A PRELIMINARY ANALYSIS OF THE IMPACT OF MILES-IN-TRAIL RESTRICTIONS ON NAS FLIGHT OPERATIONS

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Abstract

The National Traffic Management Log (NTML) was deployed nationally on December 17, 2003 to, among other objectives record the implementation of various traffic management initiatives (TMIs) including Miles-In-Trail (MIT) restrictions. Using these data we developed an algorithm to identify the flights involved in each MIT restriction. Based on a limited sample of these data, this paper presents a preliminary analysis of the impact of MIT restrictions on National Airspace System (NAS) operations with a focus on airborne delay, actual flight spacing, and arrival compliance during Ground Delay Programs (GDPs). This initial analysis led to the following conclusions:

- It does not appear as though MIT restrictions have a significant impact on airborne delay, flight spacing, or GDP arrival compliance based on the limited MIT restriction data evaluated in this study.
- 39% of MIT restrictions implemented between May 1-14, 2004 involved 5 or fewer flights, indicating these restrictions potentially may not have been needed.
- Further analysis is required to evaluate the potential impact of MIT restrictions on departure delays.

Introduction

Miles-In-Trail (MIT) restrictions are widely used in the National Airspace System (NAS) as a means of controlling en route demand [1][2][3]. Previous work [4] has established the need for a reliable electronic version of MIT restriction data for analysis purposes. The National Traffic Management Log (NTML) was deployed nationally to all en route centers, several TRACONs and Towers on December 17, 2003. One of the objectives of the NTML is to provide a means of recording and distributing information on traffic management initiatives (TMIs), including MIT restrictions. Prior to the NTML the only complete set of MIT information resided in the form of individual Air Traffic Control (ATC) facility logs. Therefore, there has been little opportunity to conduct rigorous analysis of the effectiveness of MIT restrictions and their impact on the NAS as a whole.

As part of the Federal Aviation Administration's (FAA) Integrated Concepts for the Evolution of Flow Management (ICE-FM) project, we received a two month sample of NTML restrictions data from the NTML Program Office covering February and May 2004.

Our initial analysis of the MIT restrictions data had several goals. The first was to develop an understanding and facility with the NTML data. Our second goal was to develop a method to match each MIT restriction to the flights that were controlled. Our third goal of this analysis was to explore the effect and impact of MITs on the NAS, which eventually may lead to improved MIT use or alternative Traffic Flow Management (TFM) strategies.

Background

The EUROCONTROL approach to traffic flow management emphasizes the application of assigned departure times as the primary means of mitigating en route congestion [5].

Airspace congestion is dealt with differently in the NAS in that MIT restrictions are implemented to manage en route demand to provide systematic spacing of airborne traffic. In many cases MIT restrictions may be implemented to prevent key NAS resources from becoming overloaded during periods of uncertain conditions where demand predictability is not considered reliable.

MIT restrictions have been blamed by many including FAA and NAS users as a contributing factor to many of the NAS performance problems. Current procedures do not require post-analysis of MIT restrictions by the initiating facility. Therefore, much information is to be gained from evaluating the impact of MIT restrictions on a NAS-wide level.

Analysis Methodology

In this section we describe our processing and characterization of the NTML data including some of our results to detect regular patterns within the data. We follow this with a discussion of our methodology to match flights with MIT restrictions.

NTML Data Characterization

The NTML, among other functions, records all log entries regarding MIT restrictions implemented by the various ATC facilities. The data is manually entered using a collection of computer based entry forms. Each of these log entries is stored in a central database. For any given MIT restriction there may be numerous log entries detailing its proposal from the originating facility, its approval, and any modifications that may have been made.

After obtaining two months of MIT restriction data (February and May 2004), our first task was to process these records to combine information from sometimes several different log entries into a single record per actual MIT restriction. Next we computed some basic statistics using the data.

Figure 1 shows the daily count of restrictions during May 2004 with an average of 480 restrictions occurring each day. Weekdays are shown in light blue, which typically included more restrictions then weekends.

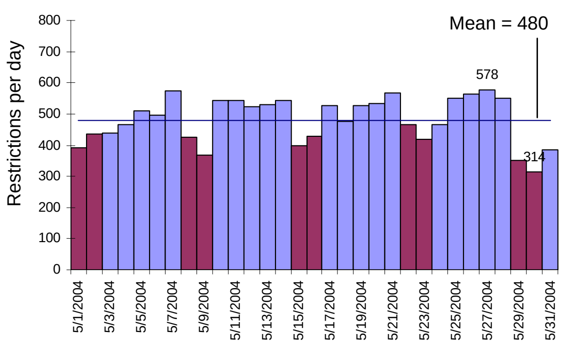

Figure 1: Restrictions per day from May 2004 NTML Restriction Data

In the NTML MIT restrictions are categorized by the TFM specialists into three types: departure restrictions, en route restrictions, and arrival restrictions depending on nature of the flow of traffic they are trying to manage.

Departure restrictions constituted only 12% of the MIT restrictions in this study. En route and arrival restrictions made up the majority of the data with 50% and 38% of the MITs, respectively.

The reason (OPSNET code) for a restriction is also recorded through the NTML as shown in Table 1. Volume was cited as the cause for more than 75% of the restrictions in the sample.

Table 1: Top 10 Causal Factors for NTML MIT Restrictions

Reason	Feb-04	May-04
VOL: ENRT SCTR	32%	31%
VOL: Arrival Demand	27%	30%
VOL: ARPT	13%	7%
VOL: EnRoute Center	5%	6%
WX: Low Ceiling/Visibility	5%	2%
TM Initiatives:MIT/MINIT:VOL:Terminal	3%	2%
WX: Wind	2%	-
RWY: CONST	2%	2%
WX: TSTMS	2%	10%
VOL: Complexity	2%	2%
TM Initiatives:MIT/MINIT:VOL:Enroute	-	1%

Figure 2 shows the distribution of the magnitude of the MIT restrictions. In our data sample the most common MIT value was 20 nautical miles separation, which occurred in 35% of the MIT restrictions.

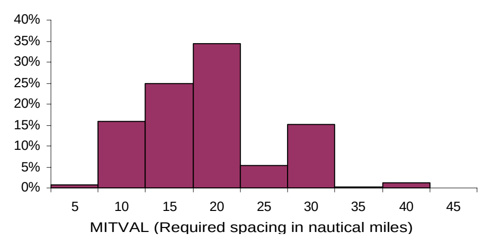

Figure 2: Distribution of MITVAL for NTML MIT Restrictions

Figure 3 shows the distribution of MIT durations. Half of the MIT restrictions in February and May 2004 were 60 minutes or less in length.

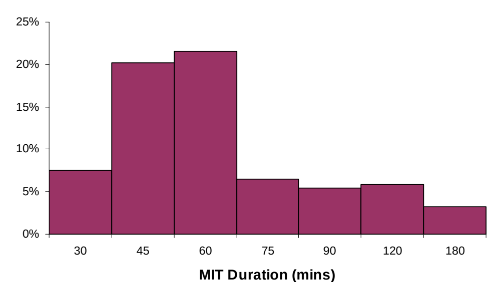

Figure 3: Duration of MIT Restrictions

Regularly Occurring Restrictions

Beginning in the late 1980s the practice of regular MIT restrictions, later to be known as Historically Validated Restrictions (HVRs), was established whereby daily reoccurring restrictions would be implemented without the required coordination efforts between the different Traffic Management Units (TMUs). HVRs were a source of consternation for some NAS users, because they felt that HVRs were overly restrictive and contributed to unnecessary delays en route. After the September 11, 2001 terrorist attacks the practice of using HVRs was terminated. Today, TMUs are required to evaluate all restrictions and only implement those that are truly needed based on current demand projections.

As part of our characterization of the NTML MIT data, we tried to identify those restrictions that occurred on a regular basis. To be included in this list, a restriction had to occur 20 or more times in a month and operate on the same flow. This last criterion takes into account that MIT restrictions on a particular traffic flow may be specified in the NTML data using different parameters. For example, one restriction might use the departure/arrival airports while another restriction might use particular fixes or NAVAIDs to define the same flow.

We compared the list of 190 HVRs (published prior to 9/11/2001) to our list of regularly occurring MIT restrictions for the month of May 2004, and found:

- 79 'Old HVRs' appear to still be in place; although, on average they are ~13 minutes shorter than the matching HVR
- 83 new HVR-like restrictions

Matching Flights to MIT Restrictions

Developing a methodology for identifying the set of flights involved in each MIT restriction was the second goal of our analysis. Considering there are approximately 60,000 flights in the NAS per day and approximately 480 restrictions, we needed to conduct the flight to MIT matching algorithmically. We faced the following challenges in developing our flight-to-restriction matching algorithm (FRMA):

- NTML data is entered manually resulting in a lack of consistency in the entered information
- The inaccuracy of Enhanced Traffic Management System (ETMS) track (TZ) altitude data makes it difficult to evaluate flight inclusion in MITs with altitude limits.
- Methods for matching flights to restrictions are different for each restriction type and the inclusion of other certain parameters such as fixes, aircraft type, and exclusions required special processing.

We broke the processing into four steps which are discussed in the following sections:

- Parsing NTML data
- Gathering ETMS track (TZ), route, and boundary data
- Filtering ETMS TZ altitude data
- Defining and applying matching rules that identify sets of flights involved in each MIT restriction based on parameters in the NTML data

Parsing NTML Data

The parsing step involved reading parameters from the NTML MIT restriction data and attempting to match these data to known values. Special logic was added to handle many of the inconsistencies in the NTML data format. For example, Table 2 provides a subset of the variations appearing in the NTML EXCLUSIONS parameter to signify a normal set of exclusions. Exclusions are used to specify a group of flights exempt from a MIT restriction. FRMA was programmed to interpret many shorthand entries used in the NTML data.

Table 2: Variations in the NTML exclusions parameter interpreted to imply normal exclusions

NO
NONE
NORM
NORMAL
NORMAL EXCL
NORMAL EXCLUSIONS
NORML
NORMX
NRM
NRML
NRML EXCL

Not all of the NTML MIT restriction data, however, could be matched to known parameters. For example, a handful of restrictions listed "LASVEGAS" as the NASELEMENT. This, is not a recognized NAVAID, fix or airport name (LAS would have been expected). Restrictions having any number of unrecognizable or invalid entries were eliminated from the remaining flight-to-restriction matching processes as these records did not provide complete information for isolating the intended flow of traffic. Twelve percent of the MIT records contained data that our algorithm could not parse.

The parsing process described in this section might be improved through enhanced algorithm design. However, it is assumed that these types of anomalies will be addressed as the demand for NTML data increases in support of enhancing current and future traffic management support tools and programs. Data anomalies are being reported to NTML to point out areas where potential improvements could be made to the NTML user interface, design, and error trapping.

Gathering Additional Data

The FRMA requires data from a variety of additional sources; sector, ARTCC, TRACON boundary definitions, names and locations of airports, NAVAIDS, and jet routes. ETMS TZ data was used to determine whether the actual flight path crossed through a region of airspace involved in a MIT restriction. ETMS scheduled, filed, and amended route messages were also inputs as these define the physical class of each aircraft, intended cruise altitude, and set of planned waypoints all of which may be qualifying criteria for involvement in each MIT restriction. Boundary crossing times were computed to determine which flights were within the impacted facility during an active MIT restriction.

Filtering ETMS TZ Altitude Data

Six percent of MIT restrictions in our sample had altitude criteria. To identify the flights that met these altitude criteria, we had to use TZ altitude data. Due to the known issues with the accuracy of the TZ altitude data, we applied a filtering-smoothing algorithm before evaluating whether a flight was within the restricted altitude range. Figure 4 shows the raw TZ altitude data as a thin red line with the processed altitude data overlaid in a thick blue line.

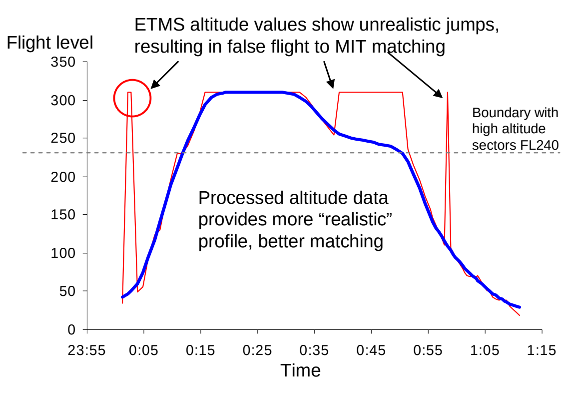

Figure 4: Filtering ETMS TZ altitude data

In evaluating altitude-specific MIT restrictions, we simply compared the actual altitude, referenced from the filtered altitude data, to the restricted altitude listed in the NTML MIT parameters. This altitude comparison was conducted at the time each flight crossed the point where the restriction was applied.

Matching Flights to MIT Restrictions

Flights were then matched to MIT restrictions by applying rules we developed through consultation with our subject matter experts. These rules considered whether a flight qualified for a MIT restriction based on its parameters and the actual flight progress as defined by the collection of ETMS TZ messages. Qualifying for a restriction, in this analysis, simply refers to a flight that matches all the parameters stipulated in the NTML data for that restriction. The flight-to-MIT restriction matching process aimed to identify the sets of flights that ATC was controlling during the implementation of each restriction.

A flight's active route was an additional factor in the flight-to-MIT restriction matching. For example, consider a departure MIT restriction issued by Washington Center (ZDC) to ZNY for JFK departures over WHITE. In seeking flights involved in this restriction, FRMA considered all JFK departures that flew within a 10-mile radius of WHITE and crossed the boundary into ZDC while the restriction was active. The 10-mile radius was used to identify flights that came within close proximity to the restricted 'NAS element' parameter. We then examined the active route from the time the flight passed the NAS element to verify that it was an intended waypoint during flight. The active route was evaluated to separate flights that planned on using the restricted NAS element from those that may have come within 10-miles but were not a part of the intended flow. The 10-mile proximity threshold was chosen based on our subject matter expert recommendation.

Our subject matter experts worked with us to develop the logic needed to match flights to other types of MIT restrictions. The methodology was initially validated by comparing the FRMA-generated flight lists to the list of flights hand selected by our subject matter experts as being the intended flow of traffic for a selection of MIT restrictions. The observed limitations of FRMA are discussed with the results.

Preliminary Results

This section presents the results of our preliminary analysis of the impact of MIT restrictions on NAS flight operations. We begin with a look at the number of flights involved in MITs. We follow that with the results of our initial evaluation of the impact MIT restrictions on en route delay, airborne flight spacing, and GDP performance.

MIT Restrictions Involving Conflicting NTML Parameters

We applied FRMA to identify the sets of flights that qualified for any of the 6,678 MIT restrictions in the May 1-14, 2004 sample. Ten percent (674) of the MIT restrictions were not matched to any flights. Upon further investigation, we discovered that many of the unmatched restrictions included NTML parameters that were mutually exclusive.

For example, one such conflicting NTML entry was an en route MIT restriction issued for all DTW-bound flights crossing from Cleveland ARTCC (ZOB) into Indianapolis ARTCC (ZID) as depicted in Figure 5. The figure shows that the airport and Center parameters imply opposing flows of air traffic. If the restriction had been entered in as a departure restriction, rather than an en route restriction for instance, the NTML data would have been consistent in that DTW would have been interpreted by FRMA as the origin airport, which is congruent with flights crossing from ZOB into ZID.

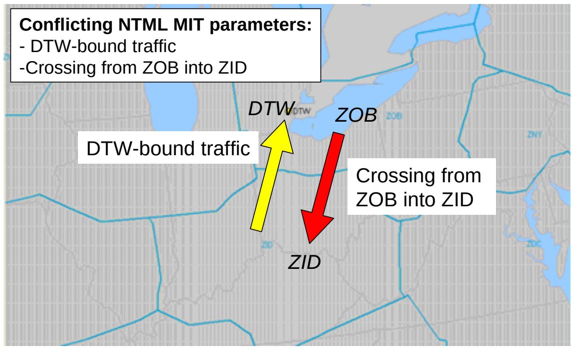

Figure 5: NTML MIT restrictions involving conflicting parameters were not matched to flights

Limitations in FRMA may be responsible for other cases of restrictions not matching to flights. While we look for opportunities to improve the parsing and the matching rules in FRMA, we expect that improvements in NTML data quality, through user interface design and training, will also result in improved flight-to-restriction matching. Our results are being shared with the NTML program office.

Flights per MIT Restriction

Figure 6 shows the distribution of flights matched per MIT restriction, which had a mean of 12.4, median of 8, and mode of zero. We excluded from this distribution the MIT restrictions containing conflicting parameters as discussed in the previous section.

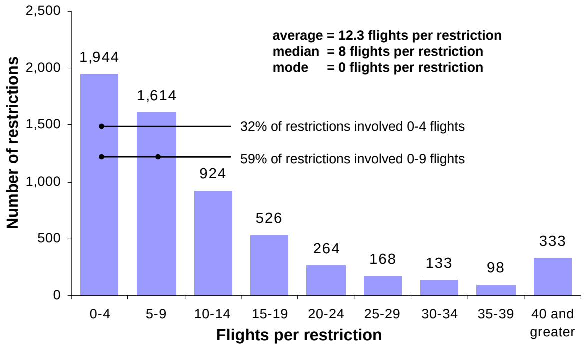

Figure 6: Flights per MIT restriction based on May 1-14, 2004 NTML data and FRMA matching logic

We should take a moment to explain the mode (most common) count of zero flights per restriction, which represented 13% (757) of the remaining MIT restrictions. These zero counts occurred for restrictions in which no flights met the MIT parameters between the start and end times, however, there was at least one flight that did meet the parameters if the start and end times were expanded by 30 minutes.

For example, given an MIT restriction with an end time of 1200Z and the only flights crossing the restriction point did so at 1205Z, 1210Z, and 1215Z, respectively. These flights did not technically qualify for the restriction in that the restriction had already expired.

One possible explanation is that the start and end times entered into the NTML were departure (or arrival) times at the airport listed in the restriction instead of the intended crossing time at the restriction point. This is a case that requires further study.

MIT Restrictions with Insufficient Demand

Our subject matter experts advise that MIT restrictions involving a small number of flights are potentially not needed, as one might expect. Table 3 shows the number of MIT restrictions involving 5 or fewer flights. More than one third of the MIT restrictions in our May 1-14, 2004 sample involved 5 or fewer flights.

Table 3: Portion of MIT restrictions involving 5 or fewer flights, May 1-14, 2004 NTML data

Flights per MIT restriction	%
0	13%
1 or fewer	17%
2 or fewer	22%
3 or fewer	27%
4 or fewer	32%
5 or fewer	39%

MIT Restrictions per Flight

Some flights encounter multiple MIT restrictions. We looked at how often this occurs. Of the flights qualifying for at least one MIT restriction, Table 4 shows the number of restrictions encountered per flight as count 1. Three quarters of the flights qualifying for at least one MIT restriction qualified for just one restriction.

The maximum number of restrictions encountered by a single flight was 11. This is not to say that a flight was involved in MIT restrictions at 11 separate locations during a single operation. Rather the flight may have qualified for more than one restriction at the same place and time. For example, if restriction "A" called for all flights crossing from ZOB into New York Center (ZNY) and restriction "B" was more specific calling only for ZOB-ZNY traffic along a particular jet route, it is possible that flights along the jet route might qualify for both restrictions simultaneously. In essence, we found MIT restrictions that appeared to overlap one another based on the NTML parameters.

We attempted to isolate the unique locations where restrictions were being applied by counting the number of places during each flight where the flight qualified for a restriction. The count of unique restriction locations per flight is represented by count 2 in the table. Notice from count 2 that the maximum number of MIT restrictions per flight was 4 when counting only the unique restriction locations with 80% of MIT-restricted flights were restricted at only one location during flight.

Table 4: MIT restrictions encountered per flight during May 1-14, 2004 (count 1 = number of MITs a flight matches, count 2 = number of separate restriction points)

MIT restrictions encountered per flight	count 1	%	count 2	%
1	42,786	75.8%	45,223	80.1%
2	10,822	19.2%	9,728	17.2%
3	2,338	4.1%	1,441	2.6%
4	380	0.7%	42	0.1%
5	79	0.1%	8	0.0%
more	37	0.1%	0	0.0%
Total	56,442	100%	56,442	100%

En Route Delays and MIT Restrictions

It is generally assumed that MIT restrictions cause en route delays due to the ATC action required to effectively space airborne traffic. Quantifying the en route delay incurred by MIT-restricted flights was a major goal of our analysis. This section describes how we estimated the en route delay taken by flights due to MIT restrictions. Based on these preliminary results, we did not find MIT restrictions to have a significant impact on en route delay.

En route delays were measured by comparing the actual flight progress to the forward progress made along the active route using the methods developed in [6]. This method took into account winds aloft, airborne route amendments, and ETMS TZ data. We then used FRMA to isolate all flights that were involved in en route or arrival MIT restrictions. Flights involved in departure MIT restrictions were placed in the complementary set because it was assumed that any en route delays taken by these flights would be incurred after crossing the MIT restriction boundary at which point the en route delays would not be related to the departure MIT restriction.

Figure 7 shows the total en route delay for all flights involved in en route or arrival MIT restrictions during May 1-14, 2004. Note that en route and arrival restrictions make up 88% of the restrictions in our sample. Delays are the total en route delay during each flight.

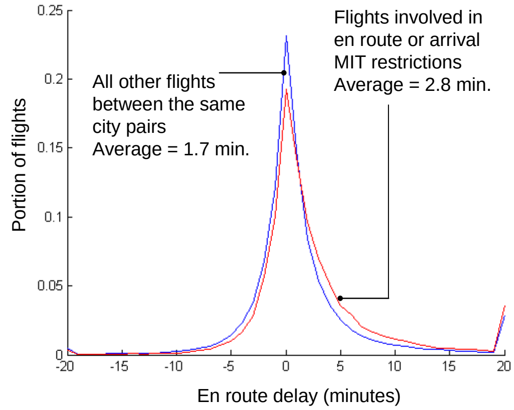

Figure 7: Flights involved in en route or arrival MIT restrictions do not appear to receive significantly more airborne delay based on the May 1-14, 2004 sample

The complementary set of flights used in the comparison was limited to those that flew between city pairs used by flights involved in the en route or arrival MIT restrictions. Our intent was to make comparisons of en route delays for "restricted" and "non-restricted" flights within the same flows. The difference in average en route delay of 1.1 minutes does not represent a statistically significant deviation. The preliminary analysis based on this sample of data (2 weeks) suggests that MIT restrictions do not significantly impact en route delays. Further study using a broader data sample is needed in this area.

Flight Spacing during MIT Restrictions

In our first attempt to examine actual spacing relative to the spacing required by an MIT restriction we used ETMS track data to calculate the distance between a flight as it crossed the restriction point (typically the center boundary) and the flight immediately behind it in the restricted flow for all the restrictions on a single day, February 5, 2004. We limited our analysis to only those MITs that required a spacing of 10 or more miles. Figure 8 shows the distribution of the spacing in excess of what was required (i.e. actual – required). The left part of the figure shows that a significant number of flights cross the restriction point at a spacing less than required by the MIT restriction (thus having negative 'excess' spacing). Discussions with subject matter experts indicated that this indeed can be the case; however, we need to also point out that our spacing calculations have an approximate accuracy of +/- 7 miles based on the resolution of the ETMS track data. The long tail on the right side of Figure 8 shows that many flights are spaced much farther apart than required.

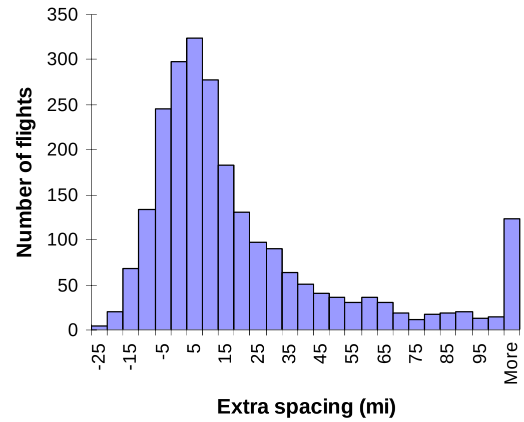

Figure 8: Distribution of the (actual – required) spacing for MIT restrictions on February 5, 2004 excluding MIT restrictions requiring less than 10 miles separation.

Does this indicate that these flights were being over controlled, or was the demand insufficient? To answer this, we looked at the en route delay of these flights. Figure 9 shows the distribution of excess spacing that could have been avoided had there been less en route delay. The negative part of the distribution is the same as that in Figure 8 (the binning is different) and shows that some flights were spaced less than required. The interesting part of distribution in Figure 9 is the positive part of the axis, which shows that there is some tendency for flights to be spaced further apart than required at the expense of airborne delay. On the other hand, the tail of the distribution in Figure 9 is significantly smaller than the tail in Figure 8. This might be interpreted as evidence that some of the restrictions on this day were not needed or could have been reduced in scope because the demand was naturally spaced greater than what was required.

We should also point out that another perspective on the necessity of a particular MIT is that it might be implemented only to provide an upper limit on traffic flow as a defense against uncertain demand predictions. However, it does require a certain level of coordination and workload to implement a MIT restriction. Therefore, the identification and elimination of regularly occurring MIT restrictions that result in spacing in excess of what is required would be of benefit, and is the subject of further study.

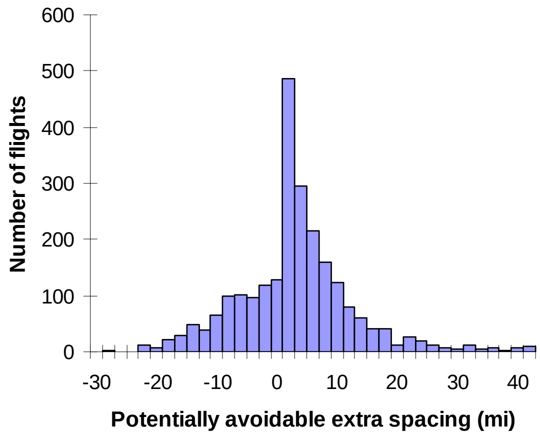

Figure 9: Distribution of extra spacing when limited to a maximum that could have been avoided by eliminating actual airborne delay converted to distance (MITs on February 5, 2004 excluding MIT restrictions requiring less than 10 miles separation).

Our second attempt to examine actual spacing relative to the required spacing focused on individual MIT restrictions. This approach involved creating "flow graphs" to visualize the distance gaps between individual flights as they crossed the restriction point. Figure 10 displays an example from a MIT restriction involving only 3 flights. The figure shows distance *vs.* time for the three DTW-bound flights involved in the restriction. Line slope, therefore, represents the rate of forward progress towards the destination. The actual spacing of these flights is computed and plotted as they cross the boundary between ZOB and ZNY. This MIT restriction required 20 miles-in-trail, yet the actual spacing was 13 and 93 miles.

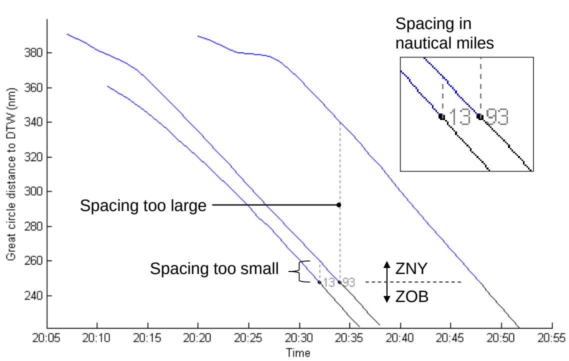

Figure 10: This MIT restriction specified 20 miles-in-trail yet the actual spacing was 13 and 93 miles

After viewing a large number of spacing flow graphs for various MIT restrictions, we observed a consistent pattern of spacing non-compliance with a tendency towards over-spacing as illustrated in Figure 11.

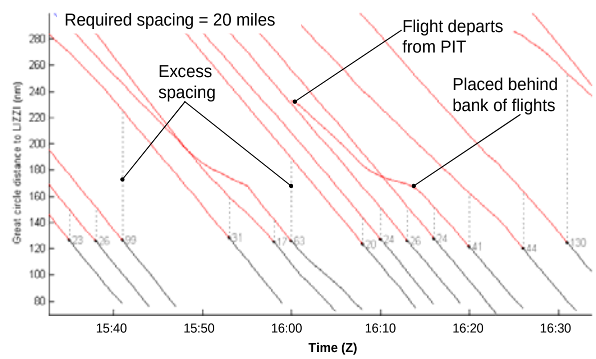

Figure 11: Actual spacing during a 20-miles-in-trail restriction. Insufficient demand is seen resulting in over-spacing while other flights are blended with the overhead stream.

This restriction involved 51 LGA-bound flights as they crossed from ZOB into ZNY. The required spacing was 20 miles yet notice the numerous gaps in demand. The figure also shows a flight departing from PIT into the overhead stream, which might be an indicator of departure delays. The impact of MIT restrictions on departure delays is the subject of further research.

MIT Restriction Impact on GDPs

MIT restrictions are often suggested as the cause or at least a contributing factor in the under delivery of Ground Delay Programs (GDPs). The theory is that flights receiving delays due to MIT restrictions will often fail to comply with their arrival slot causing additional delays and some slots to go unused. Furthermore, because MIT restriction data is not fed into ETMS, it does not consider any projected en route delays due to MIT restrictions when assigning controlled departure times.

We took a preliminary look at this question as part of our analysis of MIT restrictions. We selected a number of GDPs that had poor arrival compliance as measured by the difference between their Actual Runway Time of Arrival (ARTA) and their Controlled Time of Arrival (CTA) that was in effect at the time of departure. We then eliminated those GDPs that had poor departure compliance that potentially could explain the poor arrival compliance. Of the remaining GDPs we choose to examine those where MIT restrictions in place controlling some of the same flights during the GDP.

Table 5 lists the average arrival compliance and average en route delay for flights in the resulting list of GDPs segmented by whether the flight was involved in a MIT restriction. The first item of interest the table shows is that a large fraction, 37% on average, of the GDP flights are also under the control of MIT restrictions. Looking at some of the individual programs we see that in cases such as SFO on February 2, 2004 and PHL on May 17, 2004 we see that the restricted flights indeed have poorer arrival compliance and greater en route delays. Conversely, the table also shows in cases such as ORD on February 3, 2004 and EWR on May 17, 2004 that the restricted flights do not appear to do worse than the unrestricted flights in terms of arrival compliance or en route delay. Thus, within this data set there is no clear relationship between MIT restrictions and GDP performance.

Table 5: Comparison of mean arrival compliance and mean en route delay for restricted flights versus unrestricted flights for select GDPs. The GDPs examined were those that had arrival compliance problems that were not (fully) attributable to poor departure compliance and that had MIT restrictions controlling some of the GDP controlled flights.

		Arrival Count		Arrival Compliance (mins)		Enroute Delay (mins)	
		Total Flights	Percent Restricted	ARTA - Departure CTA Restricted	Unrestricted	Total VDP Delay Restricted	Unrestricted
SFO	2/2/2004	220	11%	14	6	8	2
EWR	2/3/2004	192	36%	2	1	5	3
LGA	2/3/2004	255	20%	4	0	12	1
ORD	2/5/2004	679	73%	9	10	4	4
EWR	2/6/2004	294	35%	-4	-1	3	0
PHX	2/8/2004	526	33%	-2	-5	0	0
ATL	5/17/2004	376	28%	11	-2	9	0
EWR	5/17/2004	218	26%	-3	7	3	3
ORD	5/17/2004	321	**74%**	0	-3	2	2
PHL	5/17/2004	182	21%	18	9	19	5
SFO	5/17/2004	127	22%	3	-1	4	-1
ATL	5/18/2004	589	50%	7	1	3	1
DFW	5/18/2004	473	**8%**	-12	-4	-1	0
DFW	5/18/2004	295	32%	-1	-5	4	2
IAD	5/18/2004	180	26%	3	2	3	7
PHL	5/18/2004	101	21%	7	1	4	6

Conclusions and Next Steps

This work has shown that:

- We developed methods for identifying flights involved in MIT restrictions based on NTML data and ETMS data
- 39% of the May 1-14, 2004 MIT restrictions involved 5 or fewer flights, suggesting that these MIT restrictions may not have been needed
- In our limited data set, MIT restrictions do not appear to have a significant impact on en route delay, actual en route spacing, or GDP arrival compliance.

Next steps for this work include:

- We analyzed airborne delay for flights in MIT restrictions. Next, we need to investigate departure delays for flights being held on the ground by the restricting center to fit into the overhead stream.
- This analysis evaluated flights that qualified for MIT restrictions based on actual trajectories. We are currently developing additional algorithms to identify those flights that may have been impacted by MITs, but did not actually cross the restriction point (by being rerouted elsewhere).
- Proposing improvements in the NTML restriction data, in terms of standardized terminology and automated error trapping to remove data anomalies, which will benefit future analyses of MIT restrictions
- Identify those regular restrictions that are not needed due to insufficient demand that could potentially be eliminated.

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Key Words

Miles-In-Trail, MIT, Delay, NTML, En route delays, airborne delays, spacing, restriction, GDP

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Ved Sud has over 32 years experience in engineering and engineering management on a wide variety of projects. For the past 22 years, he has supported the FAA on numerous projects for modernizing the United States' Air Traffic Management (ATM) system. Currently he is with the FAA in Air Traffic Operations as the Manager for Research on Traffic Flow Management Programs. He provides leadership on TFM research and strategic planning for TFM programs. Ved has a Master of Science in Computer Science from the State University of New York at Stony Brook and a Bachelor of Technology in Electrical Engineering from the Indian Institute of Technology, New Delhi, India.