HUMAN-IN-THE-LOOP EVALUATION OF A MULTI-STRATEGY TRAFFIC MANAGEMENT DECISION SUPPORT CAPABILITY

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Abstract

Traffic flow management (TFM) in the U.S. is the process by which the Federal Aviation Administration (FAA), with the participation of airspace users, seeks to balance the capacity of airspace and airport resources with the demand for these resources. This is a difficult process, complicated by the presence of severe weather or unusually high demand. Actions to manage demand are themselves complex, and interact in difficult-to-predict ways. Decision support tools could assist traffic managers in choosing actions to solve resource allocation problems while keeping delay at manageable levels.

Such tools must have the capability to evaluate the impact of the multiple, different flow management strategies commonly used in the U.S. National Airspace System (NAS) today. MITRE and the FAA are developing a TFM Integrated Impact Assessment (IIA) capability in which a traffic manager can specify any combination of reroutes (for avoidance of severe weather or congested airspace) and miles-in-trail (MIT) spacing restrictions. The capability predicts the sector load impact and the imposed delays due to the combined strategy, and allows the traffic manager to adjust reroute and MIT restriction parameters to improve the proposed solution.

This paper provides an introduction to the features of this capability as implemented in an experimental prototype, and a detailed report on the operational evaluation activities – including a human-in-the-loop (HITL) experiment using NAS traffic managers – that have been done to develop the concept-of-use and functional requirements for this capability. This work is in Technology Readiness Level category B, as defined in the Call For Papers for this seminar.

Keywords: Traffic flow management, decision support, en-route congestion, sector load prediction, miles-in-trail, rerouting, ETMS

Background

TFM Problem Solving

Traffic managers have many options when trying to address excess demand on a resource. For excess airport demand, a ground delay program is often used, in which arrival "slots" are rationed among airspace users, and flights are assigned delayed departure times such that available arrival capacity will be efficiently used. En route sector congestion, resulting from unusually high demand or when available airspace is limited due to hazardous weather, can be controlled in several ways. Flights can be rerouted around hazardous weather and/or congested areas. Access to airspace can be limited by imposing MIT restrictions at the airspace boundary, by applying ground delay, or in extreme cases by halting departures to some destinations altogether (ground stop).

In general, the traffic manager's goal is to choose a set of actions to maximize throughput while maintaining safe traffic volume. This means that a useful decision support tool would be able to project the combined impact of proposed actions on resource demand (arrival/departure rates, sector loading) and on flight delays. Ideally, the information provided would help the traffic manager develop a solution to manage resource demand while keeping overall flight delay as low as possible, and (if feasible) allocating delays equitably across airspace users. Without this information, traffic managers must rely on experience and difficult mental computations, leading to conservative solutions that may unnecessarily restrict traffic flow.

Decision Support for Multiple Strategies

MITRE is working with the FAA to develop problem recognition and strategy evaluation capabilities to meet TFM decision support needs. Earlier work has focused on capabilities to (1) identify airspace congestion problems, and (2) develop reroute plans to address congestion or severe weather situations [1, 2]. Some of these capabilities have been matured through laboratory studies and evaluation by FAA traffic managers, and are now either deployed or being developed for deployment in the FAA's Enhanced Traffic Management System (ETMS) [3].

The new capabilities described here extend these initial efforts to handle multiple traffic management strategies, by allowing the traffic manager to evaluate and compare strategies based on a combination of reroutes and MIT restrictions. Related research at MITRE seeks to provide automation assistance in choosing effective reroutes and other flow restrictions for solving complex weather and congestion problems [4], and NASA researchers are also studying the issue of integrated TFM decision making [5]. It is envisioned that these and other efforts will eventually produce a single, integrated decision-support system that can evaluate and compare any feasible combination of TFM strategies.

Rerouting

Reroutes are most often employed in one of two situations: (1) when airspace becomes restricted or unavailable due to severe convective weather, and (2) when airspace congestion is severe. In the first case, the reroutes are often large scale and developed collaboratively during teleconferences involving the Air Traffic Control System Command Center (ATCSCC), the affected Air Route Traffic Control Centers (ARTCCs), and representatives of participating airlines. These large scale reroute plans often last several hours, and are designed to proactively avoid unmanageable sector congestion due to weather deviations. In the second case, smaller scale reroutes can be used to prevent unsafe traffic levels on a more tactical time and geographical scale.

Miles-In-Trail Restrictions

MIT restrictions impose a spacing criterion for flights passing a boundary. Separation assurance standards provide 5 nautical mile (nmi) horizontal spacing for co-altitude flights, but MIT restrictions impose additional spacing of 10, 20, or more nmi, and may be applied without regard to altitude. In this way, MIT restrictions can be used to directly control the flow rate of aircraft across a boundary.

A survey of FAA traffic managers and traffic management logs has been done to better understand the operational application of MIT restrictions [6]. According to the traffic managers, MIT restrictions provide a means of: (1) reducing the overall average rate of air traffic flow over a fix or boundary, bound for a resource such as a sector or runway, (2) regularizing a flow, i.e., providing predictable, repeated spacing between successive flights, and (3) reducing the complexity of the air traffic that will be handled by each controller or controller team. MIT restrictions are an often-used traffic management technique. For example, Indianapolis ARTCC (ZID) used an average of 96 MIT restrictions per day during the 17 days studied in the survey [6].

Integrated Miles-In-Trail/Rerouting Strategy Evaluation

The prototype rerouting and MIT impact assessment capability is based on the Collaborative Routing Coordination Tools (CRCT) prototype, a flexible TFM decision support research platform used in several previous studies [1,2,4]. Since the IIA prototype relies heavily on the CRCT prototype problem detection and rerouting capabilities, these are described first, followed by a description of the IIA-specific capabilities.

Problem Detection and Rerouting

The CRCT problem recognition capabilities are based on the concept of Flow Constrained Areas (FCAs). These are airspaces defined by traffic managers to bound severe weather, congested airspace, or any other area of interest. Flights predicted to enter these airspaces can be easily identified, classified, and sorted for developing strategies to efficiently reduce flow through the constrained area. The CRCT prototype provides graphical tools for visualizing flow through these areas, constructing alternate routes for affected flights, and visualizing future positions of both rerouted and non-rerouted flights.

Figure 1 illustrates an FCA being used to identify flights that will be affected by severe convective weather. In this example, routes are drawn for all flights that are planned to cross the area over the next two hours, and that do not arrive or depart within Cleveland ARTCC. Extensive filtering capabilities are provided to help classify affected flights for rerouting. The traffic display (at left in the figure) and the list shown at right in the figure are used to develop alternate routes.

Figure 2 shows the construction of reroutes to avoid this weather system. The traffic manager can specify possible reroutes graphically, via text entry, or by selecting predefined routes as in the FAA's "National Playbook." For this example, two reroutes have been specified; one for eastbound flights and one for westbound flights. The time and distance added to involved flights are calculated and displayed individually and in total in the rerouting window at right. These data aid in selection of routes that have low impact on airspace users.

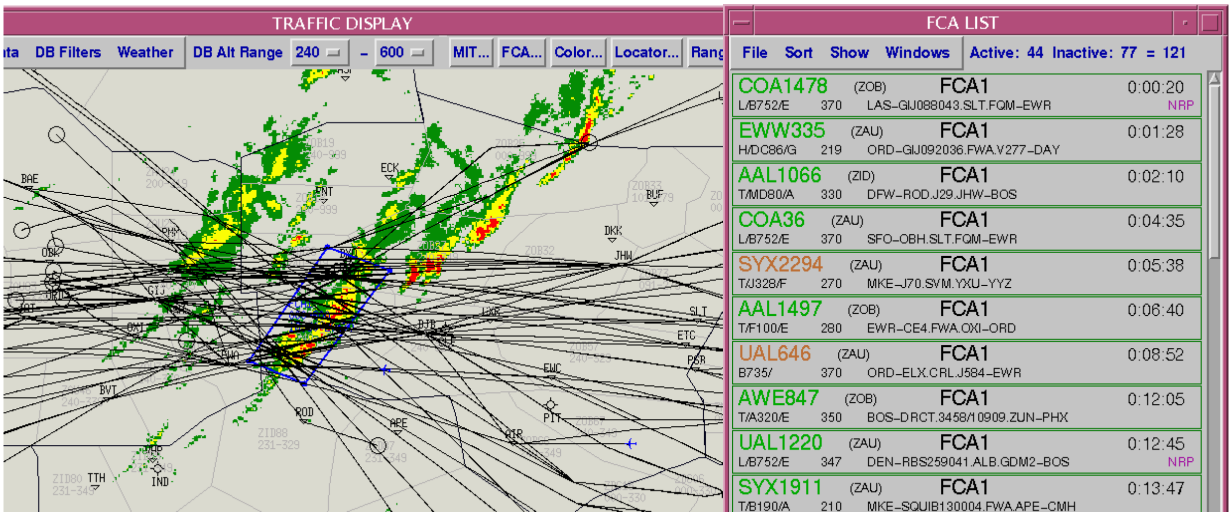

Figure 1: Using a Flow Constrained Area to Identify Weather-Impacted Flights

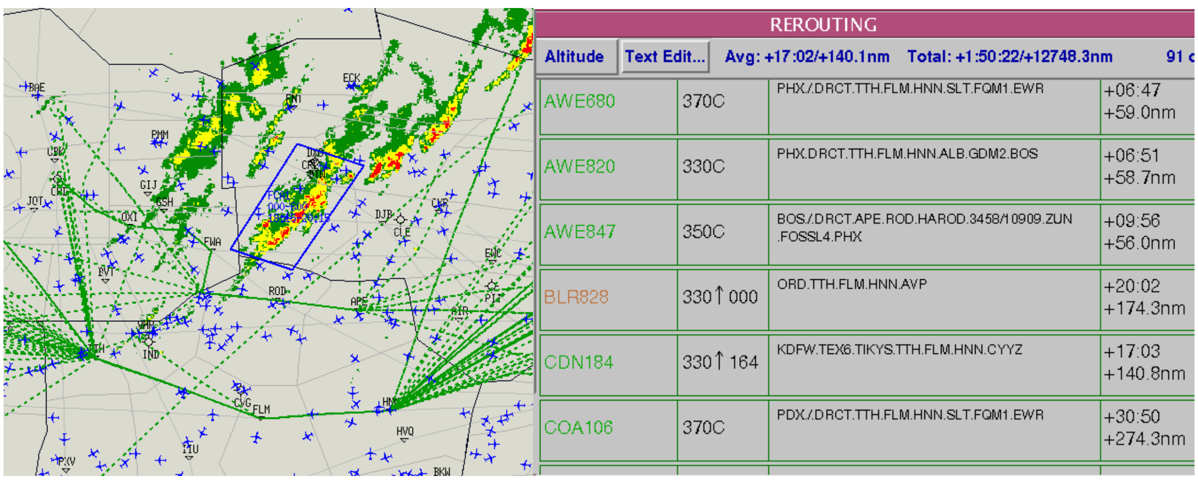

Figure 2: Developing Reroutes for Severe Weather Avoidance

The CRCT prototype provides predictions of the sector traffic counts that would result from the planned reroutes, including graphical comparisons between the present situation and the proposed reroute strategy. Figure 3 shows the Sector Count Monitor (SCM) being used to evaluate the difference in peak sector counts predicted for the proposed reroutes depicted in Figure 2. Predicted peak sector counts over 15-minute intervals (vertical axis) are shown for each sector. Each box along the horizontal axis represents a sector (top number) and a peak count threshold (bottom number). Counts above the threshold produce yellow or red alerts (shown here as lighter-shaded cells). Sectors for which predicted peak counts will increase with the reroute in place are surrounded by dark, heavy outlines; sectors with decreased peak counts are outlined in a lighter color. In this case, the predicted sector loads are very high for several ZID sectors, with peak aircraft counts predicted to be as much as 15 aircraft in excess of the threshold value (Sector 83, 19:15 – 19:29).

Note that the FCA function and a version of the sector count monitoring display have been implemented in ETMS as of December 2002. In the initial version, the latter display shows only the baseline sector count predictions, since no rerouting functions are yet available. These will follow in a later release.

Integrated MIT and Rerouting Impact Assessment

The high traffic counts shown here are frequently produced by large-scale weather reroutes, and are often addressed by placing MIT restrictions on the rerouted flows. Figure 4 shows displays from the IIA prototype for specifying and evaluating such a restriction. The traffic manager identifies a boundary at which to apply a MIT restriction, a spacing value, flow direction, and filters to select the flights that will be spaced. In this example, an MIT restriction of 20 miles has been proposed for the eastbound flow for a two-hour duration. The resulting delays are computed and displayed both in aggregate form and by flight. Two types of per-flight delay are presented: (1) due to the MIT restriction alone, and (2) due to the MIT restriction and the reroute (relative to the original flight plan). In this case, the 20 MIT restriction is relatively expensive: it would affect 68 flights, delaying them 44 minutes on average.

As noted, aside from specifying the boundary at which the restriction will be applied, the traffic manager also specifies the detailed characteristics of the restriction. As labeled in Figure 5, these include at a minimum: (1) a restriction identifier, (2) the spacing value, (3) the start time and (4) the end time of the restriction, (5) the flight direction to restrict, (6) the set of flights to which the restriction will be applied, and (7) any filters to be used in selecting flights that will be affected by the restriction. The filter set is often used to select flows by departure or arrival airport, since restrictions of that type are common in the NAS.

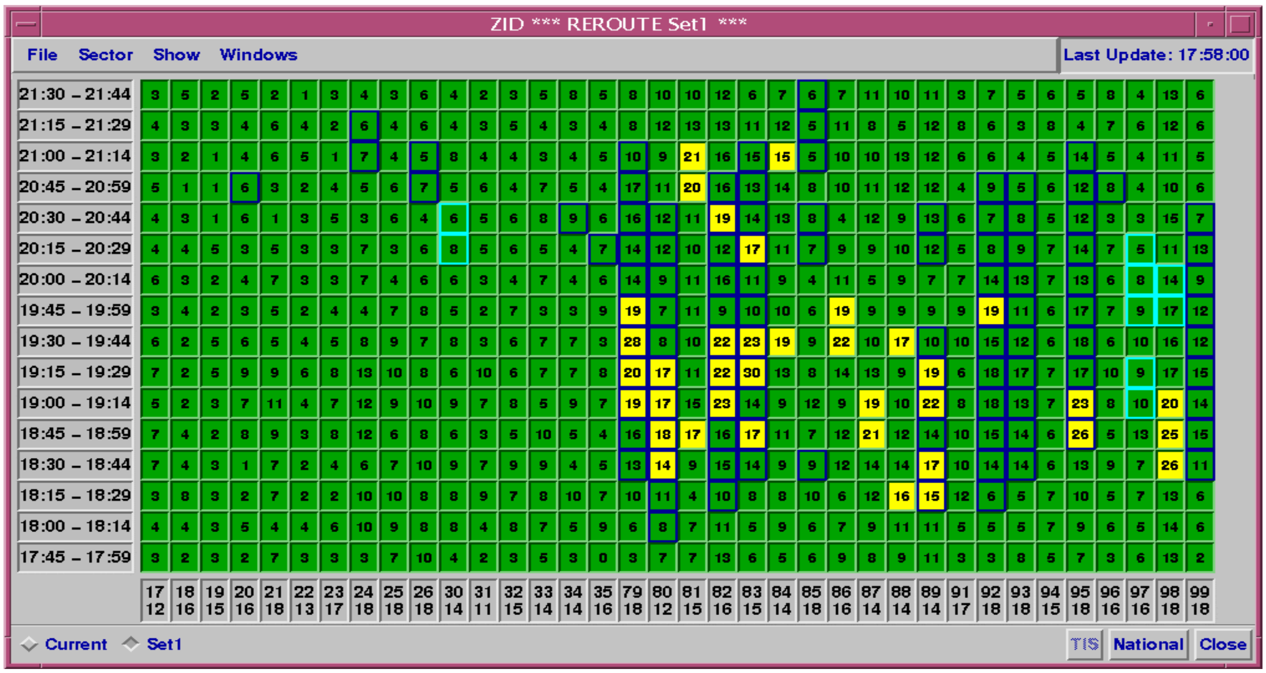

Figure 3: Evaluating Reroute Strategy with the Sector Count Monitor

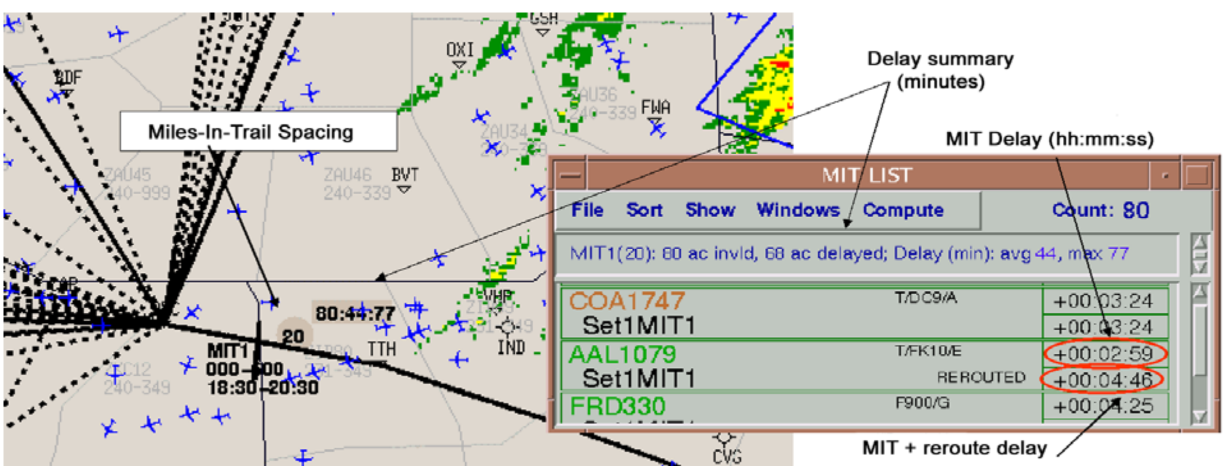

Figure 4: Evaluating a Proposed MIT Restriction

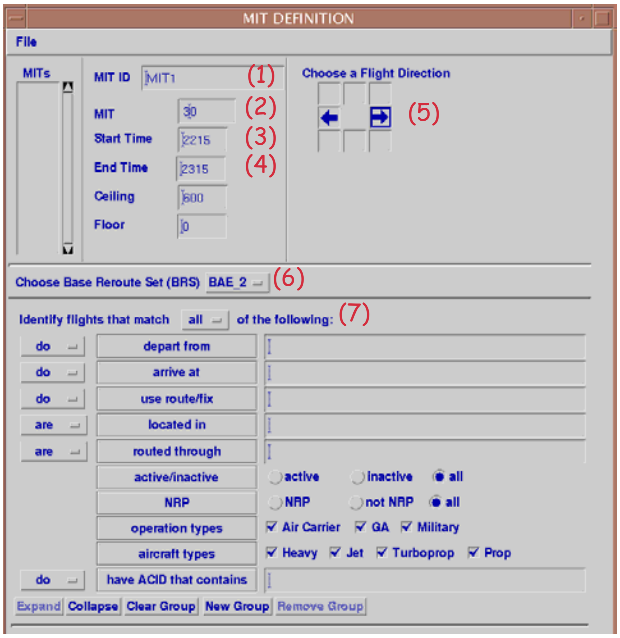

Figure 5. MIT Definition Window

The sector count impact is also computed, and displayed as shown in Figure 6. Alerted sectors remain, but the peak counts are much lower than they were in Figure 3. At this point the traffic manager can try to improve the solution. The reroutes can be redefined, perhaps to better distribute the rerouted flights across more airspace. This will tend to reduce peak sector loads, but add flying time and distance. The MIT restriction parameters can also be adjusted in several ways (e.g. duration, spacing, affected flows).

The examples shown above reflect application of the IIA prototype to a hazardous weather situation. The prototype is also capable of modeling MIT restrictions as applied to arrival and departure flows, and of modeling multiple, interacting restrictions. Figure 7 shows multiple restrictions being applied to a large-scale, weather-induced reroute, chosen from the National Playbook. Each MIT restriction is marked with its spacing value in a circle. The accompanying box shows the number of affected flights, the average delay (minutes), and the maximum delay (minutes) predicted for that restriction.

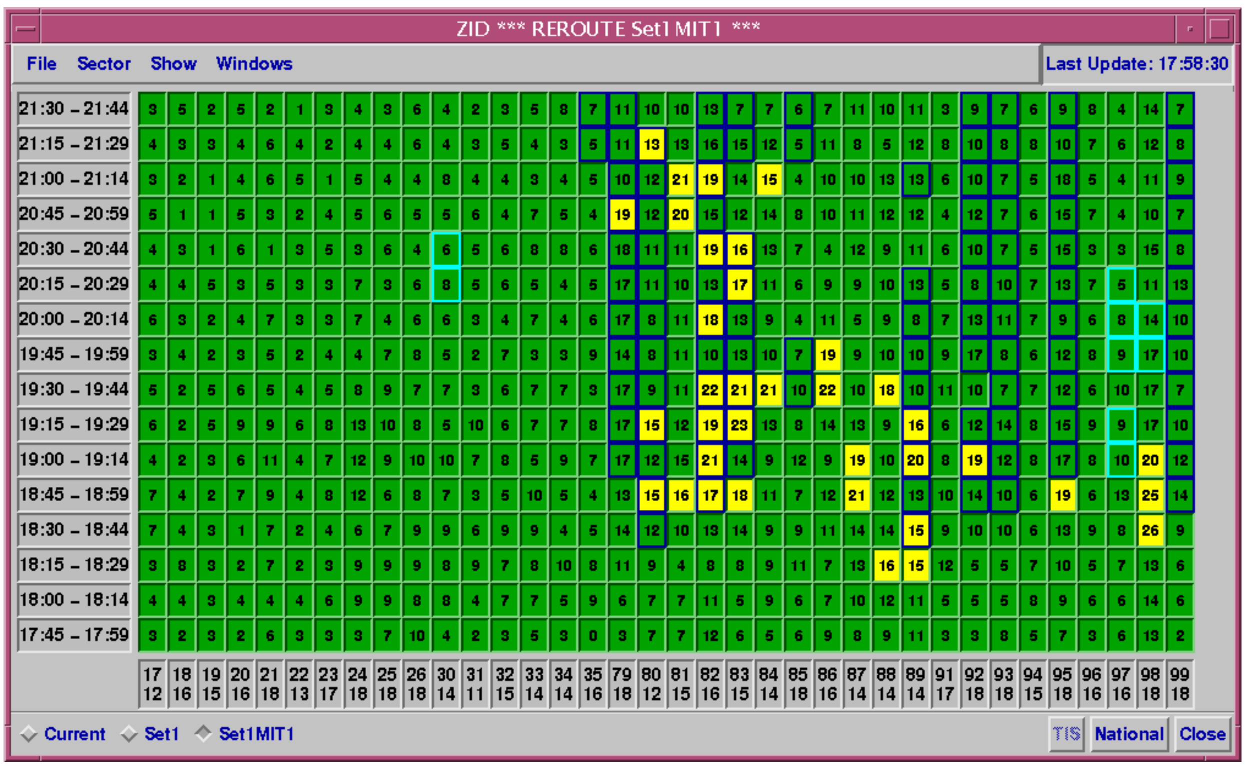

Figure 6: Predicting Sector Loads: MIT and Reroutes Together

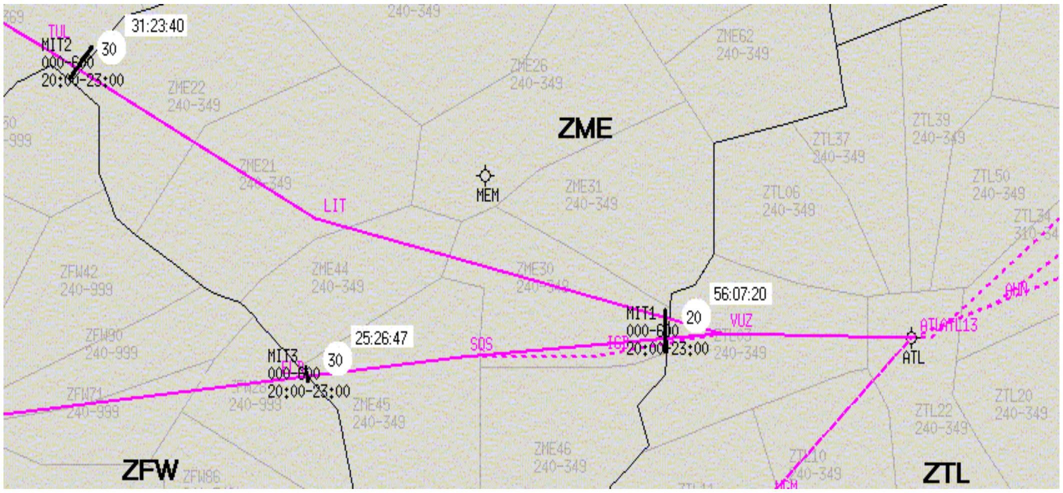

Figure 7: Applying Multiple MIT Restrictions to a National Playbook Reroute

Modeling Capabilities

In order to create predicted flight trajectories that satisfy the specified MIT constraints, the automation must make assumptions about where spacing delays will be absorbed by each of the involved flights. Spacing delays can be incurred in several ways. When a flight is departing from an airport near the restriction, a ground delay may be imposed. When the flight is airborne or coming from a remote departure airport, then airborne spacing actions such as vectoring, speed reduction, or airborne holding may be employed.

Because the predicted trajectories will be used primarily to evaluate sector loading, it is not necessary (or feasible) to anticipate and model the specific spacing actions that might be taken. However, it is desirable to place the trajectories in the correct sector as much as possible, and therefore the prototype includes a set of rules to represent when and where the delays will be absorbed. These rules are illustrated in detail in [7], but can be summarized as follows:

- Flight delays are calculated by building a “first-come, first-served” schedule at the restriction boundary, and calculating delays to achieve the required spacing.
- Flights that have not yet departed, and are departing from airports within 400 nmi of the restriction, will be delayed on the ground prior to departure.
- Other flights will be delayed in the air by tactical spacing actions, starting 200 nmi upstream of the restriction.

While these rules may not accurately represent operational procedures in all conceivable cases, field observations and feedback from traffic managers indicate that they work reasonably well in most cases. Validation and improvement of this modeling technique continue.

Initial Field Evaluation Activities

Initial demonstrations of the IIA prototype were given at the Kansas City (ZKC) and Indianapolis (ZID) ARTCCs in 2000. The traffic managers' reactions to this capability were very positive, leading to discussions of traffic management in general and of the use of MIT restrictions in specific. Even with an early development version of the prototype, it was possible to test a number of scenarios and common strategies with great impact. Traffic managers observed in several instances that the application of an MIT restriction to control sector volume was not effective, often postponing problem to a later time. Traffic managers were also surprised at the large delays caused by even seemingly moderate departure MIT restrictions. This illustrated the difficulty in determining the impact of an MIT restriction without modeling tools, and suggested the appealing possibility that this capability has the potential for both reducing the number and severity of restrictions used and improving the effectiveness of those that are employed to control sector volume.

Based on this early feedback, more comprehensive field exercises were designed. The first of these was conducted at ZKC in November 2001, and a second was conducted during January 2002 at ZID. Each evaluation exercise consisted of an interactive demonstration of the capability to operational personnel, followed by a structured questionnaire including both numerically-ranked and free text responses. Questions were posed in several areas, addressing the operational need, information requirements, human-computer interface, and potential operational impact of the prototype capability. Seven traffic managers participated in the Kansas City exercise and thirteen participated at Indianapolis. These participants had a wide range of experience both as traffic managers and with the CRCT prototype.

The primary results of this exercise were as follows. A strong majority of the participants:

- Believed there is a strong operational need for an MIT analytical capability
- Judged the modeling approach used in the prototype to be operationally reasonable
- Found the display of sector count and delay information sufficient
- Wanted the operational version of this capability to display the impact of both proposed and already-implemented MIT restrictions
- Thought the prototype capability provides sufficient information for TFM decision-making
- Stated that the prototype human-computer interface appears operationally usable
- Expected that operational use of this capability would result in a reduced number of MIT restrictions being implemented

There were also areas in which consensus was not reached. For example, though all participants agreed that sector count feedback on proposed MIT restrictions was critical to decision-making, several participants did not see much value in the aircraft delay information. This and other issues were addressed in the next evaluation.

Human-in-the-Loop Evaluation

The results of the initial exercises supported the initial operational concept and functional capabilities represented in the prototype. However, these exercises did not involve hands-on activity by the participants, and hence were insufficient for developing detailed functional requirements. Therefore, a human-in-the-loop evaluation was conducted in November 2002.

Evaluators

Twelve people participated in the evaluation. Seven were Traffic Management Coordinators (TMCs) from two ARTCCs (Indianapolis and Kansas City), and five were from the ATCSCC. The ATCSCC evaluators averaged 5.2 years of experience at the ATCSCC with a maximum of nine years and a minimum of two years. They also averaged five years of experience in an ARTCC traffic management unit (TMU) with a maximum of seven years and a minimum of three years. The TMC evaluators averaged 3.8 years of experience in the TMU with a maximum of seven years and a minimum of 1.5 years.

Experimental Protocol

The evaluation began with a brief review of CRCT prototype functions and hands-on training of the new IIA features. The training was administered by MITRE personnel on a one-on-one basis.

Following training, the evaluators executed three operational scenarios using replayed data recorded on April 10, 2002. The scenarios were based on operational situations where the MITRE evaluation team believed that IIA functions might be useful. The evaluation was conducted on a one-on-one basis. In each scenario, the evaluators were asked to complete the task using the prototype. Evaluators were not told how to perform the tasks but a facilitator was available to answer questions.

Following each scenario, a brief interview was conducted with the evaluator regarding the application of IIA to the specific scenario. After the completion of all three scenarios and interviews, a comprehensive interview was conducted to get detailed feedback about the usefulness of IIA functions, and to obtain opinions as to the effects on the TFM environment if IIA functions were implemented in ETMS.

Results

Various metrics were calculated from responses collected during the IIA human-in-the-loop evaluation. Except as noted, responses were ratings on a scale from 1 to 5, with 1 representing "not useful/helpful," 3 representing "moderately useful/helpful," and 5 representing "very useful/helpful." All charts and tables show the average response for ATCSCC evaluators, ARTCC evaluators, and all evaluators.

Overall Usefulness of IIA Capability

Evaluators were asked to rate the overall usefulness of the IIA capability, as experienced in the following operational scenarios:

<u>Departures:</u> The objective of this scenario was to protect departure sectors east of a major airport.

<u>Playbook:</u> The objective was to evaluate the impact of a MIT restriction on a Playbook route.

<u>Independent MITs into a Sector:</u> The objective was to evaluate the impact of two independent MIT restrictions on sector volume.

For each scenario, evaluators were asked "In the operational situation you just experienced, how useful was the IIA capability?" Table 1 shows the results.

Table 1: IIA Usefulness in Operational Situations

Scenario	Evaluator Group Average Rating		
	ATCSCC	ARTCC	All
Departures	4.4	4.6	4.5
Playbook	4.2	3.4	3.8
Independent MITs Into Sector	5.0	4.5	4.7

There was general agreement among evaluators that the IIA capability was more than moderately useful for these scenarios. Some evaluators stated that the capability gives the needed feedback for sector loading and shows what happens after the restriction is over, but one evaluator also stated that the goal is a reduction in complexity, not just a reduction in volume. An ATCSCC evaluator commented "Seeing max delay in the MIT List for the Playbook example is extremely helpful. It is good to see a separate display of impact of the play versus with the restriction." Some comments reflected discomfort in applying MIT to Playbook routes (except when evaluating the need for passback) when other options (e.g., moving Playbook routes, coded departure routes, additional reroutes, capping departure altitudes) might be available.

Usefulness of Impact and Delay Information

During the scenarios, evaluators could see graphic representations of the predicted effect of the proposed restrictions and reroutes on sector congestion. The evaluators were asked "How useful is the demonstrated sector impact information in supporting your decision process for MIT?" Figure 8 shows results for specific displays of impact information (i.e., aircraft counts and sector congestion), including changes to cells on the SCM, changes to sector alert indicators on the traffic display (TD)[1] and future traffic display (FTD)[2], and predicted future positions (icons) for affected rerouted flights on the FTD. Most of the evaluators rated the display of cell changes on the SCM as "very useful." Most evaluators rated alike the displays of "changes to sector alert indicators on the TD" and "changes to sector alert indicators on the FTD," even though ratings ranged from "not useful" (two evaluators) to "very useful" (four evaluators). On average, ATCSCC evaluators rated these displays as more useful than did ARTCC evaluators (who preferred the SCM), and the opposite was true for the display of "icons for affected rerouted flights on the FTD." This difference is likely due to the local expertise of the ARTCC evaluators (who already know where the numbered sectors are) and the national viewpoint of ATCSCC evaluators, who need a geographical picture.

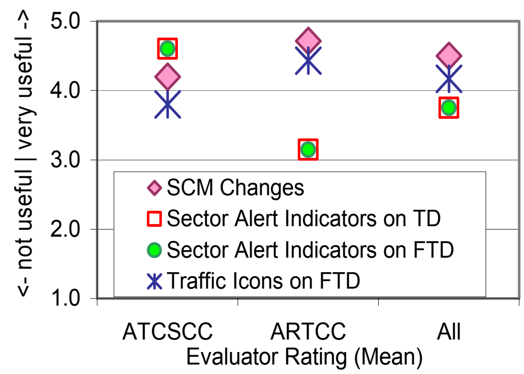

Figure 8: Usefulness of Graphic Sector Impact Information

Evaluators were asked "How useful would the demonstrated sector impact information be in assisting you in making decisions about miles-in-trail initiatives in the following situations?" Table 2 shows the results. On average, evaluators rated sector impact information as more than moderately useful. Most evaluators (nine out of 12) rated the information as "very useful," from an ATCSCC perspective, in evaluating, negotiating, and responding to MIT requests from ARTCCs. Similarly, eight out of 12 rated the information as "very useful" "for recommending or initiating adjustments or cancellations to active MIT initiatives."

Table 2: Usefulness of Sector Impact Information

Situation	Evaluator Group Average Rating		
	ATCSCC	ARTCC	All
From an ARTCC perspective, in			
supporting or negotiating MIT request to ATCSCC	4.4	3.9	4.1
coordinating MIT request with another Center	4.6	4.1	4.3
From an ATCSCC perspective, in			
evaluating, negotiating, responding to MIT requests from ARTCCs	4.6	4.7	4.7
All perspectives, for			
recommending or initiating adjustments/ cancellations to active MIT initiatives	4.8	4.6	4.6

Evaluators were also asked to rate the usefulness of delay information in coordinating MIT requests between an ARTCC and the ATCSCC, and between two ARTCCs. From an ARTCC perspective, delay

[1] Alerted sectors on the TD/FTD are shown by yellow or red cross-hatching, the same technique used in the current ETMS.
[2] The FTD allows the user to "move forward" in time to see predicted alerts and predicted future aircraft positions.

information was rated less than moderately useful on average for these cases. One evaluator stated that "delay info is good, but" he "doesn't know how to weigh it because" he "hasn't had it available to use before." One said it "supports my argument. I can show them my exact setup." However, an evaluator stated that he "thinks sector volumes will weigh higher than delay." Other ARTCC evaluator remarks related to the delay displays were "[It] doesn't matter to me how many flights there are," and "I'm not concerned [about delay] – just want to get them through."

On the other hand, delay information was rated more than moderately useful, on average, from an ATCSCC perspective, in "evaluating, negotiating, and responding to MIT requests from ARTCCs" because "it could help them quite a bit" and "may use it to challenge the request." Delay information was rated moderately useful "for recommending or initiating adjustments/ cancellations to active MIT initiatives." One evaluator stated that it is a "good indicator for doing something different." Another stated "Can see [delay] being an issue when dealing with the user – and if someone has abnormally long delay, to find that aircraft."

Overall Usability of Functions – Maturity Level

Evaluators were asked to rate the operational usability of the functions according to their assessment of how easy it was to access and manipulate the information they required to efficiently and effectively plan and evaluate traffic management initiatives. The scale ranged from 1, representing "difficult to use" to 5, representing "easy to use." Table 3 shows results for specific functions or features. All evaluators rated "definition of MIT parameters and filters" and "definition of MIT location (e.g., line on TD)" as moderately easy to use or better. While no evaluator rated "definition of direction of flight for MIT" as difficult to use, many commented that it should not be necessary to specify direction of flight since the "computer should be able to figure it out" and "should only ask the user when it is ambiguous."

Table 3: Usability of Functions

Function	Evaluator Group Average Rating		
	ATCSCC	ARTCC	All
Definition of MIT parameters and filters	4.4	4.0	4.2
Definition of MIT location	4.4	5.0	4.8
Definition of direction of flight for MIT	3.6	4.3	4.0
Sorting & displaying Planning Set results in MIT List	3.4	4.1	3.8

Additions to MIT Definition Function

To address the issue of comprehensiveness, the evaluation participants were asked, "Does the MIT Definition function allow you to specify every kind of MIT restriction you would need? If no, what kinds of MIT restrictions cannot be specified with the existing capability?" Seven people responded "yes" and four responded "no." While most evaluators had difficulty coming up with specific shortcomings, several did suggest improvements, including (1) the ability to specify MIT for a sector, (2) the ability to use MIT to resolve traffic complexity (as opposed to sector capacity) issues, (3) the ability to place restrictions by altitude, and (4) information on needed spacing on multiple streams to achieve a specified MIT spacing at a merge point.

Effectiveness of MIT Restrictions

The overall impression is that the IIA Capability will have a positive effect on the manageability and predictability of traffic. Participants were asked how the IIA Capability would impact the effectiveness of MIT restrictions from the FAA perspective and from the airspace user perspective. On a scale of 1 to 5, where 1 meant "less effective" and 5 meant "more effective," almost all (23 of 24 responses) rated the IIA at a 4 or a 5. The average for both questions was 4.4.

Several evaluators noted that the MIT will be more effective from the FAA perspective due to increased accuracy and because of the better sense gained from seeing the expected impact visually as opposed to "speculation." The IIA capability will be more accurate and easier to "fine tune" resulting in fewer restrictions; for example, only flights that are needed will be targeted and others that have no impact will be "weeded out."

Comments about effectiveness from the user perspective were slightly less enthusiastic. The one respondent who rated the capability below a 4 believed that the users have no idea now what is effective and this will not change with the IIA Capability. Another comment stated that "any delay to [the user] is unacceptable" and that the user will be able to compare between carriers and question restrictions.

Duration of Restrictions

Evaluators were asked "Compared with what you do today, what do you think would be the effect on MIT planning if the IIA capability were implemented in ETMS and used (assuming familiarity and ease-of-use) by traffic managers?" specifically concerning the average duration of MIT restrictions. Five evaluators believed that there would be no change in duration, and the rest believed the duration would be shorter if IIA were available. Reasons given were that the restriction would be "more accurate and probably reduced" and "it would be less because we could be more exact." On average, evaluators described the duration of today's MIT restrictions as less than 1.5 hours and predicted a reduction of more than 15 minutes.

Importance of Implementing IIA Capabilities

The participants were questioned as to their perceived need for having the IIA Capability (with improvements) implemented in ETMS. Responses were rated on a scale of 1 meaning "not important" to 5 meaning "very important." (One enthusiast rated it a "10 on a scale [of 1 to] 5.") The average response (crediting only 5 for the enthusiast's response) was 4.2 with half of the evaluators rating the implementation of the IIA capability as 5 and 75% rating it 4 or greater.

Comments included the following: (1) "The MIT Integrated Impact Assessment Capability provides the means for taking into account other things being planned so as to not to delay the affected aircraft," (2) "If used by everyone, then restrictions would be easier to verify and justify," (3) "Any benefit with less coordination and less restrictions will help with the airlines' bottom line," (4) "Anything that would help us be more effective is something we want to do," and (5) "It's good to see graphic presentation of MIT."

Conclusion

An integrated decision support capability has been developed that allows traffic managers to model, in advance, the combined impact of proposed reroutes and MIT restrictions in terms of sector loading and flight delays. Evaluation activities with FAA TFM personnel indicate that this capability holds much promise for improving the effectiveness of TFM initiatives employing rerouting and MIT restrictions. This improved effectiveness would mean better control of sector volume, with less imposed delay on airspace users.

These evaluations have confirmed the initial concept of use for the capability and produced valuable data for developing detailed functional requirements, supporting the ultimate goal of implementing this capability in some form in the ETMS. Research is also continuing towards a more comprehensive "progressive planning" capability, which would incorporate other possible TFM strategies besides rerouting and delay, provide more accurate estimates of sector impact and delay, and facilitate sharing and collaboration of plans between traffic managers, ATM facilities, and airspace users.

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Author Biographies

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