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Report to the Chairman, Subcommittee on Transportation and Related Agencies, Committee on Appropriations, U.S. Senate

July 1988

AIR TRAFFIC CONTROL

Efforts to Expand the New York Terminal Area Automation System

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Information Management and
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The Honorable Frank R. Lautenberg
Chairman, Subcommittee on Transportation
and Related Agencies
Committee on Appropriations
United States Senate

Dear Mr. Chairman:

In response to your letter of December 22, 1987, and follow-up discussions with your office, this report discusses the status of Federal Aviation Administration's (FAA) actions to enhance computer capability at its New York Terminal Radar Approach Control (TRACON) facility. As agreed with your office, our review raises issues for FAA's consideration, to ensure that these actions will increase system capacity to meet current and future requirements at the New York TRACON, and discusses related contract management problems.

FAA has moved to mitigate its immediate computer capacity problems, and is acting to correct known contract management deficiencies. In both areas, however, unresolved problems remain. We are highlighting those issues the FAA Administrator needs to analyze regarding the agency's plans for meeting computer capacity requirements in New York and elsewhere.

Background

FAA's mission is to promote the safe, orderly, expeditious flow of air traffic. Maintaining the required horizontal and vertical separation between aircraft is critical to safety. Air traffic controllers maintain separation by using location, altitude, and flight data, which is assembled and processed by FAA's air traffic control computer systems and displayed to controllers. While airport control towers direct takeoffs and landings, controllers at terminal radar approach control facilities—TRACONS—located at or near airports, direct aircraft arrivals and departures into and out of the jurisdiction of the airport control towers.

The New York TRACON (in Westbury, New York) is the nation's busiest. It handled over 1,680,000 instrument operations—arrivals, departures, and other control services—in fiscal year 1987. (Chicago, the nation's second-busiest, handled just over 1,100,000 instrument operations.) The New York TRACON is responsible for approaches to and departures from

Kennedy, Newark, La Guardia, MacArthur-Islip, Westchester County, and several smaller satellite airports.

Computer capacity shortfalls have occurred at the New York TRACON in recent years as air traffic has grown. Capacity shortfalls cause flickering data on displays and slow keyboard response time for controllers. FAA's next-generation air traffic control system, which is being designed to increase system capacity, will not be operational until the mid-1990s. Thus, the agency has been faced with upgrading computer capabilities at the New York TRACON to handle increasing traffic until then.

From 1984 through 1986, FAA improved system operating efficiency at the TRACON through software modification. However, FAA recognized that software modification, by itself, would not sufficiently increase capacity to handle traffic increases at the New York TRACON. (See app. I.)

The ARTS IIIE Contract

On March 14, 1986, FAA awarded a $45.6 million contract (known as the Automated Radar Terminal System Expansion—ARTS IIIE) to Sperry-Univac (now UNISYS) to expand the existing ARTS IIIA hardware and software in the New York TRACON's computer system. As of June 1988, cost estimates for the expansion ranged from $74.6 to $77 million, based on differences between FAA's and UNISYS' positions. (See app. III.)

Structured as a two-phased contract, Stage 1 was to provide controllers with new displays using internal microprocessors by June 1987; the current implementation estimate is December 1988. Stage 2 was to add more processors and high-speed solid state memories by December 1988; its current implementation estimate is February 1990.

By early 1987, FAA determined that the program was behind schedule, and in June 1987, directed UNISYS to incorporate specific segments of each stage into a new phase—the Interim Capacity Upgrade—to be implemented by May 1988 in time for peak summer traffic. The interim upgrade is composed of new displays from Stage 1, without the use of the microprocessors, solid state memories from Stage 2, and software revised by FAA. Problems with specific segments in the Interim Capacity Upgrade prevented full operational implementation by May 1988. (See app. II.)

Contract Management Issues

The ARTS IIIE program has experienced contract management problems. It has been hampered by rising costs, missed deadlines, misunderstandings between UNISYS and FAA, and hardware development difficulties. The extent to which these problems have not been resolved has implications for the management of both current and future contracts. FAA plans to increase computer capacity at 63 TRACONs across the country—supported by ARTS IIIA systems—at an approximate cost of $500 million over the next several years. FAA plans to increase capacity by modifying the ARTS IIIE contract and acquiring new displays, solid state memories, and additional processors.

An internal FAA report and two Department of Transportation Inspector General reports[1] indicate that inadequate contract management contributed to ARTS IIIE problems. FAA did not monitor the pre-award phase, allowing the contractor to make incorrect assumptions regarding design and documentation requirements. FAA later rejected initial contract deliverables and directed revisions. This led to cost increases and schedule delays. FAA has implemented some of the reports' recommendations in an attempt to improve contract management. (See app. III.)

TRACON Operations

On April 20, 1988, seven new displays were deployed at the New York TRACON and used to control traffic operations for the Newark area. The scheduled operational deployment of 30 additional new displays was postponed however, because the displays experienced several problems—the most significant of these being the excessive heat produced by the displays. As of May 21, 1988, however, the heat problem had been resolved and displays were being used for all areas.

A problem with the solid state memory delayed full implementation of the interim upgrade. During April and May 1988, 16 high-speed solid state memory modules were implemented at the New York TRACON and operated successfully for a few weeks until one solid state memory module began to cause data errors. Although FAA reverted to using core memory for a short time, on June 4, 1988, the New York TRACON began to operate entirely with solid state memories.

[1] Information: Audit of Cost Overrun on New York TRACON Contract, Office of the Inspector General, Department of Transportation, June 29, 1987.

Report on Audit of Cost Overrun on Contract to Sustain the New York Terminal Radar Approach Control Facility, Office of the Inspector General, Department of Transportation, Report Number AV-FA-8-004, Nov. 16, 1987.

On June 18, 1988, FAA began using the revised software, which is designed to provide an increase in processing capability. However, on June 25, 1988, FAA discontinued using the revised software because of unexpected problems resulting in unreliable conflict alert notifications. As of July 18, 1988, FAA was uncertain regarding the date when the revised software would be implemented. Therefore, the interim upgrade is not fully operational.

Since the interim upgrade was not fully operational by May 30, 1988, as anticipated, FAA began to control peak summer traffic without the additional capacity it planned to have available. Our review showed that FAA used its eighth (backup) processor Thursday, Friday, and Sunday afternoons during May 1988. FAA has stated that the New York TRACON's backup processor will continue to be used, if necessary, to help handle heavy traffic.

Use of Backup Processor to Handle Heavy Traffic

The TRACON's computer system has seven processors configured to process and display data, with an eighth as a backup. FAA has long maintained the importance of a backup capability at the New York TRACON. However, FAA modified operating procedures for the summer of 1987 and used all eight processors during heavy traffic periods, rather than reserving one for backup. The eighth processor is used during periods of expected heavy traffic. It is not used routinely throughout the week.

In such a configuration, however—with the eighth processor being used—the New York TRACON has no backup processor. If one processor failed while all eight were being used to process peak traffic, this could create an excessive demand on the remaining seven, resulting in slow keyboard response time. According to a New York TRACON official, however, this is an acceptable risk because while the eighth processor is typically brought on-line early in the day, there may only be a short period during which the capacity of the other seven processors is exceeded and the processing capability of the eighth processor is used.

Effects of Test Plan Changes on Stage 1

FAA adjusted test plans in order to try to meet the May 1988 deadline for the Interim Capacity Upgrade. However, these test plan changes also increase risks associated with the Stage 1 upgrade, which is scheduled to be deployed by December 1988. When FAA decided to implement the Interim Capacity Upgrade, this also included a decision to deploy the displays without fully testing the microprocessors with the communication network, as originally planned. If problems are uncovered with how

the display microprocessors operate with the communication network during Stage 1 testing, additional delays and potentially more costly and disruptive retrofits could be required.

Availability of Mode C Intruder Capability

Aircraft supervised by FAA's air traffic control system are known as controlled aircraft and are subject to FAA regulations. Commercial airline flights are an example of controlled aircraft. Aircraft not under direct supervision are known as uncontrolled aircraft and must also obey FAA regulations regarding where they can fly. Uncontrolled aircraft generally do not communicate with controllers. One obvious potential danger arises when uncontrolled aircraft stray into FAA controlled airspace—as happened at Cerritos, California, in August 1986, when a private plane collided with a commercial jetliner.

After its investigation of the Cerritos accident, the National Transportation Safety Board recommended that all aircraft—controlled and uncontrolled—be required to carry Mode C transponders (which provide altitude information to controllers) within ARTS IIIA terminal areas. The Board also recommended that all ARTS IIIA TRACONs be equipped with Mode C Intruder capability (which automatically warns controllers when two aircraft, controlled or uncontrolled, with Mode C transponders may violate separation standards), thereby reducing the chances of collisions between aircraft. The ARTS IIIA sites already have a conflict alert feature that warns controllers only when two controlled aircraft will violate separation standards within the next 2 minutes. Since the Safety Board recommendations, FAA now requires all aircraft operating in certain high-traffic density areas to carry Mode C transponders.

At issue is the date when those TRACONs in busy areas —including New York—will install Mode C Intruder capability. The requirement for this enhancement is included (for the New York TRACON) in FAA's contract with UNISYS (Stage 2)—expected to be completed in early 1990. FAA now plans to equip ARTS IIIA TRACONs with Mode C Intruder capability in the early 1990s. (See app. II.)

Issues for FAA Consideration

In light of the importance of the New York TRACON enhancement program, and its ramifications regarding the eventual enhancement of the remaining ARTS IIIA TRACON systems, we believe the Administrator of the Federal Aviation Administration needs to analyze and take action, as necessary, regarding:

- Whether adequate alternative plans are in place for handling peak summer traffic if this upgrade does not provide sufficient capacity.
- What the effect is of using the backup computer to handle heavy traffic loads at the New York TRACON, rather than preserving it as a backup, and whether a backup computer is still warranted.
- Whether continuing ARTS IIIE contract cost, schedule, and performance problems indicate the need to revise FAA's contract management practices on both the ARTS IIIE contract and other TRACON enhancement projects.

In responding to this request to review the New York TRACON computer capacity enhancement project, we reviewed both technical and contract documents and met with officials from FAA and various contractors involved in the project. Details of our objectives, scope, and methodology can be found in appendix IV. The views of responsible agency and contractor officials were sought during the course of our work; we discussed our findings with them and have included their comments where appropriate. Our review was conducted in accordance with generally accepted government auditing standards.

We will be sending printed copies of this report to the Senate and House Committees on Appropriations, Senate Committee on Commerce, Science, and Transportation, House Committee on Public Works and Transportation, the Secretary of Transportation, the FAA Administrator, and will make copies available to others upon request.

Sincerely yours,

Dan White
for Ralph V. Carlone
Director

Contents

Abbreviations

ARTS	Automated Radar Terminal System
FAA	Federal Aviation Administration
GAO	General Accounting Office
IMTEC	Information Management and Technology Division
TRACON	Terminal Radar Approach Control Facility

Status of FAA's Efforts to Upgrade the New York TRACON Automation System

Background

The Federal Aviation Administration's air traffic control mission is to promote the safe, orderly, and expeditious flow of both civilian and military air traffic. Air traffic controllers maintain the required separation between certain aircraft by using location, altitude, and other flight data. This information is assembled and processed by FAA's air traffic control computer systems and displayed on controllers' screens.

Aircraft supervised by controllers are known as controlled aircraft and must carry FAA-prescribed electronic equipment. This equipment includes radios for communicating with controllers and a Mode C transponder, which electronically transmits aircraft altitude and identity to ground radar sensors. Commercial airline flights are one example of controlled aircraft. Also, controlled aircraft must file flight plans that detail the proposed journey, including arrival and departure airports and times, flight routes, and aircraft type.

Aircraft that are not controlled by the air traffic control system are called uncontrolled aircraft, and also must obey FAA rules governing where they can fly. Uncontrolled aircraft are not required to communicate with controllers, carry radio equipment or Mode C transponders, or file flight plans.

Controllers manage aircraft within a small section of airspace called a sector. Aircraft fly through these sectors and as an aircraft crosses from one sector to another, the controller "working" the aircraft "hands off" the aircraft to the new sector controller.

At 188 locations, FAA has provided Terminal Radar Approach Control facilities. These facilities provide services to aircraft arriving at or departing from major airports. TRACON controllers rely on radar, computers, display screens, and related equipment to control air traffic. At 63 of these facilities, the computer system predicts when the separation standards between controlled aircraft will be violated in the next 2 minutes and warns the controller that the violation may occur. This warning is called conflict alert. Currently, the conflict alert function only performs the detection and warning function for controlled aircraft. There is no conflict alert for uncontrolled aircraft in terminal airspace. The warning and detection function between controlled and Mode C-equipped uncontrolled aircraft is called Mode C Intruder (see app. II).

The New York TRACON

The New York TRACON, located in Westbury, New York, provides air traffic control services for the New York metropolitan airspace. This TRACON

is responsible for approaches to and departures from John F. Kennedy International Airport, La Guardia Airport, Newark International Airport, MacArthur-Islip Airport, Westchester County Airport, and several smaller satellite airports. The New York TRACON handled 1,687,216 instrument operations during fiscal 1987. By comparison, the next busiest TRACON, Chicago, handled 1,105,157 instrument operations that year.

The New York TRACON Automation System

The New York TRACON automation system consists of 4 radar, which feed a computer complex consisting of 8 processors, 16 memory modules, controller displays, and other equipment. This computer complex is a derivative of the ARTS IIIA computer system used at 63 of the nation's TRACONS. New York's 8-processor and 16-memory module configuration is the maximum size the system design allows. FAA originally designed the New York TRACON to use 7 processors and 14 memory modules in a fail-safe mode, with the eighth processor and one or two memory modules as backup, in case one of the primary processors or memory modules failed. Subsequently, the system was upgraded in 1983 to use the 15th memory module on a regular basis.

This computer complex provides the New York TRACON with the potential to process up to 1500 tracks.[2] However, depending on the current processing demands on the system, its maximum capacity ranges from 1250 to 1365 tracks.

In spring 1984, with the addition of Westchester County Airport into the New York TRACON airspace, traffic increases exceeded the system's computer and display capacity. This capacity shortfall resulted in loss of aircraft information from displays, flickering data, and slow keyboard response when controllers initiated keyboard actions. Keyboard actions include requests for information such as aircraft identity or commands such as handing off aircraft to adjacent sectors.

From 1984 through 1986, FAA modified the system to improve its operation, providing some additional capacity. In 1984, FAA believed that further increases in traffic at the New York TRACON would make the capacity shortfall critical by the summer of 1987. FAA recognized that software modification, by itself, would not improve system performance sufficiently to handle the increased traffic. FAA decided instead to

[2]A track can be thought of as a memory slot in the air traffic control computer. Controlled aircraft, uncontrolled aircraft, false target radar reports, aircraft detected by radar but not yet associated with a flight plan, or flight plans for aircraft that radar has not yet detected can occupy memory slots or tracks.

enhance both software and hardware. This enhancement was to be an interim measure until a new air traffic control computer system is installed in the 1990s.

ARTS IIIE Contract

On March 14, 1986, FAA awarded a $45.6 million upgrade contract (ARTS IIIE) to Sperry-Univac (now UNISYS) to expand New York TRACON hardware and software to increase their capabilities. The original contract required computer capacity expansion in two stages, scheduled to be fully operational by December 1988.

Stage 1

Originally scheduled for implementation in June 1987, Stage 1 was to provide new displays with microprocessors. These microprocessors would perform display processing now done by the main processors, freeing the main processors to handle additional tracks. Additional processors would be installed to provide display processing for some airport tower displays. The processing for these airport tower displays is currently performed by the New York TRACON system. A communications network would connect the new TRACON displays and the tower displays to the main processors. These changes are expected to increase computer capacity to 1700 tracks. Stage 1 has been delayed and is currently scheduled for implementation in December 1988.

Stage 2

During Stage 2, originally scheduled for implementation in December 1988, the computer complex would be modified to include additional processors beyond the current 8-processor limitation. In addition, a new high-speed solid state memory would replace existing memory modules. When Stage 2 is fully implemented, overall system capacity would increase to 2800 tracks and support five radar. In addition, the new system could be expanded further to handle 3400 tracks and a sixth radar. Stage 2 requirements also include developing and installing Mode C Intruder software. This software, as planned, would provide controllers with conflict alert between controlled and uncontrolled aircraft, provided that these aircraft are both equipped with Mode C transponders. Stage 2 has been delayed and is currently scheduled for implementation in February 1990.

Interim Capacity Upgrade

By early 1987, FAA determined that the program was behind schedule, and in June 1987, directed UNISYS to incorporate specific segments from Stage 1 and Stage 2 into a new phase—the Interim Capacity Upgrade—

to be implemented by May 1988 to meet summer traffic peaks. To handle the expected traffic FAA also had to revise the software to allow the system to handle additional tracks.

The interim upgrade consists of the new displays from Stage 1 and the solid state memory from Stage 2. Together with revised software, these improvements are expected to allow the system to process 1550 tracks. During this interim phase, the new displays will not perform independent display processing. They will continue to depend on the main processors for display functions. The new displays, running in this mode, are expected to eliminate flickering data and lessen the loss of aircraft data from displays.

Technical Issues

New York TRACON Backup Capability

Both a spare processor and a spare memory module are normally reserved so that the New York TRACON system will have adequate capacity to continue operating without losing functional capabilities if a processor or memory module fails. This redundancy is included to provide a backup or fail-safe capability, and in the past FAA has cited the importance of maintaining this capability. However, in an effort to deal with anticipated summer 1987 capacity-related problems, FAA modified operating procedures at the New York TRACON to allow all eight processors to be used during heavy traffic periods, rather than reserving one processor for backup. Traffic was adequately handled during the summer of 1987. During May 1988, FAA used the eighth processor to handle heavy traffic on Thursday, Friday, and Sunday afternoons.

Operating procedures call for use of the eighth processor on the basis of predicted heavy traffic, good weather, and other factors. According to a New York TRACON official, a 4- to 6-second loss of computer-generated data occurs on displays when the eighth processor is brought on-line. Because of this, FAA reconfigures the system before predicted heavy traffic enters the airspace and keeps the eighth processor on-line until after the traffic diminishes. During this period, the New York TRACON is without a backup capability.

FAA has long maintained the importance of a backup capability at the New York TRACON. For example, in its response to our 1983 report[3] regarding the New York TRACON, FAA said it was better to delay phasing additional airports into the New York TRACON than to use all memory modules and lose the backup capability.

A New York TRACON official told us that using the eighth processor during heavy traffic is an acceptable operational trade-off to avoid problems associated with capacity shortfalls. Without the eighth processor, heavy traffic could put excessive demands on computer capacity, which could result in slow keyboard response time. Should one processor fail when all eight are used, processing capability would not necessarily be affected because the period when traffic actually peaks is very short, according to another TRACON official. Therefore, although the eighth processor is brought on-line early in the day, there may only be a short period when the capacity of seven processors is exceeded.

[3]FAA's Plan To Improve The Air Traffic Control System: A Step In The Right Direction But Improvements And Better Coordination Are Needed (GAO/AFMD-83-34, Feb. 16, 1983).

A contractor official also told us that since the processors are highly reliable—an average of 6000 hours between failures—the likelihood of failure during the short interval of peak traffic is very low. Therefore, FAA concludes that even if one processor should fail, the probability of adverse effects is low. Using the eighth processor primarily solves the slow keyboard response problem, according to FAA. The eighth processor does not increase the maximum number of tracks the system processes because the track limitation results from other system design constraints, such as software.

According to FAA, the seven processor configuration with the solid state memories will probably be adequate to handle the summer traffic peaks, with the eighth processor as backup. However, FAA states that the eighth processor will be used, if necessary, to handle heavy traffic.

Importance of Mode C Intruder

An uncontrolled aircraft that strays into the path of controlled aircraft is a significant problem within TRACON airspace. The conflict alert warning now performed by ARTS IIIA TRACON computers only warns controllers that controlled aircraft will violate separation standards within the next 2 minutes. Currently, no warnings are given for violations between controlled and uncontrolled aircraft. Warnings regarding Mode C-equipped uncontrolled aircraft are called Mode C Intruder. Although this warning would not be provided for aircraft without Mode C equipment, such a warning is expected to reduce the likelihood of midair collisions between Mode C-equipped aircraft.

A midair collision between a controlled and an uncontrolled aircraft occurred in August 1986 over Cerritos, California. After conducting an investigation of the accident, the National Transportation Safety Board concluded that the "probable cause of the accident was the limitations of the air traffic control system to provide collision protection." In its report, the Safety Board recommended that FAA require Mode C transponders on all aircraft operating within all ARTS IIIA terminal airspace. In addition, the Safety Board recommended that FAA implement Mode C Intruder capability at all ARTS IIIA locations. This requirement was implemented in New York TRACON airspace prior to the Cerritos accident, according to a New York TRACON official.

In its response to the Safety Board, FAA stated that it would revise regulations regarding Mode C transponders for aircraft operating in and around terminal areas. Regarding Mode C Intruder at ARTS IIIA sites, FAA initially said that these systems are operating at maximum capacity and

cannot perform additional functions without more state-of-the-art equipment. Thus, Mode C Intruder cannot be implemented at the ARTS IIIA sites until the FAA's new air traffic control computer system becomes operational in the mid-1990s. However, FAA's current plans indicate that ARTS IIIA computers will be sufficiently enhanced to permit the introduction of Mode C Intruder in the early 1990s. The Mode C Intruder capability for the New York TRACON is included in the ARTS IIIE contract and FAA expects to implement this enhancement when Stage 2 is deployed in early 1990.

Interim Capacity Upgrade Problems

According to FAA, the Interim Capacity Upgrade was to be operational in May 1988 to handle expected peak summer 1988 traffic. The primary elements in the upgrade are solid state memories, new displays, and revised software. The solid state memories were tested and implemented at the New York TRACON during April and May 1988. Although the solid state memories operated successfully at first, after several weeks, problems developed which resulted in data errors. Consequently, FAA began using core memories during the day and testing the solid state memories at night. These problems, though recently corrected, delayed implementation of the revised software until June 18, 1988.

However, beginning on June 25, 1988, unexpected problems in the revised software resulted in unreliable conflict alert warnings. Therefore, FAA discontinued using it operationally and reverted to using the older software version. The revised software is currently undergoing further development and testing at FAA's Technical Center, in Pomona, New Jersey, and FAA remains uncertain regarding when the revised software will become operational. Therefore, the interim upgrade is not fully operational.

The new displays did not meet original testing or deployment deadlines because of development delays. The new displays were not deployed on schedule, but they are now operational, according to TRACON officials. For example, UNISYS and FAA differences regarding design and other contract requirements resulted in inadequate software design documentation and hardware problems. In addition, prototype displays encountered electrical problems, such as meeting power requirements and mechanical problems (inadequate display cabinet construction, for example.) According to UNISYS, these problems were resolved during development.

As a result of these problems, production model displays were not delivered for testing as scheduled. The first production model displays were delivered to the FAA Technical Center for testing in early March 1988 instead of September 1987. Likewise, the first production displays were delivered to the New York TRACON in late March 1988 instead of early February 1988. Although UNISYS originally projected 2 months for operationally testing all displays at the New York TRACON, FAA believed five days was adequate for on-site operational testing.

On April 20, 1988, seven new displays were deployed operationally at the New York TRACON and were used to control traffic operations for the Newark area. The scheduled operational deployment of additional displays was postponed, however, because the displays were experiencing several problems —the most significant of these was the excessive heat produced by the displays. According to the program manager and New York TRACON officials, these problems have been resolved and new displays are being used to control traffic for all areas.

We believe test plan changes FAA made for the interim upgrade increased schedule and performance risks for Stage 1, which is scheduled to be deployed by December 1988. Originally, Stage 1 plans called for FAA to test the displays' microprocessors with the connecting communication network before deploying the displays in the New York TRACON. When FAA decided to implement the Interim Capacity Upgrade, the decision included deploying the displays without testing the microprocessors with the communication network. Although the microprocessors and communication network will not be used until Stage 1 is implemented, if problems are uncovered with the displays' microprocessors at the New York TRACON, this could result in additional delays, subsequent testing, and potentially more costly and disruptive retrofits than those that would have been required if these problems had been identified prior to operational deployment.

ARTS IIIE Contract Problems and Management Issues

Contract Costs

The current UNISYS contract combines three contract types: cost-plus-incentive-fee, firm-fixed-price, and government-estimated items, each contributing to the overall cost of the ARTS IIIE upgrade. The initial March 14, 1986, ARTS IIIE contract was awarded for $45.6 million. As of June 1988, FAA estimated the total cost between $74.6 and $77 million.

The cost-plus-incentive-fee part of the contract includes display equipment development, system design, development, and installation. It had an estimated value of $38.9 million, with a $35.9 million target cost and a $3 million target incentive fee. The maximum incentive fee was $3.6 million and the minimum $1.4 million. As of July 1988, FAA and UNISYS were still negotiating the new fee and general and administrative rates. The new target cost is $58.4 million.

The firm-fixed-price items include personal computers, main processors, and related main computer complex equipment. Also included in the firm-fixed-price are spare parts and development of an ARTS IIIE training program. These items were $5.2 million and are now estimated at $6.2 million.

The government-estimated items include contractor supplied spare parts, tools, and engineering support services, valued at about $1.5 million.

Negotiated firm-fixed-price items include optional remote displays (for towers), a reprocurement data package, and dedicated repair service. Costs as of March 14, 1986, are summarized below:

Table III.1: Original ARTS IIIE Contract

Cost-plus-incentive-fee		$38,928,889
Target cost	35,888,317	
Target fee	3,040,572	
Firm-fixed-price items		5,229,223
Government-estimated items		1,450,000
Total contract value		**$45,608,112**

Pre-Award Problems Caused Schedule Delays and Cost Increases

Contract management problems, misunderstandings between FAA and the vendors, and hardware development problems contributed to schedule delays and cost increases. Shortly after contract award, FAA reviewed initial design documentation and discovered differences between its requirements and contractor performance, leading to rejection of the first deliverables. According to contractor officials, UNISYS and its subcontractors made assumptions about the extent and format of the required system design documentation. Based on FAA's urgent need, ambitious schedule, and pre-award actions, the contractor and subcontractors expected that contract standards would be tailored or waived.

To accelerate design and documentation, FAA allowed the New York TRACON expansion project competitors to begin work before awarding a contract. The contractors understood that only the winner would be paid for this pre-award work. FAA did not monitor this work to avoid biasing proposal evaluations and contract negotiations. Without supervision, UNISYS believed that, because of the deadline, FAA would waive contract standards and documentation requirements. When FAA determined that contract specifications, requirements, and standards were not being met adequately, UNISYS was instructed to complete the work required to meet them.

Less than 2 weeks after contract award, FAA and UNISYS realized that Stage 1 implementation might be delayed. At a meeting held March 25 and 26, 1986, FAA told UNISYS that initial hardware and software specifications submissions were "generally inadequate" based on a limited review. According to UNISYS, FAA said specifications needed to support the system requirements review and preliminary design review provided insufficient detail. Also, FAA and UNISYS discussed parts acquisition problems, equipment delivery concerns, general contract management issues, and the possible impact of not meeting scheduled implementation dates.

A review of the March meeting minutes and UNISYS' justification for increased costs shows that FAA did not adequately provide pre-award guidance. UNISYS told us that this lack of guidance forced it to make assumptions about the level of documentation required. Also, UNISYS said that "the major emphasis was on the urgency of the schedule to alleviate capacity problems at the New York TRACON." Thus, UNISYS officials said they assumed that, to allow them to upgrade the New York TRACON quickly, documentation standards would not be rigidly enforced. FAA's rejection of the initial deliverables forced UNISYS to rewrite them at additional cost.

At the March 1986 meeting, FAA and UNISYS also discussed alternative methods of enhancing capabilities at the New York TRACON in the event Stage 1 was delayed. The alternatives included early deployment of solid state memories and new displays (FAA's current Interim Capacity Upgrade), and the use of the eighth processor.

Costs Continue to Increase

As of June 9, 1988, FAA told us that negotiations indicate that the total estimated ARTS IIIE contract costs are between $74.6 and $77 million—as much as a 69-percent increase over the original contract cost of $45.6 million. FAA and UNISYS are currently negotiating the differences in general and administrative rates and the incentive fee. We did not independently validate actual costs during our review.

UNISYS said that a $23.9 million increase was caused by government-directed scope changes and "contractor-caused cost and schedule growth." In a document titled Equitable Adjustment Support Document For Schedule Replan Proposal (February 22, 1988), UNISYS accepted responsibility for $6 million of the $23.9 million increase and would not calculate a fee on that amount. UNISYS planned to calculate a fee on the remaining $17.9 million.

FAA officials advised us that in May 1988, initial negotiations regarding the cost overrun resulted in agreement on the target cost of $58.3 million. UNISYS has taken under advisement FAA's position on lower general and administrative rates and the incentive fee—the difference between $74.6 million and $77 million.

Contract Management Problems

The ARTS IIIE contract has been characterized by misunderstandings between FAA and UNISYS, a sharp rise in program and contract costs, and an inability to meet schedules. Two Department of Transportation Inspector General[4] reports indicate that inadequate contract management contributed to these problems. Also, a November 1986 FAA internal report found fault with contract management and recommended assigning a full-time program manager and developing a comprehensive program plan. The Inspector General recommended that FAA train its

[4]Information: Audit of Cost Overrun on New York TRACON Contract.

Report on Audit of Cost Overrun on Contract to Sustain the New York Terminal Radar Approach Control Facility.

staff to use Department of Defense Software Standard 2167, which provides a structured approach to software development and documentation.

The FAA internal report states that contractor internal controls and government controls were inadequate, and misunderstandings and disagreements about software documentation standards and requirements appeared to be major problems. These misunderstandings and resulting inadequate documentation led to FAA's rejection of initial design documents. Consequently, the contractor submitted a revised product, which increased costs and resulted in delays. The Inspector General also criticized FAA's contract management and faulted FAA for failing to supervise contractor performance during the pre-award period and for awarding a contract containing vague documentation requirements.

FAA's response to the Inspector General reports states responsive actions have been initiated. Further, FAA officials said that the contractor was also responsible for early problems and that it too has taken corrective action. Based on these remedial actions, both FAA and UNISYS officials believe major contract milestones will be met and costs will be contained.

FAA has moved to improve oversight and correct deficiencies. By December 1986, FAA had appointed a full-time program manager and assigned additional contractor oversight staff. FAA has also increased its contractor facility visits and has begun training FAA personnel on the use of Standard 2167. In addition, an ARTS IIIE Project Implementation Plan describing the project scope and outlining responsibilities and tasks has been prepared. We have not fully evaluated the effectiveness of FAA's corrective actions; however, cost, schedule, and performance problems continue.

FAA plans to increase computer capacity at 63 ARTS IIIA sites by modifying the existing ARTS IIIE contract to acquire new displays, solid state memories, and additional processors. We note that if current ARTS IIIE contract management problems are not corrected, then the modified contract may experience similar cost, schedule, and performance problems.

Objectives, Scope, and Methodology

In a letter dated December 22, 1987, the Chairman, Subcommittee on Transportation and Related Agencies, Senate Committee on Appropriations asked GAO to provide information on whether computer capacity shortfalls experienced at the New York TRACON affect aircraft safety. In follow-up discussions with the Chairman's office, we agreed to restrict our scope to looking at the status of FAA's actions to enhance computer capability at the New York TRACON, related contract management problems, and raising issues for FAA's consideration to ensure that its actions will increase system capacity to meet current and future requirements at the New York TRACON.

We examined FAA's effort to solve capacity problems at the New York TRACON, which included the current use of the backup processor. We examined the current ARTS IIIE contract and the equipment to be installed for the interim upgrade. However, we did not investigate the detailed technical reasons for the delays, nor did we attempt to predict the technical risks associated with Stage 1, Stage 2, or the interim upgrade. We also did not independently validate actual costs during our review.

To obtain information on the development of technical enhancements, we reviewed the requirements specified in the contract and other documents prepared by FAA and various contractors. For information on contract management, cost, schedule, and performance, we reviewed documents, contract files, and contractor progress reports. We met with FAA headquarters officials, including the program manager, and staff located at the New York TRACON, the FAA Eastern Region, and the FAA Technical Center to discuss the progress and problems of the enhancement. In addition, we talked with UNISYS and subcontractor officials and system engineering and integration contractor officials involved in the project.

We performed our work at FAA headquarters in Washington, D.C.; the New York TRACON in Westbury, New York; the FAA Eastern Region in Jamaica, New York; and the FAA Technical Center in Pomona, New Jersey. We discussed the contents of this report with FAA and contractor officials and have reflected their views in the report where appropriate.

Our review was performed from October 1987 through June 1988. We also followed-up on various issues through July 1988. We conducted our review in accordance with generally accepted government auditing standards.

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