.

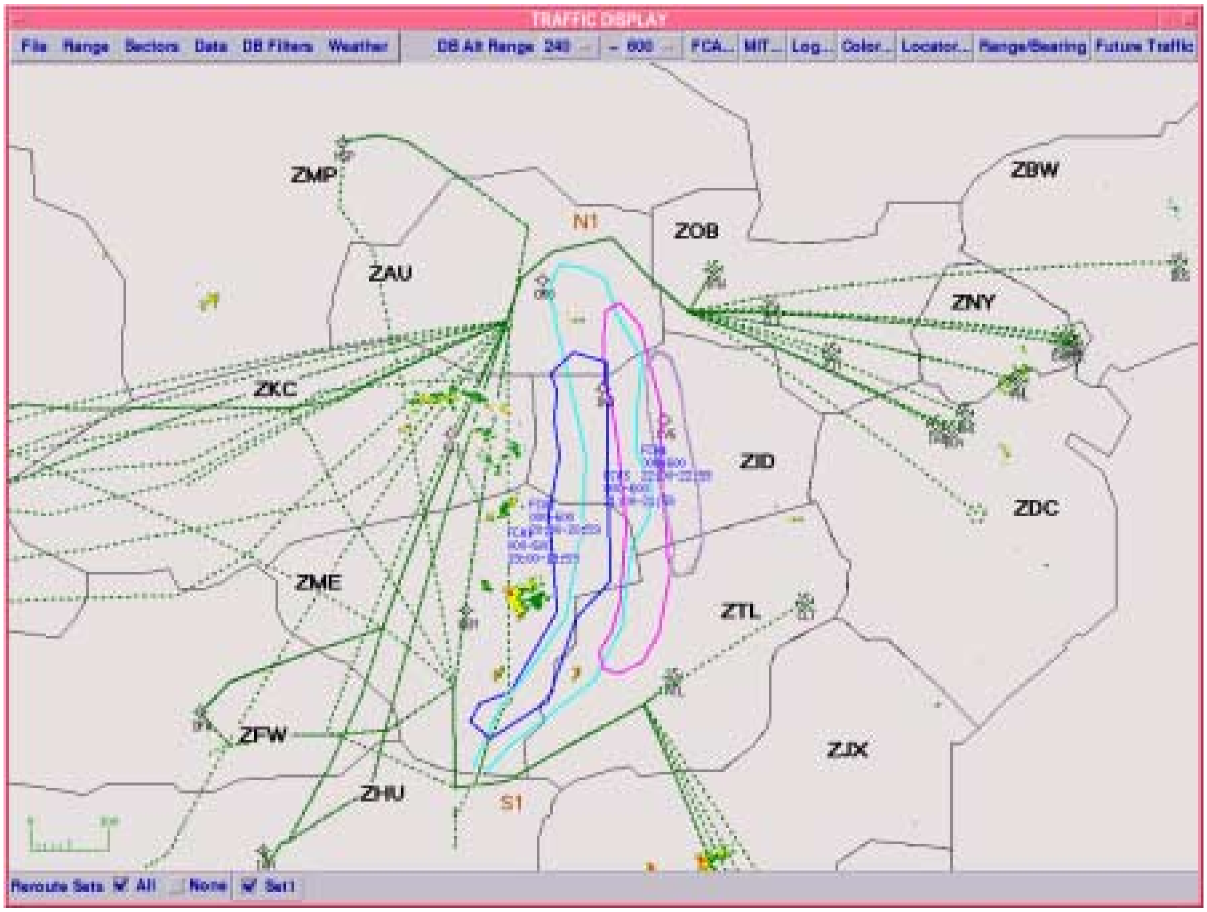

Figure 4-4. Routes N1 and S1 Take Traffic around FCAs

The prediction on sector loading for ZOB, for example, is shown in the IIA capability's Sector Count Monitor product (Figure 4-5). This product predicts the demand per sector for 15-minute time periods,[3] in this case from 1900Z–2200Z. In the bottom two rows of numbers in Figure 4-5, the sector identification number is on the top, and below is the threshold for that sector. The colored cells indicate the predicted loading.[4] If a cell is outlined in dark

3 The measure for demand in this case is peak instantaneous traffic count.

4 If any sector is predicted to contain more active flights than the predetermined threshold for one minute during a 15-minute period, the particular time period cell is colored red. If the time period count will only

blue, then the demand for the sector in that timeframe is predicted to increase as a result of rerouting onto N1 and S1. If the cell is outlined in light blue, then the demand for that sector is predicted to decrease as a result of rerouting onto N1 and S1. Several sectors are predicted to be over threshold.

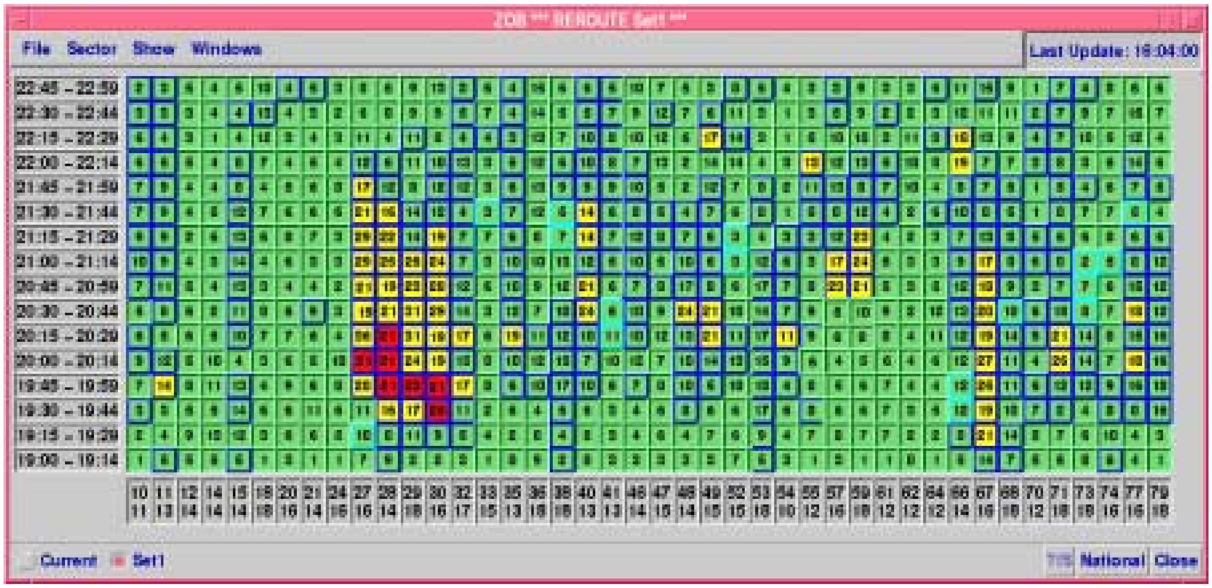

Figure 4-5. Sector Count Monitor: Predicted Sector Loading for ZOB after Rerouting onto N1 and S1

However, the demand for the impacted airspace could change considerably in the three hours before the predicted onset of the severe weather. Rather than consider additional restrictions at this time, the Command Center specialist places an announcement on the Command Center webpage that N1 and S1 continue to be the most likely routes used to travel around the predicted storm, but to expect additional restrictions if airspace users do not sufficiently reduce demand through the impacted airspace. These proposals are discussed at the next scheduled FAA-airspace user telephone conference. Furthermore, since the IIA capability can identify which of a

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be over the threshold if inactive flights are also counted, the cell is colored yellow. If the total active and inactive flight count is less than the threshold, the cell is colored green. Thus, for example, if the sector threshold for the 15-minute time period is 10, and 12 aircraft are predicted to be in the sector during that time period, then: a. if 10 or more of those flights are currently in the air, the sector is colored red, and b. if fewer than 10 are currently in the air, the sector is colored yellow. If in that time period nine aircraft were predicted to be in that sector, then the sector would be colored green.

carrier's flights are currently planned through the impacted airspace, the specialist makes this information available to each affected air carrier.

1630Z–1800Z (t-2.5 – t-1.0) Airspace users update their schedules and provide updated early-intent data to the TFM automation system

The airspace users continually watch the weather development and also keep an eye on changes in aggregate demand for their area of interest. In this time period, airspace users are sending information about any cancellations and replans to the TFM automation system. It is recognized that such airspace user intent information, provided early and updated throughout the day as needed, significantly improves demand prediction. The Command Center webpage lists the most recent capacity and aggregate demand information for key points across the NAS. Such information enables the airspace users to re-evaluate their schedules, according to their business objectives, and replan their flights if needed.

1700Z (t-2.0) Two hours before the predicted onset of severe weather, the IIA capability is used to plan an MIT strategy

Traffic managers reassess reroute strategy

A collaboration session is held with the same participants as at the 1600Z collaboration session, and is again facilitated by the Command Center specialist. Using the latest demand estimates, the IIA capability predicts sector loading if the traffic flows were rerouted onto N1 and S1 as planned earlier. Even though many airspace users responded by voluntarily rerouting flights or canceling others, the resulting number and duration of overloaded sectors are still at an unacceptable level. The traffic managers decide that MIT restrictions along the new routes will be necessary to keep sector counts within threshold.

The IIA capability is used to evaluate MIT restrictions

The specialist experiments with different MIT values for N1 and for S1, asking questions such as "If 30 MIT were applied on N1 and 10 MIT on S1, what would be the resulting impact on the NAS?" A quick check shows that, with no further restrictions, 40 MIT would be needed on N1 to bring demand within acceptable sector count levels, but would cause a maximum delay of two hours and average delay of one hour ten minutes. Similarly, the IIA capability indicates that 20 MIT would be needed on S1 to obtain a manageable volume on S1.

The TMCs decide that 40 MIT is too severe a restriction. After further discussion, the specialist uses the IIA capability to create another route to the north of the FCA and north of N1, called N2. Whereas previously N1 carried both FlowA and FlowB traffic, now N1 would carry the FlowA traffic, while N2 would carry FlowB traffic. After experimenting with different MIT values on the IIA capability, it appears that 25 MIT on N1 and 15 MIT on N2 would sufficiently reduce the sector volume to acceptable levels, yet also not create excessive delays. No change is needed for S1.

If this combined reroute/MIT strategy were implemented, then N1, N2, and S1 would become the *TFM designated routes* (formerly and loosely called “SWAP routes”). Once the TFM designated routes are activated, then flights in FlowA would be required to fly N1, flights in FlowB would be required to fly N2, and flights in FlowC or FlowD would be required to fly S1. The MIT restrictions for the TFM designated routes would be the following:

N1	25 MIT	FlowA
N2	15 MIT	FlowB
S1	20 MIT	FlowC, FlowD

The three routes are illustrated in Figure 4-6, while Figure 4-7 indicates the impact on sector loading in ZOB if the flows were rerouted onto the three TFM designated routes with corresponding MIT restrictions.

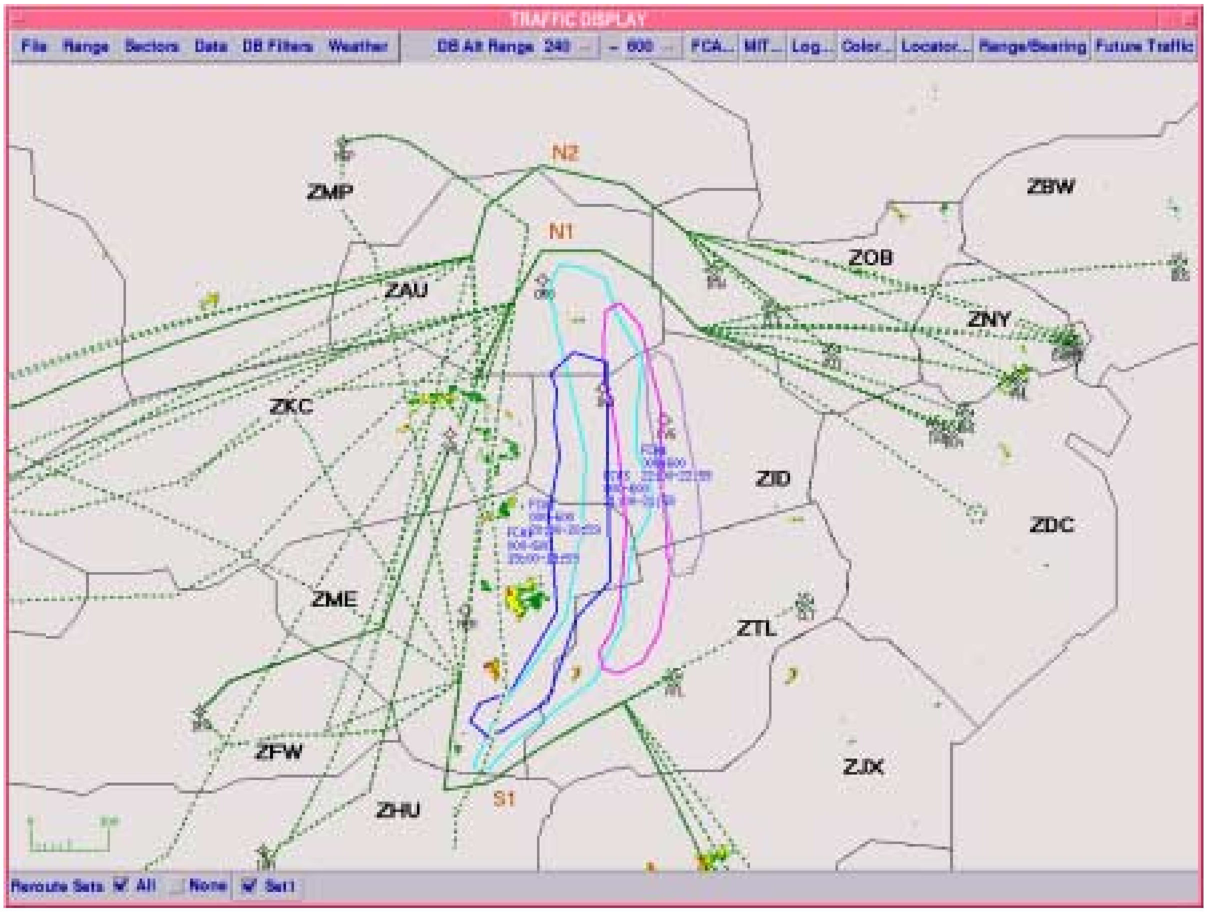

Figure 4-6. Three TFM Designated Routes Take Traffic Around the FCAs

Figure 4-7. Sector Count Monitor: Predicted Sector Loading for ZOB as a Result of Proposed Reroute and MIT Strategy

Traffic managers vary the MIT restriction on a route over time

The ZOB TMC notes from the IIA capability's Sector Count Monitor product (Figure 4-7) that there are no red sectors for ZOB and just a few times in which sectors 28 and 29, in particular, are yellow. In each case where the sector is predicted to be over threshold, the amount over is by one or two flights only. Furthermore, those yellow sectors are isolated with long stretches of time in between where the sectors are green. The specialist and TMCs confer.

Rather than run the IIA capability again to find an MIT value that would eliminate overloading sectors, the specialist uses the IIA capability to find that sectors 28 and 29 are in the path of route N1. The TMCs decide to experiment with a strategy that delays implementing an MIT restriction for N1 and, thereafter, varies the restriction over time, according to demand. They find that the following combination of MIT restrictions produces a lower, and therefore more acceptable, maximum and average delay:

N1	0 MIT	1900Z–1944Z
	20 MIT	1945Z–2029Z
	25 MIT	2030Z–2159Z
	20 MIT	2200Z–2300Z
N2	15 MIT	1900Z–2159Z
	0 MIT	2200Z–2300Z
S1	20 MIT	1900Z–2300Z

The variable MIT restrictions are included as part of the overall strategy for managing the weather situation. The new proposed reroute/MIT strategy is published on the Command Center webpage and discussed at the next FAA-airspace user telephone conference.

(The TMCs from each facility understand that the controllers' supervisors are reluctant to reduce the MIT restrictions even further. The TMCs use the corresponding sector count estimates to convince controllers' supervisors that a manageable volume of traffic can be achieved with the lower MIT restrictions.)

The IIA capability identifies the flights planned through the impacted airspace, determines which of the routes they will fly according to the particular flow, then calculates two measures of delay for each flight. As shown in the last column of the IIA capability's MIT List product (a portion of which is shown in Figure 4-7), the upper number for a flight entry lists the number of minutes of delay predicted from the MIT restriction alone, while the bottom number lists the delay predicted from both being rerouted and having an MIT restriction imposed.

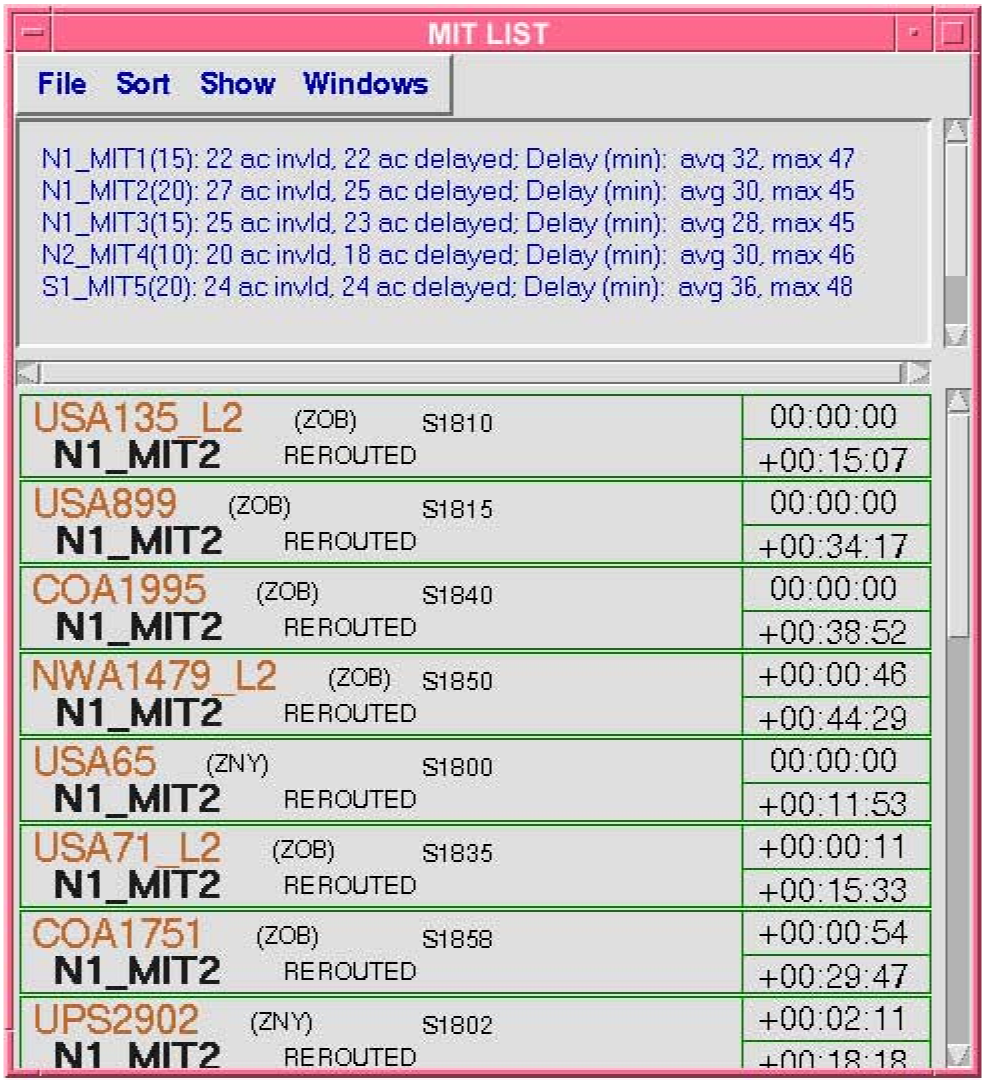

Figure 4-8. MIT List: Predicted Delay Resulting from Reroute and MIT Restrictions

En route centers pass back MIT restrictions

Sectors feeding traffic onto N1, N2, and S1 also might require some help keeping the volume through their airspace at a manageable level. TMCs from these sectors' en route centers use the IIA capability to determine whether they need to request additional MIT restrictions from downstream en route centers, and if so, what the MIT restrictions should be.

For example, the ZAU TMC might ask questions such as "Since ZMP requires that my en route center feed them traffic across our shared boundary at 20 MIT, can we manage the resulting backlog of traffic in our airspace safely, or do we need to implement MIT restrictions of our own to control the volume into our airspace—such as MIT restrictions on traffic from ZOB?" If ZAU does implement such MIT restrictions, called "pass back MIT" restrictions, then its neighboring en route center ZOB could similarly require pass back MIT restrictions as well.

The need for pass back MIT restrictions is discussed at the next FAA-airspace user telephone conference, and any resulting restrictions are published on the Command Center webpage.

1715Z (t-1.75) **Airspace users respond to the published strategy**

Per an agreement between the air carriers and the FAA, whenever initiatives such as rerouting, MIT restrictions, or GDPs are likely to be implemented, the Command Center specialist or the TMC of an en route center (depending on the scope of the initiative) notifies each air carrier of its flights predicted to be affected by the initiative. Specifically, in the case of rerouting or applying MIT restrictions, the traffic manager uses the IIA capability to identify flights that have been planned to intersect an FCA. The IIA capability also predicts the number of minutes of delay that the flight would incur as a result of the initiative.[5] The IIA capability prepares a message to the air carrier that lists each of its flights that are currently planned to fly through the FCA, and identifies the predicted delay[6] per flight. Transfer of such information can be accomplished on the CCSD, for example, for airspace users so equipped.

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5 The predicted delay means delay at the arrival airport, the difference between the IIA capability's predicted estimated time of arrival and the estimated time of arrival indicated in the user's flight plan. In the case of delay predictions involving an MIT strategy, a delay of x minutes can be achieved in a couple ways: either the user or the controller delays the departure by the x minutes (or by an amount less than x), or the controller delays the flight in the air for the x (or remainder) minutes. Issues such as how the delay should be taken, how the user can voluntarily delay the flight on the ground and be assured that the flight will not incur even more delay in the air, or whether the TFM automation system should assign a new departure time (an Estimated Departure Clearance Time, EDCT) based on the predicted delay are beyond the scope of this paper and need more research.

6 It is an issue to be studied whether users would, in fact, use the IIA predictions on delays per flight, especially the predicted delay contributed by the MIT restriction (see Section 5).

The airspace users consider each flight on the list prepared by the IIA capability. They evaluate the impact of the strategy on their overall airline schedules, and then, if necessary, make adjustments to their schedules based on their business needs. In this case, such adjustments could include the following: replanning (that is, filing an amended flight plan) to fly the proposed reroutes; replanning to other, completely different routes; replanning for a perhaps less fuel-efficient, but more available, cruise altitude; canceling the flight; or voluntarily delaying departure (for example, to traverse the airspace at a time when the FCA is inactive).

1730Z (t-1.5) One and one-half hours before the predicted onset of the severe weather, TFM designated routes are activated

The Command Center specialist studies the weather and demand situation for the affected area. Although airspace users have submitted replans throughout the day, they have not altered their schedules sufficiently to remove the need for the three routes nor the MIT restrictions on the routes.

After consulting with the TMCs, the Command Center specialist publishes an announcement on the Command Center webpage that the TFM designated routes will be activated at 1900Z with the MIT restrictions as announced earlier. That the TFM designated route is activated means that an airspace user wanting an aircraft to fly FlowA should file for N1; FlowB, for N2; and FlowC or FlowD, for S1. Concurrently, this decision is entered into the TFM automation system.

However, should a flight still be flight planned to intersect the FCA, then the following actions are taken:

- If the flight has not yet departed, the TFM automation system notifies the en route center TMC, who amends the flight plan to fly the appropriate TFM designated route.[7] The TFM automation system notifies the airspace user's AOC of the change in route.
- If the flight is already airborne, the TFM automation system prepares a message for the TMC of the en route center in whose airspace the aircraft is flying. The message indicates the amended route. The TMC forwards the message to the responsible controller who issues a clearance with the

7 Alternatively, if the TFM automation system and the ATC automation system are incorporated into a single ATM automation system, then the TMC would not need to be involved in this process. Instead, the ATM system could automatically amend the route. It is an issue whether either the traffic manager or the airspace user would find this acceptable.

amended route of flight to the cockpit.[8] At the same time, the TFM automation system notifies the airspace user's AOC of the change in route.

This process continues until the TFM designated route is de-activated.

If an airspace user expresses concern about the amended flight plan, the Command Center specialist can work with the airspace user to address those concerns. For example, the Command Center can work on the airspace user's behalf to allow two of its flights to exchange their departure times in order to decrease the delay of a higher priority flight.

1830Z (t-.5) **IIA capability is used to identify selected flights whose departure can be delayed to reduce volume in overloaded sectors**

The TMC at ZOB notices that two sectors, which are between a major airport and the start of the TFM designated route N2, are predicted by the IIA capability to be overloaded. The TMC uses the IIA capability to identify flights whose departure time can be pushed back to decrease the demand on these sectors during the periods when they are over threshold. The TMC concentrates primarily on flights transiting these sectors that are not on one of the impacted flows (FlowA, FlowB, FlowC, or FlowD). The IIA capability responds with four flights meeting the TMC's criteria, all of which happen to be air carrier flights.

The ZOB TMC confers with the Command Center specialist and the TMC of the facility controlling the departures. The specialist contacts the AOCs of these airlines. Each AOC evaluates its carrier's schedule to determine the impact of these delays on their schedule, then, finding the impact negligible, agrees to take the delay. The specialist notifies the TMCs who coordinate the delayed departure times with their facilities.

2200Z (t+3.0) **Traffic managers evaluate strategy as storm progresses**

Up to now, the thunderstorm has been developing as predicted. The latest prediction from the meteorologists indicates that the weather system will decay sooner than had been predicted earlier, and that a few thunderstorm cells will persist near Cincinnati. In the FAA-airspace user telephone conference, traffic managers decide that TFM designated routes are no longer

[8] As in the previous footnote, alternatively, the ATM system could automatically forward the amended route to the responsible controller, thus eliminating the involvement of the TMC in this process.

necessary, because the volume of traffic is such that the controller could easily manage around the isolated cells. They agree to de-activate the TFM designated routes at 2215Z. This decision is published on the Command Center webpage and entered into the TFM automation system.

4.2 Departure Flow Management Scenario

The participants in this scenario are a TMC at an en route center, a traffic management specialist at the Command Center, a TRACON TMC, and personnel at various air carriers. A key feature of this scenario is the iterative use of the IIA capability to explore various options for managing the traffic flow, as the situation evolves.

The geography in this scenario includes a major airport with departure fixes at the four corners, as shown in Figure 4-9, with both a low and a high altitude departure sector defined for each departure fix.

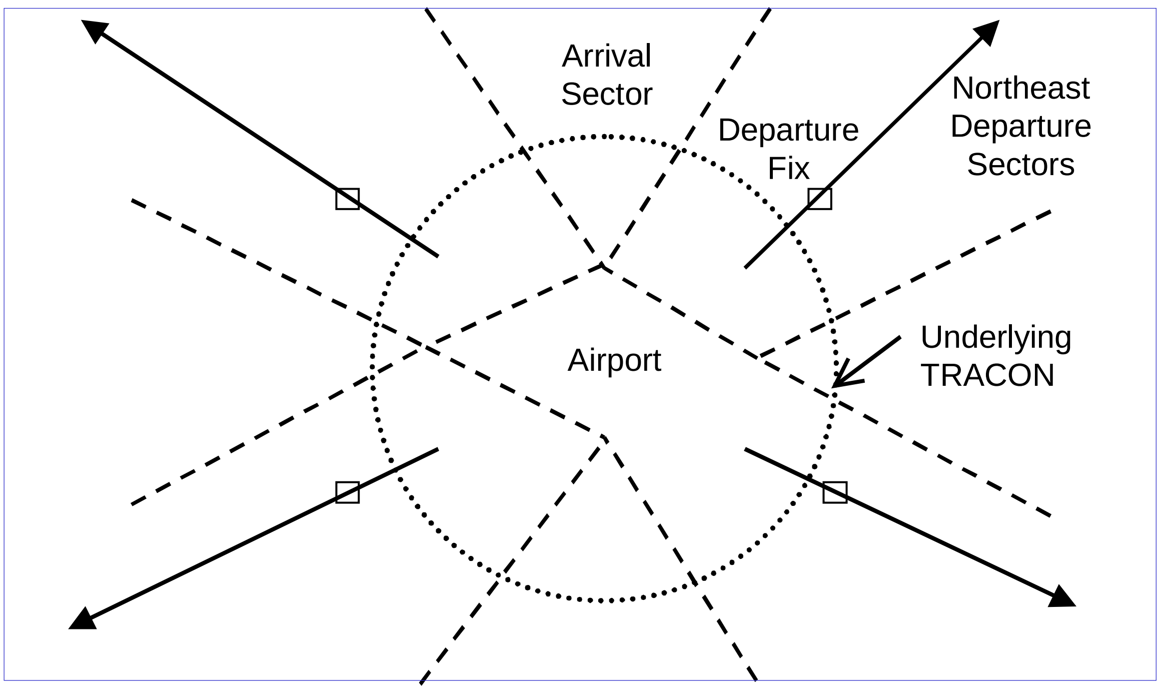

Figure 4-9. Airspace Layout Showing Typical Departure Routes

1400Z (10:00 a.m. EDT) (t-4.0) **Initial planning for predicted weather takes place**

Severe weather forecast four hours from now

Thunderstorms are predicted to materialize over the two southern departure fixes of a major airport as early as 1800Z, possibly lasting through 2200Z before moving on.

A TMC from the center overlying the airport prepares by gathering information on the surrounding airspace, equipment status, staffing levels, and other TFM initiatives.

TMC uses the IIA capability to identify departures predicted to fly through impacted airspace

Before starting collaboration with other facilities and airspace users, the TMC analyzes the problem with the IIA capability. The TMC starts by drawing a series of FCAs and setting their outlines, time periods, movements, and altitude ranges to model the predicted pattern of growth and movement of the storm. The expected extent of the severe weather between 1800Z and 2200Z, as well as the FCA's location at 2000Z, are shown in Figure 4-10.

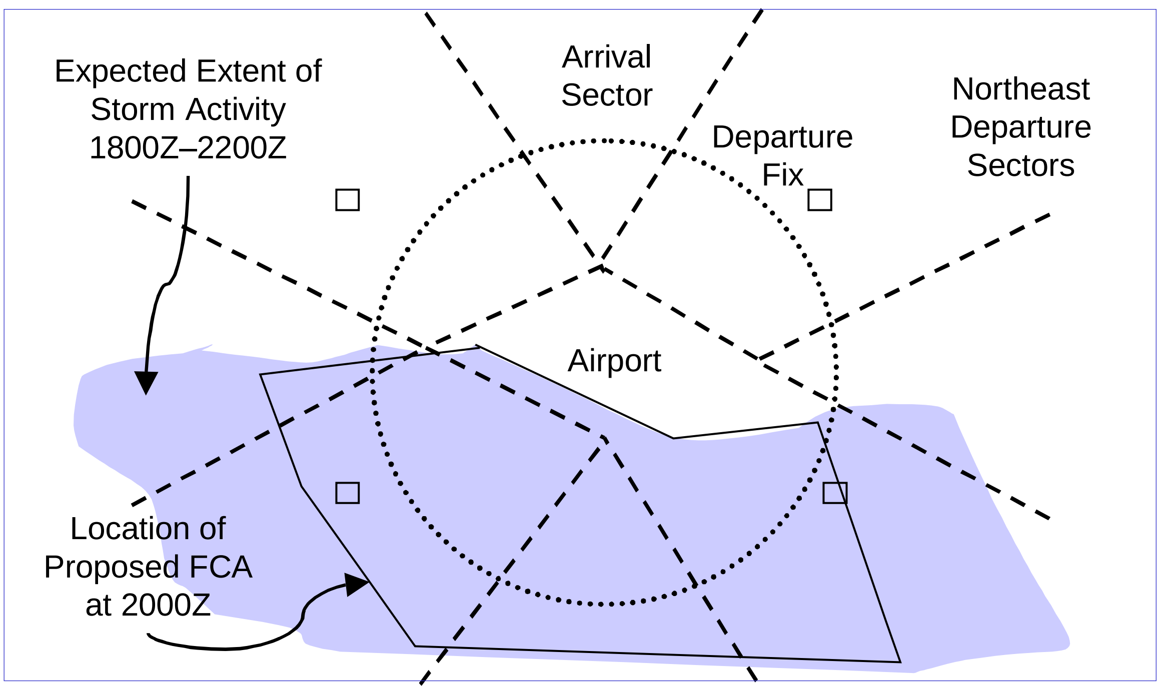

Figure 4-10. Impact of Predicted Storm Activity on Two Southern Departure Fixes

The IIA capability identifies the flights expected to intersect the FCA, as described in the en route scenario.

The TMC uses the IIA capability's traffic filters on the identified flights to select the departures that are expected to enter the departure sectors while their capacity is reduced by the weather. Traffic management actions for managing arrivals are also planned but are not discussed in this scenario.

TMC uses the IIA capability to develop and evaluate a reroute strategy

Examining the possibility that none of the selected flights will be able to depart into the southern departure sectors, the TMC uses the IIA capability to specify reroutes that send southeast departures over the northeast departure fix and southwest departures over the northwest departure fix, as shown in Figure 4-11. The IIA capability displays predicted sector traffic counts, indicating that traffic counts will exceed the acceptable threshold for both northeast departure sectors and for the high northwestern departure sector.

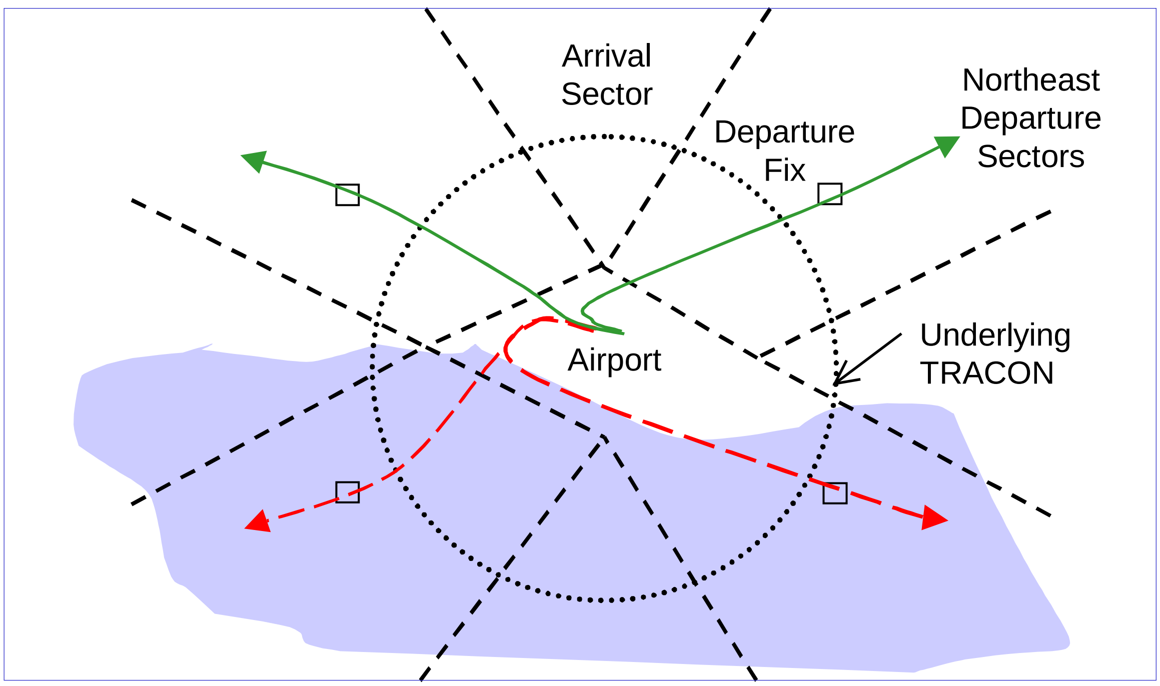

Figure 4-11. Rerouting Southern Departures over Northern Departure Fixes

TMC uses the IIA capability to evaluate MIT restrictions on departures over the northeastern departure fix

To explore what level of MIT restriction would be needed to keep sector counts within the thresholds for both northeast departure sectors, the TMC requests a "what if" in the IIA capability for 10, 15, and 20 MIT on *all* departures (not just rerouted flights) entering the **low** northeast departure sector (see Figure 4-12.) The TRACON controller would apply the MIT restriction before handing off the departures to the en route departure sectors.

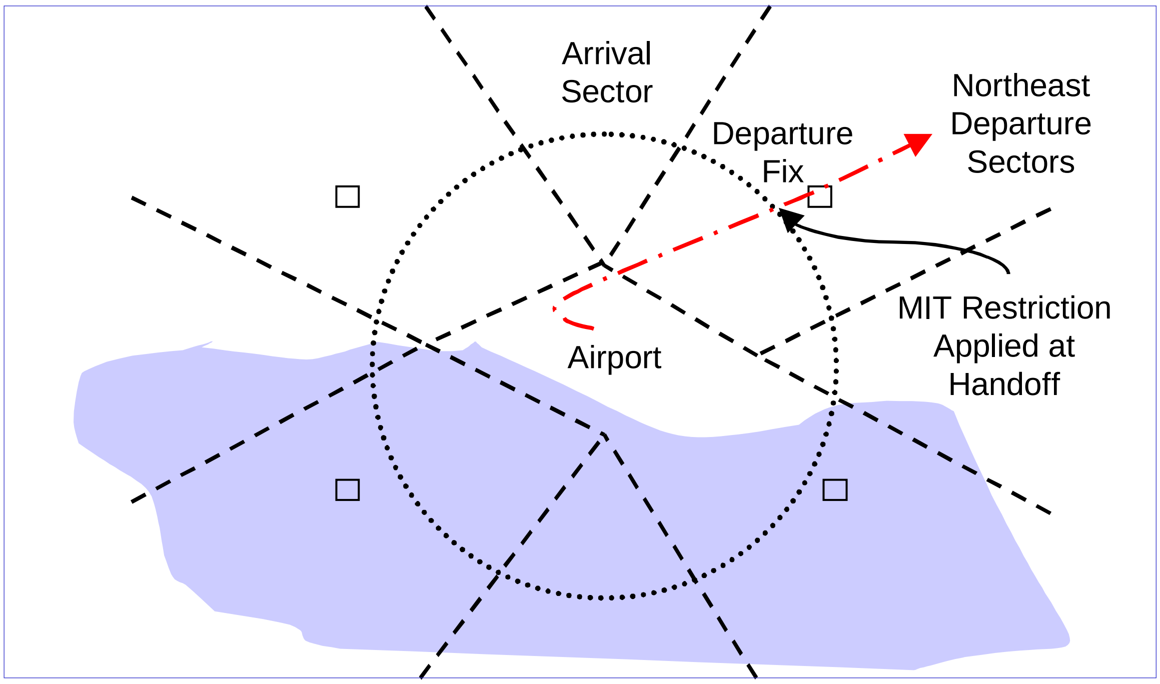

Figure 4-12. Using an MIT Restriction to Space Departures over Northeast Departure Fix

The capability displays the maximum and average ground delay on departures for each of the requested spacings, as well as the corresponding impact on individual flights and on sector workload in both northeast departure sectors. When results for various options do not differ substantially in sector workload, the TMC considers the impact on flights when choosing among the options.

The TMC compares results from the three spacings. The TMC fine-tunes these candidate solutions, modifying the start and end times on the restrictions to avoid restricting traffic too soon or too long and reevaluating them with the IIA capability.

The capability displays the revised maximum and average ground delay for each of the requested spacings. It also updates the corresponding impact on flights and on sector workload in both northeast departure sectors.

The TMC compares the results from the three spacings and selects the 15 MIT restriction, which imposes the least delay while spreading out the sector workload adequately in both northeast departure sectors.

TMC uses the IIA capability to evaluate MIT restrictions and altitude restrictions on departures over the northwestern departure fix

The TMC then requests a "what if" in the IIA capability for each of three options: 10, 15, and 20 MIT on *all* departures (not just rerouted flights) expected to enter the high northwest departure sector (see Figure 4-13).

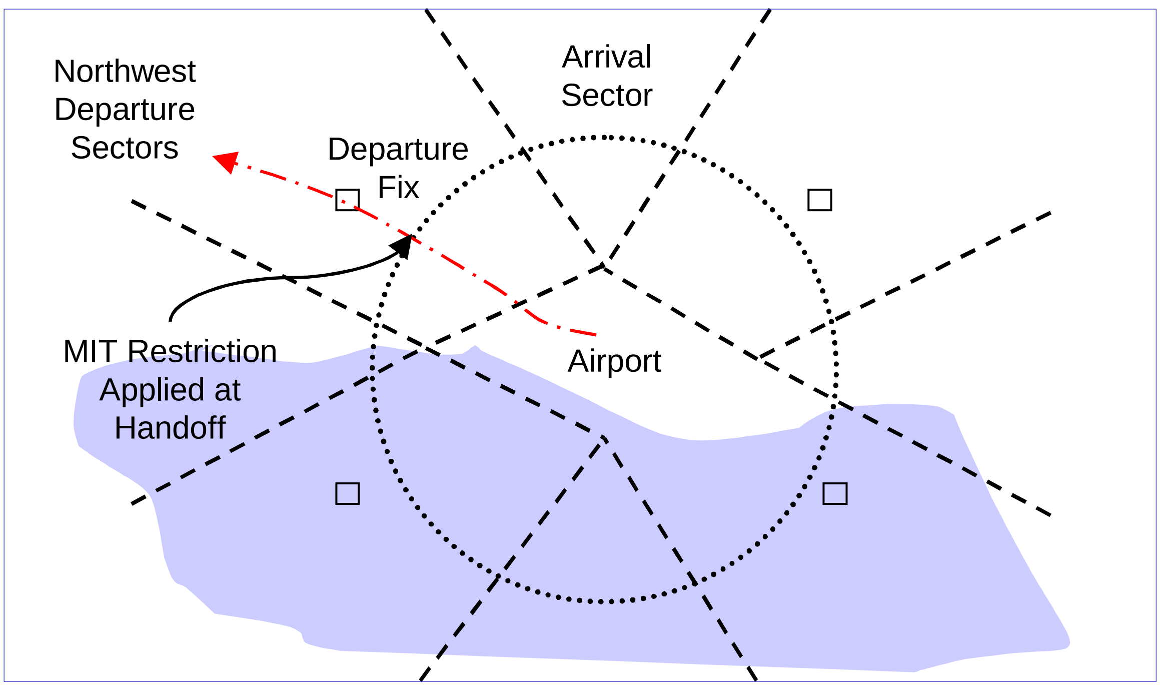

Figure 4-13. Using an MIT Restriction to Space Departures Expected to Enter the High Northwest Departure Sector

The capability displays the maximum and average ground delay on departures for each of the requested spacings, as well as the corresponding impact on individual flights and on sector workload in the high northwest departure sector.

The TMC compares the results from the three spacings and selects the 10 MIT restriction. This restriction is not sufficient on its own to adequately reduce high altitude sector counts, so the TMC uses the IIA capability to examine holding short-haul flights to a lower altitude than the cruise altitude originally requested in their flight plans. This will keep them from entering the high-altitude northwest departure sector. While flights prefer flying at a higher altitude because it is more fuel efficient, making use of available capacity at the lower altitude may be worthwhile to avoid the added delay associated with larger MIT restrictions.

The capability displays the new routes (and altitude changes) for each selected flight and updates the predicted ground delay on northwest departures for the requested spacing, as well as the corresponding impact on flights and on sector workload.

The TMC examines the revised results to verify that this combination of reroutes, altitude restrictions, and MIT restrictions spreads out the sector workload adequately in all affected sectors.

The TMC shares the defined FCAs and proposed actions with the Command Center specialist and requests that they be shared with airspace users and other facilities. The specialist distributes the proposed FCA definitions and resolutions, with the understanding that they will be updated and discussed as the situation unfolds.

1430Z–1600Z (t-3.5 – t-2.0) Airspace users react to predicted weather

Airspace users, who have access to the same weather information, have been planning their operations to account for the predicted thunderstorms. Airspace users are also able to see all proposed FCAs on their displays, request a list of their flights intersecting those FCAs, and determine how each of their flights would be affected by the proposed actions. Airspace users determine their response to the evolving situation, in some cases planning to depart over a northern departure fix and in some cases requesting that a flight be held on the ground until it can depart over a southern fix. As they provide early intent information reflecting their planning, the predicted demand information provided to the IIA capability is updated.

The TMC monitors the effect of these updates, noting that fewer of the flights identified earlier as intersecting the FCAs are now expected to depart over the southern departure fixes and that predicted sector counts for the northern departure sectors are increasing. This confirms the results from the TMC's earlier "what if" on rerouting flights over the northern departure fixes. As better information on when and where the thunderstorms will develop becomes available, the TMC updates the definition of the FCAs to reflect the revised forecasts and shares the revisions with other facilities and airspace users.

1600Z (t-2.0) **Collaboration with airspace users is needed**

While the early intent information shows that demand on the southern departure fixes is dropping, there are still more flights planned through those departure sectors than could be accommodated, given the expected reduction in capacity for the predicted weather. The TMC updates the proposed reroutes for departures over the southern fixes to reflect the revised traffic demand, by using the IIA capability to fine-tune which flights need rerouting and examine the updated impact. The TMC determines that reroutes still need to be implemented for some flights and that traffic counts will still exceed thresholds for the low northeast departure sector and both high northern departure sectors. The TMC coordinates with the appropriate controllers' supervisors and the TRACON TMC to fine-tune the proposal, updating the proposed reroutes, the MIT restrictions, and the altitude restrictions for selected short-haul flights.

The TMC then shares the updated reroutes and restrictions with the Command Center specialist. The TMC and specialist agree that collaboration with airspace users and other facilities is needed. The specialist distributes the revised reroutes and restrictions to the airspace users and other facilities, then facilitates discussion to refine the proposal. While some of the rerouted departures do enter a neighboring en route center through a different sector than they normally would, that facility determines that no additional restrictions are needed to manage the increased traffic in that sector.

Airspace users continue planning their flights and updating existing flight plans. Some choose to file the proposed reroutes, while others do contingency planning, such as calculating the additional fuel needed if flights are kept low. As they provide early intent information reflecting their planning, the predicted demand information provided to the IIA capability is updated.

1700Z (t-1.0) **Remaining reroutes are activated**

With the weather developing as expected, the reroutes are entered by the TMC for the remaining flights and sent to the tower to be issued to the departing flights. Each reroute is also relayed to the appropriate carrier AOC, to notify the dispatchers of the change. The TMC uses the IIA capability to examine the proposed MIT and altitude restrictions and updates them as needed to account for changing demand, continuing to coordinate with the appropriate controllers' supervisors and TRACON TMC. The carriers of the short-haul flights that may be subject to altitude restrictions are notified. Some choose to file for the lower altitude. Others do contingency planning but file a higher cruise altitude, in case congestion eases enough that they can be cleared to the higher altitude.

1800Z (t) **Thunderstorms develop over the southern departure fixes as predicted**

As the storms start to build, the capacity of the southern departure sectors falls. The MIT restrictions are put into place, with the TRACON spacing departures into the northern departure sectors before handing off those flights to the center. Flights selected for altitude restrictions are held below the high departure sectors. Flights that preferred waiting on the ground over accepting a reroute depart as departure sector capacity permits, working their way around the severe weather as long as that is still possible. Some flights remain on the ground until the storms move away from the southern departure fixes.

1800Z–2200Z (t – t+4.0) **Follow through and wrap up activities occur**

As additional flight plans are filed, those that do not specify that they will wait to depart over the southern fixes are rerouted over the northern departure fixes.

As the storms progress, the TMC continues to monitor whether the reroutes, MIT restrictions, and altitude restrictions are still needed. Some delayed and cancelled flights reduce demand on the northern departure fixes sufficiently that the MIT restrictions are lifted early. When the storm moves east of the southwestern departure fix, flights waiting on the ground for that route are cleared for departure.

Section 5

Issues and Next Steps

5.1 Issues

5.1.1 Role of Airspace User

An assumption made for this concept of operations is that airspace users do not have access to an IIA capability—for example, they do not have available such functions as the ability to experiment with different MIT or reroute strategies. Additional research is needed to identify which of an IIA capability's functions the airspace user needs, if any, and how the airspace user would use the functions in daily operations. Also to be determined is how access to an IIA capability would affect the role of the airspace user in strategy development.

One possible alternative to not having access to an IIA capability is for the airspace user to provide input to formulating a strategy. For example, should the airspace user be given the choice of selecting a strategy, or determining the size, shape, or location of an FCA? How would the traffic manager decide which opinion of several airspace users should be implemented?

From the two scenarios of Section 4, it is clear that the airspace user does have the responsibility to provide information on early intent to the TFM automation system. Although it seems intuitive that early intent information provides better prediction data, many questions need to be addressed, such as:

- What form should early intent information take?
- How good does early intent information need to be?
- How frequently should early intent information be updated?
- When does early intent information start to "count," that is, at what point does the user commit its flight plan to the early intent information?
- What are the benefits of early intent information?
- What is the cost to the airspace user to provide early intent information? What is the cost to the TFM automation system to accept and process early intent information?
- How much early intent information is enough?
- What is the necessary and sufficient subset of early intent information that the TFM automation system needs to provide "good" prediction data?

5.1.2 IIA Data to the Airspace User

The scenarios of Section 4 suggest that flight-specific results from an IIA capability can be forwarded to the AOCs. These results include the following: a list of the air carrier's flights that are expected to be rerouted or have MIT restrictions placed on them, the predicted delay for a flight incurred from a reroute or from a MIT restriction, the predicted additional distance flown because a flight is rerouted, and the specification of a flight's new route. An IIA capability can produce these data, but it is not clear whether airspace users need the data or how they would use that data. Furthermore, when do airspace users need the data?

Additional research needs to be conducted to determine how these data should be conveyed to the AOCs of each individual airspace user affected. Since it is assumed that the air carrier does not wish specific information about its flights to be shared with other air carriers or with the public in general, then a secure means of transmitting the information from the TFM automation system to the airspace user's AOC (for example, to its automation system, or by fax or telephone) is required.

The initial IIA capability also produces information about aggregate demand as well as capacity information for specific points in the NAS, such as pacer airports. In the scenarios, such information is illustrated as being posted on the Command Center webpage. Is this a sufficient way for airspace users to receive non-flight specific information?

5.1.3 TFM Roles and Responsibilities

This concept of operations makes an assumption that responsibilities between national versus local TFM remain about the same as they are today. However, in truth, responsibilities evolve because of such factors as the introduction of new automation and procedures, changes in user priorities or equipment, or concerns expressed by the public, regulatory agency, or other government organization.

The division of responsibilities related to an IIA capability reflects the larger question of which facility—Command Center, en route center, or TRACON—is responsible for carrying out such TFM tasks as the following: identify a traffic management situation, develop strategies to manage the situation, and monitor effectiveness of the strategy. For example, should the Command Center specialist be evaluating a departure flow management strategy for its impact on arrivals, or is this an en route center TMC's task?

5.1.4 Automating the Implementation of TFM Strategies

Today, the implementation of large-scale TFM strategies is slow, cumbersome, and a bottleneck to efficient and effective traffic management. When TFM strategies such as reroutes and MIT restrictions are selected for implementation after proper decision support and analysis, how will the controllers and airspace users be notified of the amendments to the flight plans via automation? CAASD and others are doing research in this area, but at this writing, it is uncertain when the ability to automate TFM strategy implementation would be available. An automated data distribution capability would help to shorten implementation time for TFM strategies, providing more time and opportunity for planning and collaboration. It would also reduce errors in transmission from the traffic manager to the controller or airspace user.

5.1.5 Metrics

The primary metrics used by the initial IIA capability thus far are sector count, flight delay, and difference in distance flown. Additional research is needed to determine whether such measures adequately correlate to impact to the NAS or impact to the airspace user, or whether other, more suitable metrics can be determined.

Additionally, it is not clear how "user metrics," such as difference in distance flown, would be used for operational decision making.

5.1.6 Equitable Allocation of Resources

In the en route scenario of Section 4, two routes are developed to the north of the weather system. The traffic manager assigns specific flows to the routes. Then, the flights fly the assigned routes on a first-come, first-served basis.

In the case where flows are not as easily discernable, is there a fair way of allocating the resources (in this case, "slots" on the route) to the airspace user? For example, if several different carriers desire to fly N1 (the route that is closer to the weather system), who should be able to fly N1 versus having to fly route N2 (the more out-of-the-way route)? What factors should the traffic manager consider when demand exceeds the capacity of the resource? For example, is it reasonable to allocate route "slots" to carriers based on what percentage of the total number of flights that want to fly the route belong to a specific carrier? Should the traffic manager or the TFM automation system even take on the task of allocating resources, or of allocating them in an equitable manner?

5.1.7 Procedure Implications

The en route scenario of Section 4 suggests that if a flight is not on the TFM designated routes by the time the routes are activated (see 1730Z section of the scenario), its flight plan will be amended to reflect the reroute. This action is taken either by the TFM automation system or the TMC, with a notification to the AOC. Implied in the scenario is that the TFM automation system uses an algorithm to determine how to get the flight from where it is (at the departure airport or in the air) to an entry point to the TFM designated route. Is the entire process described an acceptable procedure to traffic managers and to airspace users?

5.1.8 Timing in Scenarios

Both scenarios of Section 4 suggest timing of TFM actions. Is the timing of events suggested in these scenarios reasonable? For example:

- Should TFM designated routes be activated one and one-half hours before the predicted onset of the severe weather?
- How often or how soon would airspace users want a list of their flights that might be affected by a given strategy?
- How soon before the onset of the predicted weather should the traffic managers begin designing a reroute strategy or an MIT strategy?

5.1.9 Alternatives to MIT Restrictions

MIT restrictions tend to be conservative solutions to traffic management situations, often delaying flights that do not contribute to the problem. This inefficiency is due to the simplicity of MIT restrictions—they are easy to communicate and implement, but typically affect whole flows and are not sufficiently precise for the problem intended to be solved. What alternative, more efficient strategies could be used? What decision support is needed to use these strategies effectively in conjunction with reroutes and the accompanying decision support tools? How will the tools be used in a coordinated manner?

5.2 Next Steps

Development of the prototype of an IIA capability continues to evolve. In addition to modeling rerouting, MIT restrictions, and altitude restrictions, CAASD is exploring the integration of the following functions:

- Progressive modeling of TMIs. This function would allow a traffic manager to develop a traffic management strategy as a sequence or combination of TMIs. After the first of these is made active, the situation is re-evaluated before the next in the sequence is implemented, and so on. Such progressive modeling of TMIs helps to avoid over-constraining the NAS.
- Alternative techniques that would allow the traffic manager to directly control volume in a sector. Such techniques would attempt to solve congestion problems by delaying only the minimum number of flights necessary to bring sector workload down to acceptable levels. One possibility is a function that would allow the traffic manager to control volume in a sector by adjusting departure times on specific flights, rather than restricting an entire flow.
- Modeling GDPs, which are TMIs that delay departures for a known amount of time from airports around the United States to an impacted airport, with the goal of spacing arrivals in a manageable arrival rate. The interaction of GDPs and MIT

restrictions is problematic, since the presence of MIT restrictions in the en route airspace can change arrival times and hence the actual arrival rate could be different than arrival rate used to plan for the GDP.

- Modeling ground stops, which are TMIs that delay departures for an unknown amount of time from airports around the U.S. Ground stops are often used as a last resort when other traffic management actions fail to balance demand and capacity in en route airspace at a manageable level or when an airport can no longer accept any arrivals due to severe weather, runway closure, equipment failure, or other factors.

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Glossary

AOC	Aeronautical Operational Control
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATCSCC	Air Traffic Control System Command Center
ATCT	Airport Traffic Control Tower
ATM	Air Traffic Management
CAASD	Center for Advanced Aviation System Development
CCSD	Common Constraint Situation Display
CRCT	Collaborative Routing Coordination Tools
EDCT	Estimated Departure Clearance Time
ETMS	Enhanced Traffic Management System
FAA	Federal Aviation Administration
FCA	Flow Constrained Area
GDP	Ground Delay Program
IIA	Integrated Impact Assessment
MIT	Miles in Trail
NAS	National Airspace System
SWAP	Severe Weather Avoidance Program
TFM	Traffic Flow Management
TMC	Traffic Management Coordinator
TMI	Traffic Management Initiative
TRACON	Terminal Radar Approach Control
ZAU	Chicago ARTCC, or Chicago Center
ZHU	Houston ARTCC, or Houston Center
ZFW	Fort Worth ARTCC, or Fort Worth Center
ZID	Indianapolis ARTCC, or Indianapolis Center
ZME	Memphis ARTCC, or Memphis Center
ZMP	Minneapolis ARTCC, or Minneapolis Center
ZOB	Cleveland ARTCC, or Cleveland Center
ZTL	Atlanta ARTCC, or Atlanta Center