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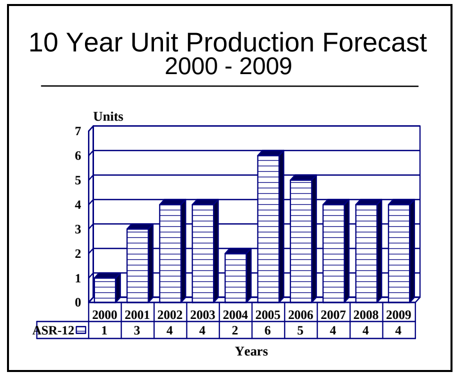
ASR-12 - Archived 8/2001

Outlook

- Solid-state follow-on to the ASR-9 with improved performance and a solid-state transmitter
- Becoming popular in South and Central American market
- Egypt and Argentina selected the system for ATC upgrades



Orientation

Description. Airport Terminal Surveillance Radar.

Sponsor. Company sponsored development.

Contractors
Northrop Grumman Corp
Electronic Sensors & Systems Division
PO Box 17319
Baltimore, Maryland (MD) 21203-7319
USA
Tel: +1 410 765 1000
Fax: +1 410 993 8771
(Prime)

Status. In production, ongoing support.

Total Produced. Through 1999, an estimated 11 systems had been produced.

Application. Airspace surveillance in Terminal Control Areas.

Price Range. The price of a radar varies with site-specific requirements. The estimated unit cost is from US$2.9 through US$3.6 million.

Technical Data

	Metric	US
Characteristics		
Frequency:	2.7 – 2.9 GHz	
Peak Power:	22 kW	
Pulse Width:	1µsec, 55 µsec	
Instrumented Range:	111, 148, 185 km	60, 80, 100 nm
Resolution		
Range:	230 m	747 ft
Azimuth:	2.8º	
Accuracy (rms)		
Range:	± 38 m	±121.6 ft
Azimuth:	± 0.12º	

Track Capacity:	1,000 targets
Clutter Improvement Factor:	55 dB
Processing:	Moving Target Detection-IV Doppler Filter Bank
Weather Type:	6-level
Filters:	6/8/10
A/D Conversion:	15 bits @7.78 MHz
Antenna Gain:	36 dB
Polarization:	Linear/Circular
Azimuth Beamwidth:	1.4º
Elevation Beamwidth:	4.8º min (Cosecant squared) to +30º
Rotation Rate:	10/12/15 rpm
Features:	Simultaneous target and radar data Six-level weather output (IACO compliant) Advanced Moving Target Detection (MTD-IV) Constant False Alarm Rate (CFAR) processing Remote monitoring and control Unattended operation Mode S compatible Multiple interface capabilities
MTBCF:	>37,500 hr
MTTR:	<15 min
Availability:	99.998%

Design Features. The ASR-12 is a modular, solid-state radar based on the successful ASR-9 that capitalizes on state-of-the-art advances in high-power transistors. It adds a solid-state transmitter to the ASR-9's solid-state architecture. The fail-soft transmitter radiates on the system's low beam, but receives on dual beams stacked in elevation.

The solid-state transmitter builds on design and production experience with the SPS-40(V) radar transmitter and the company's Mode S program. Solid-state transmitters were built for the Lightweight Aerostat Surveillance System (LASS), and over 800 solid-state drivers have been provided for the ASR-9 and NEXRAD radar programs. The transmitters were designed based on experience with the ARSR-4 and TPS-75(V) radars.

The ASR-12 was designed to have the same performance capabilities as the benchmark ASR-9 with the addition of solid-state RF technology. The system's improved false alarm performance yields a radar that matches controller demands and exceeds International Civil Aviation Organization (ICAO) requirements.

Designers focused on providing accurate aircraft position in spite of extreme weather or ground clutter conditions, natural and man-made interference, and ground vehicular traffic. Commercial off-the-shelf (COTS) processors were combined with software-implemented Moving Target Detection to improve system performance over past radars.

Azimuth resolution was also of particular interest to designers. A sophisticated software algorithm compares actual radar returns against the reference return expected from a single aircraft. If the actual return does not match the broad parameters of the reference return, the system reports the detection of two separate aircraft. This increased accuracy enables air traffic controllers to safely separate aircraft flying close together at a given azimuth.

Designers also worked to ensure good range resolution. The ASR-12 uses a unique range resolution process to detect a small aircraft flying in close proximity to a larger one. This effectively eliminates the problem of a large aircraft masking smaller ones, a critical consideration in the dense terminal environment.

Another important ASR-12 feature is its ability to detect aircraft flying tangentially to the radar. This has long been a major deficiency of moving target indicator MTI terminal radars, since aircraft in traffic and holding patterns routinely follow tangential flight paths with a low closing velocity that the MTI system tended to identify as non-moving clutter. The MTD-IV Moving Target Detection system is the latest design developed for use with the long adaptive waveforms characteristic of solid-state radars.

The MTD-IV employs adaptive processing techniques in the Doppler frequency domain to uniquely identify aircraft and clutter returns. This system is the fourth generation of a concept evolved over more than 20 years. With each new generation, significant improvements were made in the detection of aircraft in weather and ground clutter.

The MTD-IV continued this evolution and incorporated new features to improve detection performance and to reduce operating costs. Less robust waveforms such as the four-pulse MTD suffer more Doppler resolution difficulties than the MTD-IV does. For example, the MTD-IV has four to five filters spanning the same Doppler frequency as compared to only one filter in the four-pulse system. This produces a fourfold improvement in the detectability of aircraft speed and a significant improvement in the ability to detect aircraft in weather and ground clutter conditions.

The ASR-12 uses a unique switched combination of "states" to maximize performance. Two major switching events occur in the lower beam during each pulse period. The system radiates a long and short pulse in the low beam. In the first five to six nautical miles, the system receives short pulse returns from the high beam. At the end of this period, the receiver switches to the long pulse and high beam until roughly 15 nautical miles. The ASR-12 then switches to receiving the long pulse from the low beam, using this for detection out to the maximum range of the system. To optimize the clutter performance of the radar, these switching points are adjustable to best match the clutter conditions of the site. This "seamless switching," no perturbations of the radar data, gives the ability to receive both pulses simultaneously, a feature unique to the ASR-12.

The weather processor has an independent set of Doppler filters which eliminate clutter from the weather output. Special processing techniques are used to edit multi-trip and anomalous propagation clutter echoes. The weather processing is implemented entirely by software, as is the MTD-IV Doppler processing. The weather processor is expandable to allow incorporation of additional weather measurement capabilities such as windshear detection and storm motion tracking. All of these features combine to provide the controller a clear, clutter-free display of all the needed information all the time. This contributes to increased passenger safety by eliminating distractions and reducing fatigue.

The ASR-12 uses an open-system architecture with Higher Order Language (HOE) software. This combination provides for a smooth supportability path for future COTS evolution while promoting ease of upgradability and interface changes.

The ultra-reliable ASR-12 design incorporates a Remote Monitoring and Control System (RMCS) and will reduce by as much as one-third the ASR-12 life-cycle costs when compared to earlier airport surveillance radars. The RMCS, combined with the high reliability of the radar system itself, eliminates the need for on-site maintenance personnel and minimizes the overall maintenance actions needed.

The RMCS is a built-in, computer-aided "expert maintenance technician" that continuously monitors radar status, performance parameters, engine generator power, and site security. If a fault should occur, built-in-test (BIT) equipment detects the problem in real time and isolates it upon request. This capability can be controlled from a remote central maintenance or operations facility. RMCS uses a Windows™ driven graphical user interface that allows the maintainer to quickly locate faults and determine the repair needed. The use of pull-down menus with no more than one level of depth provides the user with readily understandable and accessible information and commands.

The ASR-12 is compatible with existing Secondary Surveillance Radar (SSE) equipment, including "open array" or "large vertical aperture" antennas as well as the Northrop Grumman MSSR or Mode S system. In addition, the rotary joint has three L-band SSR channels, making it compatible with the three channels of any SSR monopulse or Mode S system.

Operational Characteristics. The system was designed to ensure that the air traffic controller sees all of the information he or she needs all the time, with minimal distraction, maximum reliability, and full control of the system. The design goal was to ensure that the controllers can see ALL aircraft no matter what the weather or clutter conditions, and in spite of close spacing. The display was set up to provide the fewest false returns from clutter, vehicular traffic, and weather.

Controllers see weather and aircraft simultaneously. Weather conditions detected by the ASR-12 are measured in six levels of intensity conforming to ICAO and US Weather Bureau standards and are processed using a weather channel processor separate from the aircraft channel. The six-level weather mapping is implemented in redundant receivers and processors, making this critical information highly available.

The system is based on the ASR-9 operational architecture and made as user-friendly as possible. The system was designed to interface with the Northrop Grumman Airspace Management System featuring ergonomically designed, modular workstations with state-of-the-art 2X by 2X raster scan color displays.

The ASR-12's controls incorporate the same user-friendly, graphical interface that is used by the maintainer. Implemented in a PC, the control screen is easily modified to incorporate the MSSR and site facility controls that may be peculiar to a given radar site.

Although the ASR-12 is intended to be a terminal radar, using longer range operation on the MSSR makes it possible for controllers to use the same equipment in a limited en route role.

Variants/Upgrades

No variants have been identified at this time. Site-specific adaptations can be made in data output interfaces and Secondary Surveillance Radar selection.

Program Review

Background. The ASR-9 has been Northrop Grumman's premier terminal radar since 1989. Featuring the latest in state-of-the-art receiving and processing components and a klystron transmitter, these radars have been installed at over 150 airports around the world, 134 at key FAA terminals. But radar is not a static field. What was state-of-the-art when that radar was built may be dated now, or could be combined with new technological developments to improve the overall operation of the system.

In this case, engineers combined features of the ASR-9 with a solid-state transmitter as well as upgraded data interfaces and processing components to create a new radar. It was designed with the architectural flexibility to adapt to ATC requirements around the world.

In late 1996, the FAA and DoD selected the Raytheon Systems Company ASR-11 (DASR) solid-state radar to replace older ASR-7 and ASR-8 radars at civilian and military airfields. With the ASR-9s being relatively new systems, performing well and under contract for a major series of weather and target data upgrades, the domestic market shut down for the ASR-12. Marketing attention turned to the international ATC arena.

In June 1997, Egypt selected Northrop Grumman for a major 10-year upgrade of its air traffic control system. The award had a potential value of US$28 million. The effort would upgrade approach and terminal systems at the three Egyptian airports that handled heavy tourist traffic: Luxor, Hurghada, and Sharm El Sheikh. The installations would include the ASR-12, MSSR equipment, display and processing equipment, and communications. Plans were to have the equipment delivered in early 1998 and operational by the end of 1998. The contract included civil works, training, and spare parts support.

In another July 1997 action, the Saudi Arabian Ministry of Defense and Aviation awarded a US$60.7 million contract for a turnkey ATC system at the Prince Sultan Air Base complex.

In September 1997, Northrop Grumman received a contract from Mexico's civil aviation authority, or Seneam, for the first phase of a multiyear, countrywide air traffic control modernization program. Northrop would provide the ASR-12, co-mounted with a long-range MSSR for approach and terminal operations at the Guadalajara International Airport. A stand-alone MSSR would be located at Cerro Gordo near Mexico City to provide improved radar coverage for Mexico City's international airport.

Radar data from the two radar systems will be transmitted to the Monterrey en route control center to increase en route radar coverage throughout Mexico. The first phase of the program was scheduled for completion in August 1998. Follow-on phases of the modernization program include options for the procurement of four additional stand-alone MSSRs and two additional solid-state primary surveillance radars with co-mounted MSSRs.

Also in September, the company completed factory acceptance testing of the ASR-12 for Peru's Ministry of Transport and Communications. The system was shipped to Peru and installed and integrated at Lima's Jorge Chavez International Airport in 1997. The turnkey system included an MSSR, an en route and approach automation and display system with both radar and flight plan processing, and a stand-alone simulation system for controller training. Northrop Grumman would also provide ground-to-air communications equipment from its British subsidiary, Park Air Electronics. The multimillion-dollar turnkey ATC system was to be installed during a 12-month effort.

In October 1997, El Salvador's Comision Ejecutiva Portuaria Autonoma (Independent Port Executive Commission) selected Northrop Grumman for its countrywide ATC modernization program. The turnkey ATC system was to be installed during the following 12 months at El Salvador's international airport. The system includes an ASR-12 and an MSSR, an en-route and approach automation and display system with both radar and flight plan processing, and ground-to-air communications equipment. Training and spare parts support were included.

In November 1998, Egypt selected Northrop Grumman for the second phase of its ATC infrastructure upgrade, a project valued at US$40 million. The effort involved upgrading the approach and terminal area control systems at Aswan, Alexandria, Al Arish, and Taba. Hardware deliveries were planned to begin in 1999, with all four systems to be operational before the end of 2001. The sites will receive ASR-12 radars and MSSRs, along with new display, processing, and communications equipment. Civil works, training, and spare parts support are included in the contract.

Mexico commissioned its two radars in January 1999 while El Salvador commissioned its ATC system in February.

In September 1999, Argentina selected Northrop Grumman to develop and implement a modernized Air Traffic Control and Manage system. The Argentine National Radarization Program (ANRP) was valued at over US$185 million and was scheduled for completion in 2003. ANRP members would evaluate the current Argentine system, replacing outmoded systems with newer equipment, including the ASR-12. Siemens will manage the telecommunications network and Alenia Marconi Systems will provide RAT 31DL surveillance radars. The upgrade is being accomplished in the wake of a series of South American commercial jet disasters.

AF Test Problems Reported. In May 2000, there were reports that a confidential Air Force test report issued in February had indicated serious flaws with Raytheon's Digital Airport Surveillance Radar that could cause significant flight-safety problems unless repaired properly. The contractor downplayed the assessment, saying that repairs were being evaluated.

The report was reportedly obtained by Raytheon's DASR competitor Northrop Grumman through the Freedom of Information Act and released to the media. The report claimed that poor test results raised questions about the radar. Raytheon representatives as well as Federal Aviation Administration officials downplayed the report, noting that the problems identified were being corrected and tested and will probably cause no production or implementation delays. The company contends distribution of the report is an attempt by Northrop Grumman (which lost the competitive contract) to undermine Raytheon's award.

An Air Force unit, separate from the one that conducted the initial testing, was reportedly verifying the effectiveness of the fixes to the problems identified by the report. The cited report claimed that the interface to current air-traffic control automation systems did not meet specifications, false weather information was being generated and displayed by the system, and anomalous propagation caused clutter breakthrough in the weather channel. Primary surveillance radar probability of detection was degraded in close proximity to the ASR-11.

Raytheon moved quickly to counter the potential impact of the leaked report. In May, company officials said, in a statement provided to Forecast International/DMS, that the information in the report was "OLD, OLD data from a DRAFT report that was never finalized." The company said it had solved all the problems found by the Air Force and detailed in the October 1999 draft obtained by Northrop. The Air Force was apparently satisfied enough with the radar to award $26 million for the initial production contract. Officials verified at the time of writing that the program was proceeding as expected with no problems or surprises, and that the Raytheon statement reflected the reality of the situation.

The FAA was conducting its own testing and evaluation, and plans to use its own data to assess the reliability and effectiveness of the ASR-11 system. The Air Force has different needs and testing requirements from those of the FAA. The FAA decided that it would purchase the rest of the needed radar systems instead of switching to the ASR-12.

Funding

There is no current US funding for the ASR-12. International purchasers are acquiring the systems from their various ATC and transportation infrastructure budgets.

Recent Contracts

No recent US contracts recorded. For international awards, see text.

Timetable

Month	Year	Major Development
Jun	1997	Egypt and Saudi Arabia ATC upgrade contracts
Sep	1997	Mexico and Peru ATC upgrade contracts
Oct	1997	El Salvador ATC upgrade contract
End	1997	Peru and El Salvador installations to be completed
Aug	1998	Phase 1 of Mexican upgrade to be completed
End	1998	Egyptian Phase I system to be operational
Nov	1998	Egyptian Phase II upgrade contract awarded
Jan	1999	Mexico commissions new ATC system
Feb	1999	El Salvador commissions new ATC system
Sep	1999	Argentina selects ASR-12 for ATC modernization
	2001	Egypt Phase II to be completed
	2003	Completion of Argentinian ATC upgrade

Worldwide Distribution

To date, the ASR-12 has been procured by **Egypt**, **Saudi Arabia**, **Mexico**, **Peru**, and **El Salvador**.

Forecast Rationale

The ASR-9 terminal radar was a major improvement over older analog-based systems. The FAA acquired it for its more heavily traveled airports because it was better suited to the increasingly digitized ATC information environment; it also capitalized on advances in components and computers and became something of a standard.

The ASR-12 built on that legacy by adding a solid-state transmitter to an enhanced ASR-9 architecture. Designers kept and enhanced the overall processing and all-important weather channels and capitalized on the strong allure of solid-state rather than power tube radar transmitters. This is more of a psychological attraction than engineering decision.

High -power transmitter tubes, especially klystrons, can sometimes be smaller, cheaper, and lighter than an equivalent solid-state system. As frequencies increase, so do the design problems in creating an effective high-power solid-state transmitter. The reliability issue can be misleading. High-power tubes can be very reliable, as shown by the industry stories about tube manufacturers who went broke after supplying tubes for long-range radars hoping to provide replacement tubes on long-term basis, but the failure rate was so low, the hoped-for replacement need never developed. Based on more years in the field than this writer cares to admit, many of the tube transmitter failures were the result of mechanical problems in the cooling system.

As frequencies increase, solid-state power output and efficiency can decrease, and although the fail-soft contention reportedly favors solid state, the reliability mathematics of multiple devices increases the likelihood of failure. Solid state is the secret of success for active array antennas, but does not always surpass high-power tubes in radar applications. Solid-state transmitters usually require adaptive waveform changes which need to be compensated for elsewhere in the radar, typically in the processing chain.

The ATC market is beginning to sort itself out into distinct areas. Most governments realize they need to upgrade their air traffic control systems. A key is the ability of a company to provide systems to meet all of the needs in a single program.

Once a manufacturer begins to penetrate the market in a particular part of the world, the tendency is for most users to go with that system. This gives the advantage of interoperability and can result in some economies of scale. Success in one country can encourage a neighbor to buy the same system. In this way, South America and possibly the Middle East may become lucrative markets for the ASR-12 and its associated systems. The FAA is not likely to acquire this system because of its

ASR-11(DASR) contract to replace older ASR-7 and ASR-8 systems. The ASR-9 is too new to consider replacing.

The reports of AF test problems with the ASR-11/ GPN-30(V) apparently were a non-issue. Although some industry officials claimed that the FAA and the Air Force could easily switch to the ASR-12 for the rest of the radars for FAA and DoD installation, or at least a portion of the total remaining order, changing to another contractor would cause the FAA and the Air Force to lose the money spent during the initial phases of development. This could be costly, even if the new system could be purchased at lower cost. It is not likely that a new price could make up for the losses. Although the FAA and Air Force were buying together to reduce cost, there was a contract option not to purchase the rest of the systems from Raytheon. But exercising the option would be unusual considering the way the acquisition process normally works. Such a change is usually reserved for only the most serious of situations, not for what is not all that unusual for large, high-cost, new technology products such as the ASR-11/ GPN-30(V). The government normally buys a small number of units, tests them, and then buys the rest in batches from the same vendor. Problems are not unusual in the beginning, and the FAA noted that the Air Force had already decided to go into production with the system.

The market potential is large. Peru has 61 airports, eight of them major and many needing new radars. Company officials estimate the South and Central American market at up to 100 systems. But money is a determining factor. Many governments want to upgrade their air traffic control systems, but the need to procure a complete system and not just the radars increases overall cost and decreases affordability.

The 10-year forecast is conservative and based on sales coming intermittently in the beginning until larger programs solidify. When a country finds the money, though, the government may quickly contract for a few systems at a time. These changes will become part of the forecast as confidence develops in their probability. The forecast allows for the impact of a lack of available funds on the part of many of the potential buyers.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR PRODUCTION

			High Confidence Level			Good Confidence Level			Speculative			
Designation	**Application**	**Thru 99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**Total 00-09**
ASR-12	AIR TRAFFIC CONTROL (VARIOUS)	11	1	3	4	4	2	6	5	4	4	4	37