Turbulent Skies: The History of Commercial Aviation

by
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Chapter 10: Search for Safety
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IT WAS RAINY WITH HEAVY OVERCAST on a morning in mid-December, 1960, as a United Airlines DC-8 approached New York's Idlewild Airport. An Air traffic controller directed the pilot to fly a holding pattern near a navigational point while awaiting clearance to land. But that pilot had experienced a partial failure of his navigating instruments and could not find the point or establish his exact position. He cut is speed to three hundred knots but overshot his assigned airspace and entered the area around La Guardia.

At the same moment, a TWA Super Constellation was inbound to that airport, producing a blip that showed clearly on a radar screen. Suddenly a second and unexpected blip appeared nearby. The controller picked up his microphone and warned the TWA pilot, "Jet traffic off to your right now at three o'clock at one mile." The pilot radioed his acknowledgment, "Transworld 266, turn further left." This time there was no response. The two blips continued on a collision course before merging into one. This disaster cost 136 lives, including everyone aboard the planes as well as eight people on the ground.

It was the 1956 accident all over again, though this time it happened over Brooklyn rather than the Grand Canyon. A similarly sweeping response might well have followed, particularly since the incoming Kennedy Administration was eager to undo its predecessors' follies. Senator Mike Monroney held hearings, and JFK lost little time in directing his FAA administrator, Najeeb Halaby, to carry out a far-ranging study of requirements for air traffic control.

Yet the aftermath of this disaster proved to be more remarkable for what it reaffirmed than for what it changed. The FAA put out a new rule, instituting a 250-knot speed limit in terminal areas. It also argued that TACAN distance-measuring equipment might have prevented the accident, and made its use mandatory. And that was about it. Halaby's study, known as Project Beacon, pointed to no far-reaching innovations that were being held up or experiencing delays. Indeed, although the CAA had begun to experiment with computers for use in air traffic control as early as 1956, the Beacon report offered little reason to believe that computer-generated displays soon would see widespread use. Instead it declared that for at least the coming decade, radar would continue in use as the primary tool.

Radar in 1960 still was far from offering the easy-to-read display that would become standard. It still needed shrimp boats and would continue to use them for a number of years. These now were no longer the brass paperweights that controllers had pushed around their table maps. Instead they were plastic tabs marked with grease pencil, set beside blips and serving to identify them. All through the workday controllers sat at their scopes using such pencils as well as cleaning rags. Many of the radar screens themselves were large and horizontal, so these boats would stay put. The shrimp boats would lose their usefulness only with the advent of computer displays would await the union of computers with radar, a development that in 1960 lay far in the future.

Even with shrimp boats, radar still could be an open invitation to eyestrain. The blips on a scope often were barely visible in lighted rooms or in the control towers during heavy rain, radars would become harder to use just when everyone had the greatest need to rely on them.

Clever radar engineering offered a way out. This featured transmission of radar beams having a particular pattern of orientations of the radar waves. Nearly round objects such as raindrops would reflect these orientations about equally, producing returns with a characteristic signature. Within the radar set, an internal circuit could pick up this signature and suppress its display. But elongated objects, such as aircraft, would return a different arrangement of the orientations. These would pass through the circuit to appear on the screen.

Similar ingenuity could cope with ground clutter, at least to a degree. Ground clutter arose from the reflection of radar beams from buildings, trees, and similar objects. These all tended to show clearly on the radar screens, often drowning out the blips from aircraft much as daylight swamps the light from stars. Tilting the radar transmitter skyward helped to reduce such clutter by directing the beam away from the ground, but it also reduced the chance of picking up a return from a low-flying aircraft that was far in the distance.

A better way lay in circuitry that could determine whether an object was moving toward or away from the radar transmitter. This circuit could suppress returns form anything that appeared fixed in position. Most items on the ground then would disappear from the screen, while aircraft, which were definitely moving, would stand out more clearly. This technique wasn’t perfect, to be sure. It could pick up a moving train but suppress the blip of a hovering helicopter. And an airliner that was flying on a tangent to the transmitter would also vanish from the radarscope. But this technique was better than the alternative, which might be to see little or nothing.

It also helped to have the blips from airliners stand out more sharply. Transponders, mounted on these aircraft, proved useful. They could respond to a transmitted signal by returning an amplified pulse that would show itself brightly on the scope. Transponders could also ease the task of identifying particular blips. In the usual procedure, a controller who was in doubt would ask a pilot to execute a turn or similar maneuver to make his blip move on the radar screen in a characteristic way. With transponders, a pilot would merely hit an “Ident” button; then the blip would brighten momentarily.

As was usual within the FAA, these capabilities were reaching the field centers only slowly. As early as 1956, the first radar equipped for rainstorm-image suppression had gone into operation at La Guardia. For the FAA, a particular focus of effort lay in equipment for its thirty-five regional centers, known as air route traffic control centers (ARTCCs). These relied on radar to keep track of airliners at cruising altitudes and might have prevented the Grand Canyon disaster. But in 1960 the majority of ARTCCs, as well as most control towers, still lacked bright display radar. The situation with transponders was similar. By 1960 they were becoming standard equipment aboard jetliners, In addition, sixteen ARTCCs had the necessary transmitters. However, that meant there were nearly twenty such centers that didn't, and it would take four years before the last of them received the needed systems.

Radar improvements supported another area of effort, involving landings in very bad weather. After 1960, the question arose as to how murky the weather could be, and how poor the visibility, while still permitting pilots to land in standard fashion, with help from the Instrument Landing System, ILS.

In addressing this question, the beginning of wisdom lay in the knowledge that ILS was not a precision system. Its radio beams offered what amounted to a badly blurred view of an airport, even at major terminals such as Newark, ILS could guide landing aircraft onto only a single instrument runway. That meant that when the weather closed in at New York, for instance, only three runways would be available for instrument landings within the entire metropolitan area one at each of the principal airports.

Nor did ILS work well during the final moments of the landing approach, for at those critical times, a pilot's radio receiver would be picking up signals that might easily fail to define a proper course. The glide-path beam did not arise through direct transmission from a radio tower. Instead the transmitter required an extensive area of flat ground that would act as a mirror, reflecting part of the transmitted signal to create the necessary radio pattern. This was not an arrangement that lent itself to high precision. The localizer beam, defining the direction to the runway, had its own error sources. It could reflect off aircraft, airport buildings, power lines, and the like, producing bends or wiggles in the approach path. These problems were particularly serious immediately before touchdown, for the plane then was at a very low angle above the horizon, in a region where these reflected signals were particularly strong.

All this meant that ILS could do a good but not a great job in guiding airliners, so that pilots needed a certain amount of leeway. They particularly had to be able to see the runway from a sufficient elevation, and with sufficient visibility, to correct for cross-track errors that tended to put them to the left or right of the runway pavement. The standard for piston aircraft had long been a two-hundred-foot ceiling and half-mile visibility; after 1960 these limits applied to jets as well. They were known as Category I; if conditions were worse, the planes couldn't land. The next frontier in low-visibility landings lay with Category II, which set one-hundred-foot ceiling and quarter-mile visibility as the weather minimums. Cat II standards would then be twice as stringent as Cat I.

Certainly such weather conditions were not likely to be part of everyday experience. Within the United States, conditions of Cat II or worse exist only about three days out of the year at most airports. At New York's JFK this is only sixty hours. But it was more serious in Seattle and in London where its pea-soup fogs. In those cities, as well as elsewhere in northern Europe, that kind of weather cold sent in as often as ten days out of the year. And even within the United States, the 1961 report of Project Beacon found that weather delays were costing the airlines some $70 million annually, a figure that would increase during subsequent years. In pursuing Cat II, there was the obvious hazard of spending half the total cost of air traffic control systems to wring out that last 1 percent of operating time. But there was plenty of opportunity to try for modest improvements in the basic systems and see how far they would go.

Some airports were beyond help. At La Guardia, for instance, the ILS glide-scope beam reflected off the waters of the adjacent East River. This was not the Bay of Fundy; its tidal rise and fall was quite modest. Even so, this tidal change was enough to cause the angle of the glide-slope beam to shift during the day. La Guardia was one of the nation's busiest airports yet it could not win certification for Cat-II landings.

At other ILS runways, the reflecting clear area in front of the glide-slope transmitter would change its reflectivity, and hence the glide-path angle, if it rained or snowed heavily or if the grass grew too long. Airport officials responded by installing instruments that would keep track of these changes, shutting down the transmitter if the glide-slope angle fell outside specified limits. ILS then might be unavailable in bad weather, just when pilots would need it most.

However, localizer beams lent themselves to greater precision. Radio specialists could try different types of transmitting antenna, seeking an installation that would give a narrower beam. Such a beam would offer greater accuracy and would be less prone to bend and wiggle by reflecting off hangars. To further reduce these problems, airports could designate sanitized areas that were to stay free of aircraft during Cat-II conditions. That tended to reduce the bends in the localizer beam that such airplanes produces as they moved about.

To encourage such developments, Boeing equipped the 747 for Cat-II landings. Still, in the words of Bruce Frisch, an editor of the trade publication *Astronautics & Aeronautics:*

> FAA will have to better the record of the last six years. In 1963, the agency designated 23 runways for Cat II. The last quarterly report listed 10 in commission, one down from the previous quarter. Missing were SeaTac, serving Boeing's headquarters city, Seattle, and New York, the U.S. gateway to Europe. In fact, east of Detroit and north of Atlanta there are only two Cat-II runways, one each at Washington's Dulles and National airports. Wes of Denver, New Orleans, and Minneapolis there is only San Francisco. FAA has scheduled at least nine more by the end of 1970, truly a courageous act.

That was in 1969. Matters improved over the next quarter-century, but slowly. Even so, within the United States, 76 runways offered Cat-II landings in 1992, with 760 other ILS runways being rated at Cat I. This meant that Cat II was available at least at major cities, where weather delays would inconvenience the most travelers. But it was far from universal in coverage.

The FAA experienced similar vicissitudes in introducing computers. This began during the 1960s, when a promising prospect lay in using computers to display airliner altitudes on a radar screen, alongside their blips. This would offer three-dimensional radar, for a controller could then see each plane's altitude along with its location.

A new type of transponder, carried with an airliner's on-board equipment, represented a key element. In response to a ground command, this transponder would send out a coded string of pulses that would report its altitude. The computer would decode this information and then display it on the radar screen using alphanumerics. And while it was doing that, it could go a bit further and present the airliner's flight number as well, taking one more chore out of the hands of the overworked air controller.

A radar system then could do more than to free itself from clutter, using the specialized circuits that screened out images of rain and of buildings. It could present a comprehensive overview of the air traffic, with each blip neatly labeled.

The alphanumeric display of decoded transponder transmissions thus represented one path whereby the computer could offer new prospects for air traffic control. A second path lay in the tedious business of continually preparing and updating flight progress strips for each airplane. These were based on pilots' flight plans and on updates to those plans that reflected the delays and other vicissitudes encountered in the air. Each such strip then gave a complete picture of what a particular blip was doing. A computer could store and receive updates of this information for every plane with a wide region, printing out these strips as required to serve the needs of each controller during the working day.

By today's standards these capabilities appear elementary. You can go down to Radio Shack and buy a system that has more advanced graphics, along with power far in excess of what would serve for these simple tasks of pulse-train decoding and mass data storage. But during the early 1960s it often took a room-size mainframe to offer the speed and memory of the laptops that businessmen now carry in their attaché cases. The situation with graphics was also pretty bad. As late as 1967, when the movie *2001: A Space Odyssey* was being filmed, there was no way to use real computers to produce the detailed and quickly changing displays of HAL 9000. Instead, Stanley Kubrick had to employ an artist to produce transparent viewgraphs that would flash in appropriate succession, simulating that computer's displays.

Complementing these technical difficulties were budget problems, stemming from the fact that LBJ's Administration would more readily provide largesse for the glamorous SST than for the prosaic business of upgrading the air traffic control system. FAA funding for facilities and equipment plunged from a peak of $160 million in fiscal 1961 to only $28 million in 1967. Funding for research and development followed a similar course during those years, dropping from $64.5 million to $28 million. This meant that the FAA would enter the realm of computers in its usual way, taking its sweet time and acting largely in response to events.

The event that led to action was, as usual, an air disaster. In December 1965 an Easter Air Lines Constellation collided with a TWA jetliner over New York. It could have been the worst crash in aviation history, but the pilots of both planes managed to maintain a semblance of control and set them down with no more than four people dead. The immediate and urgent question was whether the FAA had any rabbits it could pull from a hat. Had this organization shared in the vigor of the New Frontier during the five years since the last such collision? Fortunately, it had. A few months earlier, an experimental system called ARTS, Advanced Radar Terminal System, had gone into operation at Atlanta. It amounted to a basic computer arrangement linked to a single radar, capable of displaying signals from altitude-reporting transponders in alphanumeric format on radar screens. The FAA's deputy administrator, David Thomas, ordered the removal of this equipment to New York, where it would serve a new radar center. That center, in turn, would bring together under one roof the radar controllers who had previously worked at La Guardia, JFK, and Newark and would make it easier to coordinate their efforts.

This was only a baby step toward the use of computers, but it was an important advance in the use of radar. Here lay the beginnings of TRACON, Terminal Radar Approach Control, whereby individual centers would keep watch on all traffic within major metropolitan areas. TRACON offered a particularly valuable level of control, covering areas of crowded traffic that were much broader than those near individual airports, yet focusing far more sharply than the regional air traffic centers, the ARTCCs. These had swaths of airspace that by then were approaching Montana and California in size. What made TRACON feasible were alphanumerics. They clearly tagged each blip with a label, preventing controllers from being swamped by far more blips than they could handle within a wide city area.

The advent of TRACON fitted in with another trend, toward increasing positive control of the nation's airspace. This trend had gotten its start in 1958 when the CAA designated here coast-to-coast airways within which aircraft could fly only if they followed instrument rules and accepted orders from air traffic controllers. After 1960, working with the Air Force, the FAA expanded its domains to cover broad areas of airspace. Again, though, its full commitment to positive control would develop by responding to rather than anticipating events. To put it more bluntly, once again the FAA would lock the barn door after the horse was stolen.

In July of 1967, a Boeing 727 collided with a privately owned Cessna, killing all eighty-two people aboard the two aircraft. This pointed up the dangers of having such planes share the same airspace, dangers that were particularly acute near airports. In response, nine months later, the FAA announced a plan to establish controlled areas with the airspace above major terminals. These would have the shape of an inverted wedding cake, with the air divided into geometric layers that would widen with increasing altitude. No airplane, whether built by Cessna or by Boeing, could enter these areas unless it had a two-way radio, transponder, and a VOR or TACAN navigational receiver. With such regulations, the discipline of air traffic control would reach the world of private flyers during their landings and takeoffs at the nation's principal airports.

Very quickly the FAA found itself in a collision, facing vehement opposition from the Aircraft Owners and Pilots Association. This outfit of private flyers won support from the Air Line Pilots Association, which took the view that this proposal would prove excessively complex and confusing. No one wanted t see a student pilot bring down a fully loaded 747, but these organizations took the view that all would be well if the jetliners used special corridors during takeoff and landing instead of complete upsidedown wedding cakes. That way the private flyers could continue to use the big airports, taking care to stay outside these corridors if they lacked the necessary instruments.

For the next year and a half the FAA tried to come to terms with these pilots' associations while it carried out a detailed study of the safety problems near airports. In September 1969, with the study having concluded, another small private plane collided with a n airliner and forced the FAA's hand. The agency issued a Notice of Proposed Rulemaking, announcing its intention to set up wedding-cake controlled areas above twenty-two of the busiest airports. Subsequent studies of the traffic at Boston showed that such areas actually offered greatest safety as well as the least controller workload and were much better than any corridor arrangement. The demand for corridors rapidly evaporated, and the FAA was quick in following this up.

In October 1971 it extended positive control to all U.S. airspace between eighteen thousand and sixty thousand feet. An SR-71, flying at eighty-five thousand feet, might proceed with the insouciant freedom of the old days. But any pilot venturing into this zone, anywhere in the country, would have to carry a transponder and follow air traffic instructions.

By then the FAA, finally was on the sure path toward the serious use of computers. The process began 1967, when after much dithering the agency at last decided what it wanted. During that year it gave out contracts for a comprehensive data system that would serve the regional ARTCC centers. Named National Airspace System En Route Stage A, it was to offer processing of both flight-plan and radar data. IBM was to provide both the computers and their programming, with Burroughs contracting to build digitizers that would translate radar and transponder signals into language the computers could understand. Raytheon came in as a third contractor, building display consoles that looked like radar screens but presented their blips as computer-generated data.

IBM's task was particularly difficult. In dealing with flight-plan information, its programs had to do much more than simply keep track of this data and print it on request. The system was to respond to the data intelligently, using it to estimate such items as arrival times over navigational waypoints and at the destination. It then would anticipate controllers' needs, transferring data and printing it out before anyone even asked for it.

Radar and transponder data demanded more. The software had to know the boundaries between sectors viewed by different radar screens, When a particular blip with its displayed data approached the boundary between two such sectors, it had to know that the blip would be moving onto a particular new screen. This would allow the system to execute a handoff. The first controller would push a button, causing the alphanumeric data block to blink. This would continue until the new controller pressed a key to confirm the transfer.

The computer had to know the difference between blips that represented aircraft and radar returns from ground clutter, filtering out the latter. It had to accept radar inputs from a number of sites, working with FAA, Air Force, and Navy equipment of various types. It was to create radar mosaics, taking data from several radars operating simultaneously, evaluating the data for validity, and selecting the most accurate information for display to the controller.

All this meant that the IBM software needed to incorporate a great deal of knowledge concerning both the ARTCCs and air traffic procedures. This brought problems, for programmers didn't understand air traffic control and controllers didn't understand programming. It took a while before these people could talk to each other. The FAA's David Thomas later recalled that "a frustrated programmer complained that all the aircraft flew at different speeds, and if we could only get them to fly at the same velocity, the programming difficulties could be overcome." At one point IBM had five hundred programmers working to debug the software. When complete it contained over 475,000 lines of code, far more than any previous computer program. Nor were the computers themselves immune to these difficulties. The IBM 360 was the system of choice, but IBM had to double its memory before it could deliver the first of them.

These efforts all focused on the en-route traffic tracked at the regional ARTCCs, with their California-size blocks of airspace. The FAA also needed similar systems for airports and metropolitan TRACON centers. In 1969 it contracted with Sperry Univac to build an upgraded ARTS III for use at these locations. Their installations would feature a suite of obsolescent computers with less total power than a person computer of the 1980s; yet ARTS III had its uses. In addition to alphanumerics, it could execute automatic radar handoffs. It also could determine an airplane's ground speed, a talent that made it easier for controllers to anticipate a midair collision. A separate development, ARTS II, brought computers to smaller cities such as Binghamton, New York, and Pensacola, Florida.

The FAA's research budget could pay for the developmental work, but building these systems and putting them in the control centers would take additional money. The Nixon Administration came to the rescue with the Airport and Airway Development and Revenue Acts of 1970, which set up a fund that would fill with cash from new taxes. For the traveler, the most noticeable tax came to 8 percent of the cost of each ticket. There also were taxes on air cargo, on fuel used by privately owned aircraft, and on the airliners themselves. These had the important consequence of freeing the FAA from reliance on the vagaries of congressional appropriations. It meant that the more people flew, the more money would be available for the airways. In particular, installation of the new computerized air traffic systems could go forward at full throttle.

The nation's ARTCCs were among the first centers to benefit. After 1970 they received elements of the National Airspace System at a rapid pace. Computer processing of flight-plan data reached fruition in February 1973, when the last ARTCC received this capability. Radar data processing came to all these centers by August 1975. At major airports, installation of ARTS III systems also went ahead quickly. Chicago's O'Hare received the first of them late in 1970. The sixty-third, completing the program, went in at Dallas-Fort Worth in August 1975.

Two weeks later, when the Miami ARTCC became the last center to receive radar data processing, Acting FAA Administrator James Dow traveled to that center to inaugurate the complete system. He called it "one of those rare times when we can talk, without exaggeration, of reaching a milestone." He then went to hail the new computer system as representing an advance as important as radar a quarter-century earlier. One of the air controllers put it more succinctly. The new equipment, he declared, was like "driving a Cadillac instead of riding a bike."

These computer systems helped greatly in enabling the nation's airports to cope with the continuing growth in passenger traffic: 169 million in 1970, virtually doubling to 297 million during 1980. It also would have helped if the nation had more airports, but here the situation was very clear: we weren't building many. Nor was this the result of antigrowth sentiment during the '60s; the trend had been well under way during the previous decade. As early as 1952, when the airspace over Washington was already saturated, public protests had blocked a plan to build a new airport in Virginia's Fairfax County. It had taken six additional years to settle on the eventual site of Dulles International, and this was in an era when suburbs still lay close in while outlying land was readily available. During the 1960s airport site selection would advance from the difficult to the nearly impossible.

One focus was the greater New York area, as the Port Authority set out to build a fourth major jetport. Early in the decade, Richard Hughes, governor of New Jersey, pledged there would be no such facility in the northern part of his state. The Port Authority proceeded to evaluate twenty-two sites in New Jersey and New York State, settling on a location in Morris County, thirty-two miles west of Manhattan, called the Great Swamp. The state legislature promptly rejected this proposal, and part of the area went on to become a wildlife refuge. Continuing their search, the port authority, the FAA, and a group of airlines chose a site in Hunterdon County, forty-eight miles from the city and close to the Delaware River. That didn't fly either. Local political pressure, meanwhile, was defeating a proposal for major expansion of an existing airport at White Plains, north of the city.

In the end, the metropolitan area would have to get along with only the three airports it had in 1950. It helped that these at least could be enlarged to some extent. La Guardia carried through a major runway and terminal expansion during the 1960s. Newark followed with its own improvements, adding a new instrument runway followed with its passenger terminals. The White Plains airport expanded somewhat, as did another airfield in Islip, Long Island. Nevertheless, these were only stopgaps. As with New York's subways, its system of airports would remain frozen in a design of an earlier era.

Similarly, opposition from environmentalists blocked a plan to build a new airport near Miami. That city's air services were booming, for it stood as the gateway to the Caribbean. Yet it would have to get along with its existing Miami International.

The one new airport that did reach completion, Dallas-Fort Worth (DFW), represented a special situation. Those two Texas cities were rivals, and each had built its own major airport. In 1954 the chairman of the Civil Aeronautics Board, Chan Gurney, had called for renaming with the new Fort Worth International and operating it as a joint facility with Dallas. Fort Worth had been willing but Dallas had demurred, preferring to stick to its own Love Field. A decade later the rivalry was still going strong, with each city's newspapers taking shots and the mayors joining in.

Then the FAA's Halaby ordered a cutoff of further federal airport grants to Lover Field and made it clear he wanted the cities to get together. Soon the Dallas mayor was out of office, for unrelated reasons, and a Dallas citizens' group took the initiative in working for the new facility. It certainly was Texas-size; it sprawled over a tract larger than Manhattan and emerged as the world's largest airport. Its architect, Gyo Obato, designed it to grow from an initial four passenger terminals to a projected thirteen, all to be linked by an automated electric train. But other cities did not follow this lead. As DFW was reaching completion, in 1974, Secretary of Transportation Claude Briengar told a House subcommittee that he expected few if any new jetports in the coming decade. He was right. In the ten years that followed the construction of Dallas-Fort Worth, only five new runways reached completion within the entire country. No similar airport would enter service until Denver International reached completion in 1995.

Nevertheless, even if it was unpleasant to deal with, public opposition to airport construction at least was something that people in the industry could regard as familiar. This was much less true of another problem, the hijacking of airliners. Hijackings had occurred sporadically during the postwar years and had usually met widespread cheers. They had generally been the work of people seeking escape from communist regimes, including Castro's Cuba. But beginning in 1961 the cheering stopped, as these unscheduled flights began to make their way in the other direction.

It started that May, when a man calling himself El Pirato Cofrisi forced a National Airlines craft to divert to Havana. The man had taken his name from an eighteenth-century pirate on the Spanish Main, and it developed that there were no real laws specifically aimed at this new type of buccaneering. Several other hijackings soon followed, and President Kennedy responded by sending appropriate legislation to Capitol Hill. But this early crime wave soon died out, and for several years after August 1961 there were no successful seizure of U.S. aircraft.

In February 1968 the dam broke. A man wanted for payroll robbery took a Delta Airlines DC-8 to Cuba and soon found he had launched a trend. That year saw a total of seventeen hijack attempts, thirteen of which were successful; in 1969 the score was thirty-three of forty. There was no formal air service to Havana, but the FAA introduced radar coverage and communications links, while pilots took to carrying landing charts for Jose Marti Airport. Castro meanwhile, finding that most of the hijackers were misfits and criminals rather than socialist heroes, soon put them in prison and sent them to work cutting sugar cane. In the face of such treatment, six hijackers voluntarily returned to face prosecution in the States rather than continue to enjoy Havana's hospitality. As word of this got around, Cuba's attractiveness diminished considerably.

Hijacking was proving to be a beast with many heads, however, and two new ones sprouted during 1969. Late that year an AWOL Marine, Raffaele Minchiello, took a TWA jet on a seventeen-hour adventure from California to Rome. He emerged as something of a hero in Italy, with a number of young women offering to marry him. The film maker Carlo Ponti announced he would make a movie about this exploit. The FAA dissuaded him, but there it was, Hijacking was glamorous.

Also during that year, a pair of Arab commandos successfully seized another TWA flight while en route to Tel Aviv, highlighting a weak spot that Arabs and their supporters would attack repeatedly. Airliners were so vulnerable, and passengers so numerous, that terrorists would soon regard them as the best of all targets. Their repeated hijackings not only would provide them abundant publicity for the Palestinian cause but would serve as a weapon of extortion with which to free other terrorists held in European jails.

Both motives were in the forefront in September 1970, when the Popular Front for the Liberation of Palestine shocked the world with a coordinated series of hijackings. Two Palestinians seized a Pan Am 747 and took it to Cairo, evacuating the passengers minutes before they set it afire with explosives. Other guerillas grabbed planes of three other airlines and flew them to a hard, flat area in the desert of Jordan that the British called Dawson's Field. They took the passengers as hostages and blew up these aircraft as well. Their leaders demanded the release of seven imprisoned terrorists held in Europe, including Leila Khaled, a veteran of the 1969 TWA hijack, whom the British had captured following an unsuccessful attempt to grab still another airplane. These acts brought civil war with Jordan as that nation's King Hussein sent military forces against Palestinians, who had strong support from Syria. The resulting battle left the capital, Amman, badly damaged. In the end both the hostages and the seven terrorists went free, while Hussein's attack left the Palestinians weakened but ready to strike anew.

The FAA had been achieving some success in its own war against American hijackers. It had developed profiles of these criminals that allowed airport guards to single out suspicious passengers for closer looks. Some airlines, notably Eastern, which was a prime target of hijacking, had initiated the practice of using metal detectors to search for carry-on weapons. In addition, following the Arab outrages of September 1970, President Nixon announced that a force of sky marshals would take to the air, placing plainclothes agents aboard scheduled flights who might shoot it out with the bandits.

These measures were not altogether irrelevant. A number of guns and other weapons, fished out of trash cans near boarding gates, showed that at least some air pirates were having second thoughts. The psychological profiles also helped in an unanticipated and different way, as agents seized over a million dollars' worth of narcotics. But the sky marshals did not prevent a single hijacking or carry out even one arrest, and in time that program would end. Air piracy meanwhile was showing yet another face, for late in 1971 one D. B. Cooper seized a Northwest Airlines 727 and collected $200,000 in ransom, along with four parachutes. He then leaped from the rear stairwell, joining Amelia Earhart among those who have disappeared without a trace. He also gave abundant inspiration to a new wave of extortionists, ready to regard the planes at the local airports as if they were unguarded Wells Fargo stagecoaches.

Then, toward the end of 1972, two particularly vicious event brought the matter to a head. In October, four men wanted for murder and bank robbery killed a ticket agent, seized an Eastern Airlines 727, and made it to Havana. The following month, an escaped convict joined two others and commandeered a Southern Airways DC-9. During the next twenty-nine hours they made eight landings, collecting $2 million in ransom as they threatened to crash the plane into the nuclear facilities at Oak Ridge, Tennessee. FBI agents in Florida shot out the plane's tires. One of the hijackers shot the copilot in the shoulder and ordered the pilot to take off anyway. He said it was “like driving a car with a flat tire along a railroad,” but he got into the air and landed in Cuba. Havana authorities arrested them and seized their loot, but that offered little solace.

In response to other hijackings during 1971 and 1972, the FAA already was tightening its rules on suspicious passengers, and had ordered fifteen hundred additional metal detectors. Following the Southern Airways piracy, early in December, the FAA issued an emergency order directing airlines to carry out electronic screening of all boarding passengers, along with inspections of their carry-on baggage. A month later the metal detectors were present in force, employing magnetometers to search for guns and knives. They found many more belt buckles and arch supports, while quite a few of the knives proved to be silverware snatched from airport restaurants. X-ray scanners soon followed, for use in carry-on luggage, and as these items of equipment entered general use the hijacking problem soon came under control. It did not go away entirely in this country; plastic explosives would pass though the metal detectors, and bombs of this type, real or fake, would still prove useful to creative criminals. But after 1972 these crimes dropped off sharply. And in February 1973 Castro himself joined the effort, entering a formal agreement with the State Department to extradite or prosecute these pirates.

Hijacking still was a serious threat overseas, particularly to Israel. Within that country’s airports, security was unusually tight. But it amounted to barely a sieve at places such as Athens, which was a major stopover for airliners bound to and from the land of Zion. Still, the Israelis would not be at a loss. In June 1976, a group of terrorists seized an Air France jetliner that was outbound from Tel Aviv, diverting it to Entebbe in Uganda. It quickly developed that that country’s dictator, Idi Amin, was in league with the hijackers. He cooperated with them while a man from Germany’s Baader-Meinhof gang separated Jews from the others, marking them for a fate that everyone could easily imagine. But a force of Israeli commandos arrived in time to spoil the plans, out-shooting both the terrorists and Amin’s Ugandan guards and rescuing all but four of the hostages. After that, even Israel began to enjoy a measure of safety.

As the ware against hijacking ground ahead, the nation’s air traffic controllers were facing their own problems. These people represented an elite group; like the Marines, they were the few and the proud. The profession was highly selective, with as many as twenty-five thousand people sending applications to the FAA during a typical year. They would take a day-long battery of aptitude tests designed to measure such talents as ability to think in three dimensions and to maintain awareness of many events happening at the same time.

Of the twenty-five thousand, only around eighteen hundred would score in the high 80s or 90s on these preliminary exams. These people would enter the FAA's academy in Oklahoma City. They would take course that ran for several months, which would wash out quite a few more. Following graduation, the bottom 10 percent would receive les demanding assignments at radar centers. Of the original twenty-five thousand, no more than 5 percent would realize their hopes and work as FAA air controllers. Even then, they would need over three years c further experience before they could take on sole responsibility for separating aircraft in flight.

Assignments to major centers such as Los Angeles were particular] prized. "We are the best in the business," said one such controller. "W are the front line, and we make it work. It sounds macho, but it's true. "I love it," added a colleague. "When it gets down and dirty, and I'm turning and burning twelve planes, I get on a high. It's addictive. It's an ego thing."

"It was like being inside a video game," recalled a man with to years of experience in control towers. "It was always something different! When I worked the airplanes, swishing them in and out, I'd have problems I had to pose instant solutions for, and they had to work. W used a sixth sense, one that computers will never have. We had to learn to flow with it, flow with the traffic, as if we were in an art form or part of some piece of music. You had to be the best controller in the facilit3 ()r well on your way to claiming the title. The Clint Eastwood syndrome was alive and well where we worked."

"When you had worked some deep traffic, and worked it well, i was quite a boost to your self-esteem," said a fifteen-year man. "When I worked it was like I had memorized a road map for a hundred miles around. When I handled a string of pearls out there, maybe twenty airplanes, all relying on me, and when I'd run them in without a single problem it felt good, real good. Sometimes you'd even get a letter of appreciation, and that was even better."

The wife of a controller described them as “like Marlboro cowboys; they were like giants; they were like real men, macho, crazy, eager, proud, dedicated. They loved the job, the same crazy job that wars killing them much of the time. The same job that drove them up a wall, but that also made life exciting and dangerous and real, the way they liked it." And an ex-controller admitted, "I miss it, sometimes a Iot, because I really enjoyed working airplanes. Now, life without that job is just too sedate, too damn ordinary for my taste."

David Jenkins, a Boston University behavioral scientist and author of a study of controllers, described them as independent people with extreme self-confidence. They needed it, for the responsibility was huge. "You could never admit you had any limitations," cautioned a ten-year tower chief. "If you did, and they got reported, you were in bad trouble. What's much worse were the errors you didn't know about, because when you learned about them you got a *negative* adrenaline rush. You got scared. If you want to know the truth, we were always running scared. You had to believe in the inevitability of a mistake; otherwise you got too gung ho. After an incident," such as a near miss that might have turned into a collision, "you were never any good. You worked traffic, you stayed cool, and you puked your guts out in the bathroom afterward.

The job definitely was not a matter of working nine to five and then heading home for a pleasant weekend with the family. Controllers often had to work up to ten hours a day, six days a week, with the overtime being mandatory. Time-and-a-half pay would have helped, but wages for overtime were fixed by Civil Service law, so that a controller could actually receive less than during regular hours. No rule required advance notice of compulsory overtime, and an unexpected call-up on Saturday was par for the course. Controllers with medical problems held on to their jobs until overwhelmed by stress, then were dismissed as no longer meeting FAA qualifications.

During the mid-1960s, though, changes in air traffic procedures played into the hands of the disgruntled. Prior to the jet age, controllers had coped with excess traffic by stacking the planes over their arriving airports, feeding them slowly onto the runways. But this wouldn't work for jetliners, which burned fuel at excessive rates at the low speeds of the stacks. The alternative was flow control, in which these jets would stay on the ground at their departing airports until there was room for them. Passengers might notice little difference; long hours spent circling in stacks would merely give way to equally long hours in departure lounges, awaiting new takeoff times for their much-delayed flights. But airline executives liked the new procedures because they saved fuel and reduced wear and tear on engines. And air controllers had even better reason to prefer these arrangements. If they took steps to slow the flow **of** traffic, the result would not be mountainous stacks that they would have to watch with care. Instead, flow control would limit the number of planes entering the airways, which would actually reduce their workload.

FAA rules gave controllers a certain leeway, and in 1967 a group in Chicago, seeking higher pay, used this leeway to tighten their interpretation of the safety regulations. Soon air traffic was snarling from coast to coast, and the FAA gave in, awarding raises of as much as $1,100 per year. This success encouraged the discontented in other cities, including New York. There two militant controllers, Michael Rock and Jack Maher, set out to form a national association. They persuaded the well-known defense lawyer F. Lee Bailey to act as general counsel and proceeded to set up the Professional Air Traffic Controllers Organization (PATCO). An initial meeting, early in 1968, drew an astonishing seven hundred people, and Bailey stirred them strongly as he spoke for two hours. Membership soared, and PATCO was in business.

As federal employees, air controllers could not legally strike or hold a walkout. But a Chicago-type slowdown was likely to hit the FAA where it lived, and such an action, called Operation Air Safety, got under way early in July. New York's airports were the focus, and within three days the delays were running to twelve hours. Airliners were being held up as far away as Los Angeles and Europe. This action continued through August, and again the FAA caved in. PATCO wanted more controllers hired to spread the workload, better pay, and time-and-ahalf for overtime. These demands would require congressional action, but that soon was forthcoming, and by year's end PATCO had won its initial agenda.

Its next step, in 1969, was to launch a sickout. The FAA responded by ordering 477 absent controllers, who had called in sick, to bring notes from their doctors. Those that couldn't faced suspension for up to fifteen days. Later in 1969, FAA officials in Baton Rouge, Louisiana, announced they would transfer three activists from the tower, against their will. The Baton Rouge Three became a cause celebre for PATCO, which took the view that such involuntary reassignments, perhaps to different cities, represented the rawest form of union-busting. PATCO responded in 1970 with a far more sweeping sickout, in which some thirty-three hundred members phoned in and said they were ill. It was PATCO, however, that wound up in tile hospital. The FAA struck against its members with a torrent of subpoenas, while freezing previously earned paychecks. The Air Transport Association, representing the airlines, sued PATCO for $100 million in losses. A federal judge ordered Bailey and Mike Rock to call off their job action, on pain of jail for the leaders and a charge of conspiracy against Bailey. This time it was PATCO's turn to fold, as the FAA proceeded briskly to fire the activists and suspend the absentees.

Not all was bleak after 1970. The Air Transport Association settled its suit for $100,000. A congressional act in 1972 provided that controllers could retire on a pension between age fifty and fifty-five and could receive job retraining if they couldn't keep up with the work. (Congress, however, declined to appropriate funds to support such retraining.) And in 1977, following another PATCO slowdown, the FAA boosted some controllers' salaries as the Civil Service Commission reclassified their job grades from GS-13 to GS-14.

Then came the 1980 presidential election. Ronald Reagan wrote a letter full of campaign promises to the PATCO president, Robert Poli, virtually offering to put the FAA under Poli's leadership if he were to win in November. PATCO promptly came out in support of Reagan, and following his election its leaders believed he was on their side. The air controllers' contract with the FAA was up for renewal in 1981, and Poli proceeded to present a far-reaching wish list: a $10,000 salary increase for all controllers, a boost in the top rate from $49,229 to $73,420, a workweek of four days and thirty-two hours, and a more liberal retirement plan. The FAA offered much less, and early in August PATCO voted to strike.

Against Jimmy Carter, such an action might have had a chance. But Reagan saw this as an opportunity to show that he could defy organized labor. He responded with an ultimatum: Go back to work within two days or lose your jobs. Over fifteen hundred strikers returned, but this was little more than 10 percent of the total, and later that week the FAA fired 11,345 controllers. Nor would they return; in the blunt words of Secretary of Transportation Drew Lewis, "None of these people will ever be permitted to come back. We don't want these people back." Administration officials also moved quickly to freeze PATCO's strike fund and to void its legal right to represent controllers in labor negotiations.

Though Reagan's move served his conservative agenda, its rashness was on a par with that of Franklin Roosevelt in 1934, when he voided the existing airmail contracts and turned the mails over to the inexperienced fair-weather pilots of the Army. PATIO was not so cynical as to count on a repetition of that year's crashes and accidents; the stake in human lives was just too great. But it would have suited PATCO to have the nation's airlines shut down or find themselves badly hampered, and in expecting that this would happen the strikers seriously overplayed their hand. That was only one of several major blunders.

PATCO members would find to their sorrow that they were not indispensable. The FAA still had close to five thousand staffers with which to run the system, many of whom were fully qualified controllers. These people included nonstrikers as well as others who had never joined PATCO in the first place. Supervisors, who often had been working as controllers only a few years earlier, would swell their numbers. What was more, the FAA had known that a strike was likely and had prepared by developing a thoroughgoing program of flow control to stretch its limited resources. At the nation's largest airports, the FAA ordered airlines to cut their flights by 50 percent for at least a month, But within the nation as a whole, most of the normal volume was moving within less than a week.

PATCO also miscalculated by anticipating that it would win broad support from airline pilots and from the rest of organized labor. The pilots might have refused to fly, claiming that the airways would be unsafe. Instead they got into their flight decks and taxied out as usual The International Association of Machinists was responsible for maintenance of airliners, and William Winpisinger, its president, offered to call these workers out. Although such a sympathy strike would have been illegal, it would have shut the nation's airports, greatly strengthening PATCO's position. But Winpisinger would do that only if other unions within the AFL-CIO would join him in similar actions, and other union presidents had no particular love for PATCO. The air controller would stand alone, exposed as well to a hostile press and an unsympathetic public.

In yet another blunder, PATCO leaders took a long time before they would believe that Reagan really was playing for keeps. PATCO had had its previous clashes with the government, notably in 1970; then, too, there had been threats of harsh legal action, while man leaders of the sickout had received pink slips. But the airlines in time had called off their lawyers, while the fired controllers had won reinstatement after tempers had cooled. Robert Poli and other PATCO leaders thought that something similar would happen this time. Believing this, they actually strengthened their demands, calling for FAA Administrator J. Lynn Helms to resign under fire and to take the blame for the strike. This intransigence stymied efforts aimed at settling the strike and played into Reagan's hands.

It was not long before the fired strikers found they would have little but their own families to fall back on. They were ineligible for unemployment benefits. A new law, two months into the strike, even denied them food stamps and welfare. The FAA ruled that controllers who had changed location within a year before going out on strike and had received federal reimbursement for their moving expenses would have to repay those expenses in full. For one man from the New York TRACON, that meant a bill of $16,000. PATCO meanwhile was ending its days in a Chapter 7 bankruptcy, liquidating its meager assets and vanishing from existence.

The ex-controllers represented a prime group of workers, with an average age of thirty-seven and pay that had averaged $31,000 in 1981. Though the FAA required no more than a high-school diploma for this work, many at least had some college, and their educational levels were somewhat better than that of the nation as a whole. But these people were navigating the rapids of unemployment in the face of a deepening recession, and many had never worked in the private sector.

A survey early in 1984, two and a half years after the strike, showed that most of these former controllers were nevertheless surviving. Only 6 percent were unemployed, lower than the national figure. But few were approaching $31,000 a year. About one in nine had managed to get back into air traffic control, often working overseas. Some took to selling cars, insurance, or Amway products. Others found work as repairmen, truck drivers, or electricians. Their new lives included such jobs as file clerk, data entry, bartender, assistant manager of a 7-Eleven, chimney sweep, and bill collector. These people, formerly the few and the proud, now found their futures in the mundane activities from which aviation had offered escape.

The FAA, for its part, had the task of training a new generation of replacements. That took a while. In 1985, several years after the strike, the FAA had one-third fewer fully qualified controllers than in 1981. Yet the system was handling SO percent more passengers. Mandatory overtime helped; in 1985 this smaller workforce was putting in nearly a million hours, more than twice the overtime served by the rather larger staffs of 1981, who even then had felt themselves severely burdened. Nor did the FAA take chances in the matter of distances between aircraft. Separation standards increased markedly, on the theory that airplanes were less likely to bump into each other if each one had more sky to itself.

On the whole, the post-strike FAA recalled another governmental initiative, whereby the Pharaoh Rameses had commanded the Israelites to make bricks without straw. Still, at least the system was maintaining its safety standards. During the three years of 1978-1980, prior to the strike, America's airlines sustained 382 deaths of passengers and crew. For 1983-1985, when the system was recovering after the strike while coping with many more passengers, the total was 216. Only about one passenger in five million was getting killed.

The new controllers had to work in the same old control towers, where computers were bringing only limited relief. As FAA Administrator Helms wrote in 1982, "The present system does have serious limitations. It is labor intensive, which makes it expensive to operate and maintain. Even more important, it has very little ability to handle future traffic growth or future automation needs. These limitations result from an aging physical plant and inefficient procedures and practices. For instance, the present system still has many vacuum-tube systems.

Some of these limitations stemmed from the laws of physics rather than from those of Congress. A key point involved radar, whose transmissions travel in straight lines and do not bend to follow the earth's curvature. This meant that radars could detect aircraft only out to ranges of some two hundred miles. As a result, when airliners flew out to sea, they passed through a time warp and entered the pre-radar era of the 1940s.

In that era, aircraft had reported their positions by radio. In the 1980s, this was what flight crews did when piloting a transoceanic flight. Nor could the radio take the form of static-free VHF; its transmissions also travel in straight lines and had the same limitations as radar. Instead, pilots continued to rely on shortwave, which could achieve long range by bouncing off the ionosphere. It definitely was no static free. Indeed, sometimes the interference was so bad that crew members could not get through to the ground station. A pilot the] would talk to the captain of a flight a hundred or so miles behind hoping to relay a message by relying on that other officer as an intermediary.

Still, even within these restrictions, there was ample opportunity t carry through a truly sweeping upgrade of the nation's air traffic control system. It got under way in 1981, with the name of National Airspace System Plan, and it soon showed its propensity to grow. Initially 401 forth as a ten-year, $12-billion effort, it ballooned by 1994 into a $36-billion program extending beyond the year 2000. One must give the devil his due; part of this growth resulted not from overruns but from expansions in the effort that added new projects. Even so, through its history and down to the present day, the NAS Plan (renamed the Capital Investment Plan in 1990) has faced an ongoing source of difficulty: software.

Under the best of circumstances, a skilled and experienced programmer can write four to five lines per day of fully validated and documented code. This statement may seem absurd to anyone who has written a program of a hundred lines or more and gotten it up and running, all in the space of a day. However, the FAA's real-time codes face very stringent requirements, because they must protect the safety of large numbers of travelers.

Major software packages have run to a million lines and mole. Under those circumstances, no single programmer can hope to write more than a tiny fraction of the whole. Instead, one person's contributions must dovetail neatly with those of a number of other programmers, with the complete codes then standing up to stringent tests. The few-lines-per-day figure arises when a software specialist writes a thousand lines in the span of a week-and then spends the rest of the year ill debugging and development.

Where software has been manageable, the results at times have indeed verged on the miraculous. New radars stand as a case in point. Even in the precomputer age, clever circuitry could suppress images of clutter, while removing rainstorms to make the airplanes stand out more clearly. Today's radars offer more: a digital map of the surrounding scene, made up of half a million cells. This offers an entirely new approach to detecting aircraft amid storms and clutter.

Using the old-style arrangement, a controller might suppress the storm images to see the blips, or let in these images-and often drown out the blips. But the digital map contains both types of data, in a form amenable to computer processing. This permits the system to present a radarlike display that shows the blips-neatly labeled, of course-together with the weather. In fact, it can display aircraft even if their returns are weaker than those from the rain or snow, because it picks out airplanes by noting their speed. Then, if a pilot is approaching an airport amid severe storms, a controller can immediately see how that plane can avoid the thunderclouds and can direct it onto an appropriate course.

This course may call for the plane to fly at a constant distance from the airfield. With the old-style radars, its blip would often drop from the display, because the plane would show near-zero radial velocity. The radar would then treat it as if it were clutter, which also shows no radial speed, and would delete it. But the digital map makes the radar smarter. 1 the plane proceeds, its blip enters a succession of map cells, momentarily making each of them brighter. The computer takes note of this and continues to show this blip on the display.

In the course of its maneuvers the airliner may fly dangerously close to a business jet or other small aircraft. When this happens, the two planes' radar returns merge into a single blip. However, it then will e brighter than the one that a moment ago represented the airliner. The Computer will note this as well and can issue a warning that the controller will pass on.

These capabilities are now available, in radars built by Westing-house, because the software has remained at the manageable level of 50,000 lines. The more complex codes that carry out comprehensive data processing at ARTCCs and other centers have posed different challenges. Experience has shown that the FAA will go to virtually any length to avoid having to rewrite that software.

At the ARTCCs themselves, this has not been difficult. The code runs to 1.23 million lines and features a mix of programming in assembly code and in the language jovial. Though assembly language is clumsy and hard to work with, and few people still use jovial, this software remains useful, for IBM has maintained software compatibility across the decades. The ARTCCs initially used System/360 computers of 1960s vintage; these have given way to today's IBM 3083, with greater power and far more memory. But because the two are compatible, the programming has carried over with little difficulty. The new computers went in between 1986 and 1989, boosting the number of planes that each center could track from four hundred to as many as three thousand.

By contrast, the major TRACON centers have brought substantially greater difficulties. Here the standard software has the form of a proprietary code called Ultra, written in assembly language. The standard computer is the Univac 8303, which dates to the heyday of the Beatles. It stores 256 kilobytes in main memory, while processing 500,000 instructions per second. As Gary Stix *of Scientific American* notes, it would need eight times more memory merely to run the computer game Flight Simulator. Even the secretaries' word processors have more capability.

This has led repeatedly to tales of woe. Controllers at the Dallas Fort Worth TRACON, late in the 1980s, had been losing data blocks on their radar screens. During peak travel times, they also had a problem with data blocks being attached to the wrong radar blips. They predicted that their system would go down on a particular day in 1989, when the University of Texas would play Oklahoma, bringing a flood of football fans in their private aircraft. They were right. The computer dropped all data blocks, leaving controllers to struggle as best they could with unlabeled radar blips, as in the bad old days.

New York had a similar story. By 1989 that city's TRACON, serving all three major airports, was regularly running at over 90 percent of capacity. Controllers were using home-brewed software to delete some information on planes outside the control area, hoping to prevent the system from dropping planes at random.

Why has the FAA put up with this? Why can't it simply order a set of powerful workstations from some outfit like Intel and put its TRACON problems to rest for a long time? Simple. Software compatibility. The new computers would have to run the same old Ultra code, and commercially available workstations do not accommodate this code. Nor will the FAA rewrite Ultra to allow it to run on today's computers, for that would plunge it into the thicket of software development.

Instead, the FAA is turning again to its standard TRACON computer, the Univac 8303. It is purchasing new ones, relying on the one contractor, Unisys that can build them. It is doing this even though outside the FAA this computer would be seen only in museums. At the TRACONs, these Univacs are receiving new solid-state memories and additional input-output processors, along with additional workstations. At the New York TRACON the FAA has gone further, by off-loading some of the main computer's tasks and having workstations take them over.

Such heroics smack of an attempt to keep Civil War ironclad warships in service by fitting them with new missiles. Few other computer users would attempt them. Yet the FAA has no choice, for on one point it will never, never budge: Ultra, and hence the old Univac computers that run this code must stand at the core of its TRACONs' capabilities for the foreseeable future. The alternative-a full-blown program of new software development-is too dreadful to contemplate.

Even when technical developments fall within the competence the FAA and its contractors, institutional problems can bring their own morass. A case in point involves a long-running effort to replace ILS, world's standard bad-weather landing system since 1948. By 1968, w the wide-bodies in prospect, many airline operators were concerned t the vagaries of ILS were about to get worse. Its beams tended to wiggle when some of their energy bounced off hangars, and the wide-hoc would demand larger hangars still. Accordingly, the Air Transportation Association, representing these operators, urged the FAA to develop entirely new landing system, one that would rely on microwaves. Such a system would use high-frequency transmissions that would be much less prone to interference from reflections.

After that, it took all of ten years to decide just how to proceed. A number of companies were building experimental types of microwave landing systems, and all had executives clamoring to be heard. In addition, because ILS was in worldwide use, its replacement would require global acceptance. That meant the choice of system would fall to the International Civil Aviation Organization (ICAO), rather than to the FAA. The winnowing of alternatives took several years, and it 1975 before a U.S. executive committee settled on its choice. This particular approach came from Bendix and Texas Instruments, and ICAO proceeded to match it against a British entry based on different physical principles. Finally, after much huffing and puffing, the American system prevailed, and the ICAO picked it in 1978 as the new ii national standard.

Could the FAA then award a contract and proceed by installing systems at airports? It could not, for this approach needed further development. Nevertheless, the first Bendix station entered use in February 1984, at Valdez, Alaska, where mountains had prevented the commissioning of a conventional ILS.

It was now the Microwave Landing System, with capital let and it promised a number of advantages. It offered landing approaches that were free of bends and wiggles; pilots said that MLS was like flying down a wire. This precision, in turn, opened the prospect of highly accurate landings, under weather conditions even worse than Category II.

In addition to precision, MLS offered flexibility in choosing a landing approach. ILS offered a single straight-in direction; its transmitters amounted to a lighthouse that would keep its beam fixed, requiring pilots to follow its direct line. As a result, even at important air some runways could not install ILS. At Newark, Runway 11 had no ILS because it would require incoming aircraft to fly at low altitude, creating a noise problem. At Chicago's Midway, Runway 221, lacked ILS because its signal would reflect from the Sears Tower, producing high levels of interference.

But by offering flexibility in landing approaches, MLS could serve those runways, along with many others. It also promised full airport operations even in bad weather, with La Guardia standing as an example. In clear weather, it could handle eighty takeoffs and landings every hour. Even under instrument-flight conditions, it still could keep two runways open and accommodate sixty movements. But when visibility dropped below specified minimums, the nearby JFK Airport would rearrange its traffic patterns, interfering with La Guardia's. That airport then would go down to a single runway, capable of only twenty-four movements per hour. However, an MLS at JFK would permit a curved approach path, in contrast to the straight line of ILS, and would reestablish good separation between the two airports' traffic. La Guardia then could continue to operate both its runways, keeping its capacity at high levels.

In 1983 the FAA awarded a $79-million contract to the firm of Hazeltine to develop and set up 178 MLS airport installations. The FAA was to receive the first ones in mid-1985. However, that agency bombarded Hazeltine with requests for technical changes, which drove up costs. Serious software problems raised their heads. Hazeltine indeed succeeded in building units that met the FAA's requirements, but in 1989 the program was over three years behind schedule. Hazeltine had installed exactly two units and was asking for up to $100 million more to complete the contract. The FAA responded by terminating the contract. After twenty years, MLS was still off somewhere in the distant future.

The FAA would not give up; it awarded new contracts to the firms of Raytheon and Wilcox and pushed onward. But during the early 1990s, it became increasingly clear that airliners would rely on the Air Force's Global Positioning System (GPS) of navigational satellites. Using simple receivers, pilots could determine their positions to high accuracy and could expect to land in bad weather with ease. In 1994 the FAA responded by canceling the new MLS contracts, this time with the intention of abandoning MLS for good. Its time had come and gone, for before it could win a place in the world, GPS was likely to enter routine use.

With such promising initiatives mired in delay, life at tile operational centers was showing little change. One could see this at Lo Angeles TRACON, which served LAX, the city's principal airport. LAX was the country's third-busiest airport, behind only O'Hare and Atlanta. In 1990 this TRACON was supposed to have fifty-seven full qualified controllers, but had only half that number. Six-day work weeks were still standard.

The computer was a Univac, built in the early 1970s, and its software had bugs. Sometimes, albeit rarely, the system would go down for close to ten minutes. One controller described this as "like being on the freeway during rush hour, and all the cars lose their lights at once. Heavy traffic was a nightly occurrence, with this TRACON orchestrating up to seventy-five jetliners per hour on final approach. At those times, the computer could find itself overloaded with signals. It then might wipe information about a plane's altitude and speed from the radar screen or even switch this information among the blips. Other problems in the system could lead the radar to show XXX instead c presenting the altitude. Or the computer might stop posting updates o aircraft, freezing on their last known speed, altitude, and heading.

The two-way radios were thirty years old and had their own problams. As another controller Put it, "The radios at TRACON are so had and so full of static that I can tell when the lights come on at the airport, because I hear it. Sometimes that's about all I can hear." Sometimes he and his associates couldn't talk to a plane and found themselves asking one pilot to pass on a message to another one. In the words of one of these captains, "You always know when TRACON controllers are having equipment problems: when they keep asking your altitude. I really feel sorry for them. It happens all the time."

Even so, the skies were definitely safer than in previous decades, and this showed in what counted as a dangerous event. Early one evening in February 1989, at Los Angeles TRACON, controller Keith Bell was watching five blips as they crossed his radar screen. Suddenly he saw number six. No one had handed it off to him; it was just there. "I saw a fast-moving target squawking a discrete transponder code and flying level at 9,000 feet," he later told the *Los Angeles Times.* "It lacked the usual bright flash that normally signals a handoff. My first thought was, `That's not supposed to be there.' It was directly in the path of a British Airways jumbo jet that was climbing after takeoff.

"'British Airways 282,' I said, `turn left immediately heading zero-three-zero.' The pilot didn't say anything. He just did it. But turning a jet's like turning an aircraft carrier. It doesn't happen right away. It was close."

The big airliner was carrying 286 passengers and crew. The plane it avoided was inbound to Ontario Airport with seventy people on board. The two aircraft came within two miles horizontally and zero feet vertically, which rated as one of that year's closest calls. The fault lay with a controller in nearby El Toro who had failed to execute the handoff and warn Bell that the Ontario-bound jet was coming. Bell received a letter of commendation and a $100 bonus, courtesy of the FAA, but to him, saving over 350 lives was no big deal. "You just react," he said. "The whole thing was over in two minutes.

Yet that near miss triggered an investigation by the National Transportation Safety Board, an arm of the Department of Transportation that had the responsibility for looking into air disasters. This meant that a two-mile miss received the same type of attention as the collision of the two airliners over Brooklyn back in 1960. And that in turn signified that near misses now stood at the frontier of air safety, when outright collisions once had held this distinction.

The FAA would continue to rely on overworked controllers deployed in less-than-adequate numbers, using equipment that had become obsolescent almost as soon as it had entered service. But even though everyone was just muddling through, the system nevertheless was working, usually.