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MITRE TECHNICAL REPORT

Midterm FAA-Airspace User Collaborative Routing Operational Concept

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Abstract

The rerouting of aircraft to avoid either bad weather or congested airspace is a technique commonly used by Air Traffic Management (ATM) today. It is hoped that the current process for determining the need for reroutes and developing reroute plans can be improved through increased collaboration between ATM and airspace users.

This report presents a strawman operational concept for Collaborative Routing in the midterm (2005) time frame. It was prepared as part of the MITRE Corporation's Center for Advanced Aviation System Development (CAASD) support to the Federal Aviation Administration's Collaborative Routing Research.

The report contains a scenario depicting collaborative decision making between Traffic Flow Management (TFM) and airspace users to manage traffic situations requiring routing actions. Suggested participant roles and responsibilities, implied procedural and decision support system enhancements, and outstanding research issues are also presented.

KEYWORDS: Collaboration, collaborative decision making, collaborative routing, midterm, operational concept, traffic flow management

Foreword

This paper presents an operational concept for Federal Aviation Administration (FAA) Airspace User Collaborative Routing for the midterm (defined for the purposes of this paper as the year 2005). The paper was prepared to assist the FAA and airspace users in defining and evaluating a vision for Collaborative Routing. It is acknowledged that some aspects of the ideas expressed may not be operationally realistic in the midterm. These ideas have been included, nevertheless, to stimulate discussion among airspace users and the FAA.

Acknowledgments

The concepts and open issues for Collaborative Routing presented in this report are the result of significant discussion and collaboration with individuals from many organizations within the FAA and from the air carrier community. Their contributions are appreciated by the authors. Special thanks are extended to the members of the Collaborative Decision Making (CDM) Working Group of the Air Transport Association (ATA). Inputs from members of the CDM Working Group were invaluable in expanding the authors' understanding of the issues and needs associated with collaborative routing.

We would be remiss if we did not acknowledge the extra effort taken by Kevin Kollmann (US Airways), William S. Leber (Northwest Airlines), Roger Beatty (American Airlines), and Sonny Krantz (MITRE/CAASD) to provide us with timely feedback on concepts illustrated by the Collaborative Routing scenario.

Thanks are also extended to Pauline Kapoor and Ellen Friedman for taking on the task of getting this work published.

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Section 1

Introduction

The Center for Advanced Aviation System Development (CAASD) of the MITRE Corporation has been providing Concept Exploration (CE) support to the Traffic Flow Management (TFM) Research and Development Branch of the Federal Aviation Administration (FAA). Results from CAASD's CE research provide the FAA with a basis for determining the commitment to fund further development of many capabilities. Collaborative Routing is one of the capabilities being addressed by CAASD as part of its CE support to the FAA.

The operational concept for collaborative routing presented in this report was prepared as part of CAASD's CE work on the Collaborative Routing capability.

1.1 Purpose

The primary purpose of this operational concept is to facilitate discussion among airspace users and between airspace users and the FAA about the environment for collaborative routing in the midterm (about the year 2005). The operational concept is also intended to encourage discussion about responsibilities of airspace users and Air Traffic Management (ATM)[1] personnel in this environment, procedures to enable collaborative routing, and suggested decision support tools to facilitate collaborative routing. The operational concept will be updated periodically to reflect results of user and FAA discussions.

This operational concept will be used to establish the operational and technical viability of a concept wherein the FAA and airspace users collaboratively apply a selected set of traffic management resolution strategies. It will also provide the FAA with an initial basis for estimating benefits and development costs.

The intended audience for this report includes traffic managers, the airspace user community, system developers, and FAA sponsors of TFM research and development.

1.2 Scope

The scope of this research effort has been limited to defining an operational concept for addressing traffic management problems amenable to resolution through changes in the airspace user's planned or preferred route. It is acknowledged that other options, such as user departure schedule changes or increasing ATM's ability to manage more traffic, might be used to resolve these problems.

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1 Air Traffic Management is composed of both the Traffic Flow Management process and the Air Traffic Control process.

It should be noted that although the Collaborative Routing operational concept is for the 2005 time frame, many aspects of the concept can be implemented much sooner.

1.3 Background

The rerouting of aircraft is a technique frequently used by traffic managers to balance demand with the available airspace capacity. In some instances, there is sufficient time for the airspace user to participate in the FAA's rerouting decision making process. In other instances, the decision to restrict or change routes is a tactical one and airspace users have very limited opportunity to participate in the decision making process. In both cases, traffic managers today make decisions with only a limited understanding of the potential effect of selected reroute strategies on the airspace users. When implemented, the strategies might solve the problem from a National Airspace System (NAS) perspective, while adversely affecting system users in ways that could have been avoided.

Airspace users currently have limited access to information used by ATM in identifying and formulating solutions to problems resolved through the application of reroutes. They also have few opportunities to influence the development of resolution strategies. This constrains them in the execution of their flight planning and dispatch responsibilities. It also results in missed opportunities to change the demand side of the picture in ATM's management of predicted excess demand.

The consensus goal articulated by the FAA and user community for Collaborative Routing, is the creation of an operational environment that will provide the following:

- ATM with the information and decision support systems to accurately forecast demand on the National Airspace System (NAS) resources (i.e., airspace, fixes, airports) and share those forecasts with the user community
- Airspace users with sufficient information on the status of the NAS to allow them to proactively respond to changes in weather and system congestion without adversely affecting the NAS
- ATM and airspace users with the capability to proactively address route-constraining situations strategically
- The FAA and airspace user community with the opportunity to collaboratively develop resolution strategies

Two fundamental operational needs must be satisfied to achieve the goals expressed for Collaborative Routing: common situational awareness and a collaborative approach for defining reroute strategies.

Section 2

Suggested Roles and Responsibilities for Collaborative Routing in the Midterm

In the midterm, ATM personnel and airspace users share information relating to system demand and system capacity. For the user, this information includes near-real time updates of changes in schedules and "intended routes." For ATM, this information includes current and planned system demand and constraints on NAS resources.

National and local traffic managers[2] identify flow problems related to traffic congestion, airspace manageability, and workload issues. In the case of developing weather situations, both traffic management and airspace users participate in problem definition.

For problems with significant lead time, users are able to proactively take action to address demand-capacity imbalances. These proactive user actions are taken into account by the FAA when it investigates the need for implementing new constraints.

During situations when collaboration is possible, the flow strategy (the determination of whether to use holds, reroutes or other actions) is determined through joint discussions among airspace users and the appropriate TFM facilities. The FAA takes user preferences into account when formulating a solution.

FAA traffic managers determine which constraints to impose, where to apply them, when to impose them, and for what duration. In addition, the allocation of capacity among users is also performed by the FAA to ensure fairness.

Airspace users involved in a collaboration session express preferences for their flights. The FAA takes these preferences into account where feasible.

2.1 FAA Traffic Flow Management

More specifically, TFM has the following roles and responsibilities in the midterm.

- Review demand and capacity predictions to identify potential traffic congestion situations (national and local TFM)

[2] National TFM develops a NAS-wide perspective of traffic flows and works toward NAS-wide efficiency. National TFM is conducted at the Air Traffic Control System Command Center (ATCSCC, or Command Center). Local TFM develops a unique understanding of traffic flows through its airspace and works with neighboring facilities to ensure effective utilization of NAS resources. Local TFM is conducted at en route centers, terminal radar approach control facilities, and control towers.

- Disseminate NAS status and demand information (national TFM)
  - Keep users apprised of current and predicted status of the NAS (e.g., current and expected Airport Acceptance Rates (AARs), current and expected airport configurations, current and planned TFM route constraints)
  - Keep users apprised of developing traffic flow situations
- Facilitate collaboration sessions (national TFM)
  - Facilitate FAA-user and FAA-FAA collaboration sessions, including the issuing of advisories and specifying the required response time for proposed solutions from the airspace user
  - Receive users' preferences during collaboration (also local TFM)
  - Arbitrate the resolution of system congestion (also local TFM)
- Develop and evaluate TFM strategies (local and national TFM)

2.2 Aeronautical Operational Control (AOC)

More specifically, the AOCs have the following roles and responsibilities in the midterm.

- Operational control and flight planning
- Submit flight plan information and updates to the ATM computer system up to 12 hours in advance of flight departure
  - Determine potential consequences of strategies proposed by FAA
  - Evaluate available options in order to assure the safest operation possible
  - Develop a plan to reduce the level of congestion before the FAA takes action
  - Evaluate potential effects on fleet/crew resources and schedule if the FAA takes action to alleviate a flow problem
  - Define preferences and establish priorities for their flights and communicate them to TFM
- Crew notification
  - For flights that have not departed, AOC updates the flight plan to reflect the reroutes and advises the flight crew of flight time and fuel burn for the new route as well as the user preferred route. This information is included in the dispatch release and provides the crew the necessary information to fly either route.
  - Using data link or company radio, AOC advises airborne flight crews of the possibility of a reroute and the reason. They notify the crew which routes are acceptable and the additional flight time and fuel burn for the reroute.

Section 3

Collaborative Routing Scenario

A Collaborative Routing scenario has been created to illustrate the many different ways in which airspace users and TFM collaborate when changes in preferred or planned routes are required to mitigate all or part of a predicted airspace demand-capacity imbalance situation. Although this scenario describes the operational environment for 2005, in fact, some of the capabilities and procedures illustrated may be implemented earlier.

3.1 Introduction

This scenario describes collaborative decision making between TFM and airspace users to manage traffic situations possibly requiring routing actions in a typical summer day in the NAS in the year 2005. The situations include the following:

1. A thunderstorm in the midwest that forces traffic flows into the surrounding en route centers
2. Heavy overflight traffic in the St. Louis terminal area that causes delays in departures
3. A weather system that blocks the west departure and arrival corridors of Philadelphia
4. Arrival delays into Atlanta

The scenario describes continuous planning by airspace users and by TFM, responsibilities of airspace users and TFM in managing the situations, and possible procedures and automation capabilities to support collaborative routing.

As a guide to review how a situation develops and is managed, the following thread of events for each situation is provided:

Table 3-1. Scenario Situations Overview

Situation	Thread of scenario events
1	0900Z 1100Z 1500Z 1530Z 1715Z 1720Z 1730Z 1815Z 1830Z 1855Z 2000Z 2105Z 2152Z
2	0900Z 1100Z 1500Z 1720Z 2015Z 2030Z
3	0900Z 1100Z 1500Z 1700Z 1715Z 1720Z 1900Z
4	0900Z 1100Z 1500Z 2325Z

3.2 The Scenario

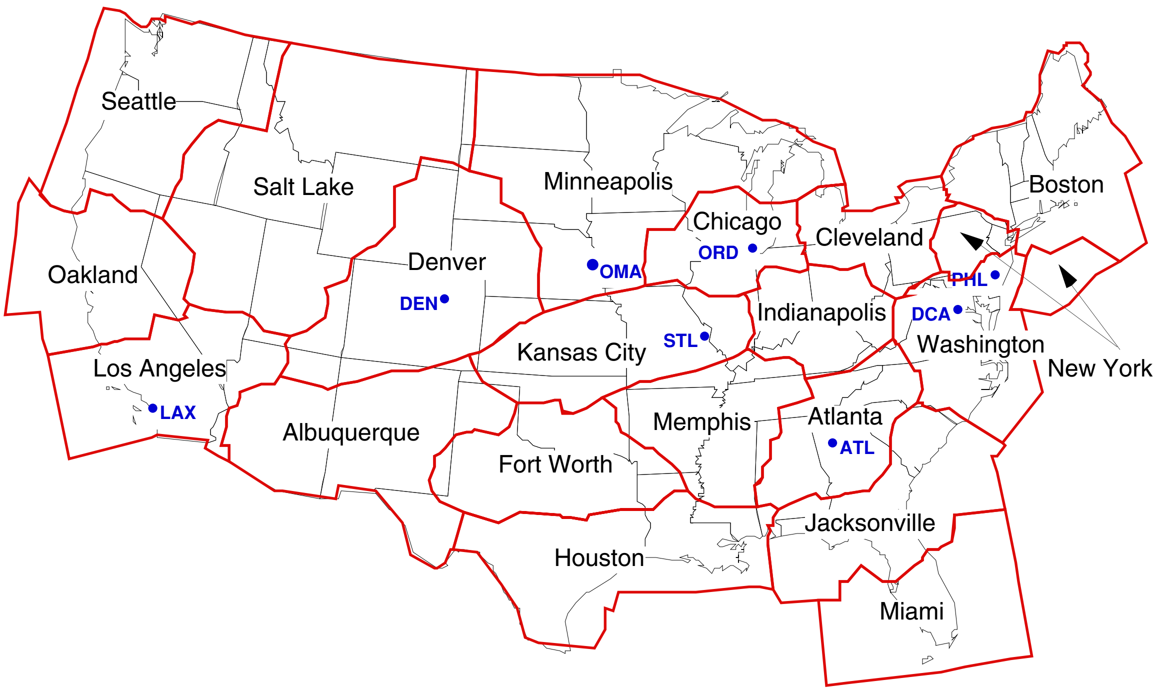

Figure 3-1. CONUS En Route Centers

July 1, 2005, 0900Z. Early morning planning – airspace users

Air carrier AOCs prepare flight plans for aircraft that are scheduled to depart in the next 12 hours. The flight plan represents the best estimate, at the time, of the flight's intentions. The AOC *submits* the flight plans to the ATM computer system. The AOCs use the following information to prepare the flight plans:

- Early forecasts of winds and weather
- The most recent traffic predictions–obtained through a variety of sources, such as the following:
  - The FAA's ATM Internet Web site
  - Commercial information providers (such as Fixed Base Operators)
  - An FAA-maintained, electronic database of NAS status information
- Predicted TFM restrictions and actions

- Historical schedule information

The ATM computer system uses the flight plan information to estimate demand on key airspace resources and airports. Throughout the day, the AOC updates and resubmits its flight plans as capacity and demand projections are updated. The ATM computer system, in turn, refines its NAS-wide demand estimates. This flight plan updating process continues until about two hours before departure time, when the AOC *files* the flight's flight plan. (It is understood that flight plans submitted as far as 12 hours in advance are based on less certain information, and therefore do not contain as reliable information as flight plans submitted, updated, or filed closer to departure. Both ATM and airspace users consider the level of information uncertainty in their planning.) An overview of the flight plan submitting and filing process is shown in Figure 3-2.

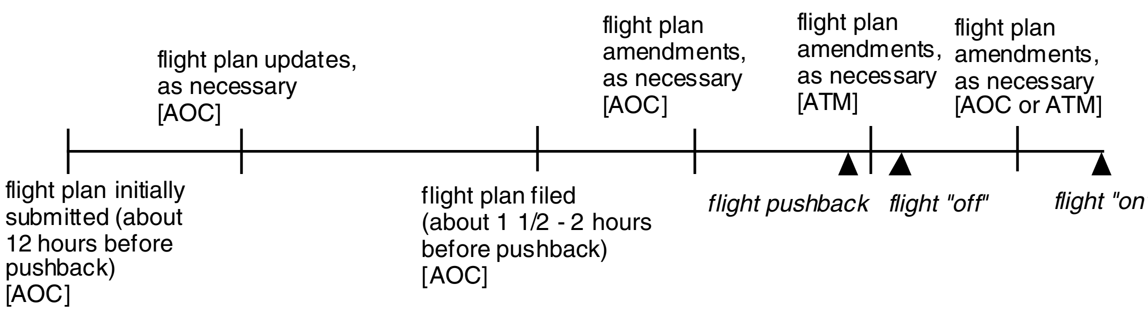

Figure 3-2. Flight Plan Submitting/Updating and Filing/Amending

XYZ Airlines is a large passenger air carrier operating hubs at Philadelphia International Airport (PHL), Atlanta Hartsfield International Airport (ATL), and Denver International Airport (DEN). On this day, XYZ's meteorologists forecast a line of severe thunderstorms in the midwestern US for mid-afternoon, and other weather systems that could significantly affect its operations at Philadelphia, Detroit, Dallas-Fort Worth, and Houston. XYZ AOC keeps an eye on the predicted weather and factors it into its operations planning.

1100Z. Early morning planning – ATM

The ATM computer system continuously updates demand estimates using flight plan information from airspace users, and using historical demand information supplied by TFM facilities. The latter includes additional demand due to special events, such as the Olympic Games, the Oshkosh airshow, or a popular annual trade show.

Traffic managers at the Command Center and the local TFM facilities estimate the capacity at key NAS resources by examining updated weather forecasts, wind patterns, availability of Special Use Airspaces (SUAs), expected traffic patterns, and other factors. Traffic management specialists at the Command Center coordinate dissemination of NAS-wide demand and capacity information through the ATM Web site and via an electronically accessible database.

The Command Center updates information on the ATM Web site, which includes such information as the following for each geographical region:

- Weather forecasts, including the probability of occurrence (for example, 75% probability of tornadoes throughout the midwest between 1900Z and 2300Z)
- Aggregate demand at selected airports in 15 minute increments
- Predicted capacity at selected airports and airspaces
- Airspace with predicted congestion (for example, hourly snapshots of FAA's traffic situation display for the next 12 hours)
- SUA availability
- Special events affecting the capacity of airspace or airports (for example, a space vehicle launch)
- Active TFM restrictions
- Likely TFM restrictions and constraints (for example, closed airspaces, miles in trail (MIT) restrictions, and directional routes) based on predicted demand vs. predicted capacity
- Likely TFM-designated routes to off-load traffic from congested or closed airspace

At this time, traffic managers note the forecast for severe thunderstorms for the midwestern US, in particular in Kansas City Center and Minneapolis Center, and estimate that capacity will be severely reduced in this airspace from about 2000Z to 2300Z. Meteorologists predict an 80% chance that the line of thunderstorms will contain contiguous blocks of level-5 cells. The Command Center specialists predict that east-west traffic will be blocked in Kansas City Center and Minneapolis Center, and they discuss different strategies for managing the situation, including development of TFM-designated routes. They place their problem assessments and proposed resolution strategies on the ATM Web site.

1500Z. AOCs continue to evaluate their schedules and update flight plans

Throughout the day, AOCs assess the demand and capacity information throughout the NAS, and consult with their meteorologists or weather information providers. As needed, AOCs update flight plans that had been submitted earlier and submit new flight plans for aircraft scheduled to depart within the next 12 hours.

1530Z. AOC acts on midwest thunderstorm forecast

Meteorologists at XYZ Airlines update their prediction of the severity, location, and time of onset of the thunderstorm within Kansas City Center and Minneapolis Center. The thunderstorm is now forecasted to be more severe than predicted at the beginning of the day. They notify the AOC.

XYZ AOC reviews the expected TFM restrictions and constraints from the ATM Web site, then evaluates the disruption that the thunderstorm would likely cause to XYZ's schedule. After consulting with their station personnel, the AOC decides to take the following actions immediately, and to reassess the situation in 20 minutes: cancel two flights, replan the route for several others, delay some flights on the ground, and plan for some amount of airborne holding for nearly all flights expected to fly in the en route centers neighboring Kansas City Center and Minneapolis Center.

In planning another route, XYZ AOC uses an in-house developed automation capability, part of its suite of flight planning tools, to "probe" the airspace; specifically, the automation does the following:

- Determine whether the proposed 4-dimensional flight route would be affected by any expected TFM constraints or restrictions
- Determine whether the route would violate closed airspace, such as an active SUA
- Estimate the level of congestion in the airspace the route traverses

The tool has electronic access to the FAA-maintained database of NAS status information. If a route is found to violate closed airspace, be adversely affected by TFM restrictions or constraints, or would encounter heavy congestion, the tool develops a more favorable route, if possible, and displays it to the AOC. The AOC has the option to accept the tool's proposed route or develop a different route all together.

The AOC submits updated flight plans and notices of cancellation to the ATM computer system.

XYZ AOC continually assesses the situation in the midwest throughout the day, and makes further schedule adjustments as necessary.

1700Z. Weather predicted near Philadelphia airport

Command Center specialists and the traffic managers from the East Coast en route centers conference about a weather system predicted west of PHL between 1900Z and 2000Z. The weather system is forecasted to block PHL's west arrival and departure routes.

Traffic managers at Washington Center and the Philadelphia terminal area work together to identify alternate departure routes under probable weather scenarios and demand profiles. They determine the five most likely sets of Severe Weather Avoidance Program (SWAP) arrival and departure routes, and begin coordinating with neighboring en route centers as well as with the operational supervisors at Washington Center. The candidate sets of SWAP routes are announced on the ATM Web site. These sets of routes are SWAP A, SWAP B, SWAP C, SWAP D, and SWAP E. The announcement includes the time at which the SWAP routes might possibly be finalized, 1900Z.

1715Z. XYZ AOC prepares dispatch release for XYZ123

XYZ AOC prepares a dispatch release for several flights expected to depart 1 1/2 to 2 hours from now. The first of the AOC's flights for which a release is prepared is flight XYZ123, which is scheduled to depart PHL for DEN at 1915Z.

Since it has been several minutes since the AOC has had a chance to reexamine XYZ123's flight plan, the AOC uses the flight planning automation capability to evaluate the route against predicted TFM constraints and restrictions, closed airspace, or traffic congestion. The tool proposes a different route to avoid not only the line of thunderstorms in the midwest, but also to avoid the heavy traffic flows to the north and south of the line of thunderstorms. Although requiring more fuel, the AOC estimates that the delay from flying the tool's recommended route would be considerably less than flying the TFM-designated route. The AOC indicates "NRP: WX" on the flight plan to let the ATM system know the reason for the National Route Program (NRP) route is to avoid weather. The AOC plans additional fuel for this reroute.

The AOC notes that alternate departure routes will likely be implemented at PHL. The AOC plans additional fuel for the worst-case SWAP departure route. Because SWAP B, one of the five sets of SWAP routes announced earlier, has two departure routes for west-bound traffic, the AOC calculates the fuel consumed and flight time for each departure option, and finds that it is more advantageous for XYZ123 to fly the departure route over the Modena fix. The AOC indicates a preference in the flight plan for that departure route, if SWAP B were in effect.

1720Z. XYZ AOC files flight plan for XYZ123

Because the flight plan is being filed within two hours of estimated departure, the ATM computer system provides immediate feedback to the AOC about the acceptability of the flight intent. The ATM computer system indicates that the planned route for XYZ123 is not acceptable since it would intersect an active SUA whose schedule the owner has just amended. The ATM computer system suggests an alternate route.

The AOC notes that if flight XYZ123 were to increase its speed, it could transition the SUA before the SUA would become active. The AOC submits a flight plan with such a speed adjustment instead of the suggested alternate route. The ATM computer system notifies the AOC of the acceptance of the flight plan with no further changes needed.

1730Z. Regularly scheduled Command Center teleconference

A teleconference facilitated by the Command Center is conducted each day at 1730Z. Participants include traffic managers from all en route centers and key terminal areas, and major air carrier AOCs.

On days like today when traffic in the NAS is being impacted by weather, the Command Center not only places the weather forecast on the ATM Web site, but also distributes a map of the weather forecast via the electronic chalkboard capability to teleconference participants. FAA facilities and AOCs obtain weather information from their own meteorologists or weather information providers. In addition, however, all parties have agreed to use, as a basis of discussion, a weather forecast developed "through consensus" by a volunteer group of air carrier meteorologists (including an XYZ meteorologist). It is this weather forecast that is distributed by the Command Center for the teleconference.

The teleconference participants agree that there is a 90% chance that the thunderstorms predicted in the midwest will be severe, and that all east-west traffic flows this afternoon will be affected. The Command Center uses a traffic prediction capability to estimate the demand for the neighboring airspace. As part of contingency planning, traffic managers propose routes to avoid the thunderstorm; these routes are illustrated on the electronic chalkboard and negotiated among the traffic managers. The impact of these flows on first- and second-tier en route centers is expected to be great; TFM restrictions are proposed by and coordinated among the traffic managers of the affected en route centers.

The Command Center updates the ATM Web site with NAS status information, weather information, likely TFM restrictions and constraints, likely TFM-designated routes, and expected delay at major airports. The Command Center announces a collaboration session scheduled for 1830Z to discuss reroute options for midwest traffic.

Regional hotlines are expected to be heavily used throughout the day. AOCs can participate in the regional hotlines in listen-only mode to keep up with any new developments. AOCs prepare contingency plans.

1815Z. ATM identifies flow problem

Traffic managers from the Command Center, Minneapolis Center, and Kansas City Center conference about the midwest line of thunderstorms. The Command Center displays the image of the predicted thunderstorms over a map of the contiguous US (CONUS), then uses an automation capability to draw a 3-dimensional polygon, called a Flow Constrained Area (FCA), around the thunderstorms. This image is shared with the other participants via the electronic chalkboard. The traffic managers estimate that the airspace bounded by the FCA will likely have zero capacity for several hours, from about 2000Z to 2300Z. Delays of up to four hours would be incurred if the airspace users made no changes to their demand. The participants agree that the contingency plans developed at the 1730Z teleconference will need to be activated.

The automation capability is also used to identify the flights that are scheduled to traverse the FCA in the affected time frame. The Command Center notifies the AOCs of these flights to join in the 1830Z collaboration session, as well as traffic managers of the en route centers most likely to be affected by reroute actions: Minneapolis Center, Kansas City Center, Chicago Center, Indianapolis Center, Cleveland Center, Washington Center, Indianapolis Center, Memphis Center, Fort Worth Center, Houston Center, Denver Center, and Albuquerque Center. In addition, a representative from NAV CANADA is invited to participate. Information about the situation is updated on the ATM Web site, and invitees are requested to review the information prior to the 1730Z teleconference. Each AOC is provided with a list of its carriers' flights that have been identified by the automation capability.

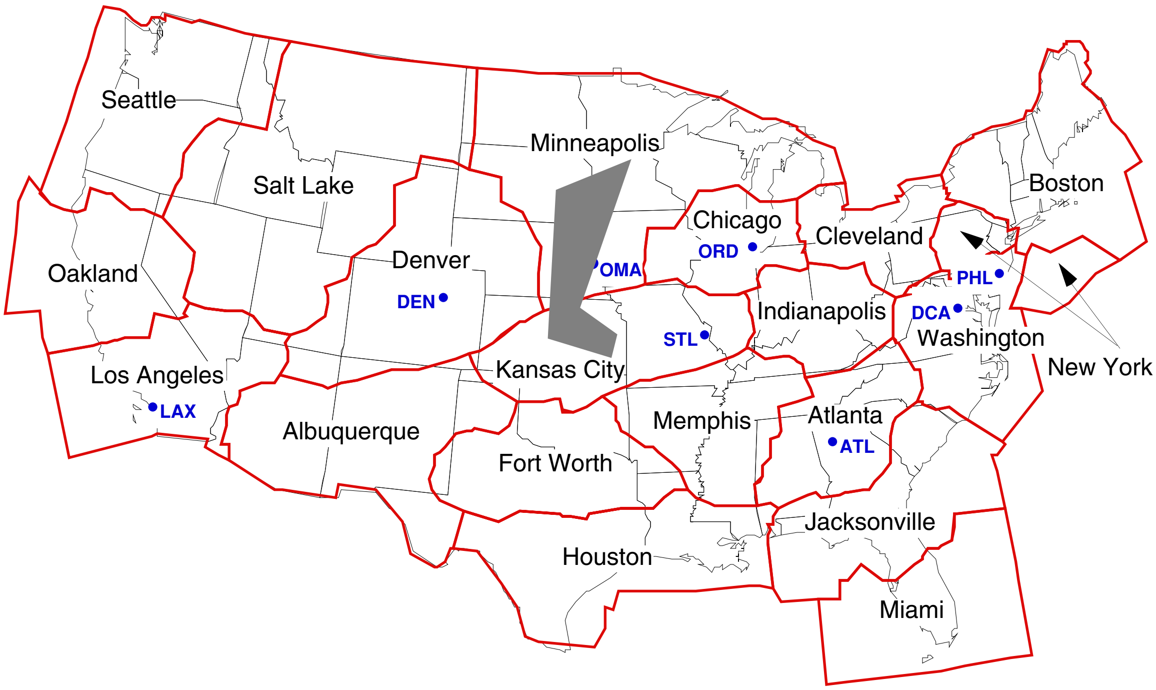

Figure 3-3. Severe Thunderstorm in Midwest

1830Z. Collaboration session about rerouting around midwest thunderstorm – round 1

The onset of the severe weather is about 1 1/2 hours away. As requested, the invited parties join the collaboration session, which is facilitated by the Command Center.

The traffic flow problem is reviewed, and the reroutes identified at the 1730Z teleconference are displayed on the electronic chalkboard. The traffic managers suggest some changes based on updated demand predictions, and all agree to call the resulting routes the *TFM-designated routes*. One TFM-designated route is located to the south of the weather through Kansas City Center, with up to three additional TFM-designated routes to manage increased volume, if needed, through Fort Worth Center and Houston Center. One TFM-designated route is located to the north of the weather through Minneapolis Center, with one additional TFM-designated route, if needed, through Canadian airspace (as negotiated earlier with NAV CANADA).

It is the option of the users to accept the TFM-designated routes, delay their flights, or propose other actions, such as fly close to the weather and hold in en route airspace until the weather clears. (This last option is acceptable to the ATM system in such cases where weather is expected to clear up as the flight approaches the airspace.)

All AOCs participating in the collaboration session are requested to propose solutions for their carrier and report back at the next round of the collaboration session in 15 minutes. The AOCs request additional time to develop solutions. They agree to hold the next round at 1855Z.

1855Z. Continuation of collaboration session – round 2

In the interim, the AOCs have consulted with their meteorologists or weather information providers, developed several strategies, and used their flight planning and schedule evaluation tools to weigh different options.

The AOCs submit their proposals–in the form of schedule, route, and altitude changes–to the ATM computer system. As expected, all AOC participants have canceled at least one flight and have also chosen to delay many departure flights on the ground. Since the tops of the thunderstorm are predicted at FL390, AOCs with airframes capable of flying above FL390 propose routing these flights at higher altitudes.

For the remainder of the flights, most AOCs agree to the TFM-designated routes in the cases where the flight's original route would have crossed the FCA between 2000Z and 2230Z. For those flights scheduled to cross the FCA after 2230Z, the AOCs plan for the flights to fly the original route and hold in en route airspace outside the thunderstorm until the weather clears up.

Two carriers, ABC Airlines and JKL Airlines, each with two flights scheduled to cross the FCA, believe there are enough holes in the weather that their aircraft can safely fly through the storm. They take their chances that this will be the case, or, if not, that the air traffic controllers can guide them around the weather. ABC and JKL submit no schedule or route changes for these flights.

The Command Center uses the traffic prediction capability to evaluate the traffic loading based on all the AOC participants' proposed replans. The tool indicates that traffic levels would be manageable. The operational supervisors at Minneapolis Center and Kansas City Center are consulted on ABC's and JKL's proposals to fly through the storm. The operational supervisors consider the controller workload, then agree to ABC's and JKL's plans.

The AOCs are requested to submit updated flight plans or file flight plan amendments for all affected flights. For those flights already airborne, the AOC uplinks the reroute, and requests the pilots to contact the controller to amend the in-flight plan with the reroute.

1900Z. Departure push at Philadelphia

A weather system moves from the south and rests west of PHL, as predicted, blocking some PHL departure and arrival routes. Traffic managers at Washington Center and the Philadelphia terminal area consult with their meteorologists; then, over the East Coast Hotline, they discuss which SWAP routes they should activate. They decide on SWAP B. This decision is announced on the ATM Web site.

SWAP B specifies two departure routes for west-bound flights, one over the Modena fix and another over the East Texas fix. Flight XYZ123 is at the gate. While entering an amendment to XYZ123's flight plan, the Washington Center traffic manager sees that XYZ AOC has stated a preference for the departure route over Modena. The traffic manager types this departure route in the amendment.

The pilot of flight XYZ123 radios the tower for a clearance. The clearance delivery controller reads the amended route. The pilot loads the SWAP B route over Modena into the aircraft's Flight Management System. XYZ123 departs at 1915Z for DEN, as scheduled.

2000Z. Thunderstorm within Kansas City Center and Minneapolis Center

The thunderstorm has materialized within Kansas City Center and Minneapolis Center, as expected. Aircraft fly the routes agreed to at the 1830Z collaboration session. Those users who did not participate in the earlier collaboration session or who had not filed a reroute are placed by Air Traffic Control (ATC) onto the TFM-designated routes.

2015Z. Departure push at St. Louis

Due largely to the line of thunderstorms in the midwest, the overflight stream at the St. Louis terminal area is congested. This is causing departure delays at Lambert St. Louis Airport (STL), and call-for-departure restrictions are in place.

Over the regional hotline, the Command Center has been discussing strategies to manage the STL departures with the traffic managers of Kansas City Center and the St. Louis terminal area. One strategy includes enabling more non-regional jets to depart and remain at low altitudes.

XYZ AOC, who has been listening to the hotline discussion, recognizes that in order to reduce XYZ's departure delays, some of its flights will need to fly at altitudes that are less than optimal.

2030Z. Reduced altitude plan for STL departures

The overflight stream of STL is expected to remain congested for the next two hours. Traffic managers of Kansas City Center and the St. Louis terminal area develop a plan to enable more departures in the next two hours to fly at low altitudes ("tunnel"). The reduced altitude plan identifies the low-altitude departure corridors and the approximate distance away from STL before the pilot should request a clearance to climb to the preferred cruise altitude. (The latter is specified to reduce the frequency congestion in the St. Louis terminal area.) The traffic managers announce the following via an advisory: "Due to overflight congestion, you can request to fly at reduced altitudes to avoid additional ground delay."

AOCs examine the flights that are scheduled to depart STL in the next two hours. They decide which flights should request to fly at reduced altitudes and which to leave subject to delay on the ground. The AOCs plan additional fuel for the reduced altitude flights, and amend their flight plan to indicate the new departure altitude as well as the desired cruise altitude.

XYZ AOC plans to fuel eight flights departing in the next hour for the lower altitudes in anticipation of flying at reduced altitudes. The AOC instructs the pilots of these flights to request a clearance to cruise altitude about 100-150 miles from STL. These flights include XYZ009, a long-haul to Los Angeles International Airport (LAX), and XYZ888, a short-haul to Chicago O'Hare International Airport (ORD). Both flights are scheduled to depart in about 20 minutes. The pilots of XYZ009 and XYZ888 request the reduced altitude option from STL tower. The clearance delivery controller issues a clearance to XYZ009 to climb and remain at "tunnel" altitude FL210, while XYZ888 is cleared to climb and remain at "tunnel" altitude FL190.

At approximately 150 miles out, XYZ009 is cleared by Kansas City Center ATC to its requested cruise altitude FL350. However, due to its short stage length and the continuing congestion at the higher altitudes, XYZ888 remains at the reduced altitude to Chicago.

2105Z. Temporary break in line of thunderstorms in the midwest

An east-west break, just west of Omaha, is predicted to occur 30 minutes from now in the line of thunderstorms in the midwest and be large enough to allow about six flights through in a period of 15 minutes, then close up. (This is about 25% of normal through-traffic capacity.)

The Command Center uses an automation tool to identify those flights that might possibly be able to take advantage of the break, including flights that had planned for airborne holding outside the thunderstorm. The Command Center issues an advisory to the appropriate AOCs, to notify them that a collaboration session will take place in five minutes. The advisory also lists the flights that the Command Center automation had identified.

The AOCs dial in; they concur that it is possible that the flights identified by the Command Center can go through the break. However, the AOCs do not necessarily wish to take all the flights off the TFM-designated routes. Instead they identify candidates for rerouting through the break. XYZ Airlines proposes 3 flights, ABC Airlines 2, DEF Airlines 2, GHI Airlines 6, and JKL Airlines 2.

After a short period of negotiation, the Command Center allocates the capacity in the airspace to the carriers as indicated in Table 3-2.

Table 3-2. Negotiated Allocations

Carrier/Airspace User	Proposal	Allocation
XYZ	3	1
ABC	2	2
DEF	2	1
GHI	6	0
JKL	2	1
A business jet unable to participate in the collaboration session	–	1

(ABC and JKL, large air carriers, had planned to fly close to the thunderstorm in anticipation of just such a break occurring.)

The AOCs determine which flights to reroute through the break, within their allocation limits. They use their flight planning software to determine the reroute, and submit the replan to the Command Center which evaluates the resultant traffic loading. The reroute proposals are accepted. The AOCs radio their pilots. Traffic managers notify the operational supervisors, and ATC issues a clearance to each flight as well as updates their flight plans.

2152Z. Break in storm closes

Flight JKL555 has flown to within 30 miles of the line of thunderstorms; the pilot realizes that he is unable to find a path on his filed route through the storm. In the next 50 minutes JKL555 deviates to try to find an opening in the weather. Unsuccessful, the pilot radios ATC to be cleared immediately onto the closest TFM-designated route south of the weather at JKL555's current altitude, FL350.

The closest TFM-designated route is operating at full capacity at FL350; to fit another flight into this flow would mean additional delay to the flights that had filed for the route.

Rather than increase the delay to these flights by fitting JKL555 into the route in mid-stream, ATC offers JKL555 the following options: backtrack 200 miles west to fly the closest south TFM-designated route at its requested altitude, or backtrack 100 miles west and descend to FL260 to fly the next closest south TFM-designated route. For either option, JKL555 does not have sufficient fuel to fly to its destination, and requests to divert to another airport to refuel.

2325Z. Arrival push at ATL

Arrival delays at ATL of up to 35 minutes are predicted starting at 0030Z. Flight XYZ456, scheduled to arrive at ATL at 0055Z, is carrying 85 passengers who are to connect to flight XYZ160 for Reagan Washington National Airport (DCA). XYZ160, a Boeing 737-100 airframe, is scheduled to arrive at DCA ten minutes before DCA's noise curfew and therefore cannot incur a large departure delay. XYZ AOC considers different options to enable XYZ456 to arrive earlier.

Using an arrival management sequencing tool, the AOC examines the sequence of XYZ arrivals to ATL within the next 90 minutes. The AOC notices that four other XYZ flights are scheduled to arrive earlier than XYZ456. The AOC uses the arrival management sequencing tool to evaluate the ability and cost (in terms of time and fuel) of moving XYZ456 into the arrival "slot" of one of these four flights, and the AOC also evaluates the impact of further delay to the other flights.

The AOC decides to exchange the arrival slots of XYZ456 and XYZ789 so XYZ456 can arrive in time for the 85 DCA-bound passengers to connect with XYZ160. The AOC telephones the Command Center to explain the situation and to discuss the rerouting required to enable the change in arrival times. The Command Center evaluates the impact on traffic congestion of rerouting both flights, finds none, and agrees to XYZ's request.

The Command Center contacts the traffic managers of Miami Center and Memphis Center, through whose airspace XYZ456 and XYZ789 are currently flying. These traffic managers notify the operational supervisors of the new plans for each aircraft. At the same time, the AOC radios the pilots of each flight and tells them to expect a new clearance from ATC. The controllers issue the clearances to the pilots and also amend their flight plans.

Section 4

Suggested Procedural Changes and Capabilities for the Midterm

The Collaborative Routing scenario suggests the existence of enhancements to current procedures and decision support capabilities for TFM and AOC personnel. A summary of the suggested changes in operational procedures and in TFM and AOC automation capabilities for the midterm is presented in this section.

4.1 Suggested Procedural Changes

- Increased use of NAS status information and aviation significant weather information through such means as an FAA Internet Web site and through electronic means to an FAA-maintained database
- Continuous update of demand information through the following:
  - Airspace users' submitting initial flight plan information as much as 12 hours in advance of departure
  - Airspace users' updating flight plan information, as needed
  - FAA's revising demand information, as a result of airspace user updates of flight plan information
- Advance notification to airspace users of possible SWAP departure and arrival routes
- Increased opportunities to fly non-ATC preferred routes (NRP)
- Increased opportunities for the airspace user to specify preferences in the flight plan (for example, to depart over one departure fix rather than another)
- Timely feedback from the FAA to properly equipped airspace users of the acceptability of a flight plan being filed
- Use of a commonly agreed-to weather forecast among FAA facilities and airspace users (the "consensus" forecast)
- Use of collaboration sessions to moderate demand for the predicted capacity, or, when possible, moderate capacity to satisfy the demand
- Ability of airspace users to keep up-to-date on the FAA decision-making process, such as via regional hotlines and the electronic chalkboard
- Increased opportunities for the airspace user to express preferences when rerouting becomes necessary
- Increased opportunities to depart at and remain at lower altitudes ("tunneling")
- A method to equitably allocate capacity when demand exceeds capacity

- Ability for air carriers to make adjustments in the assignment of aircraft to their "arrival slots"

4.2 Suggested Capability Changes

4.2.1 FAA Traffic Flow Management

- An ATC computer system that is able to process 4-dimensional flight plans which contain user preferences
- Capability to continuously update NAS status and demand information
- Capability to enable FAA facilities and airspace users to access NAS status and demand information, both visually and via electronic means
- Capability to forecast congestion on a sector-by-sector basis for up to 12 hours into the future
- Capability to identify flights to be affected by predicted congestion or reduced capacity
  - Tools to define airspace where traffic flow needs to be managed due to congestion or weather
  - Tools to inform AOCs of affected flights
- What-if tools to evaluate the impact of proposed reroute strategies
- Capability to permit FAA-FAA and FAA-airspace user information exchange and visual collaboration. This would permit such real-time sharing of situation data and decision support tool results as the following among FAA and airspace users:
  - Current and forecasted severe weather
  - Airspace congestion and TFM restrictions
  - Current and planned TFM restrictions
  - Problem resolution proposals and associated impact assessments

  This would also support the real-time sharing of routing and other strategies.
- Infrastructure to issue TFM advisory messages and notices of collaboration sessions to airspace users

4.2.2 AOC

- The ability to file a 4-dimensional flight plan with user-preferred routes and altitudes, and with other user preferences
- The ability to obtain NAS status and aggregate demand information visually or by electronic means
- An interactive flight planning capability that enables the user to receive timely feedback on the acceptability of flight plans

- A flight plan “probe” capability to identify hazardous weather, active SUAs, TFM restrictions and constraints, infrastructure outages, and areas of expected congestion that would affect a proposed route of flight
  - Flight plans are checked automatically to ensure that TFM constraints are not violated
- Capabilities to permit FAA-airspace user information exchange and visual collaboration. These capabilities would support the collaborative development of routing and other strategies
- The capability to file “intended” routes with the ATM computer system 12 hours in advance of planned flight departure times, and to update this information, as needed
- An arrival management sequencing capability to view the sequence of arrivals to a given airport and to estimate the time and fuel to move a flight’s arrival time into a different “arrival slot.”

Section 5

Issues for Further Discussion

During the course of the development of the Collaborative Routing scenario, issues arose that require further discussion and study.

5.1 Flight planning

- The scenario suggests that air carrier users *submit* the first flight plans 12 hours prior to scheduled departure and *update* the flight plans when there are changes. Is this acceptable to airspace users? Is there a less cumbersome way for the ATM system to obtain necessary demand information?
- How far in advance do the airspace users who are not air carriers submit the first flight plan for their flight? Wouldn't they need to follow the same process as an air carrier in supplying demand information?
- When does the ATM system need to have the *filed* flight plan?
  - The scenario implies that the ATM system treats the filed flight plan differently from the submitted flight plan. For example, it does acceptance checking on the filed flight plan (see the 1720Z scenario). Does this seem like a reasonable approach?
- Who should amend the filed flight plan and under what conditions? the AOC? the pilot? TFM? ATC?
- In the future, shouldn't we expect all flight plans to be *accepted* (not *approved*, as FAA does not approve flight plans today) by the ATM system, as long as they avoid active SUAs or other military/space/sensitive airspaces?
- Should flight plan filing be thought of as "reserving NAS resources"–that is, when a flight plan is filed and accepted by the ATM system, then the airspace, arrival slots, and departure slots "belong" to that user (barring an unexpected event, such as an emergency)
- If so, should such a reservation be considered first come-first served? That is, if XYZ and ABC file identical flight plans but XYZ files earlier than ABC, does the XYZ flight have priority over the ABC flight?

5.2 FAA notification of conference or NAS status changes

- Is placement on the Web sufficient?
- Under what conditions should advisories be sent?

5.3 Equity

- What is a fair way to allocate limited capacity among the users in the 2105Z situation? Should the FAA have the responsibility of doing such an allocation, or do users want to work it out among themselves? Or, should capacity be accessible on a first come-first served basis (see also Section 5.1)?
- Should the FAA set aside capacity for the smaller airspace users (for example, business jets and other general aviation users?)
- Should favorable consideration be given to those airspace users who were proactive and agreed to replan earlier (see 2152Z scenario)?
  - If so, what are examples of forms of "favorable consideration"?
  - Is it acceptable to not reward those who did not agree to be proactive and take early pain?

5.4 Departure SWAP Routes

- In the situation described at 1900Z, is there enough time for the flight to avoid delays caused by the announcement of a new SWAP route?
- Is this an agreeable and legal scenario?

5.5 Collaboration Session

- Is it acceptable for the process of collaboration to take the form of negotiating sessions – for example, in rounds – as illustrated in the 1830Z and 1855Z scenarios? If so, how many rounds of collaborating is "enough"?
- Supposing that in the 1830Z and 1850Z scenarios, the AOCs' voluntary actions did not reduce demand sufficiently, would it be preferable for TFM to hold a third round during which users would have been asked to replan additional flights in order to reduce demand to a manageable level, or have TFM decide which additional flights to maneuver?
- Had users still not voluntarily reduced demand sufficiently, the FAA would have mandated a solution, such as "XYZ, find four flights to remove from this airspace in this time period." Is this example a reasonable scenario? legal? desired?
- Is it acceptable for users to refuse to fly TFM-specified routes (such as what are called "weather routes" or "(en route) SWAP routes" today)?
- Is it acceptable for TFM to allow ABC and JKL Airlines to not replan, as the other AOCs have? (Fair? Causes too much gaming of system? Causes other users to not be proactive?)
  - Or, should the FAA be able to say, "Find a way to get out of this airspace because you're not flying it at all"?

- Or, should the users be allowed to say, "Look, if I want to fly there, let me suffer the consequences of my actions"? What should be the FAA's responsibility in this case?

- Does the situation described in the 2105Z scenario, where limited capacity is expected to be temporarily available, present a reasonable opportunity for collaboration? (See also Section 5.3)
- Are the time periods suggested (in the 1815Z -1855Z scenario and in the 2105Z scenario) reasonable for such collaboration to take place?

5.6 Lead Time for Collaboration

- What is a sufficient amount of time before the onset of an event for users to collaborate with FAA on routing options?
  - For departure-related situation?
  - For en route-related situation?
  - For arrival-related situation?

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Glossary

AAR	Airport Arrival Rate
AOC	Aeronautical Operational Control
ATA	Air Transport Association
ATC	Air Traffic Control
ATM	Air Traffic Management
ATL	Atlanta Hartsfield International Airport
ATCSCC	Air Traffic Control System Command Center
CAASD	Center for Advanced Aviation System Development
CDM	Collaborative Decision Making
CE	Concept Exploration
CONUS	Contiguous United States
DCA	Reagan Washington International Airport
DEN	Denver International Airport
FAA	Federal Aviation Administration
FCA	Flow Constrained Area
LAX	Los Angeles International Airport
MIT	miles in trail
NAS	National Airspace System
NRP	National Route Program
OMA	Omaha Eppley Airfield Airport
ORD	Chicago O'Hare International Airport
PHL	Philadelphia International Airport
STL	Lambert St. Louis Airport
SUA	Special Use Airspace
SWAP	Severe Weather Avoidance Plan
TFM	Traffic Flow Management
US	United States