National Oceanic and Atmospheric Administration
National Weather Service
NEXRAD O&M
04-02-02-001
Operational Analysis
FY2010

Executive Summary

This Operational Analysis (OA) focuses on the operational state of the Next Generation Weather Radar (NEXRAD) Operation and Maintenance (O&M) program as of September 30, 2010 and documents the program's performance during FY2010 relative to the following performance measures:

- Customer Results
- Strategic and Business Results
- Financial Performance
- Innovation to Meet Future Customer Needs

The NEXRAD O&M program directly supports NOAA's Strategic Goals to: 1- Serve Society's Needs for Weather and Water; and 2 - Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation.

The NEXRAD radar network is the National Weather Service's (NWS) prime observation system for acquiring information about tornados and severe thunderstorms (storms containing damaging winds, hail, turbulence, and lightning). It also provides information on heavy precipitation leading to timely, accurate river stage forecasts, flash flood, and heavy snow warnings. NEXRAD is also a key element in the forecasting of aviation related weather events. The NEXRAD network is composed of 159 operational radars (121 NWS, 12 FAA and 26 USAF) and 8 non-operational radars used for training and depot-level support. The radars are located throughout the United States and its territories and in four locations outside of the Continental United States, two in Korea, one in Okinawa and one in the Azores. NEXRAD is a tri-agency program of the NWS, Federal Aviation Administration (FAA), and United States Air Force (USAF).

The program is meeting established cost, schedule and performance parameters. This performance is due, in part, to a robust preventive maintenance program and an aggressive, focused, sustaining engineering program. During FY10:

- 28 towers were inspected and 4 towers were repaired and 18 radar domes were inspected and repaired to sustain the structural integrity of the radar's support structure
- Major progress on the installation of a radar in western Washington state was made. Three potential sites have been evaluated with "Finding of No Significant Impact" approved for top 3 sites. Final selection to be made in FY11; site acquisition activities were initiated by NOAA Real Property Division. Also, NEXRAD components obtained from the USAF will allow installation of an actual NEXRAD radar (versus the initially planned commercial radar) a full year earlier and at a significantly less costs for deployment and recurring O&M.

- Efforts to educate and inform the public and wind farm industry on the affects of wind turbines on NEXRAD performance continued with numerous meetings with Federal and state officials and energy industry representatives. 174 proposed wind farms were analyzed for potential impacts to WSR-88Ds for total of 755 since project began. Department of Homeland Security Contract for development of wind turbine/radar modeling tool is pending approval. Oklahoma University continues work in characterizing wind turbine clutter using laboratory scale wind turbine model and dual-pol scatterometer, and finished work on Wind Turbine Clutter automatic detection algorithm which is undergoing initial validation testing. The pressures for renewable energy and the common siting requirements for NEXRAD and wind farms are increasing the likelihood that radar interference issues will continue to arise and that the NWS may need to re-locate radars to less conflicting locations.
- Software release RPG Build 12.0 was deployed to provide improved quantitative precipitation estimates for water management decisions, and dual polarization algorithms and products were added to support that upgrade beginning in FY11. Numerous 'point' releases were deployed with operating system patches to address IT security vulnerabilities identified during quarterly scans.
- Completed deployment of new RPG routers to extend hardware supportability while addressing IT security issues and implementing mandated IPv6 communications standard. Deployed upgraded Klystron Air Flow Sensors and improved transmitter oil pump to improve transmitter reliability. Began deployment of upgraded motherboard/CPU for RDA RVP-8 Signal Processor to support additional demands of Dual Polarization processing.
- Communications upgrade to use digital communications permitted the removal 334 dial lines to avoid $250K annual recurring cost

1.0 Customer Results

The NWS provides weather, hydrologic and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas for the protection of life and property and the enhancement of the national economy. To that end, NEXRAD is the primary tool NWS forecasters use to sustain the current level of advance warnings of tornadoes, flash floods and winter storms as well as to produce aviation forecasts. It allows forecasters to see inside storms and detect wind-driven precipitation, providing a clear indication of wind rotation and developing storms in their early stages. A 2004 study (Simmons, K. M., and D. Sutter, 2004: "WSR-88D Radar, Tornado Warnings and Tornado Casualties" published in *Weather and Forecasting)* examined the impact of the NEXRAD radars on the quality of tornado warnings and occurrence of tornado casualties. Significant findings in analysis of tornadoes in the United States from 1986-1999 (before and after NEXRAD installation) show:

1 - Tornadoes warned for percentage increased from 35% to 60%
2 - The mean lead-time for warnings increased from 5.3 to 9.5 minutes
3 - The false alarm rate decreased from 79% to 76%
4 - Expected fatalities reduced 40% equating to ~79 lives saved per year
5 - Expected injuries reduced 45% equating to ~1052 injuries prevented per year

1.1 Customer Requirements and Costs

NEXRAD is a joint program in which DOC has partnered with the DOD and DOT to develop, procure, deploy, operate and maintain the joint NEXRAD network. To achieve efficiency of operation, the tri-agencies share a common set of spare parts and receive logistics and depot spares reconditioning support from the NWS' National Logistics Support Center and National Reconditioning Center, respectively. The tri-agencies jointly staff and fund the ROC which provides centralized, depot-level life cycle support for all tri-agency NEXRAD systems. The tri-agency NEXRAD Program Management Council (NPMC) provides oversight of the NEXRAD program budget, policy, resource commitments, and management guidance to ensure both common and agency unique requirements are addressed and resolved.

There are three primary agreements which define how the tri-agencies carry out this partnership:
a. MEMORANDUM OF AGREEMENT among the DOC, DOD, and DOT for Interagency Operation of the Weather Surveillance Radar-1988, Doppler (WSR-88D), dated March 2008.

b. MEMORANDUM OF AGREEMENT among the DOC, DOD, and DOT for Allocation of Program Costs of Next Generation Weather Radar (NEXRAD) Program, dated October 2009.

c. Agreement among the DOC, DOD, and DOT for Joint Interagency Integrated Support of the NEXRAD Program's Weather Surveillance Radar -1988, Doppler (WSR-88D) Integrated Logistics Support Plan, updated August 15, 2010.

The program is fully meeting the needs of a wide range of customers including:

- NOAA forecasters charged with warning responsibility
- Other Federal Agencies requiring radar data for operational decisions including the FAA, DOD, EPA, USGS, Corps of Engineers, DHS and FEMA
- State and local emergency managers and local officials charged with public preparedness and response decisions for extreme events, hazardous spills, homeland security issues, and wild fire
- Private sector environmental information providers
- Weather sensitive businesses including transportation, energy, and agriculture
- National, state, and local media
- Citizens who act on the information or are directed to respond by governmental and other local decision makers
- Waterway and reservoir managers
- Coastal fishing and marine operators
- Military and civil aviation operators and airport managers
- Highway, agriculture and forestry managers

1.2 Performance Measures

Performance of the NEXRAD O&M investment for FY10 is summarized in the table below. The measures align with Federal Enterprise Architecture Performance Reference Model. The performance goals are achieved by a comprehensive effort that: 1) provides for a robust preventive and corrective maintenance program, 2) ensures an adequate and efficient level of spares are maintained at the depot, and 3) supports an aggressive, proactive program to identify and replace components that are vulnerable to technology obsolescence or that are demonstrating

excessive failure rates. Components vulnerable to technology obsolescence are identified ahead of time and projects initiated in advance to define and develop replacements. Components having excessive failure rates are identified by continuously monitoring spares usage and projects initiated to increase component reliability. This strategy has resulted in NEXRAD consistently meeting or exceeding its performance goals.

In FY10, a change was made to the metric reported for the Process and Activities Measurement Area. The previous measurement indicator, "Effectiveness in getting radar products from the radar to the NWS Gateway", was not a meaningful challenge with current highly reliable telecommunications networks. This measurement indicator was replaced with one more appropriate for a system that has been deployed going on 20 years. The new measurement indicator, "Average number of repairable parts on backorder less than 1%", provides visibility into the health of NEXRAD's logistics supply and the effectiveness of the component obsolescence efforts.

Measurement Area	Measurement Indicator	FY2008 Baseline	Through September 30, 2009
Mission and Business Results	Network Availability	96% network availability	**99% network availability**
Customer Results	Data Access	Data available to customers in 24 hours 96% of the time	**Data available to customers in 24 hours 99% of the time**
Process and Activities	Product Delivery Effectiveness	Average number of repairable parts on backorder is less than 1%	**Average number of repairable parts on backorder is less than 0.4%**
Technology	Processor Load Level	Maintain an average processor load of 60% or less	**Average processor load of 14%**

As can be seen, this investment met or exceeded all of its performance measures. The technology refresh of the RPG processors completed in 2007 brought the average processor load back down to 10% from the 60% reported for 2006, and down to 5% in 2008 through software code optimization. This ensured the processor would not be saturated at peak operating loads and that it had the capacity to incorporate new science and increased processing demands when dual polarization modification was introduced; as anticipated, the integration of these capabilities in 2010 increased the load to 14% which leaves capacity to incorporate other new science in the next few years.

2.0 Strategic and Business Results

The NEXRAD O&M program is meeting its own goals and objectives as well as those of the agency. Program management and controls are in place to ensure the program continues to meet its goals and objectives and monitor how well the NEXRAD O&M program performs.

2.1 Strategic Goals and Results

This investment continues to meet established cost, schedule and performance goals and must continue in order for NOAA to meet its Strategic Goals of Serving Society's Needs for Weather and Water; and Supporting the Nation's Commerce with Information for Safe, Efficient, and

Environmentally Sound Transportation. The program also continues to meet the goals of our partners. The FAA and USAF rely on this information for safe, efficient civil and military flight operations. NEXRAD O&M activities are essential to ensuring the continuous flow of radar information to tri-agency users and to sustaining the operation of the Nation's $1.4B investment in the NEXRAD network. Program management controls are in place to monitor how well the program performs and ensure the program continues to meet its goals and objectives.

2.2 Business results

2.2.1 Program Management and Controls

The NEXRAD O&M program is managed in accordance with a tri-agency MOA for the operation, maintenance, and cost sharing of network O&M costs. Overall program management and decision making is shared by the three agencies. The SES-level NEXRAD Program Management Committee (PMC) is the decision making body and each agency has one voting member. By tri-agency agreement, the ROC, within the NWS' Office of Operational Systems (OOS) is lead organization responsible for operations and maintenance support of the NEXRAD network.

In addition to the tri-agency management structure, NEXRAD is also subject to, and complies with, the OMB requirements of Circular No. A-11, Planning, Budgeting, Acquisition, and Management of Capital Assets; and NOAA's Planning, Programming, Budgeting, and Execution System (PPBES). This ensures the NEXRAD O&M investment is exposed to a rigorous review and decision making process that assesses NEXRAD performance relative to its contributions to NOAA's strategic goals and that it continues to be a viable and necessary investment.

The day-to-day program and financial management of the NEXRAD O&M program is provided by program managers and analysts within OOS and every other NWS Line Office. OOS provides centralized program planning and oversight for decentralized program execution by the NWS Regions and other NWS Headquarters Offices. Critical functional tasks for engineering, configuration management, logistics management, maintenance planning, telecommunications, and training are centrally planned by OOS and other NWS Headquarters organizations with inputs by Regional field offices. Field maintenance is decentralized and conducted by the Weather Forecast Office electronic technicians.

OOS conducts quarterly reviews of program operational performance and financial performance. Key program milestones are included and tracked in the ROC, OOS and NWS Annual Operating Plans and the Exhibit 300 required Operational Analysis. Finally, the ROC conducts periodic reviews of project implementation and tri-agency funding status and ensures the tri-agency MOA terms and conditions are adhered to. The multi-level oversight of the NEXRAD O&M program has provided a sufficient level of management control and ensured continued ability of NEXRAD to meet its performance goals.

2.2.2 Monitoring Cost, Schedule and Performance

OOS program analysts use several systems to measure and track cost, schedule, and performance metrics. Furthermore, the tri-agency NPMC reviews program status semi-annually, and is consulted on major project Engineering Change Proposals, business case analyzes, and cost schedule and

performance projections. The content and schedule of software releases, including maintenance and integration of new operational capabilities and system efficiency implementations, are defined by the tri-agency Software Recommendation and Evaluation Committee and approved by the NPMC.

a. Cost: OOS has oversight responsibility for the entire NEXRAD O&M budget. OOS has managed this budget since the program was transferred from the NEXRAD Joint Program Office to the NWS in 1995. Budget development and execution have been accomplished using PC-based spreadsheets (currently Microsoft Excel) linked to the NOAA financial management systems. These spreadsheets have been used over the years to compare actual cost data with budget models and to make the required model adjustments for subsequent budget development cycles. For over ten years, OOS program analysts have worked with the Regions and other program participants to understand NEXRAD O&M costs and to establish a budget that ensures NEXRAD achieves it performance goals and that NOAA achieves its strategic goals at the lowest life-cycle cost and least risk. Cost and financial data are monitored on a monthly basis to identify discrepancies with the approved financial plan and to develop corrective actions. These data are also used to support program/budget reviews, answer questions from NOAA, DOC, OMB, and Congress.

b. Schedule: There are typically six to ten active hardware and software modification projects ongoing at any one time. These projects are planned and documented in the NEXRAD 8-Year Modification Plan that provides a long-range outlook of sustaining engineering modifications. The ROC plans and executes these projects for the tri-agencies using PC-based scheduling software (currently Microsoft Project). Once schedules are approved by the NPMC and NWS senior management, they become the baseline used to track project status. Key milestones are also included in the NWS Annual Operating Plan and in manager's annual performance plans.

c. Performance: System performance is routinely and systematically monitored by the ROC Hotline. The Hotline is staffed 24/7 and supports all radar sites in the network. Analysis of the trouble tickets generated by each call to the hotline is used to improve maintenance and meteorological training, maintenance and operations manuals and documentation. Radar maintenance and failure information and statistics are tracked in the NWS Engineering Management Reporting System. This information is used to calculate service availability, mean time between failures, and mean time to repair. Monthly monitoring of these parameters provides an overall assessment of the health of the system. In addition, these data, along with other information from the NWS Consolidated Logistics System, are used to evaluate the reliability of each radar component. Poor performers are identified and referred to the ROC sustaining engineering activity for development of modifications to improve component performance. Several key performance measures are tracked on a regular basis to determine the effectiveness of the program. Two key measures are: 1) Radar System Availability and, 2) Percent of Parts on Backorder. The Operational Analysis shows that as the system has matured it regularly exceeds the service availability the DOD, DOT, and DOC established for the system during the Planning Phase. The goal established for the system was 96% service availability. NOAA systems have consistently exceeded this availability requirement and have operated at over 99% availability.

2.3 Security

There are four IT systems funded by the NEXRAD O&M program – NOAA8104, the NEXRAD radar system; NOAA8212, the Terminal Doppler Weather Radar Supplemental Product Generator; NOAA8877, the ROC Local Area Network; and NOAA8900, the Office of Climate, Weather and Water Services. All four systems are accredited under requirements spelled out in

DOC IT Security Program Policy and Minimum Implementation Standards, including OMB and NIST Guidance and Policy. These systems also comply with all NOAA IT Security Manual requirements as well as NWS Directive 60-6 regarding IT Privacy Policy and 60-7 regarding IT Security Policy.

Name of Associated IT Systems	C&A Date	Date Security Control Testing Completed	Date Contingency Plan Tested
NOAA8104 - NEXRAD	12/17/2008	12/17/2009	12/17/2009
NOAA8212 - TDWR SPG	3/27/2008	3/31/2010	1/07/2010
NOAA8877 - ROC Local Area Network	4/29/2010	4/29/2010	4/29/2010
NOAA8900 - Office of Climate, Weather and Water Services	9/28/2009	9/29/2010	9/29/2010

3.0 Financial Performance

The purpose of the NEXRAD O&M funding is to pay recurring O&M costs for ROC operations, telecommunications, electric utilities, real estate leases, system maintenance and repair, maintenance training for electronic technicians, operator training for forecasters, data archive, preventive and depot level maintenance, repair and logistics support, and sustaining engineering efforts for NWS' entire fleet of 121 radars with the goal of maintaining the minimum performance measures shown above.

3.1 Joint Funding

In addition to the DOC funding discussed above, funding is provided by the FAA and DOD. For FY2010, DOC received $3.6M from FAA and $5.4M from USAF. This funding was used to fund the ROC operations including sustaining engineering, contract engineering and support services, hardware and software modifications, and depot level maintenance. Additional funding for operations and maintenance of FAA and DOD field radars is not shown here since that is agency-unique funding not sent to the DOC. Specific governing the tri-agency funding agreement is contained in the MOA for Allocation of Program Costs of Next Generation Weather Radar (NEXRAD) Program, dated October 2009.

FY2010 budget execution details are provided in the following table:

Budget Item	NWS	FAA	DOD
Logistics & Sustaining Engineering	$13.025M	$3.462M	$4.461M
Maintenance & Repair	$15.395M	N/A	N/A
Utilities	$8.214M	N/A	N/A
Training	$.262M	N/A	N/A
Hardware & Software Modifications	$4.416M	$0.103M	$0.977M
Telecommunications	$3.745M	N/A	N/A
Headquarters Support	$1.018M	N/A	N/A
Total	**$46.075M**	**$3.565M**	**$5.438M**

3.2 Financial Performance Review

A significant part of the NEXRAD O&M budget is expended by the government. Financial performance is monitored on a monthly basis by OOS program analysts and reviewed with the various NWS and NOAA organizations for reasonableness and cost efficiency. The NEXRAD O&M budget is reviewed quarterly by the OOS Director in conjunction with the overall OOS budget. Where applicable, monthly reports from contractors are required to ensure the Government has the information it needs to evaluate cost performance. A detailed review of work and priorities is undertaken if cost is significantly above base lined values. Also, any necessary corrective actions are also identified and implemented.

4.0 Innovation to Meet Future Customer Needs

The mission of the OOS is to provide cost effective operations and maintenance support for NWS systems in support of our customers. OOS routinely explores alternative maintenance concepts, best practices, contract strategies, technologies, etc., to provide improved services at lower costs. For example, a complete review was conducted of trends in maintenance and spares utilization as the NEXRAD systems age. This resulted in more effective/efficient maintenance and reconditioning processes for some parts, and the increase in spares stock levels for other parts that had not previously experienced much demand but demand is expected to increase. When new failure modes were discovered, several innovative reliability/availability modifications were implemented. For example, pedestal mounting smart bolts with anti-spin plates are being installed on all radars to reduce depot-level maintenance and fall protection/climbing requirements, and an inexpensive modification kit was introduced that dramatically reduced failures of expensive capacitors in the transmitters. In 2010, a new project was begun to acquire modified FAA radar components as an economical replacement for the DC Servo Amplifiers to resolve looming obsolescence and reliability issues. Likewise, OOS continues to support algorithm and signal processing enhancements with NCAR, NSSL, OHD and OU. One major accomplishment from this effort is the new super resolution version of mesocyclone detection algorithm for detecting tornadoes which was implemented in a software release during FY10; others include development and testing of new scanning strategies that can increase data refresh rate to better support fast-paced airport operations and lower scanning elevation angles in mountainous terrain to improve detection low-level weather. At the same time, these collaborations are preparing and fine-tuning Dual Polarization algorithms for the Radar Product Generator so they will be ready when the Dual Polarization modification is introduced to the Radar Data Acquisition system by the NEXRAD Product Improvement Program. The NWS has also collaborated with selected universities for the collection and distribution of Level II data (the highest resolution base radar data stream) in real time through the innovative use of Internet II. These data are collected for operational use by NWS, archived at NCDC for research, and distributed on a non-profit basis by selected university partners to commercial weather vendors who use the data to build proprietary, value-added products. Many of these products are seen daily on television broadcasts. Some vendors provide radar data services to airborne aircrews. In FY10, this Level II collection and distribution was made even more reliable and cost effective through a new communications architecture using OPSnet over the next 6-12 months.

Since the deployment of NEXRAD in the early 1990s, NEXRAD performance has remained stable in the face of unstable budgets and frequent technology changes within the approximately $46M annual O&M budget. And for the foreseeable future, no technology will be able to replace radar for this mission.