ORDER

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

1812.8

8/29/86

SUBJ: SYSTEM REQUIREMENTS STATEMENT FOR THE AIR ROUTE SURVEILLANCE RADAR--MODEL 4

1. PURPOSE. This order establishes the system requirements for Air Route Surveillance Radar--Model 4 (ARSR-4), which is consistent with the National Airspace System (NAS).

2. DISTRIBUTION. This order is distributed at director level in the Offices of Airport Planning and Programming, Airport Standards, Aviation Policy and Plans, Budget, and Personnel and Technical Training; to the branch level in the Advanced Automation Program Office, Office of Flight Standards, Air Traffic Operations Service, Air Traffic Plans and Requirements Service, Program Engineering and Maintenance Service, Systems Engineering Service, and Acquisition and Materiel Service; to the branch level at the FAA Technical Center and the FAA Depot at the Aeronautical Center; and at branch level in the regional Airway Facilities, Logistics, Air Traffic, and Flight Standards Divisions.

3. BACKGROUND. Replacement of the existing vacuum tube long-range radar systems at joint-use and other FAA facilities with a modern solid-state radar was approved in Order 1311.5, System Requirements Statement/Acquisition for Replacement of ARSR-1 & 2 and FPS -20 & -69 Radar Systems, dated April 2, 1980. The radar replacement program was reopened for review in 1981. New guidelines were established, and an extensive radar coverage study was undertaken. The United States Air Force (USAF) formally requested that FAA consider a three-dimensional radar as a replacement system for joint-use locations. The 3-D approach to the joint-use radar replacement program was addressed in the December 1981 NAS Plan. This approach complies with the USAF requirement to improve reliability, maintainability, supportability, performance, and decreased operational staffing costs of air defense radars.

4. MISSION NEED.

a. Requirements Statement. The basic requirement is to provide surveillance of aircraft in support of current FAA air traffic control and USAF air sovereignty/ air defense operational requirements at current and planned facilities. Detection of high performance aircraft with lowered radar cross sections shall be provided. The system shall provide accurate and reliable surveillance (range, azimuth, and height) data and provide detection of air carrier, military, air taxi, and general aviation aircraft in ground, weather, and angel clutter; minimize blind speeds; and reduce interference from other sources. The system shall provide weather target detection. The required system shall be compatible with the Mode Select Beacon System (Mode S) sensor, the Air Traffic Control Radar Beacon System (ATCRBS), the present air route traffic control center (ARTCC) Host and Direct Access Radar Channel (DARC) systems, the En Route Automated Radar Tracking System (EARTS), the Advanced Automation System (AAS), and the USAF Region Operations

Control Center (ROCC) Computer, AN/FYQ-93. The system shall be unmanned and operationally available 99.74 percent of the time. The system shall be capable of supporting current and planned future automated functions designed to enhance both air safety, air sovereignty, and air defense missions. The system must provide a secure mode of identification, be compatible with the military Mark XII System (including Mark XV equipped aircraft capable of responding to Mark XII interrogations), and provide measures for adequate protection for Mode 4 key loading and security. The system must support NAS system coverage requirements for primary radar and maintain existing levels of coverage until Next Generation Weather Radar or other suitable means of depicting usable weather data is available at which time the coverage requirements shall be: 6,000 feet mean sea level to flight level 200 over nonmountainous terrain and minimum en route altitude or 6,000 feet mean sea level, whichever is higher, to flight level 200 over mountainous terrain.

b. Functional Capabilities. The proposed ARSR-4 surveillance system shall have the following functional capabilities:

(1) Radar Performance. The ARSR-4 shall provide search radar detection and reporting (range, azimuth, and height) of aircraft and meet the following performance requirements:

(a) Detection Envelope. Zero to 360 degrees in azimuth; 5 to 250 nautical miles in range; from the earth's surface and above, a line tangent to the radar horizon up to 100,000 feet mean sea level; -7 to 30 degrees in elevation relative to a zero degree radar horizontal.

(b) Scan Rate. 12 seconds plus or minus 0.1 second.

(c) Range Accuracy. The range error shall not exceed plus or minus 0.125 (1/3) nautical miles over the entire detection envelope.

(d) Azimuth Accuracy. The azimuth error shall not exceed plus or minus 0.176 degrees over the entire detection envelope.

(e) Resolution. Over the entire detection envelope, resolve two targets when separated by 0.125 (1/8) nautical miles in range and on the same azimuth or when separated by 2.0 degrees in azimuth at the same range.

(f) Height Accuracy. The ARSR-4 shall determine and report target height to an accuracy of plus or minus 5,000 feet of true altitude 90 percent of the time, as measured in any 5-nautical-mile range interval, to a range of 175 nautical miles.

(g) Detection. Detect and report a 0.1 meter square, Swerling type I target out to a range of 92 nautical miles, a 1.0 meter square, Swerling type I target out to a range of 165 nautical miles, and a 2.2 meter square, Swerling type I target in a range from 5 to 200 nautical miles.

(h) Target Definition. A target shall be defined as a manmade flying vehicle with the following characteristics:

1. Radar Cross Section - .1 to 10,000 meter square.

2. Velocity - 25 to 3,000 nautical miles per hour.

3. Dynamics - up to seven times acceleration due to gravity (Gs).

(i) Frequency. The radar shall be capable of operating over a frequency range of 1,215 to 1,400 megahertz.

(2) Beacon Performance. When colocated with an Air Traffic Control Beacon Interrogator, Model 5 (ATCBI-5), the ARSR-4 shall process beacon video from the colocated ATCBI-5 facility to produce beacon target reports and meet the following performance requirements:

(a) Probability of Detection. 0.995 with round reliability of 0.76 in 40,000 fruit replies per second (30,000 fruit replies if operating Mode 4).

(b) Accuracy. The range and azimuth accuracy shall equal the search range and azimuth accuracy.

(c) Range Resolution. Resolve two transponder-equipped aircraft when separated by 0.05 nautical miles in range at the same azimuth.

(d) Azimuth Resolution. Resolve two transponder-equipped aircraft targets as follows:

1. Aircraft with identical codes and modes separated by a distance equal to or exceeding 2.4 degrees in azimuth.

2. Aircraft with different modes or codes, regardless of separation provided reply codes, do not garble or otherwise interfere with each other.

(e) Code Validation. The validation of Mode-2/3A codes shall be greater than 97 percent; validation of Mode C codes shall be greater than 96 percent.

(f) Mark X and Mark XII Capabilities. The beacon target processing shall comply with the following:

1. Order 1010.51A, Selection Order: U.S. National Aviation Standard for the Mark X (SIF) Air Traffic Control Radar Beacon System (ATCRBS) Characteristics (3-8-71).

2. Department of Defense Aims Specification 65-1000B (4-1-82) and have an integral Mark XII System.

3. Upon request, Mode 4 interrogations shall have priority over all others except that this shall not inhibit interlaced interrogations.

4. Facilities for changing Mode 4 codes from a remote location shall be provided to support unmanned operation of site.

(3) Weather Detection and Reporting. The ARSR-4 shall detect and report weather target data as follows:

(a) The ARSR-4 shall provide nondigitized log weather data for the Radar Remote Weather Display System (RRWDS). The log weather video shall have a 60 decibel (dB) dynamic range minimum.

(b) The ARSR-4 shall detect (position and intensity) five levels of weather with a range accuracy of 0.5 nautical miles and shall provide for selection of three of the five levels for digital reporting.

(c) The ARSR-4 shall provide for selection of intensity levels in weather reports in the following ranges: greater than or equal to 30 dBZ, greater than or equal to 41 dBZ, greater than or equal to 46 dBZ, greater than or equal to 50 dBZ, and greater than or equal to 57 dBZ, where dBZ is target reflectivity in decibels.

(4) Target Processing. The ARSR-4 shall process and format target reports as follows:

(a) Target Capacity. The ARSR-4 shall be capable of outputting 800 targets per scan, not including false targets or equipment status messages.

(b) False Targets. The ARSR-4 shall report no more than four false beacon or search targets per scan due to noise. False search targets per scan shall not exceed 20 due to terrain or sea returns, 70 due to vehicular traffic and angles, and 100 due to cellular precipitation, averaged over 10 consecutive scans.

(c) Timeliness. The ARSR-4 delay between target detection (aircraft at antenna peak of beam) to transmission of the digital target report shall be as follows:

1. When Colocated with a Mode S. Delay of transmission of digital target report to the Mode S shall not exceed 0.350 seconds.

2. When Colocated with an ATCBI-5. Delay of transmission of digital target reports out of the ARSR-4 shall not exceed 1.5 seconds.

(d) Search/Beacon Correlation. Correlate radar and beacon target reports to provide radar reinforced beacon target reports.

(e) Data Ports. Provide separately controlled digital data ports for USAF and FAA. The FAA shall have dual ports to provide data in both common digitizer format and AAS required (to be determined) format for transition. Provision shall be made for maintaining the security of the USAF digital data link.

(f) Programmability. All digital reports shall be programmable to have format compatible with the ROCC, ARTCC, and AAS.

(g) False Target Reduction. The ARSR-4 shall provide for selection of a process or processes which shall reduce false target report output from any FAA data port to no more than 30 false reports per scan averaged over 10 consecutive scans. The degradation of performance parameters associated with this selection shall be minimized commensurate with meeting the requirement for no more than 30 false reports per scan.

(5) Availability. The ARSR-4 shall have the following reliability and availability:

(a) System Operational Reliability. The ARSR-4 System mean time between failures shall not be less than 1,500 hours.

(b) System Availability. The ARSR-4 shall be operationally available 99.74 percent of the time when the system is unmanned. Should the system be manned, it shall be operationally available 99.87 percent of the time.

(c) Annual Maintenance. Maximum annual maintenance man-hours shall not exceed 100 hours (combined corrective and preventive maintenance). Preventive maintenance shall not be required on less than a 90-day interval.

(6) Local and Remote Maintenance. The ARSR-4 shall provide for both local and remote maintenance and monitoring as follows:

(a) On-line Maintenance. Provide capability to perform on-line diagnostics, line replaceable unit (LRU) replacement, and LRU testing without impairing on-line radar operation.

(b) Remote Maintenance Monitoring System. Provide full compatibility with the NAS Remote Maintenance Monitoring (RMM) System as specified in NAS-MD-792 and NAS-MD-793.

(c) Operational Control. Both local and remote operational control shall be provided.

(d) Diagnostics. Provide on-line performance monitoring diagnostics and off-line fault isolation diagnostics controlled through the RMM.

(7) Interference Reduction. The system shall have interference reduction capabilities as follows:

(a) Elimination.

(b) Rejection.

(c) Avoidance, such as sector radiation control and rapid frequency selection, local and remotely controlled.

(d) Radiofrequency (RF) interference strobe reporting with remote (from ROCC) and local disable capability.

5. EXISTING AND PLANNED CAPABILITIES.

a. Existing Capabilities. Electronic equipment at existing joint-use facilities include:

(1) Search radar subsystem (ARSR-1, -2, -3 or FPS-20, -60, -91, -93A).

(2) Beacon subsystem (ATCBI-5, AN/GPA-124).

(3) Military height-finder radar subsystem (FPS--6/90/116).

(4) Data remoting subsystem (FYQ-47, -49, DTE/MIM, CD-2C, WFMU, and modem).

(5) Communications subsystem (BUEC, RCAG, AN/GRR-21, -22 with AM-6155 linear amplifier, -23, -24, AN/GRT-22, and GRC-171).

(6) Environmental subsystem.

(7) The digitizers are used to detect, digitize, and format the radar and beacon data automatically before it is sent to the ARTCC or the ROCC using radar microwave link or dedicated telephone lines. Height-finder radars are operated by USAF/DOD personnel, and height information is manual (semi-automated) by site operator. With the exception of the ARSR-3, which is used at 12 joint-use locations, search and height radars are 30 years old and use vacuum-tube technology and associated analog circuitry.

b. Planned Capabilities. Replacement equipment will be the ARSR-4 radar and a radar beacon system. Mode S or ATCBI-5 will replace the UPX-14/21 beacon subsystem. The ATCBI-5 beacon subsystem will be retained at some sites and replaced by Mode S at others. Mode S is funded separately and its capabilities are discussed in Order 1812.6, System Requirements Statement for the Mode S Surveillance and Communications System. The ARSR-4 radar will replace ARSR-1, -2, -3, FPS-20, -60, -91A, -93A, digitizers (FYQ-47, -49, DTE, DTE/MIM, CD-2C), FPS-9, -90, -116, and the WFMU at joint-use facilities.

6. ASSESSMENT.

a. Shortfalls in Existing Capability. The existing radars and data processors often suffer from detection of automobiles and angel clutter; e.g., birds, convective cells, etc. This effect is closely connected with the environment, season of the year, temperature, meteorological situation, and latitude. With the existing radars, subclutter visibility is reduced by limiting ground clutter. Therefore, only large aircraft (air carrier) are detected reliably while small aircraft (air taxi and general aviation) may be eliminated. Improved subclutter visibility would improve the reliability of detection, especially for smaller aircraft.

b. Technological Opportunity. The opportunity exists for meeting the mission need through the application of existing technology. Doppler filtering, moving target detectors, scan-to-scan correlation, and RMM are examples of existing technologies that could be applied to meet the mission need. In addition, the technology required for integral search and height-finder radars exists and provides the opportunity for reducing manpower requirements at current joint-use facilities. Application of RMM technology will allow application of new maintenance concepts while continuing to meet the mission needs.

c. Physical Obsolescence of Equipment. The present ARSR-1, ARSR-2, FPS-20, FPS-60, FPS-91A, and FPS-93A, ARSR's, and FPS-116 height-finder radars use vacuum tubes and associated analog circuitry that are at least 25 years old. These equipments will be approximately 30 years old at the time of planned replacement. Hence, current radar systems will have exceeded their planned 20-year design life by 10 years. The wiring and components in existing systems are brittle with age and break easily when opening the equipment to perform daily maintenance. The condition of the equipment is in a critical state, and a replacement program must be undertaken as soon as possible in order to prevent extended outages which could place a burden on our air traffic system and the USAF air sovereignty/air defense missions. There is mechanical wear out of such major system components as RF attenuator and rotary joints for the ARSR Systems and range height indicator, cone assembly, azimuth drive, and amplidyne for the FPS-116 System.

d. Opportunity for Cost Savings. There are increasing costs in supplying replacement parts for current radar systems. Components are not available in the supply system and have to be specially manufactured. Over the last few years, the average unit price for the receiving-type vacuum tubes has increased at an annual rate of 17.4 percent, including inflation cost. The cost of solid-state devices is expected to continue to decline. A microprocessor which cost $9 in 1975 will cost $2 in 1985, a reduction of 77.7 percent. The integral height-finding capability of the proposed system will provide USAF ROCC's with automatic reporting of height without operator intervention. Currently, this function is accomplished by seven military personnel at each site. The performance of the height function will also be remote maintenance monitored and will allow the FAA to satisfy its maintenance commitment to the USAF with increased proficiency and productivity.

e. Potential Impact on Human Resources.

(1) The ARSR-4 Program is part of the continuing FAA effort to replace all vacuum tube equipment with solid-state equipment to provide greater system reliability and reduce operating costs. As a replacement system, the impact to the operating air traffic controllers will be minimal. There would, however, be expected impact to the Airway Facilities maintenance staff, primarily as a result of the change from a manned facility to an unmanned facility. The overall impact will be minimized in accordance with guidance from Order 6000.27, Transmittal of Maintenance Philosophy Steering Group (MPSG) Report, which provides the guidance that reductions in work force levels will be accomplished through attrition. There will also be possible personnel relocations, which will be considered in the program implementation plan. This will be accomplished in conjunction with maintenance staffing planning regarding colocated ATCBI, Mode S, Mode 4, and other systems.

(2) Training will be accomplished for the maintenance technician in accordance with current practices and will be detailed as part of the program implementation plan. Training will be planned to minimize impact on operations.

(3) The program office will ensure that human factor considerations, such as ease of maintenance, occupational safety and health, ergonomic design, user friendly software, etc., are part of the procurement package and specification and are given high visibility and attention throughout all implementation phases of the program.

(4) Although it is too early in the program for specific conversations with appropriate bargaining unit representatives, these representatives have been kept involved with respect to the general thrust of such programs through discussions of the MPSG report and continuing dialogue vis-a-vis the 80's Maintenance Program. The program office will, through the cognizant offices, ensure considerations of and inputs from operating personnel.

7. MAXIMUM COST AND MINIMUM BENEFIT.

a. General Cost. The total estimated life-cycle cost for the FAA/Air Force Radar Replacement (FARR) program for the ARSR-4 is summarized in the following table:

	Undiscounted (Constant FY-1985 $)	Discounted (present value) (Constant FY-1985 $)
Acquisition Cost	$605.2M	$353.7M
Operations & Maintenance Cost	221.8M	53.1M
Total Life Cycle Cost	$327.0M	$406.8M

b. Potential Benefits. It is anticipated that the FARR/ARSR-4 Program will provide or generate several areas of potential benefit. These include operations and maintenance cost savings to the FAA and USAF, reduced delay savings to users, enhanced user safety, and improved national defense readiness. Identification of these expected benefits is based on the following factors:

(1) Savings in operations and maintenance costs due to solid-state technology and RMM.

(2) Reduced labor costs due to the integral height-finding capability of the ARSR-4 System with automatic reporting of height without operator intervention.

(3) Reduced capital investment on related projects through the relocation of reusable resources to locations where they will fulfill mission requirements for those sites.

(4) Improved equipment reliability and availability will reduce user delays and maintain safety standards.

(5) Enhanced national security due to improved system performance and increased availability (for example, increased range, increased reports per scan, wider detection envelope).

8. APPROACH ALTERNATIVES.

a. Continuation of Present Approach. If no action is taken, the impact on the mission need would be to reduce the availability of the primary surveillance data to the air traffic control system. The continuing deterioration of the current systems will result in more and longer outages. The cost to the agency will be in the areas of increased replacement parts costs as systems become obsolete and parts are no longer readily available and in increased labor costs.

b. Proposed ARSR-4 Approach. No major new development will be required as part of the ARSR-4 procurement. Several manufacturers have produced systems that have capabilities that are similar to those required to meet the mission need. It is expected that these manufacturers will propose variants of their current systems.

c. Nontechnical Approaches. There are no nontechnical approaches suitable to meet the mission need.

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