ARTCC-Initiated Rerouting

Lynne Fellman[*] and Tejal Topiwala[+]
Center for Advanced Aviation System Development (CAASD)
The MITRE Corporation, McLean, VA

Rerouting flights around severe weather or congestion is an important Traffic Flow Management (TFM) strategy. The Federal Aviation Administration (FAA) has been researching ways to improve reroute planning and execution. The purpose of the work documented in this paper is to refine existing reroute planning and execution concepts to more fully address Air Route Traffic Control Center (ARTCC)-initiated rerouting or local rerouting. Local reroutes are performed primarily in instances when the weather is affecting departure routes from an airport in the ARTCC. Initial analysis has shown that the workload involved in local rerouting can be significant. This paper describes a proposal for improvements to the current operations. Central to the concept is an interactive capability available at the Traffic Management Unit (TMU) that presents the traffic manager with a selectable list of flight-specific reroutes, including those submitted by National Airspace System (NAS) users. This capability also allows the traffic manager to understand the effect of each reroute, to submit the reroute amendment to En Route automation, and to revert to the original route if the reroute is no longer needed.

I. Introduction

REROUTING flights around severe weather or congestion is an important Traffic Flow Management (TFM) strategy. The Federal Aviation Administration (FAA) has been researching ways to improve reroute planning and execution. The Future Concepts of Flow Management Sub-Team of the Collaborative Decision Making (CDM) working group has developed the Integrated Collaborative Rerouting (ICR) concept,[1] which will allow National Airspace System (NAS) users to more effectively collaborate in rerouting their flights by submitting their reroute preferences. The ICR concept focuses on capabilities that support the planning of Air Traffic Control System Command Center (ATCSCC)-initiated rerouting.

The FAA is currently designing the Traffic Flow Management System (TFMS) as a replacement for the Enhanced Traffic Management System (ETMS).[2] TFMS is scheduled for deployment in 2008. The FAA is considering implementing capabilities that support the planning and automated execution of reroutes in a scheduled enhancement to the baseline TFMS.

The purpose of the work documented in this paper is to refine existing and emerging reroute planning and execution concepts to more fully address Air Route Traffic Control Center (ARTCC)-initiated rerouting or local rerouting. A reroute is defined to be a local reroute when the ARTCC Traffic Management Coordinator (TMC) takes the lead in defining the constraint and in assigning reroutes to affected flights. Note that the ARTCC TMC may still need to coordinate with other ARTCC TMCs and with the ATCSCC Traffic Management Specialist (TMS). An ARTCC TMC takes the lead in rerouting in the following cases:

1) The weather is affecting departure routes from an airport in that ARTCC.
2) The weather or congestion is affecting an area contained within that ARTCC, and the rerouted segments for the affected flights are largely contained within that ARTCC's airspace (e.g., a flight gets back on route by the first fix in the next ARTCC).

The most common example of local rerouting is rerouting departures caused by severe weather affecting the departure fixes and is the focus of the proposed concept in this paper.

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[*] Senior Engineer, Terminal/TFM System Engineering, 7515 Colshire Drive, N450.
[+] Senior Engineer, Terminal/TFM System Engineering, 7515 Colshire Drive, N450.

Initial analysis indicates that the workload imposed on the TMCs due to local rerouting can be significant (see Section II). Based on discussions with Center for Advanced Aviation System Development (CAASD) staff who have had ARTCC flow management operational experience, limitations with the current local rerouting operations were identified and a proposed concept was developed. Key limitations with the current local rerouting operations are as follows:

1) Reroute advisories for local reroutes frequently do not get published on the ATCSCC Web Page. This reduces the common situational awareness between traffic managers at affected ARTCCs and NAS users and reduces their ability to plan effectively.

2) NAS users cannot submit reroute alternatives to indicate their reroute preferences in the event that a constraint (e.g., departure fix closure) is needed. This increases the likelihood that a TMC assigned reroute may be unacceptable to the NAS user.

3) The ARTCC TMC currently has little or no automation support to identify a reroute, assess the impact of the reroute, coordinate the reroute, execute the reroute, or cancel the reroute. Without additional automation support, the TMC has little time to consider alterative reroutes for a flight and therefore may put flights on less efficient routes or on routes that add to congestion. In addition, without additional automation support, the TMC may not be able to quickly regain the use of a resource that was previously constrained.

II.   Analysis of Local Rerouting

A previous analysis[3] examined a severe weather day (19 August 2004) to estimate the TMC workload for executing reroutes. For this day, it was determined that TMCs (across the NAS) entered 734 pre-departure amendment messages (AMs) to the en route automation system (Host) that address the route of flight that were associated with an ATCSCC Reroute Advisory and entered 1640 pre-departure AMs that were *not* associated with any ATCSCC Reroute Advisory. The 1640 pre-departure AMs were presumed to reflect ARTCC-initiated reroutes or local reroutes. Note that for this analysis, AMs entered for General Aviation (GA) flights were not included in the count because many of these were probably entered by flight service specialists using the Flight Service Automation System (FSAS), and they may be amendments entered for a variety of reasons. For 19 August 2004, this analysis shows that TMCs across the NAS entered twice as many AMs in support of ARTCC-initiated reroutes than in support of ATCSCC-initiated reroutes.

This section characterizes the workload on the TMC to handle local rerouting during a significant weather event for an affected ARTCC by examining ETMS data in detail. Washington Center (ZDC) was chosen as the target for this study because of the frequent occurrence of local rerouting due to weather, the level of complexity of the airspace, and the availability of CAASD staff with recent TFM experience in the ZDC Traffic Management Unit (TMU). The dates selected were 25 and 26 May 2004, a time period when widespread, slow-moving thunderstorms traversed the region. Significant rerouting activity took place throughout the day and affected many flights in ZDC.

The weather on 25 May 2004 had a line of thunderstorms moving from west to east across ZDC from approximately 20:30 until 04:00Z the next day (3:30 pm to 11:00 pm Eastern Daylight Time). Figure 1 shows the northern and western boundary of ZDC, the Washington, D.C. metropolitan area (DC Metro) airports (IAD, BWI, and DCA) and the airport departure fixes shared by the DC Metro airports: LDN, MOL, GVE, DAILY, FLUKY, JERES, BUFFR, HAFNR and SWANN. The line of thunderstorms initially affected JERES, BUFFR, and LDN by reducing or closing departures to those fixes. (Note that the weather affected LDN to a lesser degree than JERES or BUFFR.) As the evening progressed, the line moved east, making those fixes available for departures but closing the southern fixes MOL, GVE, and HAFNR before continuing east and affecting the eastern fixes SWANN and DAILY, and finally moving offshore.

The rerouting activity that occurred during 18:00–04:00Z was determined by examining AMs for ZDC departures. This time window was chosen to include any AMs made in anticipation of the weather entering ZDC. Only amendments that address the route of flight of the flight plan were included in this count. To capture the reroutes performed by TFM, only the pre-departure flight plan AMs were examined. Although NAS users can submit pre-departure amendments, they do not do so in practice, as they typically do not have the supporting software. Instead, NAS users revise the rerouting of flights that have a filed flight plan up to 45 minutes before the proposed departure time by submitting a *cancel flight plan* message and then entering a new flight plan. Any changes the NAS users wish to make within the 45-minute time window prior to departure must be made by phone.
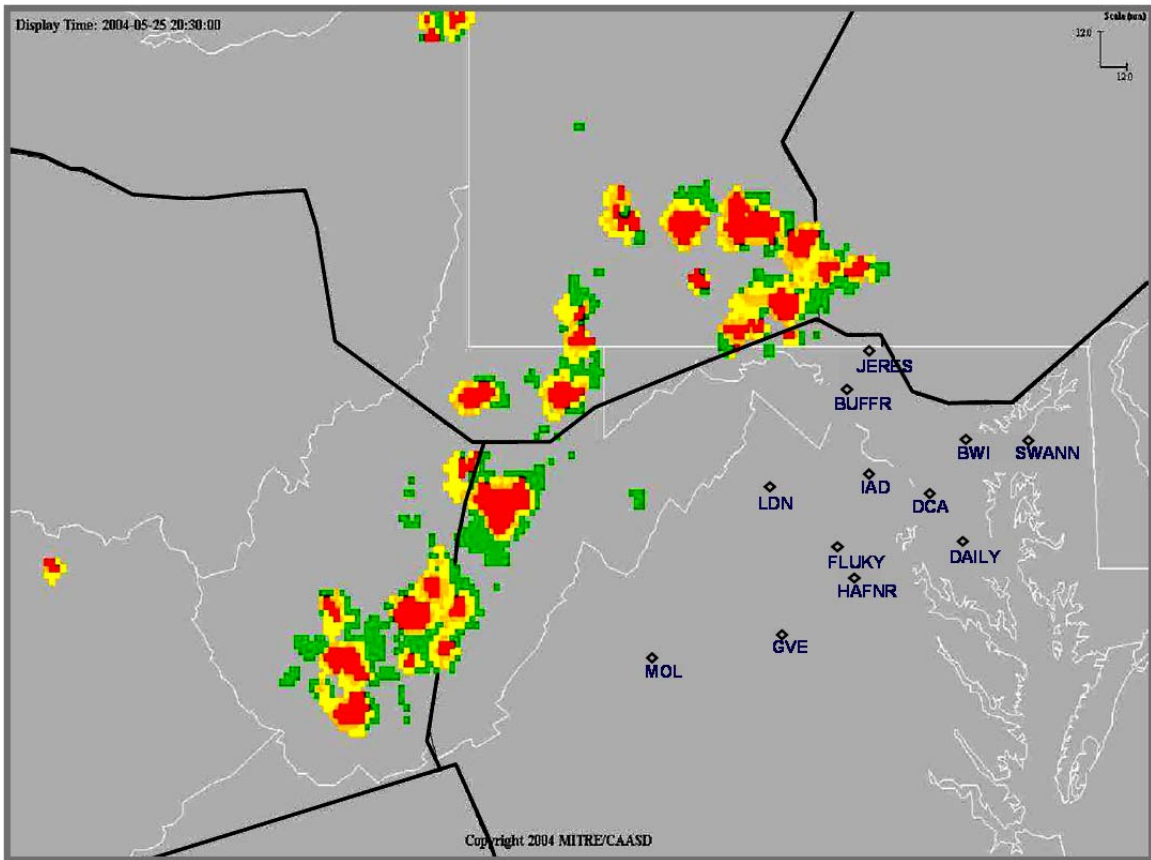
Figure 1. Weather on 25 May 2004.

Typically, at ZDC, a single TMC is responsible for identifying and entering route amendments. During busy periods, support is given to the TMC by the Traffic Management Supervisor, who assists in identification of possible alternative routes. Between 18:00 and 04:00Z, the ZDC TMC entered 229 route amendments to flights prior to departure. (Note that AMs entered for GA flights not departing from the DC Metro airports were excluded from the count as these may have been entered by the flight service specialist.) Figure 2 provides the number of pre-departure AMs entered by ZDC TMC during 15-minute intervals for DC Metro airports and for other ZDC areas. Note that 180 AMs were entered for flights departing from IAD, BWI, and DCA between the hours of 18:00 and 04:00Z. The majority of the flight plan AMs (112) were made during the hours of 20:30 and 02:00Z when the weather was directly affecting the departure fixes. Of the 80 reroutes made for IAD departures, only nine of them were based on Coded Departure Routes (CDRs)[#].

[#] CDRs are named, pre-coordinated, end-to-end routes that are stored in Host adaptation data and in the Flight Management System (FMS) computers on board equipped aircraft. Route amendments can be easily entered into the Host and communicated to the pilot by referencing the CDR name.
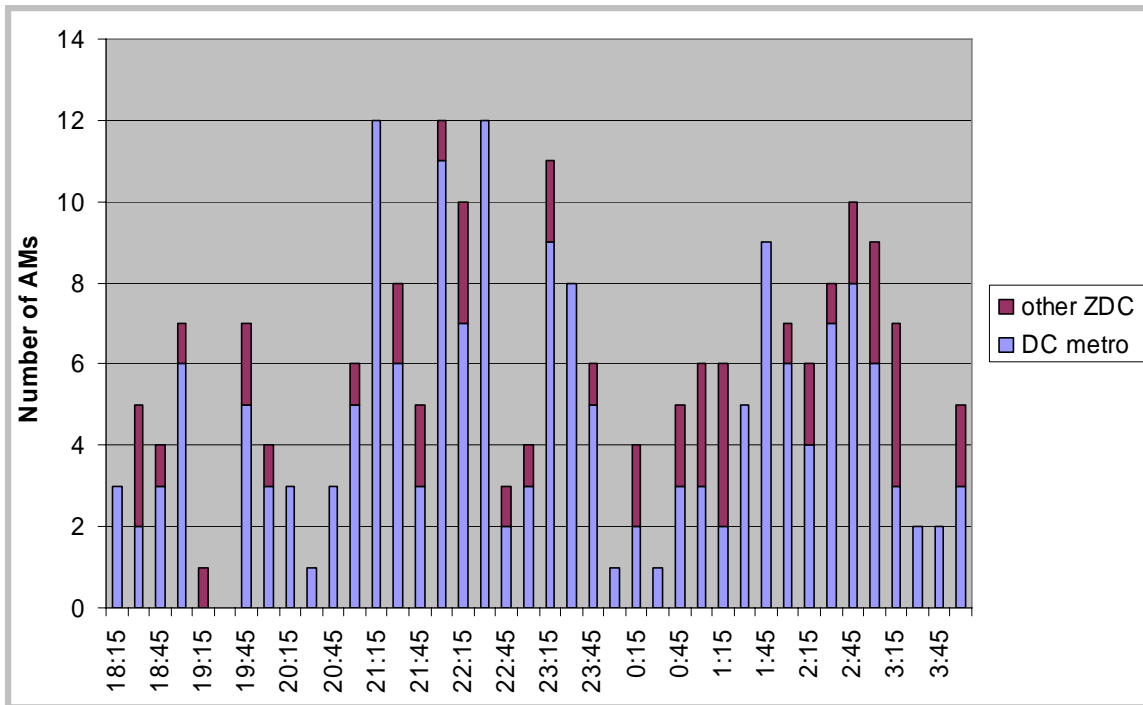
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Figure 2. Pre-departure AMs in 15-Minute Intervals.

Also in effect during this time period (18:00–04:00Z) were six ATCSCC-initiated reroutes affecting ZDC. About 35 route amendments were executed to support the ATCSCC-initiated reroutes. For an ATCSCC-initiated reroute, the TMC must monitor the flights subject to the reroutes and ensure that the planned route is filed. For flights that are not in conformance with the planned route, the TMC must enter an amendment with the planned route. For local rerouting, the TMC must identify the constraint, identify the flights involved in the reroute, determine how to reroute the flights, and enter the amendments. Therefore, the work involved for a TMC to reroute a flight for an ARTCC-initiated reroute is at least comparable to the work involved to reroute a flight for an ATCSCC-initiated reroute. For this day, the TMC entered 112 AMs for local rerouting during the peak time period 20:30–02:00Z, which is more than three times the number of AMs entered for ATCSCC-initiated reroutes during 18:00–04:00Z.

III.   Proposed Operational Concept for Local Rerouting

This section discusses the proposed operational concept for local rerouting and outlines a prototype for automation support. (Because the proposed concept is limited to local rerouting resulting from weather affecting departure fixes, the planning and execution of reroutes is for pre-departure flights only.) This concept assumes that the TMC will do incremental planning and execution of reroutes (similar to what is done today). For instance, although a weather event may be expected to last for four to five hours, the TMC can choose only to consider flights for rerouting for the next hour. Once the TMC determines what reroute to assign to an individual flight (considering any reroute alternatives submitted by the NAS users), the TMC coordinates that reroute with other ARTCC TMCs and then executes it. This procedure is in contrast to how ATCSCC-initiated rerouting is performed today. In ATCSCC-initiated rerouting, a reroute strategy is made and coordinated in advance of the time period for which the rerouting is effective, and the reroutes are made for all affected flights.

Following are three key features of this operational concept:
1) An ARTCC TMC publishes a reroute advisory on the ATCSCC Web Page for a local reroute.
2) NAS users can submit one or more reroute alternatives to indicate their rerouting preferences for a local reroute. A reroute alternative is an origin-to-destination route for a specific flight.
3) An ARTCC TMC uses the ***Reroute Management*** capability to assign flight-specific reroutes and to execute them. The Reroute Management capability provides the following capabilities:
    - The **Reroute Planning** capability is an automation tool that allows the TMC to select a reroute strategy, e.g., go over a specific departure fix. Based on the strategy selected, a list of flight-specific reroute

options is presented, and information, including additional flying time and predicted effect on sector volume, is displayed. Note that the list of flight-specific reroutes will include reroute alternatives submitted by the NAS user.

- The **Automated Coordination Support** capability allows the TMC to coordinate reroutes with the Area Supervisors in the TMC's ARTCC and with TMCs in other ARTCCs. (The capability can also be used to coordinate reroutes with traffic managers at ATCSCC.) Once a TMC has assigned a reroute to a flight, the automation will identify the affected areas and ARTCCs. The TMC can request that coordination information be forwarded to those areas and ARTCCs. The affected Area Supervisors and TMCs can review the information and specify approval or disapproval for the request. Note that, in some cases, a follow-up telephone call may be necessary.
- The **Reroute Execution** capability allows the TMC to execute a selected reroute for a flight. TFMS automation will generate a proposed flight plan amendment with the reroute and forward it to the Host replacement automation system, En Route Automation Modernization (ERAM). The new route in the flight plan AM from ERAM will be displayed to the TMC.
- The **Reroute Cancellation** capability allows the TMC to view the flights that were rerouted because of a constrained resource. The TMC can put these flights on their original route if that constrained resource becomes available.

The steps for the proposed operational concept are illustrated in Figure 3 and described below.
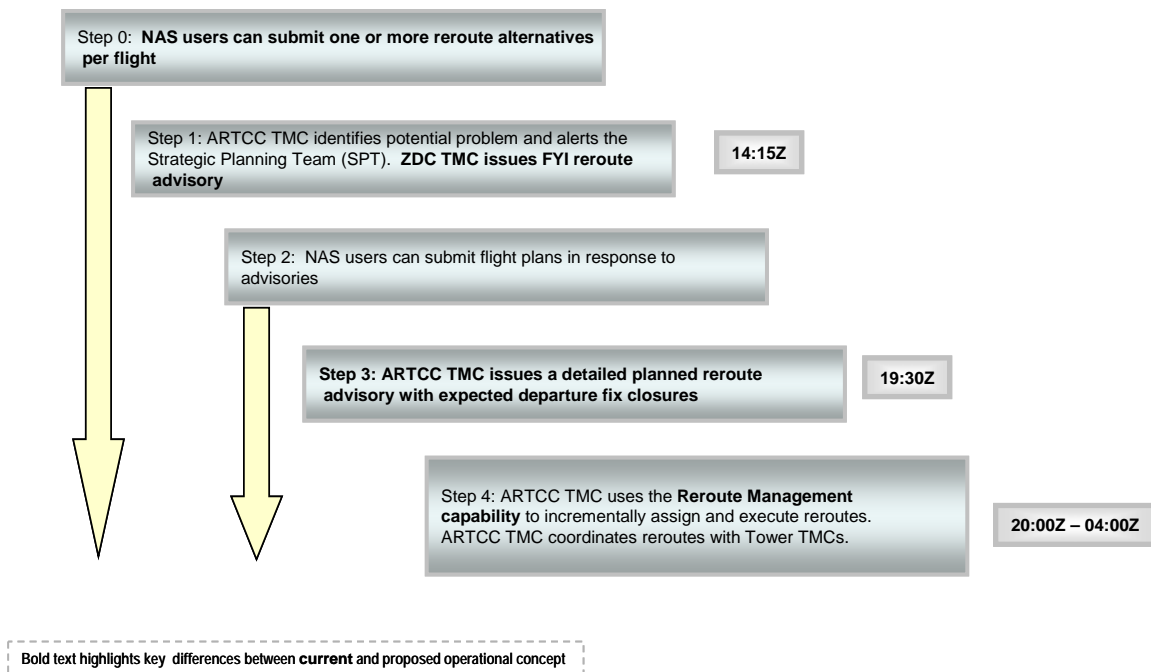
Figure 3. Proposed Operations for Local Rerouting.

Step 0: NAS users can elect to submit one or more reroute alternatives per flight to indicate how they would like their flights rerouted in the event that a departure reroute is needed. NAS users can submit their reroute alternatives both prior to and after an advisory is published. (NAS users may wish to submit reroute alternatives prior to the advisory being published in anticipation of bad weather, or routinely file flights plan with the desired route along with acceptable alternatives). They can rank order the reroute alternatives and indicate, if desired, that these alternatives are the only acceptable options. Instead of submitting reroute alternatives, NAS users can indicate that any route that meets user-defined criteria (e.g., that the added distance can be no greater than 200 miles) is acceptable.

Step 1: The TMC monitors weather forecasts and uses the strategic planning team teleconference to inform ATCSCC that rerouting for airport departures likely will be necessary.

The TMC publishes a FYI reroute advisory on the ATCSCC Web Page indicating the potential for departure reroutes at specified airports and times.

Step 2: NAS users may choose to submit flight plans in response to the advisories. If the NAS user has already submitted a flight plan, the NAS user can cancel the flight plan and submit a new flight plan up to approximately 45 minutes prior to proposed departure time.

Step 3: The TMC monitors the approaching line of thunderstorms and after coordination with traffic managers at the ATCSCC and other ARTCCs, publishes a detailed reroute planning advisory on the ATCSCC Web Page with information detailing the duration of the advisory, the affected airports, and the time duration for each of the departure fixes impacted.

Step 4: The ARTCC TMC initiates a telcon with TMCs at affected airports and at the TRACON and maintains it for the duration of the weather event. NAS users can listen in on the telcon. The purpose of this telcon is the same as in the current operations. The tower TMCs use the Reroute Management capability to indicate flights that are ready for departure.

The TMC obtains a list of flights expected to enter the regions initially affected by the weather by constructing a Flow Evaluation Area (FEA). Individual FEAs are drawn for each departure fix, and the flight lists are filtered for all flights departing from affected airports. The flight lists are dynamically updated. The flight lists are made available to NAS users to notify them of their flights that will be rerouted.

The TMC uses the Reroute Management capability to assign a route to each affected flight, taking into consideration any user-submitted reroute alternatives. Once the TMC is satisfied with the reroute and necessary coordination has been performed, the TMC "executes" the selected reroute. TFMS does the following:

TFMS submits the amendment to the enroute automation system ERAM.

TFMS also forwards the amendment to the affected NAS user (provided the NAS user has access to TFMS remote site capability) and indicates if a submitted reroute alternative was accepted.

NAS users can receive the ERAM generated Flight Plan Amendment (AF) from the TFMS Aircraft Situation Display to Industry (ASDI) feed.

The TMC continuously monitors the FEA flight lists at the key departure fixes. As the weather moves through the region, the TMC modifies the reroute strategy moving traffic from any weather-affected departure fix. If necessary, as demand resulting from reroutes increases, TMC initiate a miles-in-trail restriction at fixes. The TMC can monitor the FEA demand at key departure fixes based on flights that are ready to depart (information provided by the Tower TMCs using the Reroute Management Capability).

The TMC updates the reroute planning advisory on the ATCSCC Web Page as needed.

IV. Example Scenario

An example of how the ZDC TMC would use the Reroute Management capability is demonstrated in the following scenario, which is based on the actual weather and traffic that occurred on 25 May 2004 at ZDC. This scenario focuses on weather closing departure fixes from the DC Metro airports. Therefore, all modifications to flight plans are assumed to be done for pre-departure flights. Figures 4–6 provide a "mock-up" of the Reroute Management capability. This is provided only to illustrate key elements of the proposed concept; it is not a recommendation of the computer human interface that should be used in the implementation of the proposed capability.

At 20:30Z, severe weather has developed at the western boundary of ZDC and is moving eastward. The northwest departure fix JERES is expected to be adversely affected. The ZDC TMC decides it is necessary to reroute traffic going over JERES to use the southwestern fix LDN. The steps the TMC takes to address this problem are as follows:

1) The TMC creates an FEA to identify all flights departing the DC Metro airports using the departure fix JERES between the hours of 21:00 and 23:00Z. (Note that the TMC selects the filters used to generate the flight list. Alternatively, the TMC could generate a less restrictive list by simply filtering for all departures using JERES). The FEA flight list is generated showing all flights subject to the FEA filters.
2) To obtain a set of reroute options, the TMC uses the Route Search capability to identify route options based on specific criteria from selected sources including CDRs, historical routes and routes stored by the ARTCC. The TMC selects the alternate fix, in this example LDN, and a filtered list reroute options is generated.

3) The reroutes options are applied to the flights in the FEA and are presented in the Create Reroute window (Figure 4). For each flight, the list includes the aircraft identifier (ACID), the planned departure time or "READY" if the flight is ready for takeoff, and the "original route" which is either the first filed route, or, if no route is filed, historical route data. A filtered list of reroute options is displayed for each flight and is presented in priority order. The priority order is selectable by the TMC. This example shows the original route followed by the NAS user submitted Reroute Alternatives (RAs), the CDR routes, the routes used in the ARTCC, and the routes stored by the TMC. Each route is a complete route showing all fixes and airways from origin to destination. For each route, the additional flying time and distance compared to the original route are given.
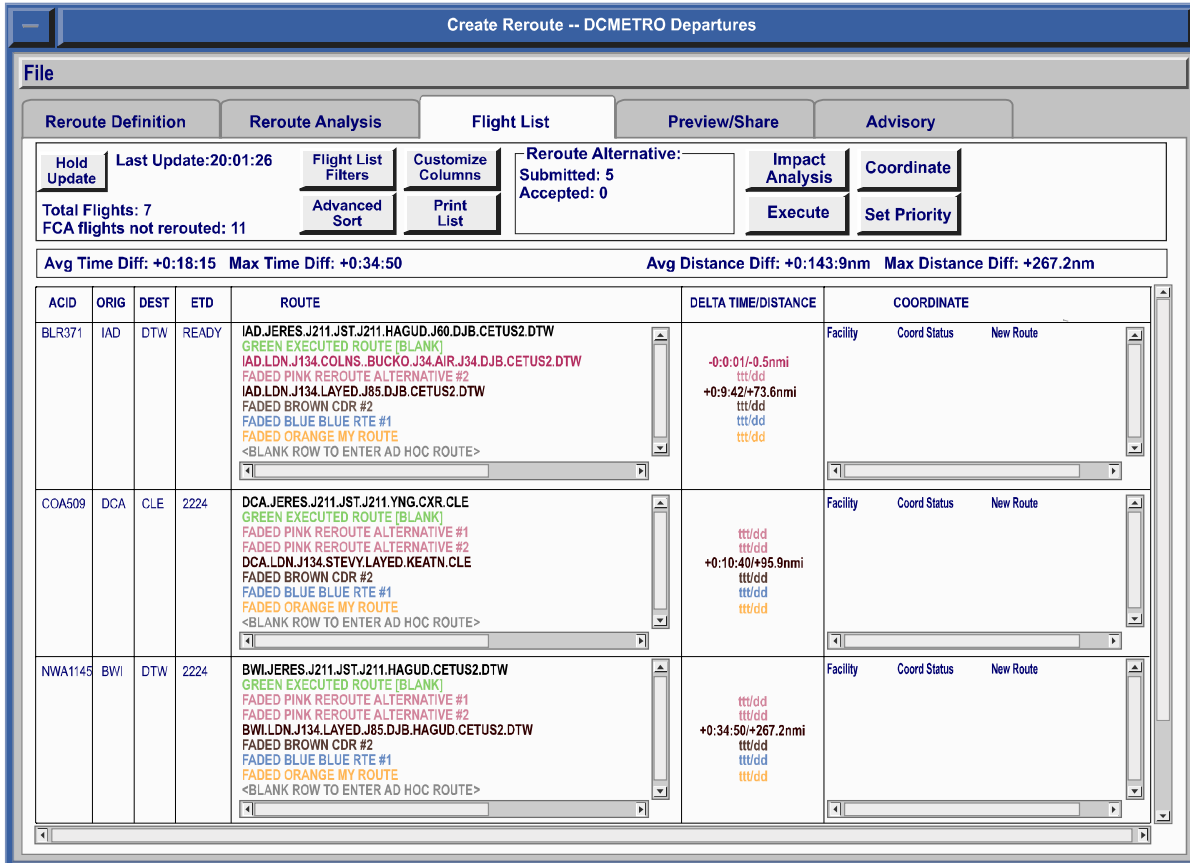
Figure 4. Flight Specific Reroute Options.

4) The TMC gets flight-specific information by highlighting one or more routes of interest in the Create Reroute window and selecting the "Impact Analysis" button. The flight-specific information includes a graphical display of the routes showing the current weather, ARTCC and sector boundaries, FEAs, and SUAs. Figure 5 shows an example of the flight-specific information. If demand for a sector is expected to exceed capacity due to either the proposed route change or the original traffic demand, that sector is highlighted on the display. The "TMIs" option displays Traffic Management Initiatives (TMI)s to which the flight is currently subject to and the TMIs that the flight would be subject to for each route option. The "Details" option displays the details or the text of the TMI. The "History" provides a list of any filed flight plans, flight plan cancellations, and amendments. Additionally, the TMC can view the impact of Current Routes or Planned Routes on selected fix counts. The TMC can also view the impact of planned routes on sector counts (not shown).

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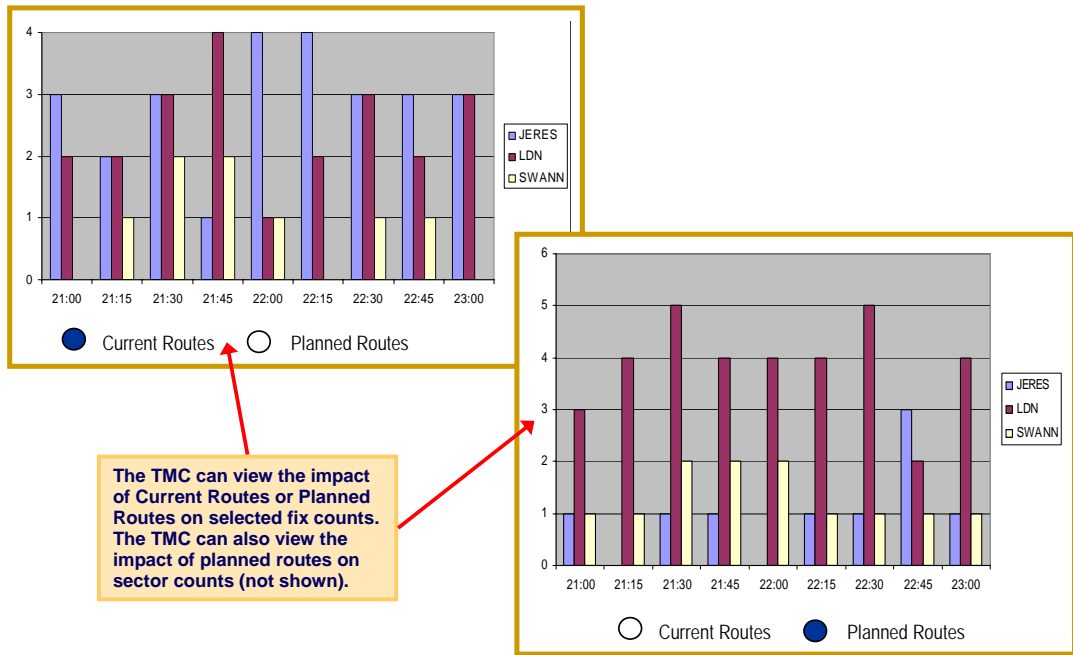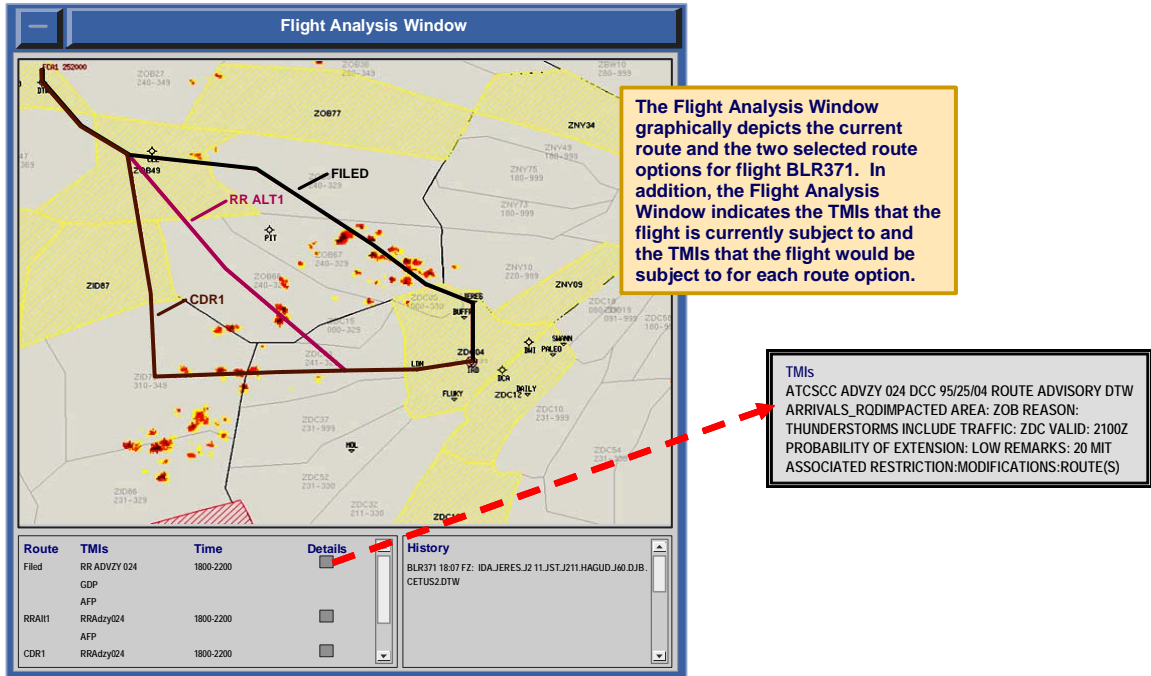
Figure 5. Impact Assessment.

5) Selecting a route also provides a list of the necessary coordination on the Create Reroute Window. The ZDC TMC can request the flights, as well as the proposed reroute, be shared with those on the coordination list, e.g., Cleveland ARTCC (ZOB) TMC and the ZDC Area 1 supervisor, by selecting the "Coordinate" option. The ZOB TMC and the supervisor receive the list (Figure 6) and can accept, alter, or reject the proposed reroutes. If the TMC elects to alter the reroute, the TMC will need to enter a Proposed Alternate route. In some cases, the ZDC TMC may need to follow up with a telephone call. For each flight, the Create Reroute display will indicate if coordination has been requested, is pending, or is complete.

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Figure 6. Reroute Coordination.

6) To submit a flight plan amendment with the modified route to ERAM, the TMC selects the "Execute" option. When the ERAM automation has completed processing the amendment, the new route (including any fixes, Preferential Arrival Routes (PARs), Preferential Departure Routes (PDRs), or PDARs inserted by the automation) is displayed.

7) The ZDC TMC can monitor the status of each flight involved in the FEA. The ZDC TMC can easily determine if the flight has an assigned route, what its status of coordination is, and whether the reroute has been executed. The ZDC TMC can view the route provided by ERAM, and can also view a summary of the status for all of the flights involved in the FEA.

8) If an executed reroute is no longer needed, the ZDC TMC can select the "original route" for the flight and execute it.

V.   Conclusion

The proposed concept for local rerouting leverages existing and emerging concepts for planning and execution of ATCSCC-initiated reroutes. The proposed concept increases the common situational awareness for potential local reroutes, allows for NAS users to submit reroute alternatives, and increases the automation support for the ARTCC TMC to identify, assess, and execute a reroute. Storyboarding exercises with FAA operational personnel are currently being planned. Feedback will be used to refine the concept. If determined to be useful, a prototype will be developed and human-in-the-loop exercises will be conducted as a preparation for the definition, validation, and documentation of requirements.

Acknowledgements

References

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