5.1 # NEXRAD OPEN SYSTEMS - PROGRESS AND PLANS

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1. INTRODUCTION

The NEXRAD Product Improvement (NPI) Program is a continuing effort to replace the WSR-88D Radar Data Acquisition (RDA), Radar Product Generation (RPG), and Principal User Position (PUP) subsystems with open systems components (ORDA, ORPG, OPUP). To meet the need for orderly WSR-88D system evolution, the NEXRAD tri-agencies established the NPI Program as a long term program to plan, manage, and execute major improvements to the WSR-88D system. The NPI Program Management is lead by the NWS Office of Science and Technology (OS&T), with individual NPI projects enlisting the participation and support of all of the NEXRAD tri-agencies. The NPI Program continues to enjoy wide participation throughout the sponsoring agencies in the NWS, the Air Force Weather Agency (AFWA), and the Federal Aviation Administration (FAA). Saffle et al [1] includes a thorough description of the Government's strategy and structure for each open systems project.

2. DEVELOPMENT STATUS

2.1 ***ORPG Status***

Significant strides have been accomplished over the past year in the development, test, and deployment of the ORPG. As this paper is being written, the ORPG software development has been completed [2] and is undergoing final field testing. Initial deployment of the ORPG was performed at selected field sites in mid-CY2001, with full scale production and deployment beginning in September 2001. Deployment at NWS sites will be performed first, followed by the FAA and AFWA sites. ORPG deployment should be completed in August 2002. Initial indications from NWS sites which have the ORPG are that the new systems far exceed the capability and reliability of the legacy RPG [3].

ORPG hardware staging, kit assembly, and packaging, is being performed by the National Reconditioning Center (NRC) in Kansas City, Missouri. Installation planning, management, and scheduling is being performed by the Radar Operations Center (ROC), with installation performed by a contractor. Installation procedures were developed and training is being conducted at the ROC and at the NRC. Operations and maintenance training plans for the ORPG were completed in 2000, with training of site personnel to occur before the sites ORPG is installed.

As deployment of the ORPG begins, design and development of the first set of capability enhancements is beginning [4]. Some of the ORPG development team members currently in place at the National Severe Storms Laboratory (NSSL) will work in collaboration with the NWS Headquarters and the ROC to develop these capability enhancements. Preliminary projections are that some of these enhancements will be deployed in 2002, so that later ORPG installations may occur with these enhancements, versus the initial deployment software.

One of the NWS goals of the ORPG development effort now underway is to integrate the ORPG and the AWIPS system, beginning with the architecture and following with functional integration. This integration will support increased operational capability; for example, it will support greater product dissemination to the AWIPS users over a LAN interface, and incorporation of AWIPS environmental data within ORPG algorithms. Further, the dissemination of base data to a variety of other users is a current capability which will be more robustly implemented due to capabilities of open systems. Plans to facilitate these efforts will continue in 2002.

2.2 ***OPUP Status***

The OPUP was added to the NPI Program in 1997 to address an AFWA requirement to replace the existing PUP with one compliant with open systems standards. The OPUP will satisfy all the requirements of the existing PUP, using open systems standards for the software design, running on multi-vendor COTS workstations. The user interface has been styled after the NWS AWIPS user workstation. The Air Force has plans to restructure its provision of weather information to Base Weather Stations. The OPUP will provide consolidated access, at regional weather centers, to multiple WSR-88Ds. The radar data will be evaluated in conjunction with other meteorological information by the regional center staffs. Consolidated weather information will then be made available to Base Weather Stations.

2.3 ***ORDA Status***

The ORDA project management and execution will utilize the experience gained from the ORPG development, test, procurement, and full scale production efforts. The ORDA proof-of-concept development efforts were completed in 2000, with full scale design and

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development beginning in CY2001. As this paper is being written, the ORDA Team is defining the approach to accomplish the complete design, development, test, and deployment of the ORDA.

The ORDA design began in early 1996 and consists of the replacement of the existing RDA Status and Control (RDASC) components and the Signal Processing components. Significant progress has been made in the design and development of the ORDA and Signal Processing equipment, with a functional proof-of-concept completed in April 2000 [5]. This effort is expected to accomplish a significant reduction in Line Replaceable Unit (LRU) count and rack space, going from the current 41 LRUs to perhaps less than 10 LRUs. The ORDA will include the immediate capacity to employ future signal processing techniques capable of supporting Dual Polarization, though components needed specifically for Dual Polarization will be procured under the Dual Polarization project. Replacement of the Signal Processing and other elements of the RDA is a significant engineering effort [6], as well as a software development effort. The Hardwired Signal Processor and Programmable Signal Processor are being replaced using current Digital Signal Processors. Other COTS boards, and one custom board, will be used to interface to the existing receiver, RF generator, antenna, and data acquisition unit. Full scale development of the ORDA, beginning with a complete ORDA design, began in CY2001, and is scheduled to be completed in 2004, with field retrofit of all systems beginning that year and being completed in 2005. Additional information on the ORDA project at NSSL may be found at http://www.nssl.noaa.gov/orda.

2.4 *Dual Polarization Status*

Dual Polarization takes advantage of ways in which the transmitted wave's polarization affects the backscattering of hydrometeors. With a polarization capable radar, information on the relative size and phase shift for the horizontal and vertical dimensions of a target can be derived. Polarimetry in the WSR-88D will:

- Improve quantitative precipitation estimation,
- Identify hail and possibly gauge hail size,
- Identify precipitation type in winter storms,
- Identify biological scatterers and wind measurement effects,
- Identify the presence of chaff and its effects on precipitation measurements,
- Identify areas of anomalous propagation (AP) and clutter, and
- Provide improved initial conditions to numerical models.

Current research by NOAA scientists at the Office of Atmospheric Research, NSSL [7] has resulted in:

- Installation of microwave hardware on the WSR-88D antenna,
- Demonstrated ability to retain single polarization signal quality with antenna modifications,
- Continuing integration of microwave hardware for second receiver required for dual polarization,
- Development of an algorithm for classification and then quantification of precipitation using research polarimetric radar data,
- Plans to hold a Joint Polarization Experiment (JPOLE) in CY2002 .

The objectives of the planned JPOLE [8] are to:

- Validate NSSL Dual Polarization engineering design:
    - Simultaneous horizontal & vertical transmission,
    - Non-degradation of volume scanning update times,
    - No operationally significant decrease in sensitivity.
- Validate operational value by quantifying improvements in:
    - Heavy rainfall estimation accuracy,
    - Direct determination of hail,
    - Direct determination of rain versus snow,
    - Direct determination of bird and insect targets,
    - Removal of anomalous propagation and clutter data.

3. WEATHER SYSTEMS SYNTHESIS

3.1 *Methods to Improve Operational Effectiveness*

The WSR-88D is providing outstanding support to the NWS, DoD and FAA weather forecasting and warning missions. Much of this success, however, has involved extensive effort on the part of forecasters to subjectively evaluate the radar information, including the use of that information in conjunction with other environmental data. While the WSR-88D generates many products for the forecaster, these products generally represent the state of the science of weather radar processing as of the late 1980 - with an emphasis on stand-alone radar algorithms. The deployment of ORPG, ORDA and OPUP units will enable the implementation of recent advances in radar-only algorithms, but the maximum operational benefit of the WSR-88D will come from utilizing its weather radar data in combination with other hydrometeorological information.

The NWS has recognized the importance of an integrated approach to WFO/RFC operations and applications development. The SCAN (System for Convection Analysis and Nowcasting) project is bringing together developers from NWS, NSSL, National Center for Atmospheric Research and Lincoln Laboratory to work collaboratively to combine features from their individual research into a common AWIPS application to support the warning decision process. The SCAN application is designed to foster incorporation of additional elements from other development activities. A key point of SCAN is that it emphasizes synergistic processing and display, using all of the environmental information relevant to a given WFO's area of responsibility. The SCAN approach can serve as a template for similar integrated applications to address other forecast and warning missions.

Supporting efforts such as SCAN, the Agencies are developing software tools to enable scattered development groups to not only collaborate more effectively, but also to enhance the compatibility of their applications with operational systems such as the WSR-88D and AWIPS. This project, termed CODE (Common Operations and Development Environment), is designed to provide Application Programming Interfaces, underlying software modules, program layout and documentation support, and other tools that are compliant with the operational system [9, 10, 11]. One expected benefit of CODE is that the integration of new science into operational systems will be enhanced, leading to a shorter time period between approval of an algorithm and its operational use. One of the goals of the open systems effort is to shorten the development and test periods for software builds, especially for scientific applications. Where current software increments take 18 to 24 months, it is planned for open system application module upgrades to occur more frequently than every 12 months. The first release of CODE, capable of supporting application development for the deployed ORPG, has been distributed to Beta users at several government laboratories.

3.2 ***Use of FAA Radar Data***

The FAA operates four radar systems that include weather channels with modern capabilities for processing and distributing reflectivity and velocity data. These systems are the Terminal Doppler Weather Radar (TDWR), the Airport Surveillance Radar(ASR) 9 and 11, and the Air Route Surveillance Radar (ARSR) 4. Although these radars have different engineering characteristics (compared to each other as well as to the WSR-88D), the three agencies can potentially use FAA weather radar information to complement WSR-88D coverage for [12]: WSR-88D cone of silence, low level phenomena at long range, different perspective angles on storms to better sample radial velocity maxima and morphology, potential mitigation of obscuration of storms due to range folded echoes, data in areas of incomplete WSR-88D coverage, backup data during WSR-88D outages, multiple Doppler analysis to provide rectilinear wind fields, improved "best information" mosaics of radar data over WFO County Warning Area, improved quality control of WSR-88D data for problems such as anomalous propagation and beam blockage.

The engineering factors involved in using the FAA weather radar data are not complex. They consist mainly of establishing a communication link to a given FAA site, processing the received data into weather products useful to forecasters (similar to the WSR-88D products), and distributing the products to user agency display systems. The larger issues are to validate the utility of the data to operations, to develop sound estimates of budget requirements, and to plan and execute the development and implementation project. The NWS's general approach to these issues is to:

- provide products derived from FAA weather radar data to selected WFOs for real-time, operational evaluation of their utility,
- develop prototype NWS applications and products within the frameworks of operational systems, e.g., ORPG and AWIPS, and
- define and promote a project under NEXRAD Product Improvement for development and implementation of capabilities to utilize FAA weather radar data in conjunction with WSR-88D data.

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