ARTS III Review, 1973

by DOT #092650

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Edited with Microsoft Word.

PROLOGUE

This DOT paper #092650 has been shortened from 43 to 13 pages by dropping some detail program schedule tables. It presents the government viewpoint of the program versus the Contractor view as documented on the VIP Club website data about the ARTS III and many follow on Air Traffic Control projects. See https://vipclubmn.org/aircontrol.html. Prologue and Epilogue added by editor.

Program Description and Status

The Federal Aviation Administration (FAA) is responsible for ensuring the safe and efficient use of our national airspace. Marked increases in air traffic have occurred during the last few years and are predicted for the future. One of the recommendations of a presidential task force, established m 1961, called for the application of computer technology to the air traffic control system. The FAA's automation efforts have been in two related, areas-- the **enroute system** and the **terminal system**.

The purpose of the Automated Radar Terminal System (ARTS III) is to increase safety and to provide better service to the user by providing for (1) alphanumeric information on the terminal area air traffic controller's radar display and (2) the automatic transfer of flight data between computers in the terminal areas and the Air Route Traffic Control Centers. The ARTS III system consists of three subsystems: (1) a data acquisition subsystem; (2) a data processing subsystem; and (3) a data entry and display subsystem. Sixty-four (64) of these systems are being procured for locations throughout the country. As of February 1, 1973, 63 systems had been delivered; initial operating capability had been achieved by 56; and operational readiness demonstrations had been achieved by 48 sites.

CONTRACT DATA

On February 20, 1969, the FAA awarded a firm fixed-price multi-year contract to the Univac Federal Systems Division of Sperry Rand Corporation for the production and installation of 64 ARTS III systems. The ARTS III system consists of three subsystems: (1) a data acquisition subsystem, (2) a data processing subsystem; and (3) a data entry and display subsystem. UNIVAC, the prime contractor, produces the data processing subsystem, the computer software, and is also responsible for integrating the subsystems with the software, installing, and completely testing each system through Initial Operating Capability (IOC). The current value of the FAA contract with Univac is about $60.9 million. UNIVAC has a multi-year fixed-price subcontract with the Burroughs Corporation for production of the data acquisition subsystems. This subcontract has a value of about $2.9 million. The production of the data entry and display subsystem was subcontracted to Texas Instruments, Inc., under a multi-year fixed-price contract. The current value of this subcontract is about $15.3 million. The contractor submitted an index of drawings and technical memoranda, contract financial reports, narrative progress reports and Program Evaluation and Review Technique reports on a monthly basis.

RELATIONSHIP TO OTHER SYSTEMS

The ARTS III program is a follow-on system of the earlier ARTS I and ARTS IA systems installed at Atlanta and New York respectively. The ARTS II system is an automation system being designed for smaller airports served by FAA radar-equipped control towers. A contract was recently awarded by the FAA for delivery of prototype systems for testing and evaluation.

INTRODUCTION

Simplistically speaking, air traffic control brings safe and efficient order to what could be a chaotic situation. The extent of increase in air transportation in the United States is common knowledge. Less well known are the estimates for future demand. In 1960, there were 62 million passenger enplanements for domestic and international flights. Enplanements in 1971 reached 170 million. The Federal Aviation Administration (FAA) of the Department of Transportation estimates this will increase to 435 million by 1982. Without the coordination provided by the air traffic control system, the number of delays and collisions would reach horrendous heights.

The FAA is charged with ensuring the safe and efficient use of the nation's airspace, by military as well as civil aviation, and with fostering civil aeronautics and air commerce (emphasis added). In this regard, the FM has been engaged in automating the ex-traffic control subsystem of the National Airspace System since the appearance of the Project Beacon Report in 1961.

These efforts have been directed toward meeting the expected air traffic growth by Increasing the capacity and efficiency of the air traffic control subsystem and by relieving the air traffic controller of those tasks that could be better performed by machines. Essentially, these efforts have been in two areas--the enroute system and the terminal system. As an analogy, one might relate the enroute system to our interstate highways and the terminal system to the beltways and major arterial streets through our larger cities.

Prior to 1936 all air traffic control centers in the United States were operated by private airlines as a joint venture. In July of that year the Federal Government, under the auspices of the Bureau of Air Commerce, took over these operations. There were only three enroute traffic control facilities at that time--Newark, Cleveland, and Chicago. Enroute traffic control facilities are described as having responsibility for the separation of aircraft within a great expanse of airspace. Contrasted to this are the terminal facilities which relate to aircraft in the Immediate vicinity of an airport. Following the Civil Aeronautics Act of 1938, the Federal Government expanded its control to include responsibility for the operation of terminal air traffic control towers. The Federal Aviation Act of 1958 charged the Federal Aviation Agency (now Federal Aviation Administration) with the responsibility for ensuring safe and efficient use of the nation's airspace by civilian and military aircraft. In accordance with this Act, all aircraft operating in this airspace must adhere to the rules and regulations of the FM. Of approximately 12,000 aircraft in flight dally over the United States during the daylight hours, 80 percent fly under Visual (see and be seen) Flight Rules (VFR). Under these rules the task of maintaining separation from all other aircraft is the pilot's responsibility.

The remaining 20 percent, mostly commercial and military, operate under Instrument Flight Rules (IFR). Under these rules air traffic controllers located at one of the nation's 20 Air Route Traffic Control Centers (hereinafter referred to as enroute centers) rely on radar to keep these aircraft separated from other IFR operating aircraft. Effective control occurs when the ground controller can identify each airplane by position, altitude, and speed. While the control of all IFR aircraft during all phases of flight is necessary, it becomes even more critical in the terminal areas. A terminal area may be described as an airspace from five to 60 or more miles in diameter in which one or more airports are located. Due to the congestion of arriving and departing planes the likelihood of delay or collision is greater there. The separation of IFR aircraft operating in the terminal area is the responsibility of air traffic controllers in one of the air traffic control towers within the terminal area. Again, these controllers rely on radar in maintaining separation of aircraft. In early 1972 FAA employed approximately 16 thousand air traffic controllers at the enroute centers and terminal areas. This report is primarily concerned with a review of the actions taken by the FAA to introduce automation into the control of air traffic operating within a terminal area.

History of Automated Air Traffic Control

In 1961, President Kennedy asked for a long-range plan to insure safe and efficient control of all air traffic within the United States. A task force was established by the Administrator of the FAA to prepare this plan. The task force report, under the name "Project Beacon," submitted an analysis of the existing methods of air traffic control, recommended several near-term improvements, and presented an advanced concept for an air traffic control system to meet future needs. The task force recognized the huge demand for air transportation and the implications the rapid rate of increase would have on the air traffic controllers, who were already considered to be operating at capacity.

One solution to this problem, obviously, would have been to steadily increase the number of controllers. Terminal facilities are limited by space however, and this answer would have prompted more problems than solutions. An alternative, which "Project Beacon" recommended, called for the application of computer technology to the system.

The Automated Radar Terminal System (ARTS) is one outgrowth of this proposal. In addition, they recommended IFR aircraft be equipped with a transponder which would electronically provide the aircraft's identity and altitude to the controller. Control of aircraft in the terminal airspace requires that each aircraft be precisely identified by position, altitude, and speed. Prior to automation, the controller identified each "blip" on his radar display by extensive radio communications with the pilot. Not only was this time consuming; It was also arduous and inefficient as the controller either relied on his memory or wrote all this data on paper or plastic strips ("shrimp boats") which were then placed on the radar display adjacent to its associated blip. As the aircraft and its corresponding blip moved on the radar display, the controller then physically moved the associated shrimp boat.

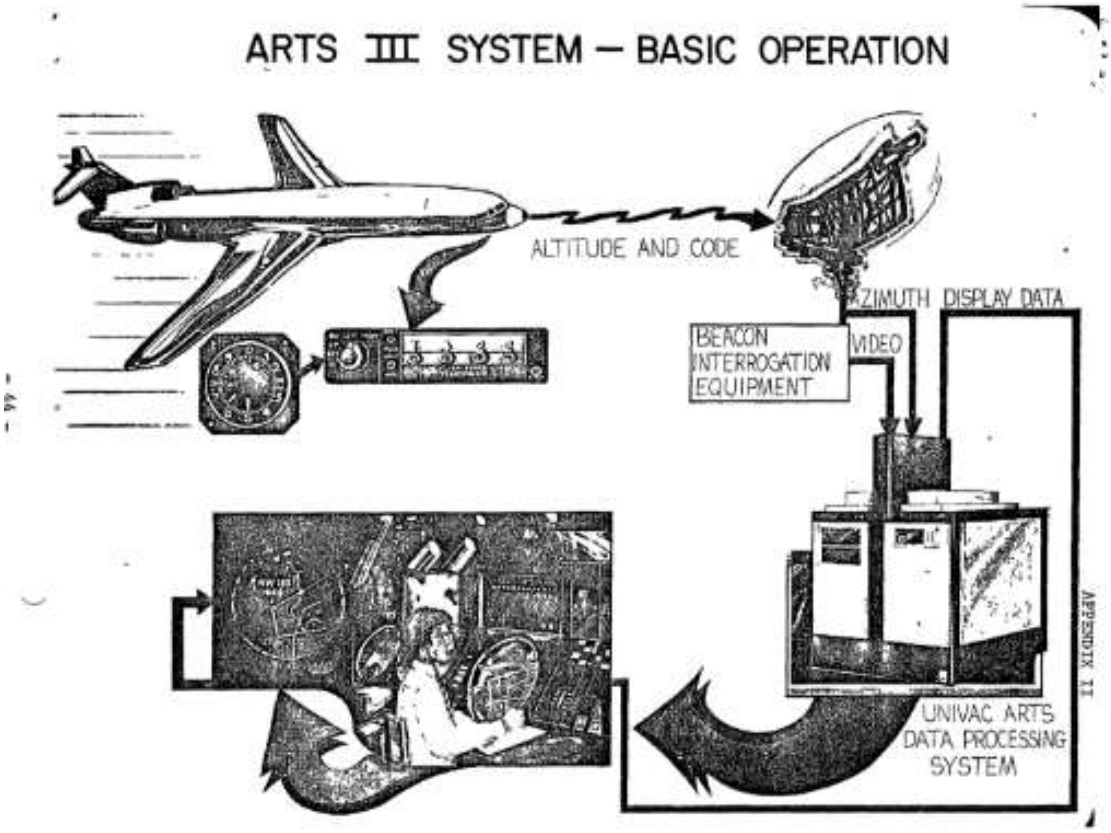
ARTS was conceived to eliminate these manual chores and reduce the amount of radio communications required to establish aircraft identity. Continuous positive aircraft Identity, ground speed, and altitude would now be obtained via the transponder and computer and shown in code (alphanumeric) directly on the radar display. As a result, the controller would be free to effectively serve more aircraft than before. Safety hazards inherent in the old system would also be overcome. FAA completed a system implementation plan in June 1962 and work was then begun on the development of a workable automated air traffic control system for use in high volume terminal areas. The first installation (ARTS-I), at Atlanta, served as an operational test system.

Later, an automated terminal system (ARTS I-A) was installed in a common IFR room established to provide airports m the New York City area with radar control capability. Originally, the FAA planned to use the same type of terminal automated air traffic control equipment as that being developed for the enroute centers. However, the requirements for terminal operations are significantly different than those for enroute centers. For instance, terminal controllers are primarily interested In the actual position and identity of each aircraft. Enroute controllers, though, are concerned more with the reconciliation of planned position to the actual position. Another difference, due to greater concentration of aircraft in the terminal airspace, is that a higher radar antenna rotation rate is required in the terminal areas.

Also, obtaining physical space for the installation of automation equipment presented more of a problem at the terminals than it did at the enroute centers. In February 1969, the FAA awarded a contract to the Univac Federal Systems Division of Sperry Rand Corporation for development, production, and installation of an automated radar terminal system (ARTS-III). The ARTS III system consists of three subsystems: (1) a data acquisition subsystem; (2) a data processing subsystem; and (3) a data entry and display subsystem.

The data acquisition subsystem receives beacon video and control signals from which it detects beacon replies, generates range and azimuth data, and transmits reply-messages to the data processing subsystem. The latter performs target detection, tracking, processing of flight data, transfer of control, controller message processing, and display processing consisting of "formatting" display data and refreshing the data entry and display subsystem.

This last subsystem displays the analog representation of both the radar and beacon video, displays the alphanumeric data, and transmits controller-entered keyboard data to the data processing subsystem. UNIVAC, the prime contractor, produces the data processing subsystem and computer software. The data acquisition subsystem is built by the Burroughs Corporation and the data entry and display subsystem by Texas Instruments Incorporated, as Univac subcontractors. Sixty-four (64) of these systems will be installed throughout the country. As the demand for service increases at each airport and as more functions are required, these systems can be expanded modularly. The first system was delivered on December 22, 1970. Since then, an additional 62 have been delivered (as of February 1, 1973) and current projections are that the last system will be tested and in use by late-1973.



Scope

Information on this program was obtained by reviewing plans, reports, correspondence, and other records and by interviewing officials at contractor plants, various FAA locations (Headquarters offices, regional offices, air terminals, and enroute centers), and the officials formerly assigned to the National Airspace System Program Office.

We evaluated management policies and the procedures and controls related to the decision-making process, but we did not make detailed analysis or audits of the basic data supporting program documents. We made no attempt to: (1) assess the technology involved, (2) develop technological approaches, or (3) involve ourselves in decisions while they were being made.

PROGRAM STATUS

Since this is our initial review of the ARTS III program, this chapter will highlight the cost, schedule, and performance experience of the overall program.

Program Cost Experience

The current estimated cost of the ARTS III program is $64.5 million. This compares with an initial program estimate of $33 million made in June 1967, and a $51.3 million planning estimate made in October 1968, and again in February 1969, when the contract was awarded. The $64.5 million estimate, made In September 1970, has remained unchanged since that date. In addition to the fact that the program estimates and the planning estimate made no provision for inflation.

Program Schedule Experience

The major milestones in the ARTS III program were (1) the delivery date; (2) the completion of installation and checkout, i.e. initial operating capability (IOC); and (3) the operational readiness demonstration (ORD), for each of the 64 systems. The delivery date and IOC date for each system were established in the basic contract. Subsequent modifications to the contract in January 1970, May 1971, and November 1971, however, have changed the delivery schedule, the IOC schedule, some of the locations involved, and the relative order in which certain locations were to receive the systems. Key events (Including the three milestones mentioned above) in the ARTS III program for each of the 64 locations were prepared by the FAA in October 1971 and subsequently updated monthly. The ORD date for each system has generally been established as four months after the IOC date.

Delivery

The first ARTS III system was delivered to the FAA Academy in Oklahoma City on December 22, 1970. A second system was delivered to Chicago's O'Hare Terminal on December 27, 1970. While the first delivery slipped six months in comparison with the milestones established m the original contract, it was only two months late in comparison with the modified contract. One of the 64 systems was undelivered as of February 1, 1973. Three of the systems (Dallas/Fort Worth, Sacramento, and San Antonio) are being held in storage by Univac pending completion of site preparation. The system for the San Francisco/Oakland terminal will be shipped to the FAA Depot for temporary storage while awaiting completion of construction of a new building. FAA officials estimated that delivery of all 64 systems would be completed in February 1973, which is only four months later than the completion date specified in the original contract.

Note that the time for the 64 systems has been compressed from 28 months (i.e. from 16 to 44 months after contract award for the original contract) to 26 months (LA., from 22 to 48 months after contract award as shown for actual and projected delivery). The average delivery date for an ARTS III system has increased from 33.2 months after contract award in the original contract to 35.2 months in the modified contract and is projected to be 36.7 months if delivery is completed in February 1973. We were advised that the major factor delaying delivery of the initial ARTS III systems was associated with the development of the data entry and display subsystem. This problem area is discussed further under the Program Performance Experience. We were Informed that during production of the data entry and display subsystem.

This problem area is discussed further under the Program Performance Experience. We were Informed that during production of the data entry and display subsystem, Texas Instruments, Inc., encountered problems with two of its suppliers. These were solved by the purchase of the suppliers' production facilities in one case and by advancing funds to the suppler in the second case. In addition, Texas Instruments used a second shift during a portion of the production phase to maintain the delivery schedule which had been compressed because of the development delays.

Initial Operating Capability

Initial operating capability (IOC) was first achieved by an ARTS III system on February 19, 1971, at the FAA Academy. While this is a slippage of three months when compared with the milestones established m the original contract, it is only one month late when compared with the modified contract. Based on the original contract the average IOC date for an ARTS III system is 36.9 months after contract award. This average increases to 38.8 months in the modified contract and is projected to be 39.3 months for the entire program.

Operational Readiness Demonstration

The first operational readiness demonstration (ORD) of an ARTS III system was also held at the FM Academy m February 1971. While the ORD milestone was not Included In the original contract, FAA officials informed us that the first ORD was on schedule. Based on the National Airspace System Program Office Official Schedules, dated October 1, 1971, the average ORD date for an ARTS III system is 42.9 months after contract award. As of February 1, 1973, ORD has been achieved by 48 systems with the average ORD date being 41.2 months after contract award. It is projected that the average ORD date for the entire program will be 43.5 months after contract award date.

Program Performance Experience

The ARTS III is an outgrowth of the "Project Beacon" Report which was submitted to the FAA and then to President Kennedy in September 1961. Two significant recommendations of that report were (1) utilization of an Air Traffic Control Radar Beacon System for data acquisition and (2) utilization of general-purpose digital computers to provide air traffic controllers with aircraft position information. Subsequently, design concepts developed by the FAA's system design team resulted in an experimental model of an automated radar terminal system, known as ARTS I, installed in the Atlanta terminal. While this model was initially used to provide a field environment for appraisal of early concepts, it has been used for routine operational service since 1966.

The air-traffic congestion problem in the New York metropolitan area in the mid-1960's led to the ARTS IA, an improved version of the ARTS I, which was installed at the John F. Kennedy Airport in New York between late 1966 and early 1968 and placed into routine operational service In June 1969. The experience gained in the design, installation, and operation of the ARTS I, and the analysis of the air traffic situation leading to the ARTS IA, permitted the FAA's Systems Research and Development Service to clearly identify the task to be performed by the follow-on system--the ARTS III--which was to be installed at the nation's busier air terminals. (Note: The ARTS II is an automation system being designed for smaller airports served by FAA radar-equipped control towers.)

A comprehensive operational and technical description of the ARTS III is contained in FAA document "ARTS III System Description (SPO-MD-600)."

In addition, a description of the equipment and services to be procured is also contained in the ARTS III Procurement Plan, dated May 17, 1968. FAA officials advised us that their experience with ARTS I and ARTS IA also permitted preparation of comprehensive performance specifications for the ARTS III. While the performance specifications were developed by the Systems Research and Development Service, they were reviewed by the users of the system (the Air Traffic Service and the Airway Facilities Service) and the contracting officials (the Logistics Service). While several operational problems did arise during development and the early months of the program (e.g. excessive number of data acquisition subsystem alarms, inoperative power supplies in the data processing subsystem, display tubes that had a halo effect and were difficult to read, overheated display keyboards, circuit board failures, integration of ARTS III equipment with the radar surveillance systems, etc.) It appears that the ARTS III equipment has been operationally successful and has met with enthusiastic acceptance on the part of the user.

We found that during the lifetime of the ARTS III contract there have been only 14 modifications made that reflect changes in performance or technical characteristics of the system. We were advised that these changes were made to correct errors, reflect newer technology, or to meet modified requirements and that they have improved the operation, maintenance, and reliability of the system.

FAA and UNIVAC officials told us that the that the major performance problems of the ARTS III could be attributed to the data entry and display subsystem. UNIVAC officials said that at the beginning of the ARTS III program they considered that the system was reasonably well defined, and the technical goals were reasonable. The one major problem area that they did envision was with the display device which was subcontracted to Texas Instruments Incorporated. This device was a new development item and consequently considered a risk area. When major problems did occur during the development of the display device, the FAA and UNIVAC obtained the attention of Texas Instrument's top management who in turn assigned their most highly qualified people to the program. In addition, UNIVAC assigned a program manager in residence at the subcontractor's plant during the most critical period of the development.

FAA officials confirmed that problems did exist in the early development of the display device. Through combined actions the major problems were solved; however, a slight schedule delay did result. Texas Instruments officials advised us that the data entry and display subsystem was to be manufactured m accordance with performance specifications developed by UNIVAC and the FAA. They stated that the specification was very strict, but well defined; and while the data entry and display subsystem was not beyond the state-of-the-art, it was a new piece of equipment, and some problems were encountered during its development. A Texas Instruments official closely associated with the subsystem stated that the basic problem was that Texas Instruments grossly underestimated the time and effort required for development. The first data entry and display subsystems were scheduled for delivery approximately one year after the company entered a subcontract with UNIVAC on March 20, 1969.

In early 1970, UNIVAC and the FAA informed Texas Instruments that its contract was not on schedule and, in fact, that it might be terminated. It was at this time that Texas Instruments changed project managers and upgraded the entire project. One of the first decisions of the new project manager was to change the development approach being used.

While the first project manager had been attempting to develop a subsystem which would fulfill all specifications requirements prior to beginning production of equipment for delivery, the second project manager started developing a system meeting as many of the specification requirements as possible, but which could later be upgraded to comply fully with all specifications, either during the production phase or retrofitted at the site.

TEST AND EVALUATION

Tests and evaluation are the primary methods whereby a program manager receives assurance that contract end items will meet performance speculations and that program objectives will be achieved. To obtain this assurance, an effective test plan requiring an orderly, phased progression of tests must be developed and implemented. We found that the ARTS III Test Plan, prepared by UNIVAC--and reviewed by the FAA--was consistent with this requirement. In the ARTS III program, we noted various levels of testing, inspection, and acceptance. These levels include the inspection of components delivered from vendors; the factory inspection and testing of the subassemblies and subsystems; the integration of the subsystems into a system at each site with appropriate tests and checks at each stage of implementation; the stages of initial operating capability, operational readiness demonstration, and operational changeover; and eventually the commissioning of the facility.

In addition to these various levels of testing, we found that the test plan provided for several classes of testing to include (1) design qualification, (2) production, (3) support software, (4) reliability, (5) maintainability, and (6) type. The ARTS III tests were further categorized as either factory tests or on-site tests. The on-site tests were classed as site acceptance, system shakedown, and operations changeover.

The factory tests on the ARTS III equipment and software were designed to demonstrate specification compliance to the FAA Resident Quality and Reliability Representative. These tests have been conducted at the UNIVAC facilities in St. Paul, Minnesota and Salt Lake City, Utah and at the Burroughs and Texas Instruments, Inc. (subcontractors) factories in Paoli, Pennsylvania and Dallas, Texas respectively. The FAA has had Quality and Reliability (Q&R) Representatives assigned to each of the contractor or subcontractor facilities engaged in the ARTS III program. Some of the more important duties and responsibilities of the Q&R representatives are to effectively execute the FAA quality control program and monitor the contract quality control program for adequacy and to determine the compliance of equipment, materials, and services to the contract requirements.

In accomplishing these duties, the Q&R representative is expected to (1) assist the contractors in establishing and Installing acceptable inspection systems, (2) recognize and analyze defects m equipment produced to ascertain causes of deficiencies, and recommend any changes necessary in manufacturing techniques, quality control procedures, or inspection practices; and (3) authorize any necessary deviation in equipment and material provided they did not affect price, delivery, or end use. In integrating the ARTS III systems with the on-site equipment, the on-site tests are conducted in three phases and, in our opinion, have been as extensive as the factory tests.

Phase I testing consists of the physical installation of the systems to the greatest degree possible and static electrical checks of these equipment to demonstrate system integrity prior to interconnection with site facilities.

Phase II testing demonstrates the ARTS III performance after Interconnection with the site facilities, Phase III testing demonstrates complete site adaptation of an ARTS III system. This test includes a final check on operating controls and the operational computer program, Initial Operating Capability (IOC) is attained upon satisfactory completion of Phase III testing. UNIVAC, the prime contractor, is responsible for the integration of the three subsystems with the necessary software and for site installation and testing of each system through the achievement of IOC.

FAA officials explained that system shakedown, which begins after IOC, is a learning and optimization process wherein personnel become familiar with the system and the system is tailored to the specific needs of the terminal. Shakedown tests for the ARTS III were designed to be compatible with the normal control of air traffic yet had to be conducted with the least possible interference to ongoing air traffic control operations. The system shakedown activities are directed toward bringing the entire system, including personnel and procedures, to a state of operational readiness and culminate in an operational readiness demonstration (ORD). Satisfactory completion of the operational and maintenance tests in the ORD indicate that necessary performance standards have be met and the ARTS III is ready for operational use. Successful completion of ORD is also the point at which the National Airspace System Program Office turns the ARTS III system over to the user--the Air Traffic Service-- for operations changeover, which is that phase of implementation wherein the system is phased into the ongoing air traffic control operations at a facility on a commissioned basis.

Progress Measurement

The following prerequisites for an effective progress measurement system were evident in the ARTS III program: (1) The personnel involved understood what had been contracted for and what the product was to accomplish. We were advised that the system was state-of-the art and was relatively uncomplicated in comparison with some of the electronic systems being produced. (2) The system was such that it could be divided into various subsystems, components, and pieces. A prime contractor and two subcontractors were involved with each being responsible for a particular subsystem, (3) A system was employed whereby actual work performed and problems encountered were made known to higher levels, i.e., subcontractors to prime contractor to the FAA Program Manager.

The contractor was required to submit an index of drawings and technical memoranda, contract financial reports, narrative progress reports and Program Evaluation and Review Technique reports monthly to the FAA. Formal program reviews were also held at the contractor's and subcontractor's plants and the FAA Headquarters on an unscheduled basis. UNIVAC officials informed us that these program reviews were very beneficial in that they kept all parties aware of the status of the entire program. The UNIVAC Program Manager was responsible for determining the degree of surveillance that UNIVAC exercised over the subcontractors and for phasing the subcontract milestones in with those of the prime contract. The subcontractors provided monthly reports to UNIVAC with sections pertaining to technical problems, program status, reliability status and financial status. In addition to the contractor reports, the FAA received weekly reports from their Quality and Reliability representatives at each of the contractor/subcontractor facilities. Based on our discussions with FAA and contractor officials it seemed that the formal progress measurement reports were generally "after the fact" type reports submitted in compliance with the contract. It appeared that meaningful information was exchanged by telephone calls between the program managers.

PROGRAM MANAGEMENT

As increasing emphasis was placed on automating the enroute system, a National Airspace System Program Office was established by the FAA in April 1966. The mission of the System Program Office was to manage the effort required to define, develop, acquire, test, and turn over to the user, designated elements of the air traffic control automation program.

In late 1966, when it became apparent that automation of the terminal system was lagging, the Air Traffic Service and the Systems Research and Development Service began a joint exploratory project to develop a modular terminal automation system. By June 1967 a decision had been reached to provide alphanumeric capability at all FAA terminal radar approach control facilities and FAA-operated military radar approach control facilities. The directive announcing this decision assigned the primary responsibility for the major efforts to various offices and services of the FAA. Technical program management, preparation of engineering requires vision of applications engineering field guidance were assigned to the Systems Research and Development Service. Operational requirements, determination of priorities, and review of facility operational plans were assigned to the Air Traffic Service. System procurement was assigned to the System Program office.

During 1967 and 1968, the system documentation (specifications, system description, etc.) for the ARTS III was prepared within the Systems Research and Development Service and in early 1968 a procurement plan for the ARTS III was prepared by an Advance Procurement Techniques Group. These actions culminated in the award of the ARTS III contract in February 1969. We were advised that the late start of the terminal automation program (in comparison with the enroute automation program), the emphasis assigned to the program by FAA senior officials, the urgent need to automate the busier terminals, and the fact that a system program office was in existence were all factors leading to the assignment of the ARTS III program to the System Program Office in September 1969. We noted evidence of the high-level emphasis attached to the automation programs by the fact that coincident with this assignment, the System Program Office was placed under the executive direction of the Office of the Administrator.

The System Program Office was responsible for providing a single unified management for coordinating the development, planning and acquisition of an air traffic control system capable of meeting the expanding needs of the aviation community. Two distinct divisions were established within the System Program Office --one for the enroute and one for the terminal system. In examining the position descriptions, we found that the Chief, Terminal System Division was responsible for supervising the programming and management of the establishment and implementation of terminal automation systems and equipment and the development of in-service improvements to such systems and equipment from both the technical and planning standpoints." Therefore, for this report, we have considered the Chief, Terminal System Division as the Program Manager for the ARTS III program and the Director of the National Airspace System Program Office as the Program Manager for the overall air traffic control automation program. Unless noted otherwise, further references to the Program Manager will refer to the Chief, Terminal System Division. The ARTS III Program Manager The Terminal System Division, headed by the Program Manager, was organized into three Branches --an Engineering Branch, a Deployment Branch, and an Integration and Test Branch --and at one time 26 people were assigned to the Division.

The Program Manager advised us that this size of staff was sufficient only because he had quick access to additional personnel resources outside the organization when the need arose. In examining the degree of control held by the Program Manager, we found that he had primary responsibility for or played a part in designing the system, determining the type of contract, inserting key provisions in the contract (i.e. the options, testing requirements, etc.), determining the project milestones, proving out the system, advancing to the next stage of deployment or production, accepting the systems, changing the delivery schedule, recommending options to be exercised, determining quantities of items required, maintaining surveillance over contractors' and subcontractors' progress, etc. We were advised that with a few exceptions, all ARTS III program decisions were made within the System Program purview and with the Program Manager having direct and dally access to the Director of that office, most decisions were made quickly. Certain decisions, such as the go-ahead notices for Lots 2 and 3 and the change in certain locations that were to receive the ARTS III, required action outside their purview and some proved to be quite time-consuming. At the time cognizance over the ARTS III program was transferred to the System Program Office, the contracting responsibility (for automation projects) was moved from that office to the FAA's Logistics Service. Therefore, neither the Program Manager nor the Director of the System Program Office had full control over the ARTS III contracting activities.

AGENCY REVIEW

A draft of this staff study was reviewed by FAA officials associated with the management of this program and comments were coordinated at the Headquarters level. The FAA's comments are incorporated as appropriate. As far as we know there are no residual differences in fact.

CONCLUSIONS AND RECOMMENDATIONS

There is a definite need for an effective air traffic control system. The ARTS I program appears to have been a highly successful (based on cost, schedule, and performance criteria) steppingstone to such a system. We believe that the good working relationship between the acquiring agency and the contractor, and the rapport that developed between the various program managers, contributed immeasurably to the success of the program.

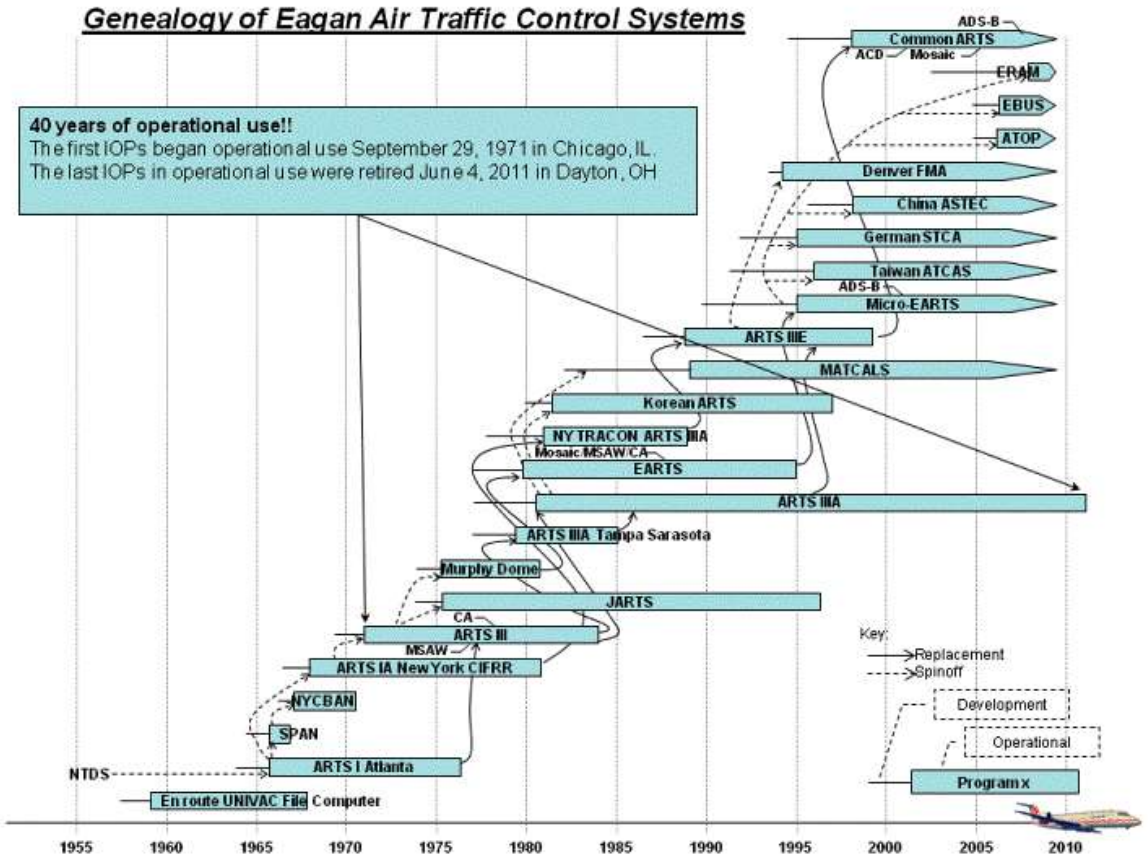
The ARTS III systems have been delivered close to schedule with most of the major delays experienced being attributed to site preparation problems. The ARTS III equipment has been operationally successful and has met with enthusiastic acceptance on the part of the user once the user has become familiar with its operations and uses. The efforts exerted by FAA personnel to keep the ARTS III program within the $64.5 million cost estimate are commendable.

The decision to appoint a program manager for the ARTS III program was based on similar criteria as that used by the military, i.e., large resources needed and long delivery schedule. The program manager's responsibilities were also quite like those of the military in that he must meet cost estimates and performance and schedule requirements. His staffing was like that of Navy program managers, in that, he had a small staff assigned but could draw on the permanent functional organizations for support when necessary. In this regard the program manager was able to direct most of his time to the accomplishments of the ARTS III program rather than to administrative detail.

Placement of the program manager in the organizational structure differed from that found In the military. There were few managerial layers between the program manager and the Administrator. The strong point noted in the FAA program management concept was the wide latitude given the program manager to insure a successful program. The one weak point noted was that neither the program manager nor the Director of the System Program Office had direct control over the ARTS III contractual efforts. Based on the present volume of air traffic and the projected rate of Increase, we believe that additional automation efforts, like those contained in the National Aviation System Policy Summary, will be forthcoming, and that centralized management (such as that formerly exercised under the National Airspace System Program Office Concept) may be desirable for such a program, rather than the functional approach now planned.

EPILOGUE

The 1969-73 FAA Program Managers of ARTS III system should be proud of the continued life of their ARTS III system as illustrated in this diagram. DOT wrote a good 1973 development report!



The Input Output Processor (IOP) of ARTS III is a 30-bit machine using the same basic Instruction Set Architecture (ISA) as the Naval Tactical Data Systems of the 60s-80s. The lead IOP logic designer was John Bonnes, BEE 1965 - University of Minnesota.

Thanks to all DOT, FAA, and UNIVAC/Sperry/Unisys/Lockheed Martin/Leidos personnel who are providing millions of passengers annually with safe air travel. *Lowell A. Benson*, BEE 1966-UofMN.