World

March 1982
Volume 12 Number 3

US Department of Transportation
Federal Aviation Administration

national AIRSPACE system plan

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FAA WORLD is published monthly for the employees of the Department of Transportation/Federal Aviation Administration and is the official FAA employee publication. It is prepared by the Public & Employee Communications Division, Office of Public Affairs, FAA, 800 Independence Ave. SW, Washington, D.C. 20591. Articles and photos for FAA World should be submitted directly to regional FAA public affairs officers:

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The Administrator's View

The Best System To Be Made Better

By J. Lynn Helms

Even before I came to FAA, it was apparent to me as a frequent user of the National Airspace System that the system needed to be restructured and modernized along more efficient productive lines.

That doesn't mean I had any questions about the integrity or safety of the system. I've flown in countries all over the globe and I know it's the best system in the world.

But the present system does have some serious limitations, which are familiar to all FAA employees. Among other things, it's very labor-intensive, which makes it expensive to operate and maintain. Even more important, it has very little capability to handle future traffic growth and no capability to accommodate future automation needs. In addition, new technology can make the task of air traffic control and equipment maintenance much easier and improve service to our customers—the pilots. Remember, it's not our airspace; it's theirs. We are paid merely to help them use it safely.

These limitations result from an aging physical plant and inefficient procedures and practices that have evolved over the years on a piecemeal basis in response to specific needs. For example, the present system is characterized by vacuum-tube electronics; different computers and consoles in different air traffic control facilities; multilayered and overlapping navigation aids, communication sites and radar facilities; and an extensive network of expensive leased-communications lines.

Consequently, one of my top priorities when I took office was to initiate a comprehensive in-house review of all FAA technical programs, ranging from collision avoidance to ATC computer replacement. At the same time, we began a similar study with industry of the agency's ATC procedures and regulations to see what we could do to improve the overall flying environment.

We saw early in our review that the technical framework of the air traffic control and air navigation system had to be recast. A simple extension and more of the same wasn't good enough for the projected traffic volumes of the next 20 years. Moreover, we concentrated our efforts on the total system, evaluating each element not only on its own merits but also on its contribution to the system plan. Our objective was not just to enhance safety and efficiency in traffic control. We also wanted to design in enough flexibility to exploit new technology whenever it appears and minimize both the initial and recurring costs.

The first tangible result of this technical review was my selection last summer of the Traffic Alert and Collision Avoidance System (TCAS) as an independent airborne back-up to the ATC system. The TCAS decision was an important building block in the total program, because it enabled us to terminate a 20-year debate on collision-avoidance systems and discontinue development of the very expensive, ground-based Automatic Traffic Advisory and Resolution Service (ATARS) and mandatory Discrete Address Beacon System (DABS). This, in turn, simplified the requirements and greatly reduced the cost of implementing the voluntary Mode S as a replacement for the present air traffic control radar beacon system (ATCRBS), since Mode S no longer had to support the ATARS function.

The selection of Mode S was another core decision in developing our final plan of action. Mode S not only performs the secondary surveillance radar function, it also provides an air-ground communications link that is an indispensible element of the future system. Essentially, this results from the fact that Mode S interrogates individual aircraft and, thus, creates a channel for automatic data-link communications of both air traffic control and weather data.

The last major hurdle in the planning process was the ATC computer-replacement program. We examined a broad range of options before settling on a step-by-step replacement as the fastest, most practical and cost-effective means of bringing new computers on line. The decision means that, by the mid-1980s, the en route centers will have new "host" computers—that is, ones capable of using existing software—with sufficient capacity to handle traffic growth projected for this period. Concurrent with this effort, we will be developing new sector suites and a new computer software package that will accommodate the evolution to much higher levels of automation.

Moreover, the new computer and display complex will be designed for the highest level of commonality between en route and terminal functions. Our intention is to blend these functions and achieve consolidation of facilities wherever feasible. Keep in mind that our responsibility is not just to the FAA employee; it also is to the American tax-payer.

By the year 2000, we anticipate that a network of approximately 60 centers and hub terminal radar control facilities will handle all en route and approach control services in the contiguous 48 states. However, FAA employees should be aware that this is a long-range program that won't really get underway in the terminals for another 10 years when the new computer complex and consoles become available. Also, our staffing projections will be tailored to achieve a smooth transition to the new structure, so no one—controller nor technician—should fear losing his or her job.

The final product of this 10-month review now has been published in a 450-page document entitled the National Airspace System Plan. It includes not only the items already mentioned but also some now underway, such as the flight service station modernization program, remote maintenance monitoring and replacement of all vacuum-tube electronics with solid-state equipment. Considerable attention also is given to improving the agency's interfacility communications and auxiliary services, such as flight inspection of navigation aids, with the aim of improving service, reducing cost and exploiting the latest technology.

We think the plan provides a logical blueprint for modernizing the National Airspace System over the next 20 years. Still, no one should take its implementation for granted. Although the Administration will support the program, we still must obtain a front-end funding commitment from the Congress. In addition, we need the support of all the various and diverse elements of the aviation community, who will be asked to pay for the program in new and higher user charges, as well as of FAA employees, who will have the ultimate responsibility for making the modernized system work.

So, much remains to be done before the plan is translated into action. Yet, I remain confident of success, because I believe there is no realistic alternative to proceeding with the plan.

In many ways, our situation parallels that of the private sector where some of our major industries have lost their competitive edge and must modernize to survive in today's international marketplace. Our sense of urgency in this regard is no less compelling nor less critical to the nation's economic health. The United States needs a solid industrial base, supported by a strong, healthy and viable air transportation system, if it is to achieve the goal of economic recovery set by the President. The National Airspace System Plan will further that objective—and the time to implement it is now! ■

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Outline of an Innovative Plan

It's commonly called the "brown book," which hardly does justice to a plan that *Aviation Week* has called "one of the most far-reaching and probably the most innovative in FAA's history."

Actually, this brown-covered document, of which this issue of FAA WORLD is an extract, goes by the more formal title of "National Airspace System Plan." It is the agency's response to what Administrator J. Lynn Helms has identified as the number one problem facing aviation—that is, how to expand system capacity to accommodate the projected growth of air travel over the next 10 to 20 years.

The 450-page document lists and describes specific improvements in facilities and equipment that are needed in the National Airspace System by the end of the century. These include the replacement of the current air traffic control computers, the modernization of the flight service station network and the deployment of new radar, communications and airport landing systems.

At the same time, the plan recognizes that hardware improvements alone cannot entirely solve the capacity problem. Airports will continue to be the major constraining element in the National Airspace System. Few new air carrier airports are anticipated, and most major airports have limited expansion capability due to physical, environmental, airspace, runway and/or landside limitations.

A limited amount of additional capacity will be achieved primarily through a reduction in separation standards resulting from technological advances, refinements in ATC procedures and through runway, terminal and access improvements.

The plan also considers development efforts that do not directly affect the consolidation and modernization efforts currently planned but which promise to yield potential benefits for the future ATC system. These include, for example, satellite technology for navigation, surveillance and communications and automated airport services.

According to the best estimates, the implementation of the entire package would save the taxpayers approximately $25 billion over the next 20 years in reduced operating and maintenance costs. A detailed estimate of how much it would cost was scheduled to be sent to Congress this month. In the meantime, the Administrator estimated the cost to run between $8.7 and $9 billion for the first 10 years.

The underlying assumption reflected in the plan is that the air traffic control system will continue to be fundamentally ground-based. However, the role of the FAA employees who operate and maintain the system will evolve with the introduction of new technology and more automation. They will become the system's managers of the future.

Pilots also will assume new responsibilities in the future system. With the introduction of the Traffic Alert and Collision Avoidance system (TCAS), for example, they will have an anti-collision device that operates independently of the ground-based ATC system but is fully compatible with it. Moreover, the data link feature of the Mode S radar beacon system will give pilots increased access to ground-based flight and weather data sources.

The National Airspace System Plan is the first of four plans FAA employees will be hearing more about in the months ahead. It will be followed by the Engineering Plan (the "red book"), which will spell out how the agency will design, develop and procure the facilities and equipment identified in the 20-year NAS plan. The Systems Support Plan, which is yet to be assigned a color, will show how the equipment will be maintained once it has been purchased and installed. And, finally, the National Airspace Review Plan, which will focus on changes to airspace design and management as well as procedural aspects of the air traffic control system to bring them up to date and more in line with projected changes in aviation.

However, for the time being, the "brown book" holds center stage. Since FAA employees are a key part of the plan and also will play a major role in implementing it, this entire issue of FAA WORLD is devoted to a summary of the plan's main sections. Highlights of those sections follow:

TOTAL NATIONAL AIRSPACE SYSTEM ACTIVITY

	1980	1985	1990	2000	PERCENT GROWTH 1980-2000
NASP Airports	3163	3637	3631	4000	26.5
Aircraft Operations (millions)	134.1	179.7	212.7	290.0	116.2
Itinerant Operations (millions)	74.0	98.8	117.3	159.5	115.5
Instrument Operations (millions)	38.2	48.1	54.2	65.6	71.7
IFR Aircraft Handled (millions)	30.1	37.2	42.2	53.7	78.7
FSS Operations (millions)	64.3	83.9	98.6	139.6	117.1
Domestic Enplanements (millions)					
Air Carrier	278.1	360.8	454.0	589.8	112.1
Commuter	13.1	21.8	30.6	42.0	220.6
Aircraft Fleet (thousands)					
Air Carrier	2.4	2.7	2.9	3.4	42
Commuter	1.6	2.4	3.2	4.5	175
General Aviation	210.3	254.5	298.1	408.5	94
Pilots (thousands)					
Instrument Rated	247.1	309.5	369.6	481.9	95.0
Total Pilots	814.7	891.0	1050.6	1331.3	63.4

En Route and Terminal Services

At present, FAA has IBM 9020 computers in the 20 air route traffic control centers.

The 9020s will be replaced in the mid-1980s with a new "host" computer capable of using 9020 software with only minimal modifications.

At the same time, the agency will proceed to develop new software and new sector suites to replace the existing consoles and displays. Each sector suite will have its own microprocessors that will generate information for controller displays and serve as a back-up to the central computer complex.

The new computers, which eventually also will be used in radar terminal facilities, will provide the capacity and informational framework for implementing higher levels of automation known as Automated En Route Air Traffic Control (AERA) in the 1990s.

By the year 2000, the present total of approximately 200 en route centers and terminal radar facilities would be reduced to about 60 facilities providing nationwide coverage.

Flight Service Systems

The FAA program to consolidate its more than 300 flight service stations into a network of 61 automated facilities already is underway. Contracts to purchase computerized systems for 41 of the 61 sites were awarded in the fall of 1981, with deliveries expected to begin in late 1983.

The new equipment will provide FAA flight service station specialists with rapid retrieval of information they need to brief pilots on weather and other flight conditions. The data will be processed and stored in the computers for immediate call-up on TV-like displays at the specialist's position.

Eventually, this system also will be able to give pilots direct access to the computer data base from remote com-

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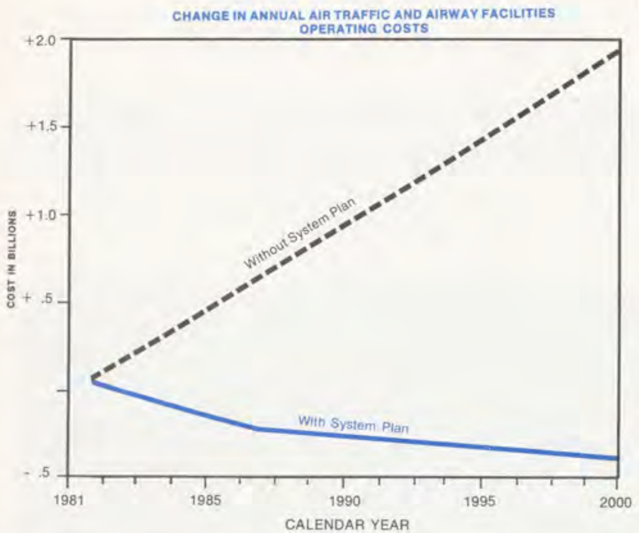


puter terminals at airports and other accessible locations.

Ground-to-Air Systems

A new secondary radar system known as Mode S will be implemented to improve both aircraft surveillance and air-ground communications. The "S" in this case stands for selective address.

Mode S, like the Air Traffic Control Radar Beacon system (ATCRBS) it would replace, obtains information on aircraft by querying transponders in these aircraft, reading out the coded replies and presenting this data on radar displays. However, Mode S has the additional capability to interrogate aircraft individually, rather than on an "all call" basis, thus avoiding the interference problems that plague ATCRBS in busy terminal areas.

With the implementation of Mode S and Doppler radar, FAA will phase out primary radar in the en route section, although retaining it in terminal areas.

Doppler radar will provide controllers and pilots with much more detailed weather data than is available to them today. FAA currently is working with the National Weather Service and the Department of Defense on the development of such a system, with installation scheduled to begin in 1987. In addition, the plan calls for the agency to begin installing the new microwave landing system (MLS) at airports in 1984 and have more that 1,250 in place by 1998.

Interfacility Communications

The plan calls for an integrated telecommunications network with the potential for use by other elements of the Department of Transportation. It also recommends a mix of owned, leased and satellite communications facilities, necessarily taking advantage of rapidly changing and lower-cost technologies in telecommunications.

Another major recommendation involves the establishment of a national airspace data interchange network (NADIN) between 1981 and 1985. The plan says NADIN will evolve into a general-purpose, data-transmission system with alternative routing capabilities to bypass breakdowns or heavily saturated areas. The system also will be designed so that it can transmit by whatever medium proves to be most cost-effective at the time it evolves.

Auxiliary Systems

A major cost-saving item in the plan is remote maintenance monitoring of facilities, which will permit the consolidation of work stations and the reduction of staffed facilities. For example, the plan says that the implementation of remote maintenance monitoring will cut the number of staffed facilities from the present 1,000 to 300 in 1992.

Similar maintenance savings are anticipated from the replacement of vacuum-tube-type electronic equipment by solid-state devices. This program already is well underway with FAA contracts to replace more than 900 radio navigation aids. The first delivery of this equipment is scheduled for this spring.

Significant savings also are envisioned as a result of changes in the program for flight inspection of navigation aids. These include the replacement of the present flight inspection fleet with more fuel-efficient turboprop aircraft, the introduction of automatic flight-inspection equipment and procedures and the consolidation of flight inspection field offices. ■

En Route Systems

FAA presently has 20 "domestic" air route traffic control centers that handle aircraft operating under instrument flight rules (IFR) between airport terminal areas. In addition, the agency runs three "offshore" centers in Anchorage, Honolulu and San Juan, Puerto Rico.

A typical domestic center is responsible for more than 100,000 square miles of airspace and thousands of miles of airways and jet routes. A center's geographic area generally is divided into 30 or more sectors with a team of controllers responsible for each sector.

The domestic centers use the IBM 9020 computers, developed in the mid-1960s, to process both flight data and radar data. The three offshore centers use Sperry Univac en route automated radar tracking systems (EARTS) to perform similar but more limited data-processing functions.

Despite their capabilities, the current 9020 computer systems are not considered adequate to handle the projected growth of air traffic beyond the late 1980s. In addition, major enhancements to the operational software are not possible because of capacity limits. For example, the system is incapable of ensuring the total reliability that is needed for the upgraded automation, where system availability is essential.

Another problem is spare parts. The computer manufacturers cannot continue to support the systems indefinitely, regardless of the cost.

FAA, therefore, plans to replace the ATC computers with new equipment based on evolving technology. The new

The ARSR-3 long-range radar (right) dwarfs its predecessor in Mcook, Ill.
Photo by Neil Callahan

computer system will be designed for approximately 100 percent functional availability of en route services.

Moreover, the new computers, software programs and displays, now under development, will be capable of providing both en route and terminal services. This will enable the agency to consolidate and reduce the number of facilities needed, eliminating or considerably diminishing the present, somewhat arbitrary, demarcation of enroute and terminal services and, thereby, reducing operational overhead.

The new computers also will permit implementation of the agency's Automated En Route Air Traffic Control program. AERA will relieve controllers of routine, time-critical tasks and will assume increasing responsibility with the passage of time.

FAA's plans call for the replacement of the 9020 systems in the mid-1980s with a "host" computer—that is, one that can use existing instructions, or software. The host computer will be capable of running the 9020 software package with minimal modifications, thus providing the necessary capacity to meet the projected growth of air traffic.

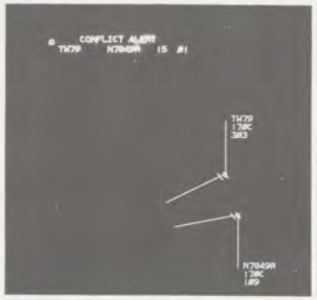
At the same time, the agency will begin action to procure new "sector suites," which include distributed processing minicomputers capable of handling the functions now resident in the display channel computers. This contract also will provide for the development of replacement software programs partitioned to run in the host computers and sector suites.

Major operations requiring centralized processing will be accomplished in the host, with all remaining functions performed within the minicomputers at the individual sector suites. This will reduce the impact of most failures to a single sector, with sufficient backup capability to provide 100 percent functional reliability.

The sector suite will consist of three displays. One will provide a plan view of traffic and weather using surveillance and weather radar data in a manner similar to the current displays. The second display will be primarily for alphanumeric flight data, eliminating the need for flight-strip processing. The third display will be primarily for the advanced functions associated with AERA. A connection to various universal busses will allow the sector suites access to all necessary information shared with other systems.

Flight data strips will pass from the scene.

John Richardson at Jacksonville flow control, which will move to the Washington ARTCC. Ray Stafford photo, Florida Publishing Co.



With the en route scope's map suppressed, we see a conflict alert tag and data tags blinking for aircraft in adjacent sectors on a collision course at the same altitude.

The en route and terminal sector suite of tommorrow is tested at the Mitre Corp. At the left is the planning display, for which the operator is using a computer touch-entry device. The middle is the usual plan view display; the right is for flight data.

The capability of the system to accomplish processing of both en route and terminal input and functions allows for the consolidation of terminal facilities into the centers and the use of the same or a downsized system in the terminal environment for the consolidation of terminal radar approach control (TRACON) facilities.

The integration of a computer-controlled voice switching and radio control system into this evolving situation will increase productivity by saving controller time and technician workload, since communcations changes can be made automatically without rewiring. This electronic approach to switching will permit resectoring as needed.

It also will reduce leased-line and equipment costs and permit the eventual integration of voice and data communications over a satellite-based system. This will even further reduce transmission costs.

During this period, the agency's replacement of the central flow control computer complex system at Jacksonville will improve central flow control and

The Jacksonville, Fla., ARTCC's IBM 9020.

allow expansions to cover more of the system. The long-range goal will be its coupling with en route and terminal programs for a total national flow control concept. This will be more predictive and include consideration of essentially all of the National Airspace System.

Over the near term (to 1985), the FAA will develop a replacement for its 9020 computers with a new host computer capable of running slightly modified 9020 software programs. It is slated for complete development in 1985 and will provide the additional capacity needed to handle the growth in air traffic expected in the mid-1980s.

During this same period, agency plans call for more automated interfaces between en route and terminal facilities providing better coordination of operations.

Near-term agency plans also call for improving weather information by combining center weather-processing capability with weather information from flight service stations.

The replacement of mechanical, labor-intensive flight-strip printers and flight-data entry and printout equipment with more reliable and faster electronic equipment is expected to improve productivity. Near-term software improvements will be aimed at improving airspace efficiency, safety and reliability.

The agency plans to implement new en route metering for high-altitude traffic. This should also cut back on delays and produce optimized-fuel descent profiles. Conflict alert will be expanded to include detection of aircraft equipped with Mode C transponders when they intrude into controlled airspace. Additional software improvements will include the development of conflict-resolution logic that will alert controllers to potential violations of separation standards.

Similarly, the software for the en route automated radar tracking systems (EARTS) in the offshore centers will be improved over the near term to provide conflict alert and minimum safe altitude warning systems (MSAW). Among the first improvements to oceanic control systems will be automated conflict probes, along with the logic needed to decide on the most fuel-efficient routings.

The capability of the backup direct access radar channel (DARC) will be expanded to provide full data information tags and individual display switching. This will eliminate the need to convert the displays to a horizontal position, to use shrimp-boats and to switch six displays at a time to the backup channel, as is now the case.

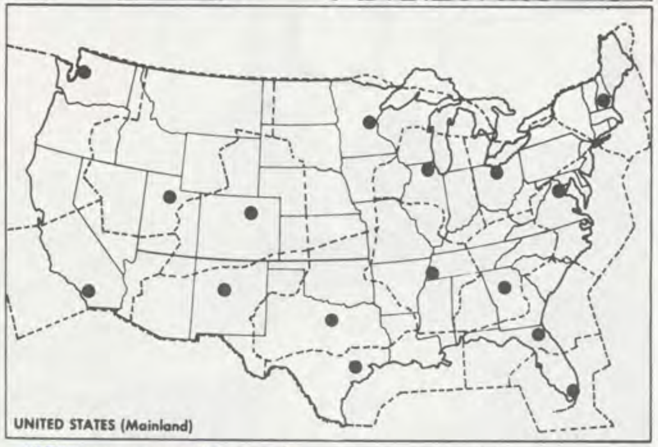
During this period, the 9020 computer at the Jacksonville central flow control computer complex will be replaced by an interim IBM 4341 computer, and the complex will be relocated to the Washington en route center for better coordination with FAA's Washington headquarters. The manual central altitude reservation (CARF) and airport reservation office (ARO) functions also will be automated at that time.

The consolidation of facilities also will proceed, with the number of domestic U.S. centers reduced from 20 to 18.

During the intermediate period (to 1990), the display channel processors and displays will be replaced by sector suites, including software development of redistributed processing between the host computer and sector-suite processors. This also will allow for the integration of terminal functions within the ARTCC and serve as a basis for future levels of automation.

Replacement of the present air traffic control radar beacon system (ATCRBS) with the Mode S (selective address) system will provide a major enhancement by 1990. Mode S will furnish improved surveillance, especially in high-density terminal areas. In addition, the Mode S data link feature will provide rapid dissemination of control and other information to specific aircraft.

Alphanumeric capacity and switching for DARC will be improved. Photo by Dennis Hughes



ARTCC coverage areas will change as the number of centers decline in 1990-2000.

In addition, during this period, automated flight data distribution systems will be provided for offshore centers. These systems will replace obsolete systems currently in use.

A complete switching and control system for voice, which complements the capabilities of the new sector suite, will be developed and implemented during the intermediate period. This will allow the reconfiguration of sectors as needed, further reducing workload.

The central flow-control function will be significantly upgraded with the introduction of a new computer system. Along with software to enhance its ability to project and estimate NAS congestion and delay levels, it will evaluate alternate flow-management strategies based on various sources of information.

The number of domestic centers, meanwhile, will drop to 16 and offshore centers to two. No CERAPS (center/approach control facilities) will exist by 1990.

During the long term (to 2000), air traffic control will become increasingly automated. Early on, the increased computer capacity and software designs will provide the tools for operator use of the system at higher levels of automation. During this period, the AERA functions will be implemented incrementally in the following sequences:

(1) direct fuel-efficient routing,
(2) flow planning and traffic management,
(3) strategic clearance delivery and
(4) full tactical control.

The central flow-control function will have been further upgraded to work with AERA and integrated flow management (IFM) functions.

These activities will result in higher levels of safety and efficiency through the use of automated conflict-probe-and-resolution, systemwide direct routing, and the capability to operate a sector with one person.

In summary, FAA's present en route plans are designed to replace current air traffic control systems to meet future needs of greater capacity and reliability. With higher levels of automation, present en route plans will improve both safety and productivity. The new system will be capable of providing both en route and terminal services, thereby enabling the agency to consolidate and reduce the total number of facilities needed to do the job. ■

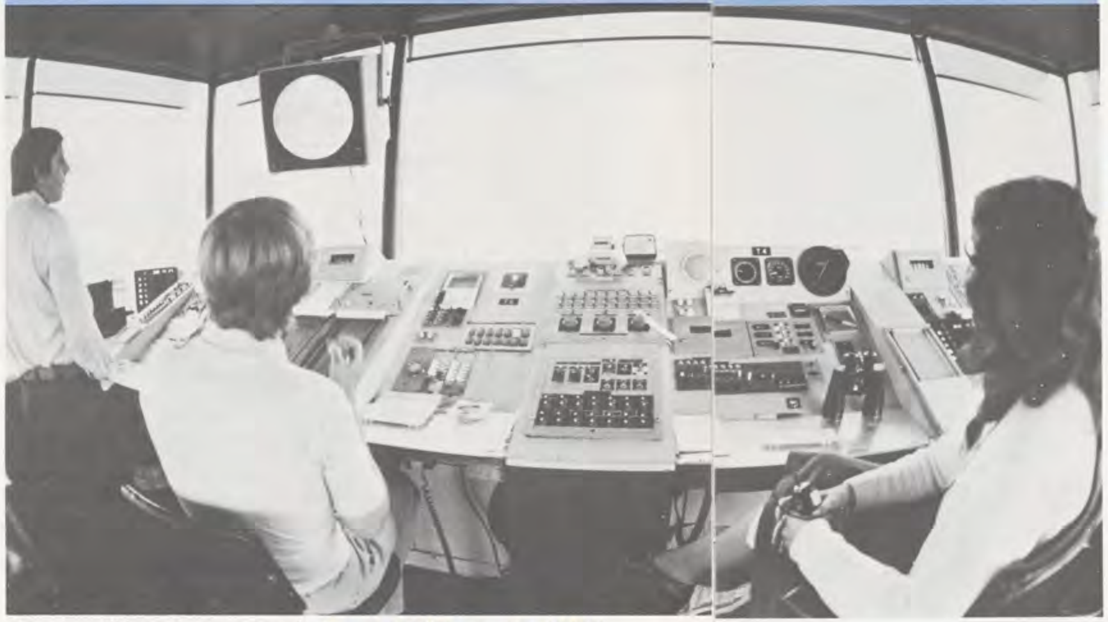
Terminal Systems

The FAA terminal air traffic control network includes nearly 450 facilities, although approximately 60 of these were temporarily closed following the controllers' strike. These terminal facilities, or control towers, are responsible for guiding aircraft in the immediate airport area, with radar-equipped towers providing approach and departure services up to 40-50 miles from the airport.

At present, 188 terminal facilities are radar equipped, with associated computer systems that provide the controllers with direct readout of the same basic flight information as the automated systems in the air route traffic control centers. Included are the identity and altitude of all properly equipped aircraft in the terminal area.

The two major automated radar terminal systems (ARTS) are the Sperry Univac ARTS III at the 63 busiest airports and the Burroughs ARTS II at 89 medium-activity locations. The agency also has a less-sophisticated automated system, known as the TPX-42, at some 35 low-activity locations, but these are scheduled for early phase out and replacement.

One of the principle differences between ARTS II and ARTS III is that the latter includes a "tracking" function. This means that the computer keeps a history of all aircraft equipped with a radar beacon transponder and predicts where they will be on the next sweep of the radar antenna. In addition, the upgraded version of ARTS III, known as ARTS IIIA, is capable of tracking primary radar targets as well as transponder-equipped aircraft.



Tower cab BRITE scopes from ARTS II TRACONs will be replaced.

ARTS III also has both a conflict-alert feature and a minimum safe altitude warning (MSAW) capability. In the first instance, the ARTS III computer projects the flight paths of aircraft under control and warns the controllers when a potential conflict is detected. In the second case, the computer flashes an alert when an aircraft equipped with an altitude-reporting transponder is below or predicted to go below a predetermined minimum safe altitude.

The objectives of the terminal system improvement plan are to maintain a very high level of safety, impose minimum constraints consistent with efficient use of the system and at the same time minimize FAA operations costs. The strategy involves extended use of automation and consolidation of the number of air traffic control facilities.

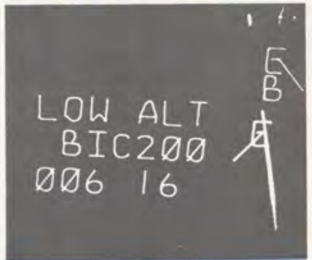
What used to be called an Uninterruptible Power System is now called a Power Conditioning System: battery banks and an inverter as an emergency power supply.

For the near term (to 1985), this means making the hardware and software improvements to existing ARTS installations and improvements to the facilities and voice communications switching which coexist with them. For example, ARTS II will be upgraded to include both conflict alert and minimum safe altitude warning. In addition, the capability to hand off aircraft and transfer flight data automatically between ARTS II facilities and air route traffic control centers will be added to approximately 50 locations to reduce controller workload. A similar ARTS-to-ARTS interface also will be created.

Also in this time period, the ARTS III memory will be expanded to provide additional capacity for traffic growth. And the ARTS III conflict-alert function will be improved to reduce the number of nuisance alarms.

Other near-term projects include

A minimum safe altitude warning (MSAW) flashes on an ARTS III radar scope.



radar remoting to satellite towers to reduce further the midair-collision risk at these locations and the replacement of vacuum-tube BRITE I and II radar displays in tower cabs with solid-state equipment that will reduce the workload on maintenance personnel. Also, an integrated communications switching system (ICSS) will be purchased on a competitive basis to decrease leased communications costs, and power conditioning systems will be provided at ARTS III locations to improve system reliability.

In addition, the plan calls for research and development to get underway on

The TRACON configuration will be changing to a "sector suite" design also common to the en route centers.

the new air traffic control computer/sector suite complex that will be used in both the centers and the terminal hubs. Work also will proceed on an integrated flow-management system and on automated airport advisory services to determine their capabilities to supplement or replace VFR (non-radar) towers.

During the intermediate term (to 1990), the agency will begin consolidating terminal radar control facilities into hub locations and into the en route centers. This move will be keyed to the availability of the new computers and sector suites. The computers provided to the hubs will be subsets of those used for the en route centers and employ common software. Sector suites used at hub TRACONs will be identical to those developed for the ARTCCs and have identical processing capability.

A modular version of the sector suite also will be developed for tower cab use. It will contain identical processors but have unique displays for use in the space-limited, high-intensity-light environment of the tower cab. The sector suite will draw on terminal, en route and flight service station data bases and will satisfy the traffic control requirements for radar flight position, identity, flight data, weather data and flow-planning information.

In the far term (to 2000), automation will be extended to create an integrated flow-management system that will maximize airport capacity, smooth traffic flow and reduce aviation fuel consumption. The consolidation of facilities will be completed with the present 188 terminal radar control facilities merged into 30 newly established hub TRACONs or existing ARTCCs by the mid-1990s.

A high-activity tower at Dallas-Fort Worth.

Tower communications and switching will be improved, more cost-effective.

The trend over the period will be to blend separate functions of terminal and en route air traffic control into approximately 60 major ATC facilities and supporting towers. Facility consolidation is expected to reduce the flight coordination between pilots and controllers and result in significant savings in equipment, personnel and costs. ■

national AIRSPACE system plan

Flight Service Systems

The FAA network of 300 flight service stations offers a broad range of pre-flight and in-flight services especially aimed at general aviation (non-airline) pilots.

These services include processing flight plans, briefing pilots on weather and aeronautical matters important to the safety of flight and assisting pilots in distress.

The present FSS network, however, is highly labor intensive, and the agency estimates it would need more than twice as many specialists as now to keep pace with projected demand for services by 1995.

However, by automating this network and consolidating today's more than 300 facilities into 61 automated hubs, FAA estimates the FSS network can handle the projected 1995 demand with substantially fewer personnel and significantly less cost. Moreover, the quality of the service to pilots will be vastly improved, particularly in the area of more complete and timely weather reporting.

The procurement of new computer systems for the automation of flight service stations already is underway. Contracts to purchase computerized systems for 41 of the 61 sites have been awarded, with deliveries slated to begin in 1983. The new equipment will provide flight service specialists with rapid retrieval of information they need to brief pilots on weather and other flight conditions. The data will be processed and stored in the computers for immediate call-up on TV-like displays at the specialist's position.

In providing more weather products to FSSs and directly to users, more airports will gain installations of Low-Level Wind-Shear Alert Systems (LLWSAS).

Pre-flight at the AWANS test in Atlanta.

In the near term (to 1985), Model 1 of the automated system will have the capability of displaying weather and aeronautical data in alphanumeric form on the specialist's display. Moreover, during this time, FAA will begin implementing the more advanced Model 2 at all 61 sites. Model 2 will include a second display for weather radar, charts and other graphics. It also will include the capability for demonstrating direct access by pilots to the computer data base from remote computer terminals.

Also during the near term, a computer-generated voice-response system will be available in certain geographical areas to provide pilots direct access by Touch-Tone telephone to limited aviation weather data, such as surface observations, terminal forecasts and winds aloft.

The replacement of low-speed teletypewriters with data-terminal equipment will begin, as well, and the development of improved weather sensors and products will continue.

These automated weather sensors will provide current airport weather information directly to pilots and to the agency's aviation weather collection system. Satellite weather photos will be available at certain locations over facsimile recorders, displaying the location of cloud cover and weather systems.

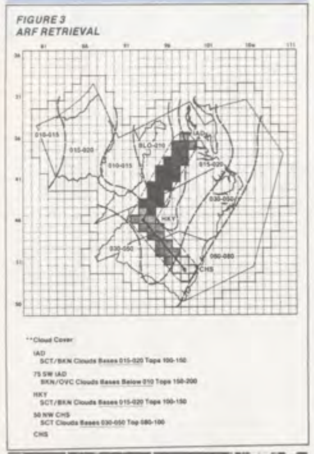
Low-level wind-shear equipment will be added at more airports to detect hazardous wind conditions along the final approach. Six levels of weather radar contouring, outlining storms, will be on television displays for en route meteorologists and specialists in automated flight service stations.

In the intermediate term (to 1990), consolidation of the more than 300 flight service stations into 61 automated facilities will be accomplished. In addition, the Model 2 automation system will be fully implemented at all 61 sites. Moreover, the voice-response-system capability for direct pilot access to certain weather data will be expanded, and direct pilot access to the computer data base via remote computer terminals also will be implemented, with the goal of later providing pilot access to the data base via Touch-Tone telephone as well.

New communications switching systems for the 61 consolidated facilities also will be installed to provide improved pilot access and expedite coordination with flight service specialists. The replacement of low-speed teletypewriter equipment will be completed, and computer-aided direction-finder equip-

A voice-response system (VRS) will provide direct user access to weather via Touch-Tone telephone or other keypads.

Photo courtesy of AT&T



A tailor-made Aviation Route Forecast will be based on a digital grid data-base that can be displayed on a CRT.

Cockpit weather radar will be able to display radar images, messages and maps via coded transmissions over VOR.

ment will be introduced to expedite locating and assisting lost aircraft.

Major improvements in aviation weather services for pilots will be introduced during this period. Using the data-link capability associated with the improved Mode S transponder, for example, automated weather information will be available to pilots flying above 12,500 feet mean sea level and at certain airports. Request-reply weather service will be available as will significant meteorological reports from center meteorologists.

VOR radio navigation stations will provide the routine weather broadcasts. Computer-generated voice weather broadcasts will be presented continuously over a national VOR network, with coverage provided for a 2,000-foot altitude and higher above the terrain. Automated weather-sensor voice outputs will be broadcast over VOR stations giving airport surface weather information and allowing lower weather minimums for landings. Flight service station voice communications with pilots will take place over other local and remote communication outlets.

The weather processor at air route traffic control centers will distribute current weather radar information to the flight service specialist, center meteorologist, central flow control and tower cabs at major airports.

In addition, the weather processor will provide automated distribution of alphanumeric and graphic weather information to operating positions in flight service stations, via the flight service data-processing system. More accurate and timely weather radar information will be provided through improved FAA terminal radar weather channels.

Over the long term (to 2000), Mode S data-link coverage will be extended downward from 12,500- to 6,000-foot altitudes above mean sea level, giving automated weather service to aircraft at lower altitudes. Improved weather radar data will continue as the next generation of weather radar systems, called NEXRAD, are added. ■

MAPS was another test precursor to flight service station automation conducted at the Washington FSS.

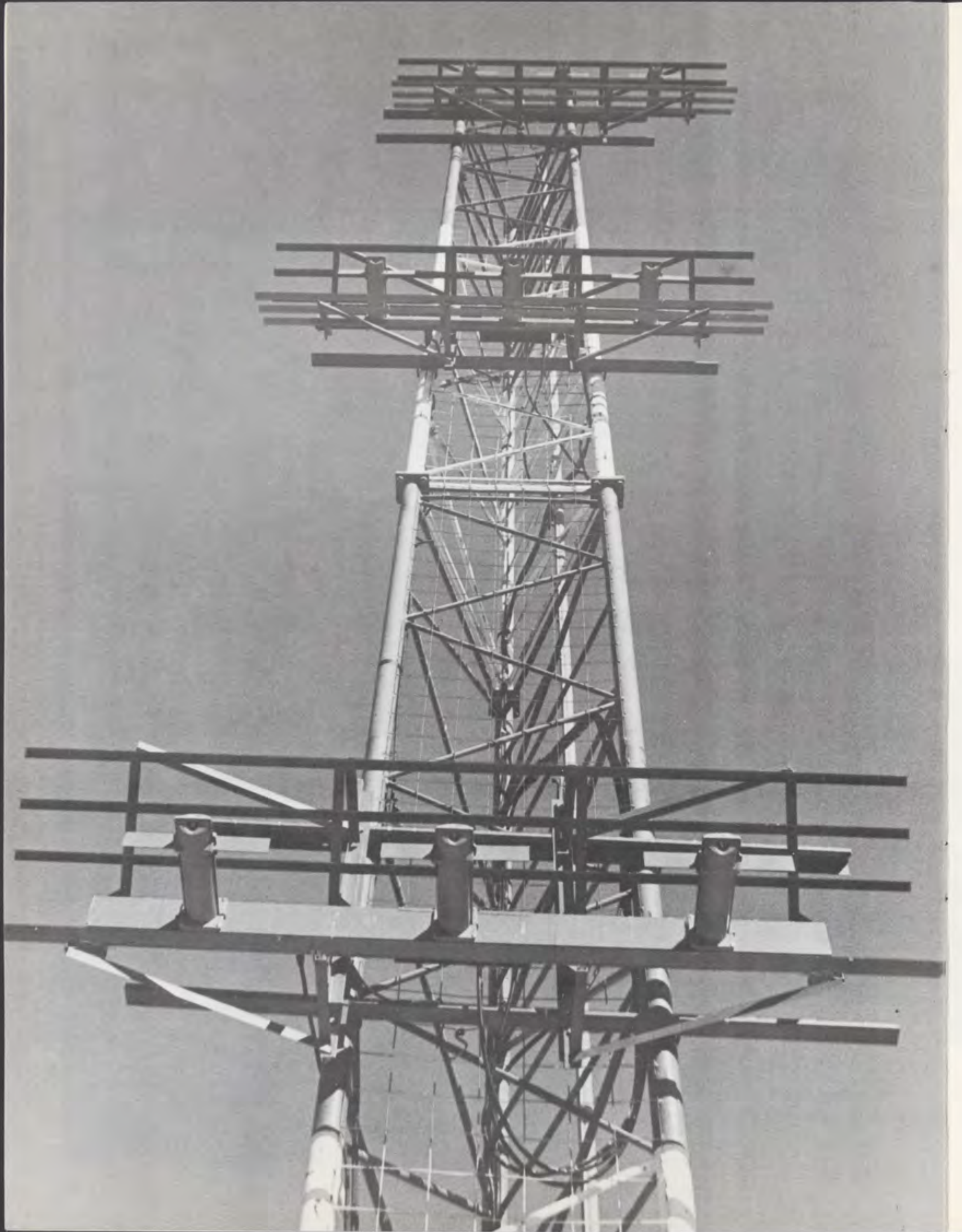
Ground-to-Air Systems

The title "ground-to-air systems" includes the navigation facilities that guide aircraft along the airways, the remote communications outlets that link pilots with air traffic control facilities and flight service stations and the primary and secondary radars that provide controllers with real-time information on both aircraft and weather movements.

The present air navigation system is based on the VOR, or very high frequency omnidirectional radio range. The VOR signal tells pilots their relative position from the transmitting facility. In addition, most VORs are collocated with military tactical air navigation systems (TACANS) or distance measuring equipment (DMEs) that provide pilots with information on their dis-

An FAA Technical Center aircraft flies an approach over the elevation antenna of the microwave landing system at Cape May, N.J.

A V-ring localizer antenna for the Burlington, Iowa, instrument landing system sits at the approaches to Runway 36.
Photo by William L. Bedford



Capture-effect glide slope antennas for a Burlington, Iowa, instrument landing system. All will become solid-state until micro-wave landing systems take over.
Photo by William L. Bedford

tance from the transmitting station. These combined facilities are called VORTACs and VOR/DMEs and there are more than 950 in the United States.

The standard precision approach and landing aid used at U.S. and other airports around the world is the instrument landing system. The ILS, as it's known, transmits two radio beams that line the pilot up with the center of the runway and also define the proper glide angle to touchdown. Also, as many as three marker beacons are placed along the approach path to indicate the distance to the end of the runway.

A doppler VORTAC on Taboga Isle, Panama. All are being converted to solid-state.
Photo by Jack Barker

Surveillance of the airspace is provided by two types of radar: primary radar and the radar beacon system, also known as secondary radar. They generally are located at the same site.

Primary radar obtains information on aircraft by reflecting signals off their surfaces. Information on weather phenomena, such as rain or snow, is obtained in a similar manner. The beacon system works by triggering airborne devices, called transponders, which signal aircraft identity and, in many cases, the altitude.

The beacon system presently is the main source of surveillance used for air traffic control. Primary radar supplements the beacon data by providing information on aircraft without transponders. The primary radar also presents some weather information, although its capabilities in this area are limited because the equipment is designed primarily for air traffic control.

Air-ground communications remain the back-bone of the air traffic control and flight service station network, with FAA maintaining hundreds of remote communications sites to provide virtually nationwide coverage. In recent years, the agency has been replacing vacuum-tube transmitter-receiver equipment with solid-state gear, and the modernization of en route facilities is nearly complete. However, the majority of transmitter-receiver stations serving terminal facilities and flight service stations are still vacuum-tube type and need to be upgraded. Similarly, the signaling and control equipment in both the en route and terminal facilities is obsolete and needs to be replaced.

FAA's 20-year plan calls for a general upgrading of all ground-to-air systems with a complete conversion to solid-state equipment and the implementation of

Medium-intensity approach lighting system will continue to be replaced with frangible supporting structures, as in the foreground here at JFK International.

national
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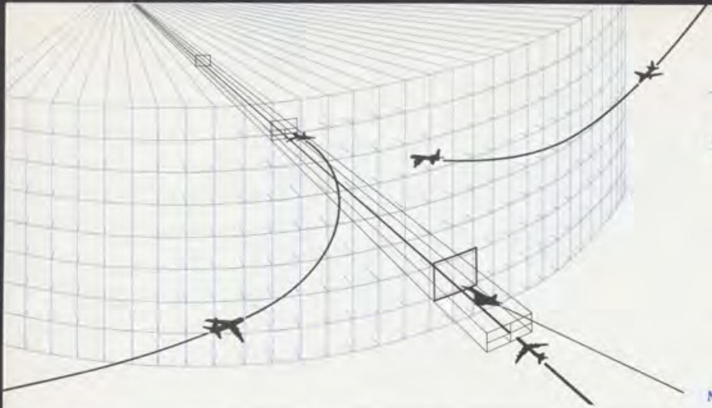
system plan


Microwave landing system.

remote maintenance monitoring. The agency also will consolidate the location of navigation, communications and surveillance facilities and put new and more capable equipment into operation, such as Mode S, to replace the present secondary radar and the microwave landing system to replace the current ILS.

To develop a nationwide system of navigation, surveillance and communications, as well as weather radar coverage, a concept called networking will be used. These networks will result in significant cost savings by reducing the number of systems and facilities while assuring the required coverage. Due to line-of-sight transmissions and the earth's curvature, some systems will give coverage at lower altitudes the closer an aircraft is to a facility. The ultimate for surveillance—Mode S and weather radar coverage—is a 6,000-foot altitude above mean sea level or the minimum en route altitude, whichever is higher. En route navigation, direction finder and communications coverages will be available above 2,000 feet above the terrain, except where there is little air traffic.

During the near term (to 1985), most of the navigation and communications improvements will focus on replacing obsolete vacuum-tube equipment with solid-state technology. Remote maintenance monitoring will be almost complete in the VOR-DME and VORTAC navigation stations. Where immediately needed, a limited number of new ILS facilities will be installed, but the installation of microwave landing systems will be started. Eventually, MLS will replace ILS, providing pilots with more precise guidance over a much broader area than the present equipment.

During the intermediate term (to 1990), surveillance coverage will be provided above 6,000 feet and down to the surface at qualifying airports. The network will include solid-state en route and terminal radar-beacon systems. The new terminal radar will have a channel for radar weather. Department of Defense requirements will be met or exceeded by using a national perimeter of new high-performance, low-maintenance long-range radars known as minimally attended radars. To accomplish this, conversion to all-digital remoting of data from en route and terminal surveillance and weather radar systems will be required.

New terminal radar with a separate weather channel will be installed at qualifying airports. Primary en route radar will be retained for FAA weather and air traffic control requirements until the next generation of weather radar becomes operational and other agency requirements are met.

With Mode S, each aircraft has its own beacon channel and can be interrogated individually. This channel also can be used for the automatic data-link transmission of air traffic control and weather information. Mode S and data-link coverage will be provided by 1990 above an altitude of 12,500 feet above mean sea level and down to the surface at qualifying airports. The network will consist of 137 systems. To obtain ATC clearance, aircraft will have to be equipped with Mode S and the associated data-link equipment to fly above 12,500 feet by 1990.

This will improve separation assurance and air traffic efficiency. Aviation weather will be given to pilots automatically by data link on a request basis and will include significant meteorological reports generated by the ARTCC meteorologists. Data link also will be used to transmit air traffic control information.

Existing VOR-DME and VORTACs will have been replaced with solid-state equipment. Extended area navigation will be direct point to point or on parallel tracks. With the increased use of area navigation, the number of VOR-DME stations may be reduced. TACAN will be discontinued if the Department of Defense places its orbiting satellite Global Positioning System (GPS) into operation, and its aircraft are equipped with proper receivers.


A forest of communications antennas grows atop Mt. Franklin, El Paso, Tex.
Photo by Michael J. Proio

In addition, the direction finder sensor network will be expanded to assist lost pilots and aid in other emergencies; remote maintenance monitoring will be added; and vacuum-tube instrument landing systems will be replaced with microwave landing systems.

Voice communications coverage for towers, centers and flight service stations will be provided above 2,000 feet, as mentioned above. However, because of frequency requirements, conversion of ground and airborne systems to 25-kHz channel spacing will be required.

The consolidation of identical communications equipment into common buildings or with other compatible facilities will provide significant operations cost savings, since the three existing networks have overlapping coverage. Remote communications systems will also be located at the same site with VOR-DME stations and en route surveillance facilities. Where possible, navigation facilities will be consolidated—in some instances with direction finders.


The newest terminal radar beacon antenna, which will serve Mode S in tomorrow's system, is a five-foot open array atop an ASR-8, here at Miami International Airport.

Aviation weather will be provided from FAA primary radar used for air traffic control, until NEXRAD—the joint service Doppler weather radar—is fully operational. FAA en route primary radars will be replaced with a NEXRAD system on a one-for-one basis to maintain the FAA weather radar network and coverage above a 6,000-foot altitude.

The existing 12 vacuum-tube airport surface detection equipment radars (ASDE) will be replaced with solid-state, and 17 new systems will be established. This system enables controllers in the tower to pick up planes and airport vehicles on runways and taxiways in all types of weather.

During the long term (to 2000), data-link coverage will be extended from 12,500 feet down to 6,000 feet above mean sea level, giving weather and air traffic services to lower flying aircraft. To receive air traffic control service in designated airspace, planes will have to be equipped with Mode S data link. Weather radar information will be improved as additional NEXRAD systems become operational.

FAA en route primary radar will be decommissioned when enough planes flying at 6,000 feet and above carry Mode S transponders and the NEXRAD doppler weather radar is in the system. ■

national AIRSPACE system plan

Interfacility Communications & Auxiliary Systems

Improvements to approach lighting systems will make them switchable when visibility permits to effect energy conservation.

FAA operates and maintains a vast network of communications and auxiliary systems in support of its responsibility for the nation's air traffic control and air navigation systems.

Essentially, the communications network provides a voice and data link between the various air traffic control facilities and between those facilities and smaller remote facilities like radar sites and ground-to-air transmission stations.

Auxiliary systems include such items as buildings, access roads, maintenance, logistics, flight inspection, and the facility and equipment (F&E) process itself.

Part of the communications network is owned by FAA, a notable example being the approximately 16,000 miles of microwave links that are used to remote radar data to airport terminals and en route centers. Most of the communications facilities used by FAA, however, are leased, generally from local utility companies.

These leasing arrangements were made at a time when circuit costs were relatively inexpensive. Recently, however, telecommunications costs have escalated, creating a major financial burden for the agency. At the same time, competition within the telecommunications industry has emerged, and opportunities now exist for FAA to develop an interfacility communications network which will provide better service to air traffic control at lower operating costs.

Improvements to flight inspection include the Automated Flight Inspection Computer System, now installed in 15 Sabreliner 80s and five Jet Commanders.

A similar potential for increased effectiveness at reduced cost exists for auxiliary systems, particularly in the area of maintenance, flight inspection, training, logistics and FAA-owned housing and energy.

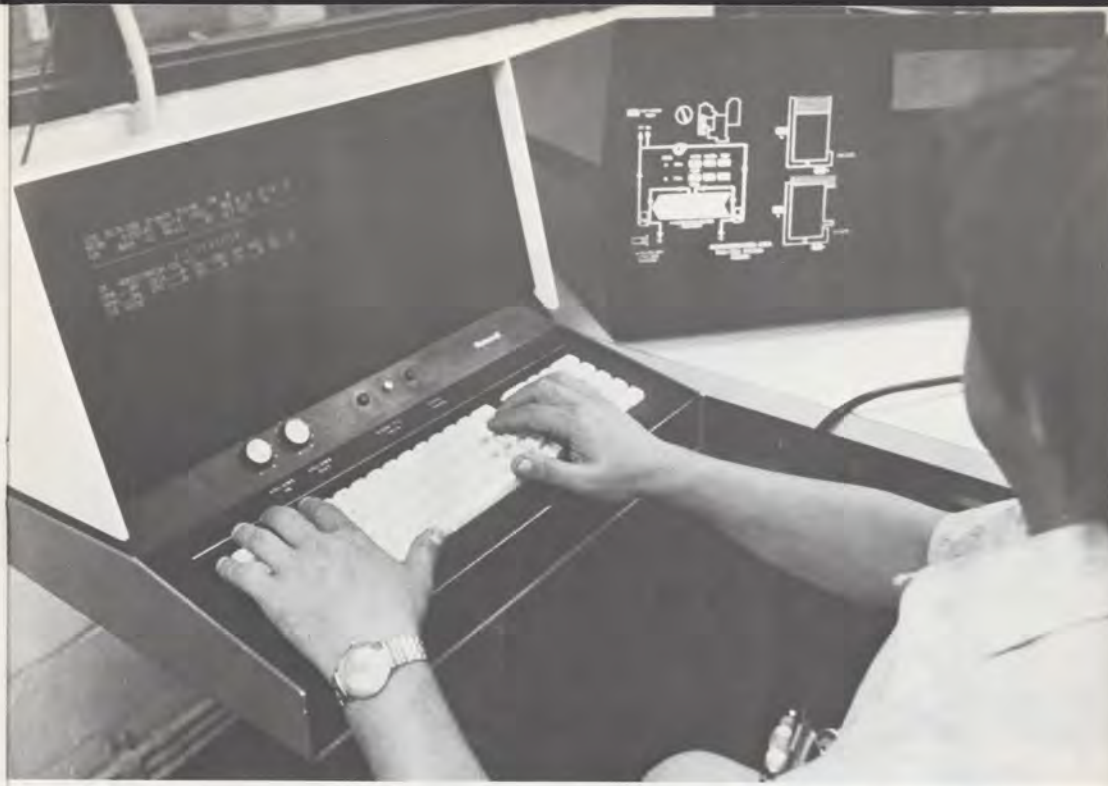
Programs are already underway in the near term (to 1985) to improve the interfacility communications network. For example, a project has begun to replace all teletypewriter lines and equipment in Alaska—where maintenance and leased-line costs are most severe—with higher-speed, multiplexed services and state-of-the-art terminals.

Also during this time frame, FAA will explore the potential for adding certain equipment to its radar microwave links (RML) to expand the uses of RML from only carrying radar data to the ARTCCs to carrying other information between FAA facilities.

The agency also will begin to establish during this time a national airspace data interchange network (NADIN) that will tie together all FAA air traffic facilities into a fast, more reliable, coordinated communications network.

During the intermediate term (to 1990), the NADIN ultimately will evolve into a general-purpose data switching and transmission system with alternate routing capabilities to bypass breakdowns or heavily loaded circuits. It will, in essence, provide the backbone of the FAA communications systems.

In addition, as new computer-controlled switches for voice communications replace the manually wired circuits at the en route centers, they will be linked to form an integrated voice network, capable of matching sector configurations, and also provide trunk circuit switching for NADIN, which would lower overall system costs.



Remote maintenance monitoring will consolidate the technician work force and cut operations costs by $100 million.

Moreover, main trunk lines will be increased through multiplexing, which essentially involves pulling various circuits into one main line, thereby eliminating the costs associated with a large number of dedicated or individual lines.

Radio remoting, using packet radio technology, also will be used during this intermediate period to avoid the use of expensive leased lines and the cost and disruption of excavating to lay in cables, say at an airport to connect navaids to the tower. Basically, packet radio is a form of multiplexed data transmission using point-to-point radio.

During the early part of this intermediate period, the transmission media

Using fiber-optic cables—where light pulses are the means of communication—is one approach to replacing aging electric cables at airports. Photo courtesy of AT&T

likely will be a mix of satellites, ground links and radio links, with existing RML upgraded and expanded for general interfacility use. The end of the intermediate period (1990), however, will likely see the network transmission media evolving into a mix of RML and satellites.

In the long term (to 2000), as more facilities are consolidated and Mode S secondary radar and automated en route air traffic control (AERA) impose increasing interfacility requirements, voice and data will eventually evolve into an integrated digital network with an increasing number of earth stations.

As for auxiliary systems, the near

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For advanced en route automation and other voice and data interfacility communications, it is likely that satellite technology will be used. This is an AT&T/GTE satellite earth station at Hawley, Pa.

term will see the introduction of a new, revolutionary program for maintaining air traffic control facilities. Currently, the maintenance is accomplished by a staff of electronics and environmental technicians from approximately 1,000 staffed facilities linked with 115 sector offices. The Maintenance Program for the 80s, as the new program is named, calls for the replacement of vacuum-tube technology with more-reliable, less-costly solid-state equipment and the introduction of remote maintenance monitoring of facilities.

Under remote maintenance monitoring, FAA technicians will be able to continually monitor systems' performance from central locations instead of doing periodic preventive maintenance and making frequent on-site visits, often to remote locations. This will reduce travel requirements and, therefore, costs. It also will allow FAA to consolidate maintenance personnel into a relatively small number of centralized sector offices. By 1985, for a start, the number of sectors will be reduced from 115 to 103.

By the end of the intermediate period (1990), the number of sectors will be reduced to 86, and by 1992 the new Maintenance Program will be fully implemented, with the number of sectors reduced to about 67.

A similar evolution has been planned for the flight-inspection program, which is responsible for certifying the operation of FAA facilities that transmit the precision signals needed for navigation and surveillance. New techniques, more fuel-efficient aircraft, new system capabilities for automatic flight inspection, the consolidation of the work force and the coupling of flight-inspection requirements with schedules consistent with remote-monitoring feedback—all will be implemented. These actions are expected to significantly reduce operating costs.

During the near term (to 1985), flight inspection field offices will be consolidated from seven to five. Upgraded avionics also will be integrated into the fleet, and semi-automatic flight inspection will be eliminated, its function incorporated into an automatic flight inspection program. By the end of the intermediate period (1990), the fleet will be replaced by turboprop aircraft providing significant operating cost reduction. The number of flight-inspection-operations hours will be reduced from 27,000 annually in 1981 to 20,000 by 1985 and finally to 10,000 hours by 2000.

Computer-based instruction for Airway Facilities personnel will be expanded and sited at ARTCCs, sector offices, work centers and regional offices.

An emergency communications network will be in place by 1988. It will evolve from today's high-frequency (HF) single sideband (SSB) networks as follows: By 1985, an eastern and western command network will interface with the HF-SSB network. By 1990, regional frequency modulation (FM) networks will be added to complete the emergency communications network.

Computer-based instruction is another area identified in the 20-year plan where considerable cost-savings can be effected. The current costs of training Airway Facilities personnel and the travel associated with that training, for example, exceed $6 million per year. With the implementation of computer-based instruction (CBI) on a full scale, however, approximately 70 percent of that cost can be saved. This is over and above the benefits derived from improved employee productivity resulting from a self-paced course of instruction offered by CBI. So, the agency plans to establish CBI training centers at most of its major field personnel concentrations, including sector offices, en route centers, work centers and regional offices. By the end of 1982, a limited number of AF courses will be provided at 40 field locations. Full system implementation, called for under the plan, provides for training centers at 272 locations. ■

The NOTAMs section of the National Flight Data Center, with specialists (l-r) Jim Casey, Patti Graham and Joe Schneider. Processing will be switched from NATCOM in Kansas City to NADIN buildings.
Photo by Jay Carroll

An FAA flight inspection Sabreliner 80. Replacement with turboprop aircraft to save on fuel is in the cards.

Radar microwave links can be converted to provide interfacility communications in addition to radar remoting.

People

Alaskan Region

■ **Douglas W. Cook,** team supervisor at the Anchorage ARTCC.

■ **Henry F. Dodd,** chief of the Plans, Programs and Evaluation Branch, Air Traffic Division, from the Operations, Procedures and Airspace Branch.

■ **Richard A. Ericson,** team supervisor at the Anchorage Flight Service Station/International Flight Service Station, from the Big Delta FSS.

■ **Lorin N. Johnson,** maintenance mechanic foreman at the Nome Airway Facilities Sector Field Office of the Fairbanks AF Sector.

■ **Robert D. Mitchell,** chief of the Deadhorse AF Sector Field Office, Fairbanks AF Sector, from the Barrow AF Sector Field Office.

■ **Timothy R. Rahmn,** team supervisor at the Homer FSS.

■ **Billy R. Rhodes,** chief of the Aircraft Maintenance Base in Anchorage, from the Flight Standards National Field Office in Oklahoma City.

■ **Donald V. Schmidt,** area officer at the Anchorage ARTCC.

Central Region

■ **Keith I. Blythe,** chief of the Atlanta, Ga., Aircraft Certification Office, from the Southern Region's Engineering & Manufacturing Branch, Flight Standards Div.

■ **Charles M. Bumstead,** team supervisor at the Kansas City ARTCC, from the Operations, Procedures & Airspace Branch, Air Traffic Division.

■ **Walter F. Horn, Jr.,** chief of the Chicago Aircraft Certification Office, from the Great Lakes Engineering & Manufacturing Branch, Flight Standards Division.

Eastern Region

■ **Charles J. Bell,** chief of the Morristown, N.J., Tower, from the JFK International Tower in New York.

■ **Mathew M. Calendar, Jr.,** data systems officer at the Baltimore, Md., Tower, from the New York TRACON.

■ **Albert F. Douglas, Jr.,** deputy chief of the JFK International Tower, from the Operations Branch, Air Traffic Division.

■ **Frederick L. Gibbs,** deputy chief of the Philadelphia FSS, from the Operations Branch, Air Traffic Division.

■ **Richard E. James,** team supervisor at the Atlantic City, N.J., Tower.

■ **Richard J. Roach,** team supervisor at the Poughkeepsie, N.Y., FSS, from the Lebanon, N.H., FSS.

Great Lakes Region

■ **Joel W. Campbell,** watch supervisor in the Detroit, Mich., AF Sector.

■ **Larry E. Ellison,** crew chief in the Indianapolis ARTCC Airway Facilities Sector.

■ **Robert A. Frink,** deputy chief of the Chicago O'Hare Tower, from the Automation Branch, Air Traffic Division.

■ **Robert L. Miller,** area officer at the Chicago ARTCC.

■ **Terence E. Miller,** team supervisor at the Moline, Ill., Tower, from the Chicago O'Hare Tower.

■ **Evans Spencer,** chief of the Detroit FSS, from the Regional Communications Control Center.

Northwest Mountain Region

■ **Walter G. Allard,** unit chief at the Cedar City, Utah, AF Sector Field Office in the Salt Lake City AF Sector, From the Colorado Springs, Colo., AF Sector.

■ **Mark E. Baldwin,** chief of the Denver, Colo., Aircraft Certification Field Office, from the Engineering & Manufacturing Branch, Flight Standards Division.

■ **Thomas V. Cowan,** team supervisor at the Denver Tower.

■ **Robert L. Daniels,** team supervisor at the Yakima, Wash., Tower, promotion made permanent.

■ **Joe Hink, Jr.,** team supervisor at the Broomfield, Colo., Tower.

■ **Thomas A. Lemmons,** chief of the Pendleton, Ore., Tower, from the Portland, Ore., Tower.

■ **William M. Rhode,** team supervisor at the Denver FSS.

Southern Region

■ **Billie Lee Abram,** chief of the Atlanta, Ga., Aeronautical Quality Assurance Field Office, from the Miami, Fla., Transport Aircraft Team, Flight Standards Division.

■ **David E. Graham,** program support officer in the Jackson, Miss., AF Sector.

■ **Robert R. Johnson,** chief of the Wilmington, N.C., AF Sector Field Office in the Charleston, S.C., AF Sector, from the Electronic Engineering Branch, Airway Facilities Division.

■ **James P. Kendrick,** assistant chief at the Atlanta, Ga., International Airport Tower.

■ **Robert N. McDaniel,** assistant chief at the Memphis, Tenn., ARTCC.

■ **Rafael A. Nieves-Freire,** program support officer in the San Juan, Puerto Rico, AF Sector.

■ **George W. Scott,** chief of the Greenville, Miss., Tower, from the Chattanooga, Tenn., Tower.

Southwest Region

■ **Bert F. Bass,** team supervisor at the Oklahoma City, Okla., FSS, from the Fort Worth, Tex., FSS.

■ **William G. Fournier,** team supervisor at the Albuquerque, N.M., ARTCC.

■ **Arthur D. George,** chief of the Pine Bluff, Ark., Tower, from the Little Rock, Ark., Tower.

■ **Phil Harris,** military liaison & security officer at the Fort Worth, Tex., ARTCC, from the New York ARTCC.

■ **Jimmie L. Vaughan,** team supervisor at the Houston, Tex., ARTCC.

■ **Joseph Zaremba,** navaids/communications specialist at the Oklahoma City AF Sector in Ponca City, Okla., from the Frequency Management & Leased Communications Staff, AF Division.

Western-Pacific Region

■ **George H. Ackerman,** team supervisor at the Maui Tower in Kahului, from the Honolulu Tower, Hawaii.

■ **Sheryl D. Becker,** team supervisor at the Oxnard, Calif., Tower, from the Burbank, Calif., Tower.

■ **David K. Fowler,** programs officer at the Ontario, Calif., TRACON.

■ **Gerald W. Graham,** team supervisor at the Las Vegas, Nev., Tower, from the West Memphis, Ark., Tower.

■ **Glenn J. Miller,** unit supervisor in the Guam AF Sector at Andersen AFB.

■ **Robert H. Perez,** maintenance mechanic foreman in the Guam AF Sector in Finegayan, Guam.

■ **R. Keith Shippee,** assistant chief at the Ukiah, Calif., FSS.

■ **Robert E. Starkey,** team supervisor at the Fullerton, Calif., Tower, from the Orange County Airport Tower in Santa Ana, Calif.

■ **Leland J. Wingard,** team supervisor at the Napa, Calif., Tower, from the Las Vegas, Nev., Tower.

O'Hare Tower's radome glistens like a translucent jewel. Photo by Neal Callahan

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