

The terminal area is our most dangerous area because [aircraft] are converging, because there is a mixture of high speed and low speed[aircraft], and because there is a mixture of controlled and uncontrolled flight. – Najeeb Halaby¹

From Flow Control to Air Traffic Flow Management

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The Federal Aviation Administration's (FAA) predecessor agency, the Civil Aeronautics Administration (CAA), anticipated and began planning for flow control measures at the end of World War II. Concerned that post-war increases in air traffic would cause delays throughout the national airspace system, the agency adopted a number of new procedures to help relieve congestion in metropolitan areas. When procedures alone, could not correct the concerns, the agency looked for technological solutions to the problem.

In 1969, the FAA established an experimental Air Flow Control Center at its headquarters in Washington, DC. The agency made that facility permanent, and on July 29, 1970, it replaced it with the Air Traffic Control Systems Command Center (ATCSCC) to integrate the functions of the Central Flow Control Facility, Airport Reservation Office (ARO), Air Traffic Service Contingency Command Post, and Central Altitude Reservation Facility (CARF). This marked the beginning of a fifty-five-year journey of evolution, innovation, and growth as the FAA and ATCSS staff worked to meet the demands of the national airspace system and establish the concept of cooperative global air traffic management.

By the time the FAA established the ATCSCC, demand began to exceed the capacity of airports and airspace, initially in the northeastern section of the country. The 1970s saw the first

central flow control office begin to control departure times and routes to make the system more efficient. In the following decades, collaborative discussions to increase efficiency yet allow air traffic to flow safely led to today's Collaborative Decision Making (CDM) process. CDM enhances national airspace system (NAS) safety and efficiency by transitioning from a centralized command and control system to a distributed planning system. It is a joint government/industry initiative to improve air traffic management through increased information exchange, shared situational awareness, equitable resource allocation, and performance analysis.

Planning for Flow Control

As World War II began winding down and air traffic grew exponentially, the aviation industry, military, and the Department of Commerce Civil Aeronautics Administration (CAA) began discussing how to improve the air traffic control system. On March 27, 1945, an interdepartmental memorandum between the State, War, Navy, and Commerce Departments set up the Air Coordinating Committee (ACC) to achieve an integrated and coordinated federal aviation policy. On September 19, 1946, President Harry Truman formally chartered the ACC. Membership included the State, War, Navy, Post Office, and Commerce Departments, the Civil Aeronautics Board, and the Bureau of the Budget (nonvoting member). Subsequent executive orders changed the ACC's membership until the committee was abolished in October 1960.

On June 12, 1947, at the request of the ACC, the Radio Technical Commission for Aeronautics (now known as RTCA) established a special committee (SC) 31 to study and develop recommendations for the safe control of expanding air traffic. RTCA, established in 1935, comprised members of the aviation community (private industry, government, academic, and research and development) with an interest and skill in aviation and willing to provide their

expertise as volunteers to produce engineering standards documents. In 1948, SC-31 recommended developing an air traffic control system using VHF omnidirectional range (VOR) and distance measuring equipment (DME) as the primary navigation system. The committee also saw the need for airport surveillance radars at busy airports and air traffic control centers in its report.²

Regarding terminal airspace, they argued that the development and deployment of semi-automated computer equipment would be instrumental in developing flow control procedures into and out of busy airports. The flow control in a low-traffic area could be accomplished by occasional position reports from the aircraft to the controller, manual posting boards, and manual sequencing. In the most crowded terminal areas, continual radar position determination, automatic monitoring, and resequencing of aircraft, where necessary, would be required.³

The committee members said the major item necessary for the flow control system in high density terminal areas would be the development of a computer able to receive reports from the radar system, as well as the desired flight plans from flight-path-planning equipment and information about weather and icing conditions which could temporarily shut down specific air routes. Based on data generated by the computer, the flow control system would monitor the flight of all aircraft in its area to ensure that any changes introduced into the flight path because of pilot error or change of weather had not introduced hazardous conditions. The SC-31 committee expressed the acute need for careful system engineering rather than unplanned accumulation of gadgetry.⁴

In 1949, CAA Administrator D. W. Rentzel⁵ further explained the need for automated flow control procedures, “The increasing military use of jet aircraft has introduced a serious complication into air traffic control. A conventional airliner carries substantial fuel reserves.” He continued, “However wasteful and inefficient the process, an airliner can, if necessary, hold near an



Delos Rentzel
Courtesy: FAA

airport for long periods awaiting its turn to land. Jet planes have no such fuel reserve; unless they can be assured of an immediate landing, they must operate far below their normal ranges." He posited, "The answer to this problem lies in traffic flow control, which assures a reserved landing time for each aircraft before it leaves the ground. The transition program will meet the immediate needs of jet aircraft in this respect, and the ultimate system will provide complete flow control."⁶ Rentzel predicted

completing the flow control project would take ten years."⁷

Rentzel's ten-year prediction failed to become a reality. Despite the need to modernize the air traffic control system, developmental projects moved slowly, as do most research and development programs. In addition, post-war CAA budgets could not fund large development projects, especially during the Korean War and the beginning of the Cold War. National security needs outweighed improvements to the national airspace system at the time.

On May 4, 1955, President Eisenhower requested William Barclay Harding to serve as a consultant to study long-range requirements for aviation facilities and aids. Harding's Aviation Facilities Study Group submitted its report on December 31, 1955. Concluding that the need to improve air traffic management had already reached critical proportions, the group recommended that an individual of national reputation, responsible directly to the president, be appointed to provide full-time leadership in developing a program for solving the complex technical and organizational problems facing the government and the aviation industry.

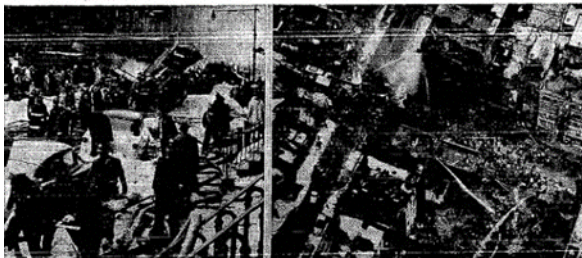
On February 10, 1956, following approval of the Harding Committee recommendations, President Eisenhower named Edward P. Curtis his Special Assistant for Aviation Facilities Planning. He directed Curtis to coordinate "a long-range study of the Nation's [aviation facility]

requirements," to develop "a comprehensive plan for meeting in the most effective and economical manner the needs disclosed by the study," and "to formulate legislative, organizational, administrative and budgetary recommendations to implement the comprehensive plan."

Curtis submitted his final aviation facility planning report on May 10, 1957. He warned of a crisis in the making as a result of the inability of the airspace management system to cope with growing congestion and complex patterns of civil and military traffic.⁸ He recommended the establishment of an independent Federal Aviation Agency "into which are consolidated all the essential management functions necessary to support the common needs of the military and civil aviation of the United States."⁹ Curtis's recommendations for improving air traffic included setting aside all airspace above a designated altitude for controlled separation at all times and dividing certain airspace below this zone into funnels reserved for instrument flight rule (IFR) traffic.¹⁰

As a result of those recommendations, the 1956 midair collision over the Grand Canyon, and the passage of the Federal Aviation Act of 1958, a new Federal Aviation Agency (FAA) stood up in December 1958. By then, it became abundantly clear that the predominately manual air traffic control system could no longer keep up with increasing air traffic. Airport safety and capacity had to increase to prevent system delays. Schedule delays also cost the air carriers millions of dollars annually, not to mention the cost to passengers over and above inconvenience and discomfort.

TOLL RISES TO 134 IN COLLISION OF PLANES OVER NEW YORK CITY



Debris Fires 10 Buildings
Jet Narrowly Misses School; Worst Crash in Aviation History
NEW YORK (AP)—Two airliners, one a jet, collided in the air Friday and plunged down into New York City. There were 134 persons killed in the worst disaster in the history of aviation.
Of 128 persons aboard the two planes, the sole survivor was one small boy.
The jet plunged into a crowded block of ten-story buildings, killing a group of children at their school and other persons. A third plane and a car escaped with four deaths and injuries.
The other plane, a four-engine, propeller-driven model, apparently exploded and came down in a burning streamer in Hudson Street, across the harbor mouth at New York Harbor. It failed to ignite and, during earlier investigations, broke apart.



The Post-Standard (Syracuse, New York), December 17, 1960

Terminal area concerns became abundantly clear on December 16, 1960, when United DC-8 and a TWA Super Constellation collided in midair over Brooklyn, New York, killing all 128 occupants on

board the planes and eight people on the ground. In its report of the accident's probable cause, the Civil Aeronautics Board determined that the United flight had proceeded beyond its clearance limit and the confines of the airspace assigned by air traffic control. The DC-8's high speed, coupled with a change of clearance that reduced the distance the aircraft needed to travel by approximately eleven miles, contributed to the crash. The Board concluded that the crew did not take note of the change in time and distance associated with the new clearance. The crew's workload was increased because one of their two VOR radio navigational receivers was inoperative, a fact unknown to controllers. As a result of the accident, the FAA required that pilots operating under instrument flight rules report malfunctions of navigation or communications equipment and prohibited aircraft from exceeding 250 knots within 30 nautical miles of a destination airport and below 10,000 feet. The agency also required airlines to equip all turbine-powered aircraft with distance measuring equipment, or DME, except for specific military jets requiring a higher minimum speed for safe operation and other steps to strengthen air traffic control procedures.¹¹

The accident highlighted that separating traffic in metropolitan areas where traffic is converging into and out of multiple airports remained a complex and serious problem. The FAA provided nationwide radar coverage of airborne traffic at the time of the accident. Controllers separated air traffic arriving and departing major metropolitan airports by having pilots fly laterally over prescribed routes defined by radio navigation and vertically by altimetry. Terminal radar was needed to provide real-time monitoring to allow controllers to resolve conflicts and sequence aircraft more accurately.¹²

On March 8, 1961, President John F. Kennedy requested the FAA's second administrator, Administrator Najeeb Halaby,¹³ "to conduct a scientific, engineering review of our aviation



facilities and related research and development and to prepare a practicable long-range plan to ensure efficient and safe control of all air traffic within the United States." In response, the administrator established the Project Beacon task force. This study group brought together eight recognized experts in aeronautics and related technologies under the chairmanship of Richard R. Hough, vice president-operations of the Ohio Bell Telephone Company.¹⁴

The task force submitted its report on September 11, 1961.

While finding that the air traffic control system was "expertly operated by a highly skilled organization," the report's authors concluded that substantial improvements were needed to meet the future challenge of aviation's projected growth.¹⁵ The FAA urgently needed an overall systems plan. In effect, they said improvement would involve a major reorientation of the modernization effort launched in 1957 following the Curtis report. Keyed to using an air traffic control radar beacon system (ATCRBS) as a primary means of providing controllers with aircraft position information, the new concept found little promise in ground-based altitude measuring devices such as the 3-D radar under test as part of the earlier program. The report urged expanded use of general-purpose computers rather than unique computer systems formerly under development for air traffic control.¹⁶ Task force members also urged various changes involving airports, such as the segregation of controlled traffic, all-weather landing systems, and the extension of positive control and weather information.¹⁷

Regarding terminal areas, the report's authors noted, "The present terminal area system achieves safety of operation through delay." They warned, "As the level of traffic in the more crowded terminal areas increases over the next 5 to 10 years, the present system will require

substantial improvement to avoid increased delay and a serious, if not impossible, problem of maintaining safety.”¹⁸ On November 7, 1961, Kennedy directed Halaby to carry out the report's recommendations. Halaby established a System Design Team within the Systems Research and Development Service to develop a comprehensive system plan to carry forward the guidelines of the Project Beacon report. The team issued its long-range plan for “National Airspace Utilization” on June 30, 1962. The plan’s writers, however, warned that the plan was not static and “must grow and evolve with changing conditions and with new technology.”¹⁹

While waiting for the plan to improve safety and efficiency in terminal areas, on December 26, 1961, the FAA issued the first national standards for conducting flight operations on and around all controlled airports throughout the country. At airports providing federal traffic control tower service, the new rules established airport traffic areas, approach and departure procedures, and pattern altitudes; required two-way radio communications; and set airspeed limits within the airport traffic area. The airport traffic area affected was defined as airspace within a five-mile horizontal radius from the airport's center extending from the surface up to 2,000 feet.²⁰

Early Technology Developments

The “National Airspace Utilization” plan proposed developing an automated flow control process, then called the metroplex terminal project for busy airports.²¹ According to the agency’s Systems Research and Development Office, metroplex terminal area planning necessitated the development of computerized equipment in concert with radar. The metroplex terminal concept called for a team of air traffic controllers to carry out the functions of marshaling traffic, planning arrival and departure traffic flow, and delivering clearances to pilots. Arrival and departure planning would be performed on a centralized basis for all the airports within the metroplex terminal area.

Generally, one or two controllers would carry out the planning function associated with the metroplex traffic, including satellite airport traffic receiving control service. Once the marshaling controller assigned or approved computer-generated schedule times, they would be remoted to the arrival and departure planning computer displays and the data processor.²²

An arrival planning console, equipped with a traffic board and fixed postings for the holding fixes, would serve as the feed points for incoming traffic at the airport. The fix postings would become holding stack boards when terminal area traffic exceeded the airport acceptance rate. The arrival controller would assign holding altitudes and expected approach clearance times for aircraft delayed at those points. Metroplex departure planners would use traffic and route boards. The latter included enroute fixes or geographic points near the end of each terminal departure route.²³

By 1966, the FAA had changed the name of the metroplex terminal area project to TRACON (terminal radar control) M, as part of the NAS En Route Stage A modernization program. The agency intended the NAS TRACON M to be deployed to metropolitan terminal complexes generating more than 300,000 instrument operations annually, typically including more than one major airport served by more than one radar system. A highly sophisticated automation package, TRACON M would be capable of alphanumeric display and tracking radar and beacon data. It would perform such computer-based functions as flight-plan processing and intersector coordination. Terminal areas meeting the requirements for TRACON M included New York City, Chicago, Los Angeles, Oakland-San Francisco, and Washington, DC. Since much of the equipment planned for TRACON M was similar to that being developed for the NAS En Route Stage A, testing and development paralleled that of the air route traffic control center (ARTCC) equipment, saving development time and money.²⁴ Despite completing the TRACON M system description

during fiscal year (FY) 1965, the FAA postponed the program in 1967 and redirected resources to the “more general problem of air-traffic control at medium-density terminals.”²⁵

With few system upgrades yet in place and with traffic growing exponentially, especially in the metropolitan New York area (called the Golden Triangle because of the proximity of LaGuardia, John F. Kennedy, and Newark airports), on January 15, 1969, the FAA adopted a new method of regulating the flow of traffic into that terminal area. The new procedures went into effect each time the delay forecast for IFR aircraft flying into New York exceeded one hour. When this happened, air traffic controllers would limit the flow of air traffic into New York by keeping New York-bound aircraft on the ground at their points of departure. Though the new procedures did little or nothing to reduce the delays incurred by New York-bound aircraft, they did reduce the time spent in airborne holding patterns to an hour or less. This, in turn, reduced congestion on the airways leading to New York and facilitated the flow of non-New York traffic using or crossing the routes.²⁶

As early as 1962, Najeeb Halaby noted the need for a metroplex in the New York airspace. He explained to Congress that the metroplex should be designed with the airlines because it “is like highway engineering, only it is airway engineering of all the routes, the letdowns, the holding patterns for this huge and densely populated airspace area in New York. They must change this from time to time, as traffic changes, or increases, as these facilities are installed or removed.”²⁷ Eight years later, Administrator John H. Shaffer²⁸ reiterated that since the Golden Triangle is often the key to delays in other parts of the country, “reducing congestion in this area, should produce beneficial effects throughout the system.”²⁹

On June 25, 1970, the FAA introduced significant changes in air traffic patterns and procedures to handle better traffic flow into New York. Known officially as the New York

Metroplex, the new procedures reduced traffic congestion in and around New York airports and accelerated aircraft movement along major north-south routes. Under Metroplex, primary holding patterns, or arrival fixes, were moved farther from the city's center for area airports. This enabled the FAA to add five new en route corridors, significantly increasing the number of departure routes, improving traffic distribution, reducing bottlenecks, and minimizing the crisscrossing of incoming and outgoing flight corridors.³⁰

Najeeb Halaby had earlier told Congress that the design of the metroplex, done in consultation with the airlines, “is like highway engineering, only it is airway engineering of all the routes, the letdowns, the holding patterns for this huge and densely populated airspace area in New York. They must change this from time to time, as traffic changes, or increases, as these facilities are installed or removed.”³¹ In explaining the need for the metroplex, FAA Administrator John H. Shaffer noted that since the Golden Triangle is often the key to delays in other parts of the country, “reducing congestion in this area, should produce beneficial effects throughout the system.”³²

Common IFR Room



The introduction of the new procedures, first scheduled for April 2, 1970, but delayed by an air traffic controllers strike, was made possible by the opening of the New York Common IFR room at John F. Kennedy International Airport. The new facility gave the New York area a greater and more flexible traffic handling capability than the older, unintegrated terminal control system.

The FAA began experimenting with the concept of a Common IFR Room at Chicago's O'Hare airport in 1962.³³ A Common IFR Room provided radar coverage of landings and takeoffs from one central location, which eased controller workload in the airport towers and improved efficiency and capacity in the national airspace system. By 1963, radar controllers in the Common IFR Room in Chicago handled O'Hare and Midway airport approach and departure control and smaller satellite fields in the area: Meigs, Du Page country, Glenview, and Palwaukee airports.³⁴ A Common IFR Room, also referred to as a Terminal Radar Approach Control (TRACON) facility, became operational at Oakland International Airport in October 1967.³⁵ The New York Common IFR Room opened in July 1968.³⁶

High Density Rule

During the summer of 1968, rising demand and work slowdowns brought on by tensions between the FAA and the new air traffic controllers union, the Professional Air Traffic Controllers Organization (PATCO), led to a 30 percent increase in airport delays nationwide. Limited airport capacity, overscheduling by airlines, and unlimited access to airports by general aviation compounded the problem. When airports could not handle the influx of traffic, the FAA allowed each affected air traffic control facility to initiate its own flow control restrictions that often conflicted with each other and created more severe national slowdowns.

In addition to the new Common IFR Rooms, the FAA issued the High Density Traffic Airports Rule, commonly called the High Density Rule, on November 27, 1968. The rule limited LaGuardia, John F. Kennedy, Newark, National, and Chicago O'Hare slots. Effective April 27, 1969, the rule placed quotas on IFR operations at the five airports between 6 a.m. and midnight. In a February 24, 1969, amendment to the regulation, the FAA delayed implementation until June 1,

1969. The amended rule assigned the following hourly quotas: Kennedy, eighty (seventy for air carriers and supplemental operations, five for scheduled air taxis, and five for general aviation); O'Hare, 135 (115 for air carriers and supplementals, ten for scheduled air taxis, and ten for general aviation); LaGuardia, sixty (forty-eight for air carriers and supplementals, six for scheduled air taxis, and six for general aviation); Newark, sixty (forty for air carriers and supplementals, ten for scheduled air taxis, and ten for general aviation); and National, sixty (forty for air carriers and supplementals, eight for scheduled air taxis, and twelve for general aviation).³⁷

The rule did not count other scheduled air carrier flights (such as hourly shuttle flights) against the established quotas except at Kennedy. The agency permitted the airport ten extra air carrier operations per hour during the peak traffic between 5 p.m. and 9 p.m. Until the FAA issued the rule, airports allocated slots on a first-come, first-served basis. As a result, during peak-demand periods, air carriers queued on the ground waiting to take off or remained stacked in the air waiting to land.³⁸

The FAA required pilots flying on IFR to reserve each operation into one of the five designated airports. Pilots obtained IFR reservations by contacting the FAA's Airport Reservation Office (established May 30, 1969) in Washington, DC, or any FAA flight service station. Under visual flight rules (VFR), aircraft had to reserve their arrivals about thirty miles from their destination. Air traffic control facilities serving the five high-density airports handled the departure reservations for VFR aircraft. The agency initially planned to discontinue the rule on December 31, 1969.³⁹

The agency, however, extended the rule to October 23, 1970. On that date, the FAA suspended the hourly limitations at Newark, where peak operations during fiscal year 1970 averaged eighteen less than the assigned quota of sixty.⁴⁰ On August 18, 1971, the FAA extended

the rule to October 25, 1972. Flight limitations remained unchanged at LaGuardia and Washington National, but at O'Hare and Kennedy, the FAA increased the quota time to between 3 and 8 p.m.⁴¹

An October 20, 1972, change continued the rule until the same date in 1973 when the FAA published another amendment indefinitely extending the regulation. At the same time, the agency eliminated the requirement that VFR pilots at the four airports file a flight plan. The requirement was no longer necessary since those airports now operated under the terminal control area concept, which required pilots to establish radio communications with the tower to receive permission to enter the terminal airspace.⁴² The agency continued to revise and extend the rule as needed.

Area Navigation

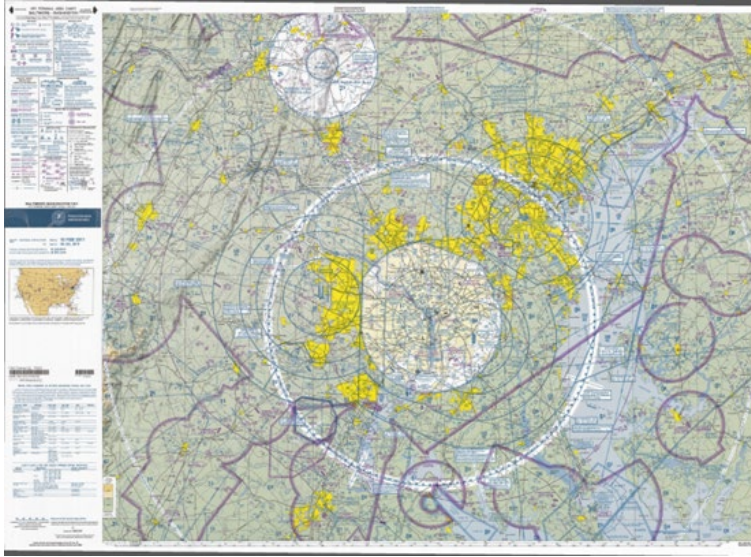
The primary air navigation system in the United States in the late 1960s and early 1970s required pilots to fly directly toward or away from a ground-based radio navigation aid (a VOR or VORTAC) transmitting a line of position or radial. This often resulted in congested airspace along the airlines and traffic jams into airports. To help resolve such issues, on October 1, 1969, the FAA opened sixteen area navigation routes between eleven U.S. cities on an interim basis pending formal rulemaking. The new routes became the first in a projected nationwide area navigation route system designed to increase airway capacity. The routes ran between the following cities: Chicago and New York (two routes); Los Angeles and Chicago (two routes); Kansas City and Minneapolis (two routes); San Francisco and Chicago (two routes); Atlanta and Pinehurst, North Carolina (two routes); Knoxville and Atlanta (two routes); Houston and Dallas (four routes). Additional cities were linked in succeeding months as the agency developed more routes.⁴³

With the success of the area navigation program, on March 6, 1972, the agency announced the establishment of a FAA-Industry Area Navigation Task Force to advise and assist in the further

application of the area navigation system. The action followed a January 24-25, FAA-sponsored international symposium on area navigation during which participants identified a need to review FAA's program. In subsequent months, the task force conducted in-depth studies and tests to assess the system's value and to determine how area navigation could most effectively be implemented. The test results generally confirmed the previously supposed advantages—that area navigation provided cost benefits by allowing an aircraft en route to stay higher longer, thus conserving fuel, and arriving at the descent point at precisely the correct time for a letdown without delays. In addition, by analyzing terminal area operations, the tests confirmed that area navigation equipment could move traffic at the same efficiency level as radar vectors while reducing controller workload by restoring greater responsibility to the cockpit. By the end of fiscal 1973, a nationwide system of high-altitude area navigation routes had been established consisting of approximately 156 route segments.⁴⁴

With area navigation, aircraft did not have to fly a track to or from a navaid, though they did depend on signals from VORs or VORTACs. Pilots flying appropriately equipped aircraft could follow any preselected arbitrary track within the system's limitations. An airborne computer calculated the aircraft's position and displayed track and distance to a point selected by the pilot or prescribed by the controller. The system's advantages included: routes could be established along the shortest and most convenient paths; parallel and one-way routes could be established to reduce congestion; aircraft could be segregated according to speed and destination; nav aids could be placed at accessible points on more favorable terrain; departure routes could be designed to lead directly from the runway to the appropriate parallel airway; and arrival routes could be designed to accept traffic directly from en route airways.⁴⁵

Terminal Control Areas



2011 Group II TCA, Baltimore-Washington
Courtesy: FAA

In a significant new safety rule effective on June 25, 1970, the FAA established the terminal control area (TCA) concept. The agency designed the rule, first proposed in September 1969, and re-proposed in revised form in March 1970, to minimize the midair collision hazard around the nation's

busiest airports. A TCA consisted of

controlled airspace within which all aircraft would be subject to special operating rules and pilot and equipment requirements. Although the boundaries of each TCA would be determined separately, their general shape resembled an "inverted wedding cake" with its smallest layer touching the ground. TCAs were broken into two categories, with the most congested locations designated as Group I. The rules for Group I required:

- Air traffic control clearance for all operations.
- Large turbine-powered aircraft to stay above the TCA's floor unless otherwise authorized by air traffic control.
- The speed limit beneath the TCA's lateral limits to be 200 knots (230 mph).
- Takeoffs and landings by solo student pilots to be banned.
- Aircraft to carry an operable two-way radio.
- Fixed-wing aircraft to carry an operable receiver for VOR or TACAN (standard navigation aids) and a radar beacon transponder. The transponder requirement did not apply to IFR operations to and from secondary airports within the TCA.

For Group II TCAs, the rules were the same as for Group I, except that solo student operations were not banned and that aircraft using VFR need not carry transponders. Because of this less stringent transponder requirement, air traffic control would provide added separation service—separation

from VFR and IFR traffic. The FAA tentatively selected ten locations as Group I TCAs and fourteen as Group II. Because of varying local conditions, the agency designated each by a separate rule, beginning with those in Group I. The agency established the first TCA in Atlanta on the same day as the TCA concept. It set the second in Chicago on July 23.

Central Flow Control

As the ARTCCs and TRACONS adjusted to the TCAs, high density rule, and area navigation, it became apparent that limitations on the controller's ability to collect and share information on activities caused domino-like delays in the national system. To diminish such delays, in 1968, Robert W. Martin,⁴⁶ chief of the Operations and Procedures Branch of the FAA's Air Traffic Service, led a small team of air traffic controllers and managers to study how the agency could reduce delays in the national airspace system. Martin, now regarded as "The Father of Traffic Flow Management," studied the flow control measures used in the New York metropolitan area to determine their applicability nationwide.⁴⁷

Martin suggested the development of a national central flow center that could maintain a "minute-by-minute watch around the nation of traffic tie-ups, weather conditions, and other factors affecting the flow of traffic." In May 1969, the FAA established an experimental Air Flow Control Center at its Washington, DC, headquarters in a small room on the 4th floor of Federal Office Building 10A (later moved to the 6th floor into a twenty-five-by-thirty-five-foot room⁴⁸). In the center, subsequently called the Central Flow Control Facility (CFCF or CF²), staff operated in a room filled with wall-to-wall teletype equipment and telephones linking the facility to all ARTCCs nationwide. One of the major technical hurdles that had to be overcome in the early days was the design and procurement of the teleconference bridge used to connect the centers for briefings. It

could not function with everyone on the line at one time, so CF² held an East and West conference daily. The agency subsequently added a new area to focus on routing issues. The first flow controllers volunteered for duty from across the United States, served six-week tours, and brought specialized knowledge of en route centers, airports, and agency regional operations.⁴⁹ Malcolm “Max” Champagne served as the first manager of the facility, followed by Lonnie Parrish.⁵⁰

The FAA initially only used the new center to apply restrictions at Newark Liberty, John F. Kennedy, and LaGuardia airports, Chicago’s O’Hare, and National Airport in Washington, DC.⁵¹ In January 1970, the FAA began a three-month trial of using the center nationwide. According to FAA’s air traffic chief, William Flener, the change’s purpose was to “rethink ATC [air traffic control] operational procedures” nationally. On May 10, 1970, Flener proclaimed to the *New York Times*, with central flow, “We found we could move a lot more traffic than we thought we could. We’re now planning to keep the center open full-time.”⁵²

The FAA declared the three-month experiment a success and worked to create and outfit a permanent center that could maintain a minute-by-minute watch for traffic tie-ups, weather conditions, and other factors affecting the nationwide flow of traffic. The controllers and managers at the CF² developed basic flow control first procedures just in time for a March 25-April 10, 1970, air traffic controller sickout. During that time, some 3,000 air traffic controllers, all members of the Professional Air Traffic Controllers Organization (PATCO), remained absent for a day or two, others for the entire seventeen-day period.⁵³ The command center successfully managed the national disruption through strategic planning and negotiations with the en route centers and industry.

On April 27, 1970, the FAA made the Central Flow Control Facility a permanent part of the air traffic control system. The facility took over from the air route traffic control centers some of the

responsibility for restricting the number of aircraft moving from the control of one center to another. Central flow controllers collected and correlated system-wide air traffic and weather data, using the information to prevent isolated clusters of congestion from disrupting the overall traffic flow. Linked by teletypewriter and telephone to all twenty-one centers, the facility detected potential trouble spots and suggested to the other centers such solutions as flow-control restrictions or rerouting.⁵⁴

The regional centers retained the authority to accept or reject the facility's recommendations. Still, managers could now make decisions based on broad information about the overall condition of the ATC system. Lacking such information, the centers had previously tended to be over-defensive. For example, when a traffic buildup forced one center to restrict the number of incoming aircraft from an adjacent center, the adjoining center might fear an impending traffic buildup in its area and institute restrictions against yet another center. The spreading restrictions could eventually affect IFR aircraft throughout the ATC system.⁵⁵

On July 29, 1970, the FAA established the Air Traffic Control Systems Command Center (ATCSCC) at its headquarters to integrate the functions of the Central Flow Control Facility, Airport Reservation Office (ARO), Air Traffic Service Contingency Command Post, and Central Altitude Reservation Facility (CARF).⁵⁶ In theory, establishing the command center would ease air traffic delays nationwide because the flow controllers could help reroute traffic or impose ground delays when congestion occurred. However, better systemwide information and communications could significantly improve the flow control process.

MITRE provided the initial automation support through its Advanced Flow Control Procedures software. The software ran the simplex 9020 system at Kansas City ARTCC and later moved to the Department of Transportation's Transportation Systems Center in Cambridge,

Massachusetts. Five GS-15 non-supervisory flow controllers ran the watches – Mike Ollis, Jim Hutchins, Joe Regan, Jim Lang, and Maurice Davis. Four GS-14's supported operations – Sam Rosenzweig, Bob Christopher, Merle Pitts, Wally Cronkite, and Roy Nelson – as well as two meteorologists – Fred Bear and Tex Eakin. Addison Scott ran the CARF.⁵⁷



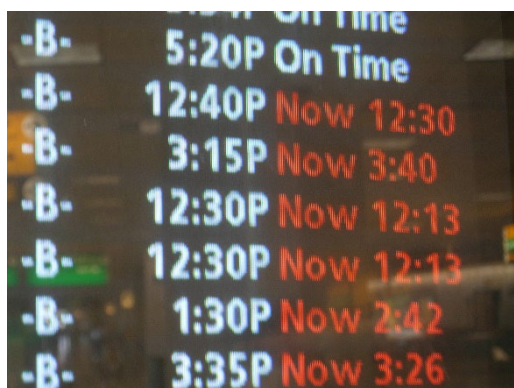
The FAA housed the computer system for the ATCSCC, the IBM 9020, in the Jacksonville, Florida ARTCC. In the fall of 1970, the FAA began experimenting with new data retrieval technology at fourteen airports. The prototype airport information retrieval system (AIRS), developed at the Department of Transportation's Transportation

Systems Center in Cambridge, Massachusetts (now the Volpe National Transportation Systems Center), could access departure and arrival scheduled times from the *Official Airline Guide (OAG)*. The first operational implementation of AIRS I began in January 1972. AIRS provided demand data for all domestic airports served by air carriers scheduled in the *OAG*. This capability is for scheduled flights only and did not provide for real-time flight progress input. The program offered primary data in hourly summary form for each airport's arrivals and departures.⁵⁸

On October 26, 1972, the FAA began operating central flow control on round-the-clock operations, changing from a sixteen- to twenty-four-hour daily operation.⁵⁹ The agency upgraded the facility's capabilities as computer and radar technology matured. During fiscal year 1973, for

example, the agency installed software that provided terminal demand and delay information for significant airports and continued to upgrade the facility as technology matured. Soon after, a new communications system linked all operating positions at the ATCSCC and all ATC facilities. This allowed flow managers to distribute the workload to specialists at the center. They divided the country into five geographical areas: the northeast, southeast, north-central, south-central, and west. Each specialist maintained direct contact with the air traffic control facilities in their geographical area.

During the 1970s, controllers began using quota flow procedures to ease en route delays. The FAA first used those procedures at the Chicago ARTCC when it became evident that controllers needed to limit operations during reduced acceptance rates at Chicago's O'Hare International Airport.⁶⁰ Rather than keeping aircraft in airborne holding patterns, controllers held aircraft at their departure airports until cleared for takeoff to a destination airport. Flow controllers temporarily imposed restrictions whenever they deemed it necessary based on factors such as heavy traffic concentrations, periods of peak traffic en route over specific routes, meteorological conditions, or any other circumstances that are disruptive to the normal flow of traffic.⁶¹ By the late 1970s, flow controllers used en route arrival software to help ensure efficient arrival flows based on an airport's arrival capacity.⁶²



Flight Status Screen showing delays
Courtesy: FAA

Controllers quickly recognized the need for substantial improvements to the automation support of the ATCSCC. As air traffic increased throughout the 1970s, the semi-automated system could not keep up with the growth. To avert congestion and delay problems before they surfaced, controllers pressed for a fast, dependable,

and accurate central flow control system that would be predictive rather than reactionary.

Understanding the need for better technology, the FAA continued to upgrade AIRS with new software as it became available. For example, in July 1972, the FAA implemented Advanced Flow Control Procedures, followed by Quota Flow in February 1973, Fuel Advisory Delay procedures in February 1974, and Expanded Flow Control.⁶³

The FAA designed the Quota Flow procedure to saturate safely the arrival center and the adjacent center airspace to keep a constant demand pressure in the arrival airport. Based on a review of scheduled and known demands, the software could estimate when the arrival center's maximum holding capacity would be reached. Once air traffic reached that point, the ATCSCC imposed an hourly quota. With a quota imposed, controllers would assign ground delays to the departures from the arrival and adjacent center areas to the affected airport, if necessary, to limit airborne holding. Long-distance flights originating beyond the adjacent center areas would generally be permitted to proceed to a point just short of the arrival center boundary, where a delay would be assigned.⁶⁴

Fuel Advisory Delay (FAD) protocols came from the need at the Chicago and Denver ARTCCs to limit center operations during periods of reduced acceptance rates at O'Hare and Stapleton terminals. FAD conserved fuel by detaining aircraft on the ground, with engines turned off, at the departure point until the ATC system could absorb the flight with no more than thirty thirty-minute delays.⁶⁵ Once FAD became operational at the original two ARTCCs, the FAA expanded its use to be applied to any terminal in the system. The subsequent "Quota Flow and Fuel Advisory Departure Test and Plan" process entailed having all centers and select airports work together to move a set quota of airplanes into a destination airport. When the number of aircraft at a destination airport queue became full, the ATCSCC controllers would contact all the centers and institute a quota for each.

The Expanded Quota Flow (EQF) program, developed in the late 1970s, replaced FAD.⁶⁶ Flow controllers generally implemented EQF to manage airport traffic with reduced capacities due to constraints caused by weather, airport construction, accidents, or equipment outages. EQF provided improved computer-assigned estimated departure clearance times, enabling the absorption of delays on the ground rather than in the air. Chicago O'Hare International Airport became the first airport to participate in the EQF program. Aided by the new technology, traffic management specialists would contact O'Hare tower controllers and inquire how many aircraft they felt they could land. They entered the number into a computer program that generated the quotas and issued the necessary departure times to meet the objective. As with other programs, the FAA adopted EQF procedures nationwide.⁶⁷

During congestion, EQF moved aircraft departures from one fifteen-minute block to a less busy fifteen-minute block. This reduced the controller workload but did not ensure equitable delays to system users. Controllers generally implement EQF about two hours before a forecasted problem to allow users to plan their activities. When the system problem abated, flow controllers would not abruptly end the EQF procedures. Instead, they would gradually stop the procedure because the sudden termination of a program would usually create another traffic congestion problem.⁶⁸

Deregulation and the 1981 Strike

The new competitive environment created by airline deregulation resulted in a greater demand for service, a change in flying routes as airlines formed hubs in major cities, and growing congestion throughout the aviation system. Congestion resulted from the interaction of many factors. The combination of fare decreases and hubbing led to increased air travel. However, the air traffic control equipment limitation and long lead times for airport expansion stymied system

capacity. As system complexity increased, so did calls for better technologies to keep the aviation system safe and efficient.

Research and development of new systems often proved complicated, time-consuming, and costly. The exploratory nature of research only sometimes resulted in successful production. In addition, the modernization of the national airspace system faced budgetary and political concerns and, in some cases, created international issues. Although the FAA had deployed a semiautomated air traffic control system in the mid-1970s, many believed only full automation could compensate for increasing system complexity and lessen controller workload. The agency had been fielding new technology incrementally as new tools and resources became available. However, FAA officials realized they needed a systematic, long-term plan for modernization. Only system modernization could address the safety concerns raised by the increasing commercial and general aviation accident rates.



Controllers on the picket line.

Courtesy: FAA

While struggling with modernization issues, the FAA also faced growing union concerns. By 1978, the FAA became convinced that the Professional Air Traffic Controllers Organization,

PATCO, planned to strike in 1981 when its contract with the agency expired. As a result, the agency began preparing to keep the national airspace system open during a strike. Contingency planning and developing a flow control process would be crucial to success. Between 1978 and the strike, the FAA modernized its central flow control facility to improve communication networks.

Air traffic managers held meetings with controllers in the centers, towers, regional offices, and central flow control facility to explain the facility's capabilities. They briefed air carrier operations officers on flow control procedures. Administrator Langhorne Bond⁶⁹ explained, “A whole lot of engineering, capital investment, and procedural development was put into the perfection of the Flow Control System.”⁷⁰

In September 1979, the FAA moved its flow control school from the FAA Academy in Oklahoma City to Washington, DC, where the administrator, air traffic division managers, and flow controllers learned more about a systems approach and flow controller responsibilities. By January of 1980, the FAA opened its classroom doors to include airline officers, chief pilots, and dispatchers along with U.S. commercial aviation entities and international air traffic managers. The new 50113 course launched a new era of cooperation among government, local and international, and the corporate world.⁷¹

When the PATCO strike began, on August 3, 1981, the FAA adopted Special Federal Aviation Regulation (SFAR) 44, establishing provisions for implementing an interim air traffic control operations plan. That plan allowed the FAA, among other things, to limit the number of aircraft in the national airspace system.⁷² The plan, dubbed Flow Control 50, required air carriers to cancel approximately 50 percent of their scheduled peak-hour flights at twenty-two major airports. The agency maintained an en route horizontal spacing between aircraft under instrument flight rules of up to thirty miles. Controllers kept aircraft on the ground, as necessary, to support this spacing. The agency prioritized medical emergency flights, presidential flights, flights transporting critical FAA employees, and flights dictated by military necessity. General aviation flights operated under the severest restrictions. The agency prohibited aircraft with a gross takeoff weight of 12,500 pounds or less from flying under instrument flight rules. It also prohibited aircraft flying under

visual flight rules from entering terminal control areas. Controllers served other general aviation aircraft, as conditions permitted, on a first-come-first-served basis.⁷³

From Flow Control to Traffic Management

By the early 1980s, advances in computing technology helped the agency shift from a tactical flow control concept to a more strategic traffic management concept. In December 1983, the ATCSCC began operational use of IBM 4341 computers. Called “the monster” by controllers,⁷⁴ the IBM 4341 had fourteen times more memory. It was 70 percent faster than the older IBM 9020A computer. It enabled a technological leap from one-way data communication between FAA HQ and regional centers to two-way communication and eliminating data relays through eight specific centers. The new network was physically co-located at the FAA Technical Center in Egg Harbor, New Jersey, and at a Department of Transportation facility in Boston, Massachusetts. “The monster knows where every plane is and where it's going” Sam Rosenzweig, an operations manager at the command center. “If things build up, the computer calculates the delays needed to sequence the individual flights into the individual airports.”⁷⁵

New computer networks, linked by landline to terminals used by Central Flow personnel at headquarters, laid the foundation for new traffic monitoring capabilities of aircraft in flight, as well as departure and arrival information. During Fiscal Year (FY) 1984, the FAA established Traffic Management Units (TMU) at the Air Route Traffic Control Centers and developed new computer programs to predict more accurately excessive en route air traffic congestion and to trigger traffic management action. The agency set Improved Engineered Performance Standards for twenty of the twenty-two pacing airports (which collectively enplaned 75 percent of all U.S. air carrier

passengers) to ensure efficient arrival flow and assist the airlines in developing more efficient schedules.

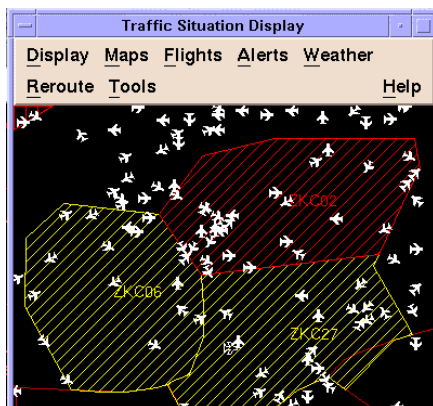
By the spring of 1985, a new automation effort further reduced the time and calculations required to manage flow control plans. Using a rationing algorithm known as Grover-Jack, ostensibly named after two controllers who helped design the software,⁷⁶ marked the beginning of the first automated ground delay program. The software used an airline's estimated arrival time published in the *OAG*. The system could not accommodate the dynamic changes system users made to their schedules. Grover-Jack proved inequitable and discouraged the airlines from providing accurate information. Because of a misaligned incentive structure, airlines would neglect to notify the FAA of flight delays or cancellations, and valuable airport arrival slots would often go unused. The agency quickly realized it needed more sophisticated technology to enable the Central Flow facility to make tactical and strategic decisions to keep air traffic running safely and smoothly and reduce the impact on the TRACON and tower controllers.

Despite efforts to reduce delays, by the mid-1980s, terminal delays increased to the highest level ever experienced. About 60 percent of the delays at the twenty-two pacing airports were attributable to six: Atlanta Hartsfield- Jackson International Airport, Chicago O'Hare, Denver Stapleton International Airport, New York John F. Kennedy International Airport, and La Guardia Airport, and New Jersey's Newark Liberty International Airport. Adverse weather primarily caused the delays, which involved only about 5 percent of the nation's scheduled flights. The FAA worked to counter such capacity and delay problems with traffic management improvements, concentrated controller training, voluntary adjustments in airline schedules, and other initiatives.⁷⁷ To better manage the en route flows of air traffic during the severe thunderstorm season, for example, the agency implemented a program titled Cluster Control in 1985. Cluster Control used long-range

weather forecasts and early weather tracking, facilitating earlier planning and redistribution of traffic flows, resulting in greater system efficiency and reduced delays.

In May 1985, the agency began using the Controlled Departure Time (CDT) software program. The CDT algorithm provided a more accurate traffic flow and reduced inequities in the delays received. It assigned each flight a specific delay rather than giving the same delay to all flights scheduled to arrive within the same fifteen-minute block. The FAA enhanced the CDT program in November 1985 to allow for further reductions in system delays. Upgrades to the system provided more efficiency by assigning delays to flights arriving via a specific route. The software moved flights from a high-demand period to periods of lesser demand. The resulting delays seldom exceeded twenty-five minutes. The CDT program provided the flexibility to manage air traffic on a single arrival route when the situation dictated, without impacting other arrival traffic.⁷⁸

On August 21, 1986, FAA's Air Route Traffic Control Centers handled 112,467 en route operations, the highest single-day traffic to that date. Record operations levels at many facilities in fiscal 1986 helped to create a 19.85 percent increase in delays as compared to the previous year. During the fiscal year, the FAA proceeded with the implementation of a Traffic Management System integrating certain air traffic control functions to create a more orderly traffic flow. Work also continued on the Expanded East Coast Plan, the first phase of which was scheduled for implementation in 1987. Under development since 1982, the plan was designed to alleviate congestion in the New York area and associated airspace through the use of additional departure routes and other techniques. During fiscal 1986, the FAA also deployed mobile "tiger teams," personnel with expertise in a variety of air traffic control disciplines, to improve traffic management in areas experiencing substantial delays.⁷⁹



By the late 1980s, the FAA invested capital to implement even newer traffic management capabilities to help controllers in the flow control facility at its headquarters and regional centers. The Aircraft Situation Display (ASD) and Monitor Alert software built upon the computer enhancement capabilities, enabling controllers to predict nationwide air traffic demands, leading to earlier corrective action. Controllers began operational use of ASD in May 1987. It allowed the ATCSCC computers to show every airplane being handled by air traffic controllers in any sector of the country. If the traffic flow showed potential congestion, flow control managers could advise controllers to reroute some traffic, slow down some aircraft, or expand the separation between some aircraft.⁸⁰ In 1988, the FAA added monitor alert software to ASD. The software automatically forecasted where congestion was likely to occur so flow controllers could anticipate problems before they happened.⁸¹ The FAA deployed the Flight Schedule Monitor (FSM), developed by Metron Aviation, system-wide in 1999 to the ATCSCC and over 100 other FAA facilities, as well as facilities in Canada and twenty-four domestic and international airlines, to facilitate CDM procedures.⁸²

A Unique Role for the ATCSCC

On August 24, 1992, Hurricane Andrew swept through South Florida, causing devastation that included damage to airports and resulting flight cancellations. The storm caused the most damage at the FAA's Richmond Long-Range Radar site and the tower and International Automated Flight Service Station at Tamiami Airport. Facilities at Key West lost communication lines, and other agency installations experienced significant damage, power loss, and outages. By the

following day, however, Miami, Key West, West Palm Beach, and Fort Lauderdale Executive airports reopened. The hurricane moved into Louisiana on August 26. During the height of the storm, most FAA facilities in the affected part of that state shut down or were placed on standby status, and several airports were temporarily closed.

The hurricane destroyed or badly harmed the homes of about 144 FAA employees in the Miami area, and the agency organized an airlift to provide emergency relief. A committee representing local agency organizations coordinated the distribution of supplies and funds donated by FAA employees throughout the country while the agency provided such benefits as administrative leave, counseling, and emergency loans. At the same time, the FAA rushed the restoration of airspace system facilities and supported the overall federal relief program.⁸³

During the hurricane and recovery efforts, the ATCSCC took on a new role as it became involved in providing ground services. The ATCSCC employees arranged for and coordinated the interstate movement of rescue vehicles providing food and other services from northern locations to south Florida. FEMA later modeled some of its disaster relief work on the action taken by the command center during the storm.⁸⁴

Collaborative Decision Making



Graphic courtesy of FAA

By the early 1990s, the FAA faced the overwhelming task of automating additional flow control activities. The challenge of converting paper to computer, finding space for massive information storage, and combining computer hardware, software, and communication networks into flow management systems required a range of data processing professionals, such as systems engineers, systems analysts, and automation specialists. Three such

specialists, Rick Oiesen, Ken Howard, and Michael Wambsganss, collectively known as the “Volpe Triplets” by controllers, in developing the next flow control software program, Enhanced Traffic Management System (ETMS).⁸⁵ The ETMS maintained and monitored national air traffic data and displays the data to traffic management specialists in various forms on a graphics display. The ETMS derives air traffic data from several primary input types: airline schedules from the *OAG*, messages generated by computers at twenty ARTCCs, oceanic position messages from ARINC, and directly from the Dynamic Oceanic Tracking System.

The airline schedule data files arrive weekly by communication link from the *OAG*. The messages are sent in real-time to the FAA Tech Center through the Inter-facility Flow Control Network. The ETMS processes airline schedules and NAS messages at the central site and stores the combined data in interrelated databases. The *OAG* file provides the ETMS with the planned schedules of all flights arriving in the United States or Canada, departing from the United States or Canada, or flying over the United States for the next month. The contents of the NAS messages provide the ETMS with the filed flight plans and the current state of IFR air traffic in the CONUS. The DOTS messages provide position updates for oceanic flights. It handles the substitution requests between the ETMS and the users.⁸⁶

On November 15, 1990, the FAA announced it had completed the first installation of the ETMS. It became operational nationwide on December 3, 1990. ETMS, subsequently renamed the Traffic Flow Management System (TFMS), provides information processing support for FAA traffic management personnel as they responded to excess demand conditions. TFMS receives information on planned and active flights, generates forecasts of demand from the current time to several hours ahead, presents this information to traffic management personnel, and provides automation support for traffic management initiatives to resolve or ameliorate congestion. The

program supports advanced planning for anticipated adverse or restrictive conditions. It also facilitates post-event analysis and evaluation of actions taken. TFMS archives the information it receives and generates, making it available for researchers and developers.⁸⁷ TFMS made possible the FAA's Airline Data Exchange (FADE) project, which developed a prototype system for distributed, collaborative planning among the FAA and the airlines, which later became the FAA's Collaborative Decision Making (CDM) program.

CDM's origin dates to September 1993, when the FADE experiment highlighted the benefits of NAS users providing real-time updated schedule information. The demonstration proved that FAA access to updated airline schedule information would positively aid air traffic management decision-making. This work led to the CDM concept. Flow controllers exercised the CDM concept in August 1994 in preparation for subsequent operational demonstrations with the airlines. Those human-in-the-loop tests resulted in a total reduction of 10 to 40 percent in assigned airline delays. In December 1994, the FAA conducted an exercise with the airlines at Metron Inc., in Reston, Virginia,⁸⁸ to measure the combined effects of improved decision-making. Depending on the airport and scenario, that test resulted in a 10 to 35 percent delay reduction.⁸⁹

Officially established in 1995, the CDM Program is now a joint government-industry initiative that develops new technology and procedures to ensure a safe and efficient national airspace system. The FAA and airspace users developed and agreed to the CDM Roles and Responsibilities in mid-1995 to enhance CDM use. In March 1996, they established the Communications Working Group to determine the communications link over which real-time data would be exchanged. The Collaborative Routing Working Group worked to determine the most effective means of negotiating flight routes between the airline operations centers (AOC) and air

traffic control before departure. In October, major airlines tested the CDM concept and applications using Flight Schedule Monitor (FSM) software to run “what if” scenarios.⁹⁰

The Communications Working Group debuted its AOCnet in February 1997, and it became operational in July with seven airlines. One year later, in January 1998, the FAA and airlines used San Francisco and Newark airports as CDM test sites. Initial results showed reduced delays by up to 48 percent and significant cost savings. Prototype operations then expanded to LaGuardia and St. Louis airports and, in September, extended to all U.S. airports. The FAA deployed the Flight Schedule Monitor (FSM), developed by Metron Aviation, system-wide in 1999 to the System Command Center (ATCSCC) and over 100 other FAA facilities, as well as NAV CANADA and twenty-four domestic and international airlines to facilitate CDM procedures.⁹¹

To support CDM operations, in March 1999, the DOT and the FAA established the CDM Hub Site at DOT’s Volpe National Transportation Systems Center to house the CDM software and hardware. The following month, the facility initiated CDM training for new airline participants. In June 2000, the CDM Ground Delay Program Enhancement (GDPE) program moved from prototype to operational status and became fully functional in the Fall of 2000.⁹²

FAA’s CDM program allows airspace users to share their data with the FAA’s traffic flow management system up to twenty-two hours before scheduled operations. It comprises representatives from government, general aviation, airlines, private industry, and academia who work together to create technological and procedural solutions to the Air Traffic Flow Management (ATFM) challenges faced by the NAS. The advent of collaborative decision-making (CDM) brought about significant changes that dramatically improved the efficiency of GDPs. With CDM, the FAA and the airlines agreed upon resource rationing algorithms as equitable means for improving GDPs.⁹³

TFMS provides information processing support for FAA traffic management personnel as they coordinate the use of the NAS and respond to conditions of excess demand. The system receives information on planned and active flights, generates forecasts of demand from the current time to several hours ahead, presents this information to traffic management personnel, and provides automation support for traffic management initiatives to resolve or ameliorate congestion. TFMS supports advanced planning for anticipated adverse or restrictive conditions. It supports post-event analysis and evaluation of actions taken. TFMS archives the information it receives and generates, making it available for researchers and developers. It collects and distributes metrics on the use of the NAS and the contribution of the Air Traffic Organization (ATO) to air traffic efficiency and effectiveness.

The advent of collaborative decision-making brought about significant changes that dramatically improved the efficiency of ground delay programs. With CDM, the FAA and the airlines agreed upon resource rationing algorithms as equitable means for improving ground delays.⁹⁴

Relocation

As flow control technology matured so too did the ATCSCC. On May 19, 1994, the FAA moved the facility from its headquarters building to rented space in Herndon, Virginia. Administrator David Hinson proclaimed during the dedication ceremony that the 29,000-square-foot facility would allow “the FAA to exploit rapidly changing technology by leasing facilities and computer services without the need for additional hardware investments.” Hinson continued, “Managing traffic flow to maximize system efficiency has become a core FAA strategy, and we are able to do it more efficiently in this new facility.”⁹⁵

The new center had eight large screen projection systems that provided controllers with a near-real-time picture of aircraft in the national airspace system. It included state-of-the-art workstations, 400,000 feet of fiber and copper cable pairs, and three communications distribution networks. It allowed U.S. controllers to share data with their Canadian counterparts as the FAA worked to establish a similar collaboration with the United Kingdom and Mexico. As Hinson explained, “Ultimately, we envision a worldwide linkup of all air traffic flow management systems for real-time sharing of demand and capacity information,” creating a global air traffic communications system.⁹⁶

In 1997, the FAA rededicated the Herndon facility as the David J. Hurley Air Traffic Control System Command Center.⁹⁷ In remarks at the ceremony, Jack Kies, the center’s manager, noted that Hurley “was instrumental in redefining the role of air traffic flow management and its global implications. . . . His vision became our reality.”⁹⁸

From CDM to Strategic Intelligence

The annual growth of air transport necessitates solutions to ensure operational efficiency and security in air traffic management. Air traffic flow management and collaborative decision-making are processes that help balance demand against capacity and increase operational

David J. Hurley

The maturation of electronic traffic flow management in the 1980s made visionary thinking possible on new ways to elevate information-sharing and collaborative decision making in previously unknown ways. David J. Hurley (1938-1997) was one such visionary.

Early in his career as an air traffic controller, Hurley recognized the importance of system planning and full automation of the air traffic control system. He played a crucial role in redefining traffic management and positioning it to meet future challenges.

Hurley worked tirelessly on relocating the Command Center from its location in FAA Headquarters to a much larger space in Herndon, Virginia. He also played a key role in redefining the Traffic Management Organization and positioning it to meet future challenges.

As you enter the operations room of the Command Center, there is a prominently displayed portrait of Hurley. Along with the picture is a sentiment which states, “His vision . . . our reality.”¹

coordination between aviation stakeholders, creating a safer, more efficient traffic flow. Those processes included both strategic and tactical operations.

Within the past five years, new systems and modes of information sharing have enhanced traditional air traffic management methodology, helping the Air Traffic Organization gain a more holistic picture of the health and status of the national airspace system. Two major events highlighted the need for strategic intelligence and accelerated evolutions to the Air Traffic Organization's daily strategic and tactical response.

On September 11, 2001, nineteen radical Islamic extremists with the group al Qaeda penetrated security at three major airports, seized four U.S. domestic airliners, and turned them into missiles that destroyed the World Trade Center in New York City, and damaged the Pentagon in Arlington, VA, killing thousands. For the first time in history, the FAA, through the ATCSCC, issued a ground stop for all U.S. air traffic. FAA Headquarters, the Air Traffic Control System Command Center (ATCSCC), the Northeast Air Defense Sector (NEADS), and various air traffic control facilities, established a conference call to coordinate information concerning the hijacked aircraft. The original conference, initiated to coordinate NAS security, evolved into what is now referred to as the Domestic Events Network (DEN).

Before the attacks, the FAA received information that the Intelligence Community believed had a bearing on aviation, and FAA intelligence analysts then screened that information looking for credible threats. This often meant the FAA did not receive all the intelligence that might have a bearing on aviation. The 9/11 Commission made numerous recommendations that led to cultural, capability, policy, and process changes to improve collaboration. The DEN, perhaps one of the most enduring symbols of post-9/11 reforms in information sharing, now facilitates the sharing of

operational information in real time between Departments and Agencies across the Federal Government to ensure shared situational awareness and support coordinated action.⁹⁹

The DEN is a 24/7 interagency unclassified telephonic conference dedicated to real-time coordination of NAS security. Information is shared via the DEN so that federal, state, tribal, and participating local government agencies can come together to analyze an incident and form a collaborative Interagency response on how to manage the event.

The ATCSCC also played a key role on September 26, 2014, when an arsonist set fire to equipment in the basement of the Chicago Air Route Traffic Control Center in Aurora, Illinois. The fire caused substantial damage to the FAA Telecommunications Infrastructure (FTI) system, which allows the Chicago Center to digitally share flight data throughout the NAS, resulting in the grounding and diversion of thousands of flights. Numerous elements within air traffic, technical operations, and system operations worked together to recover and restore operations, which occurred on October 13. Other real-world incidents such as the Haiti earthquake (2010), Hurricane Irma (2017), Hurricane Humbert (Bermuda, 2019), and the Covid-19 pandemic (2020) reinforced the need to provide a consistent nationwide process for the FAA and the ATCSCC to prepare for, respond to, and recover from significant events in the NAS and global sector.

Another Relocation

The Command Center relocated again in March 2011 to the Vint Hill area of Northern Virginia near Warrenton. The new 63,000-square-foot state-of-the-art facility sits on a thirty-three-acre parcel of land shared with the Potomac Consolidated TRACON (PCT). The combined ATCSCC/PCT site is the first facility within the FAA, sharing infrastructure telecommunications and security resources, backup power, maintenance services, and Technical Operations staff.¹⁰⁰

The Command Center is the world's largest, such facility, providing the dynamic interface and coordination of all air traffic movement, both civil and military, in domestic and oceanic airspace, along with the services provided by air traffic control field facilities. On a day-to-day basis, the ATCSCC determines the need for national and international traffic management initiatives throughout the NAS. With the latest technology and telecommunications systems, staff collaborates with FAA headquarters and field facilities in response to real-time system operational needs and requirements, regulating the flow of air traffic to minimize delays and congestion while maximizing the overall operation of the NAS.

The Center's over fifty-year saga is a story of technological growth, the diverse contributions of countless FAA employees—engineers, scientists, air traffic specialists, managers, and visionaries—and their diligent work towards its daily success. From the ATCSCC, the FAA coordinates up to 50,000 flights in the U.S. per day; over a quarter of the world's scheduled flights arrive at or depart from U.S. airports. With 5,000 aircraft in the nation's skies during the busiest periods, numerous experts from government agencies and the aviation industry work seamlessly through a process called collaborative decision-making to manage current and future constraints in the system. They discuss flight planning, weather, runway construction, the movement of dignitaries, and other issues that may impact the system.

The Center is home to the ATO Space Operations Team, a team of air traffic and commercial space transportation experts who track all U.S. launch and reentry operations, the status of various mission events, and the display of aircraft hazard areas. The team uses automated data through a Space Data Integrator (SDI) tool to make airspace management decisions about aircraft routes and schedules during launch and reentry operations. As the number of commercial space launches grow annually, the enhanced monitoring and sharing of space operational data through

FAA communications and decision-making tools plays a key role in minimizing delays for traditional air traffic users.

In addition to the growing demands of national air travel, the Command Center has also been called upon to act as the nation's first responders to crises, at home and abroad, an evolution into the 21st century with the creation of the Joint Air Traffic Operations Center (JATOC). On August 24, 2018, the FAA authorized the establishment of the JATOC. The JATOC's mission is to integrate Air Traffic Organization (ATO) service units, enabling a unified ATO response effort to significant incidents and other major events or natural disasters that adversely impact the NAS or national security. JATOC personnel are responsible for:

- Synthesizing information, data, and intelligence regarding constraints, risks, and threats to the NAS and delivering comprehensive and timely reports to ATO leadership and other appropriate stakeholders.
- Operating as the ATO's command and control element.
- Integrating the ATO's diverse operational capabilities at a single location.
- Leveraging commonality of mission requirements.
- Eliminating operational overlap by consolidating information into a single source message.
- Supporting and making efficient use of personnel and resources.

The Future



The annual growth of air transport requires solutions to ensure operational efficiency and security in air traffic management. Air traffic flow management and collaborative decision-making are processes that help balance demand against capacity and increase operational coordination between aviation stakeholders, creating a safer, more efficient traffic flow. Those processes include both strategic and tactical operations.

Over the next five years, the FAA plans to modernize and replace the TFMS with the Flow Management Data and Services (FMDS) system to accommodate better the needs of

the NAS today and in the future to maintain efficiency and safety for all users. FMDS will provide a reliable traffic flow management automation system with a modernized architecture and infrastructure for better reliability, maintainability, and availability. It will also leverage new technologies and a new software architecture and infrastructure approach, allowing TFM activities to scale to projected air traffic growth.

FMDS updates will include faster development cycles, consolidated applications, and a streamlined interface for TFM automation system functions that will improve the user experience via an integrated situation awareness display. Its new interface will allow users to view all traffic, traffic management initiatives (TMIs), and weather in one integrated application, allowing for more proactive and efficient execution of TFM actions.¹⁰¹

As the air transportation industry continue to evolve, the FAA is exploring future info-centric NAS concepts to facilitate advanced data-sharing and collaboration to the diverse range of air traffic management needs of tomorrow.¹⁰²



FAA Command Center, Warrenton, VA
 Courtesy: FAA

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¹⁸ *Ibid.*, 4.

¹⁹ Federal Aviation Agency, “The Design for the National Airspace Utilization System” (Washington, DC: Government Printing Office, 1962), foreword.

²⁰ *FAA Historical Chronology*.

²¹ A metroplex is a geographic area covering several airports, serving major metropolitan areas and a diversity of aviation stakeholders. Congestion, airport activity in close geographical proximity, and other limiting factors such as environmental constraints combine to reduce efficiency in busy metroplexes.

²² “The Design for the National Airspace Utilization System,” 53.

²³ Ibid.

²⁴ Report to the Congress from the President, *United States Aeronautical and Space Activities, 1966* (Washington, DC, U.S. Government Printing Office, 1966), 126.

²⁵ Report to the Congress from the President, *United States Aeronautical and Space Activities, 1967* (Washington, DC: Government Printing Office, 1967), 109.

²⁶ *FAA Historical Chronology*.

²⁷ United States Congress, *Independent Offices Appropriations for 1963*, 782.

²⁸ Served as FAA administrator from March 4, 1969, to March 14, 1973.

²⁹ Department of Transportation, *Fourth Annual Report, Fiscal Year 1970* (Washington, DC: US Government Printing Office, 1970), 73-74.

³⁰ *FAA Historical Chronology*.

³¹ United States Congress, *Independent Offices Appropriations for 1963*, 782.

³² Department of Transportation, *Fourth Annual Report*, 73-74.

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⁴⁰ *Federal Register* 35, no. 208 (October 24, 1970): 16591-16593.

⁴¹ *Federal Register* 36, no. 164 (August 24, 1971): 16574-16575.

⁴² *Federal Register* 37, no. 206 (October 25, 1972): 22792-22793; *Federal Register* 38, no. 205 (October 25, 1973): 29463-29464.

⁴³ *FAA Historical Chronology*.

⁴⁴ *Ibid.*

⁴⁵ *Ibid.*

⁴⁶ Martin joined the FAA in 1948 as an air traffic controller at Logan Airport in Boston. He came to Washington in 1959 as chief of the plans branch of the FAA's Air Traffic Service. From 1964 to 1966, he was in New York City as the Eastern Region chief of the Air Traffic Service, before returning to Washington. He retired in 1974 as the deputy director of FAA's Air Traffic Service.

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⁴⁹ "Controlling the Flow of Traffic . . . Battling the Bottlenecks," *FAA Horizons*, August 3, 1970, 4-5; "Central Flow Control Starts," *FAA Horizons*, March 16, 1970, 7.

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⁵⁶ *Ibid*

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⁶⁵ Ibid., 112.

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