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PLANNED WSR-88D UPGRADES

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1. INTRODUCTION:

The purpose of this paper is to provide an update to a previous paper (Reed et al 2003) on planned Weather Surveillance Radar-1988 Doppler (WSR-88D) modifications. As explained in that paper, there are two separate entities within the National Weather Service (NWS) responsible for leading modifications for the Nation's Doppler weather radar network, the WSR-88D. The Office of Science and Technology (OST) is responsible for long-term programs while the Radar Operation Center (ROC) is responsible for shorter-term operations and maintenance modifications. This paper covers modifications to be implemented over the next eight years by the ROC.

2. OVERVIEW OF ROC PROCESS

A previous paper (Reed et al, 2003) outlined the process for implementing modifications. In summary that process is:

(1) ROC engineering staff investigate candidate hardware and/or software and perform development test and evaluation (DT&E) to determine what candidate solutions best meet project requirements.

(2) Engineers finalize an engineering change proposal and work with other ROC staff to perform field tests on the selected hardware and software. Normally, this means selecting a few "beta" test sites where the new hardware will be installed to test system compatibility in an actual operational environment.

(3) ROC Retrofit Management Staff oversee the deployment of the new hardware or software.

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3. UPDATE ON ROC WSR-88D PROJECTS

The following describes the eight major WSR-88D projects currently planned by the ROC.

Radar Signal Design Enhancements: The ROC has continued work to mitigate the effects of the "Doppler dilemma." The efforts are to optimize unambiguous range and velocity estimates as they relate to the selection of radar pulse repetition rate. For several years the ROC has been working with the National Center for Atmospheric Research (NCAR) and the National Severe Storms Laboratory (NSSL) to develop enhanced radar signal designs to minimize ambiguous radar data. Efforts were hampered by the limited capability of the legacy WSR-88D signal processor. New hardware was needed to implement improvements. The deployment of the new Open Radar Data Acquisition (ORDA) system (Cate et al, 2005) provides a more flexible and easily programmed signal processor and several improvements are now possible. The first major signal processor improvement will be included in Build 9, planned for deployment in the Spring of 2007. That enhancement will be the implementation of the Sachidananda Zrnich-2 (SZ-2) range velocity technique that uses phase encoded pulses to recover overlaid echoes (Saxion et al 2005). Upgrades beyond Build 9 are also under development.

Communications Upgrades: Since initial deployment, WSR-88D communications interfaces have continuously evolved. All communication interfaces were based on then state-of-the-art X.25 communication protocols and initial communication changes were based on that standard. As the TCP/IP suite of communication protocols became widely available, the WSR-88D was upgraded to take advantage of this more robust and reliable communication standard. Initially, internal WSR-88D Radar Product Generator (RPG) interfaces and the interface to the NWS Automated Weather Information Processing System (AWIPS) were converted to TCP/IP, followed by the interface to the Department of Defense (DoD), Open Principal User Processor (OPUP). The ongoing upgrade of the WSR-88D Radar Data Acquisition (RDA) system to open technology presents the next major communication upgrade opportunity. The legacy X.25 RDA to RPG interface will be upgraded to TCP/IP. This conversion is expected to considerably increase the reliability of RDA to RPG links. Currently, a minor noise burst causes lost data, restarting a radar volume coverage pattern with resultant time delays. Tests have shown the new RDA to RPG links will be more robust because of the error checking/correction and retransmission capabilities inherent in TCP/IP.

The ROC has been working to upgrade Federal Aviation Administration (FAA) interfaces. The ROC initially developed a Multicast scheme for use on FAA communication networks (Jing et al 2005). This scheme made efficient use of FAA communication networks, but was not accepted because of FAA network security concerns. As a substitute, the ROC will use a WSR-88D data format and Application Programming Interface (API) known as cm_tcp. This format will be implemented in Build 8, planned for deployment in spring 2006 as the standard means of transferring data over a new FAA data network.

Interfaces from AWIPS to DoD and FAA owned radars have suffered from insufficient capacity to meet an increasing demand for more data. In 2004 and 2005, these interfaces were upgraded to digital frame relay technology, resulting in more reliable and higher capacity communication links. These frame relay links present the possibility of implementing a central WSR-88D data monitoring capability. Once implemented, ROC staff can remotely monitor radar status and view remote maintenance data to assist local maintenance personnel troubleshoot difficult problems.

Microwave Line of Sight (MLOS) Replacement: Four NWS WSR-88D radars use government owned MLOS links to pass T1/wideband radar data from the RDA to an RPG. The frequency spectrum used on these links has been migrated to other uses, although the Government can continue to use the links so long as there is no change to link characteristics or hardware. The MLOS hardware is aging and future requirements may dictate RDA to RPG bandwidth increases on these links. A hardware change or bandwidth increase means purchase of a new, costly hardware suite operating on different frequencies. The ROC is investigating several communication alternatives, only one of which is new microwave hardware. The other alternatives are: the availability of commercial land line service (not as widely available at the time WSR-88D radars were first implemented), the use of satellite T1 service and the cooperative use of other federal and state owned and operated communication services. At the moment, it appears a different solution may apply to each of the four legacy microwave links in question.

RPG Distributed Processing: The ROC is performing planning and engineering to replace RPG computer hardware. The major focus of this project is replacement of the RPG Sun processors that are out of production and for which spare parts are difficult to procure. At the same time, considerable new or improved science has been implemented on the main RPG processor. New science has improved the ability of forecasters to predict severe weather, but has come at the price of consuming available reserve processor capacity. RPG software Build 8 (to be deployed in Spring 2006) is projected to fully consume available RPG processor capacity. The RPG processor upgrade is planned to coincide with RPG software Build 9, which cannot be implemented without additional processor capacity. Build 9 is expected to include: Machine Intelligent Gust Front Algorithm (MIGFA), transfer of environmental data from AWIPS to the RPG, and the previously mentioned SZ-2 implementation. (The SZ-2 implementation requires both RDA and RPG processor resources). Build 9 deployment is projected to begin in April 2007. The project scope now includes all three processors in the RPG, the main RPG processor, the Base Data Distribution System (BDDS) processor, and the Master System control Function (MSCF) processor. All new processors will be PC-based running the Red Hat LINUX Enterprise 4 operating system. This will bring the RPG in line with the LINUX-based ORDA processors now being deployed.

In a related project, the ROC has coordinated specifications with the NWS OST engineers currently designing the Terminal Doppler Weather Radar (TDWR) Data project (Istok et al, 2005). This project brings FAA TDWR data from 45 FAA TDWRs into NWS forecast offices and displays that data on AWIPS. The TDWR Data system makes considerable use of WSR-88D software and the goal of coordinating specifications is for TDWR Data and RPG processors to be interchangeable in the NWS supply system.

RPG Local Area Network (LAN) Switch: The LAN switch replacement is a WSR-88D hardware upgrade driven by the obsolescence of commercial hardware products. The RPG LAN switch is rapidly approaching obsolescence and engineering development is ongoing with actual replacement planned for 2006. At the same time, new capabilities are required on the RPG. The LAN switch upgrade presents the opportunity to refresh the LAN hardware, and also provide a switch with enough capacity to meet growing requirements. Implementation is planned to be performed by local maintenance staff via a modification note.

Composite Radome: In a previous paper, (Reed et al, 2003) it was reported DoD is testing the suitability of composite plastic materials for various radome applications, equipment shelters and towers. Composite radomes represent great potential for life cycle cost-avoidance and improved supportability since they theoretically can withstand severe weather events better than current WSR-88D radome materials. The ROC leveraged on DoD work to determine if composite radomes are viable for WSR-88D application. A major aspect of the WSR-88D radar is overall radar sensitivity achieved by a combination of an excellent receiver and minimum system losses. The current WSR-88D radome is specified to introduce no more than 0.4 db path loss. Independent testing determined readily available composite radome materials introduce too much loss to be used in a WSR-88D application, although they are suitable for intended DoD uses. Additional research, potentially at significant additional cost, is needed to find suitable composite materials for the WSR-88D radome. Initiating a research and development effort only for the WSR-88D radome is not cost effective. The ROC will continue to monitor DoD composite radome initiatives, but plans no further active participation at this time.

Composite Shelters: Along with investigating the use of composite radomes, the ROC has participated in a DoD initiative to use composite materials for radar equipment shelters. Some WSR-88D shelters, consisting of steel reinforced concrete, have shown deterioration in harsh environments. Composite materials require significantly less periodic maintenance and are not as susceptible as existing shelters to deterioration in harsh environments. Use of composite shelters to replace badly deteriorated shelters is expected to provide considerable life cycle cost savings. The ROC will have a composite shelter delivered at the end of 2005 for use in a test bed environment. If the delivered shelter performs as expected, the ROC will survey radar shelters at sites in harsh environments to determine those needing replacement on a time phased basis. Procurement is expected to begin in FY 10 and 11 with an estimated 20 WSR-88D shelters eventually being replaced.

Transmitter Upgrade: The ROC has performed considerable work on transmitter upgrades. As previously reported, work has centered in the WSR-88D trigger amplifier and modulator assemblies, using depot failure analysis data to pinpoint reliability problems. Advancements in technology allow the elimination of many problematic, high voltage components in the trigger amplifier and modulator assemblies. Where high voltage components can not be eliminated, they can be replaced by state-of-the-art components that are more reliable. Implementation of improvements has begun by breaking in changes as a part of normal depot repairs at the National Reconditioning Center. These modest cost changes are expected to improve reliability by a factor of three. Additional improvements are in the design phase and are expected to begin deployment in another year.

ROC engineers have been working with Federal Aviation Administration engineers since the WSR-88D transmitter is very similar to the FAA Airport Surveillance Radar (ASR)-9 transmitter. Both parties have exchanged technical information on failure modes and proposed transmitter modifications. In summary, the WSR-88D modification approach has been to use failure data to focus on small scale modifications to incrementally improve reliability. The ASR-9 transmitter modifications are on a larger scale. The FAA changes address both reliability and increased capability issues. The ongoing FAA focus is a major transmitter modification that will improve reliability and increase clutter rejection.

Data Acquisition Unit (DAU) Replacement: The DAU consists of both digital and analog boards that provide status and alarm data to the WSR-88D Data Acquisition system. The DAU continues to be a high failure item in the WSR-88D inventory and is especially susceptible to failure during lightning storms. The ROC is investigating means to increase DAU reliability. At the same time, the ROC is assessing future requirements that may require data transmission between the radar tower and the RDA control system. To meet the need for additional data and improve reliability, a fiber optic, Ethernet based technology provides a very reliable, but costly solution. ROC engineering is prototyping solutions and studying other alternatives to determine the most cost effective means of improving DAU reliability and meeting future requirements.

Replacement of RDA Computer Hardware: The ORDA is now in deployment, but it is not too late to plan for the eventual replacement of that hardware. Experience shows commercial computer equipment reaches end of life and requires replacement every five or six years. Additionally, advances in new technology will likely require that the ORDA backplane be replaced at the same time. Current planning calls for initial investigations on ORDA replacement to take place in FY09 with deployment in FY10 and FY11. The project scope currently includes replacement hardware for the PC processor, PC bus, software, storage devices, and input/output devices.

Security Enhancements: Since 9/11, security of government and private industry systems has received considerably more attention. Government systems must undergo quarterly security scans, and security vulnerabilities are constantly being discovered and exploited in both applications software and operating systems. In conjunction with software security, there are increasing requirements for more capable firewall hardware. In response to this trend, the ROC is budgeting for and executing periodic WSR-88D security upgrades.

Although it is difficult to predict the exact nature of some security upgrades, the need for periodic hardware and software security projects is a certainty. The first such project is projected to be the implementation of a firewall on the RPG with initial development starting in 2006.

4. SUMMARY

The ROC is responsible for planning and executing projects to sustain the life of the WSR-88D radar network. These projects are documented in an eight year modification plan in which the ROC details the modifications needed to keep the WSR-88D network operating. As ROC engineers consider projects for the plan, they must keep in mind future requirements to ensure we do not miss an opportunity to provide a new, previously unavailable capability while solving routine obsolescence issues. At a minimum, the ROC updates the plan each year, deleting or changing projects as more information on specific requirements becomes available. The plan can be very dynamic as shown by replacement plans for the Radio Frequency (RF) Generator. At one time, a new RF Generator was thought to be needed for future WSR-88D conversion to dual polarization and an RF Generator project was added to the modification plan. After initial dual polarization investigations, it was determined a replacement unit was not needed and the project was dropped. Later, a parts obsolescence concern arose and a new RF Generator replacement project was begun. Further investigation showed the parts obsolescence concern was unfounded and the RF Generator replacement was again dropped. Recently, the project was again reconsidered because of ORDA compatibility, but no new project was needed. In the meantime, ROC engineers are investigating and testing alternate RF Generator sources in case a high priority replacement need arises.

5. REFERENCE

Cate, G., Hall, R.2005: MCNA NEXRAD Product Improvement – Current Status of WSR-88D Open Radar Data Acquisition (ORDA) Program and plans for the Future. 21st International Conference on Interactive Information Processing Systems for Meteorology, Oceanography, and Hydrology, American Meteorological Society 9-13 January, San Diego, CA Paper 5.2.

Istok, M., Pickard, P., Okulski, R., Saffle, R., Bumgarner, B. 2005: NWS Use of FAA Radar Data – Progress and Plans. 21st International Conference on Interactive Information Processing Systems for Meteorology, Oceanography, and Hydrology, American Meteorological Society 9-13 January, San Diego, CA Paper 5.3.

Jing, Z, Ahlert, S. and Gookin, G 2005: MCNA - A Reliable Multicast Protocol for Radar Product Distribution. 21st International Conference on Interactive Information Processing Systems for Meteorology, Oceanography, and Hydrology, American Meteorological Society 9-13 January, San Diego, CA Paper 19.12.

Reed, J. R., Evancho, D. and Fehlen, R. 2003: Planned WSR-88D Improvements. Preprints 31st Conference on Radar Meteorology, 6-12 August, American Meteorological Society, Seattle, Washington Paper 12.B2

Saxion, D., R. Rhoton, G. McGehee, R. Ice 2005: Radar Operation Center (ROC) Production Software Status for RV Ambiguity Mitigation. 21st International Conference on Interactive Information Processing Systems for Meteorology, Oceanography, and Hydrology, American Meteorological Society 9-13 January, San Diego, CA Paper P1.7.