

12B.6 NEXRAD Product Improvement - Expanding Science Horizons

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1. INTRODUCTION

The Departments of Commerce (National Weather Service), Defense (Air Force Weather Agency), and Transportation (Federal Aviation Administration) initiated the Next Generation Weather Radar (NEXRAD) program to upgrade the weather radar mission support capabilities required by the three agencies. Under NEXRAD, 158 radars, termed the Weather Surveillance Radar – 1988 Doppler (WSR-88D), have been installed at operational locations in the United States and selected overseas sites. The NEXRAD tri-agencies have since established the NEXRAD Product Improvement (NPI) Program as a long-term activity to steadily improve WSR-88D science and technology [1]. The NPI program has ongoing efforts to replace the Radar Data Acquisition and Radar Product Generation subsystems with open systems compliant software and hardware (ORDA, ORPG). These system upgrades will enable the operational implementation of new scientific applications and signal processing techniques to improve the radar data quality. Further, the NPI program is currently working on the potential implementation of dual polarization, and on integration of weather data from several FAA radar systems. An additional NPI effort is focused on developing tools to improve the process of developing, testing, implementing and maintaining the software involved with functional enhancements to the WSR-88D. This paper describes the status of NPI ongoing projects and explores the expanding opportunities for development and implementation of new radar science and techniques intended for the WSR-88D.

2. DEVELOPMENT STATUS

2.1 ORPG Status

The ORPG deployment has been completed. Initial indications from NWS sites are that the new systems far exceed the capability and reliability of the legacy RPG [2]. As deployment of the ORPG began, design and development of the first set of capability enhancements were already underway [3]. The first of these enhancements were released even before the initial ORPG deployment was finished. These enhancements

included data array products that provide the highest resolution data for both reflectivity (255 data levels, 1 km range resolution) and velocity (255 data levels, 1/4 km range resolution). These products had immediate impact on NWS tornado warning operations for storms in Iowa and Missouri.

The next set of enhancements will be released in October 2002, and further sets are scheduled for release at 6-month intervals. The contents of the future releases are not finalized, but many specific enhancements have target release dates over the next several years (Figure 1).

2.2 ORDA Status

The ORDA project [11] consists of the procurement of commercial components to replace the existing RDA Status and Control (RDASC) components, the Signal Processing components, and the analog receiver. The ORDA will include a modern digital signal processor (DSP) and a digital receiver. The ORDA is scheduled to be deployed in 2004-2005.

2.3 Dual Polarization Status

The National Severe Storms Laboratory (NSSL) [4] is developing a prototype dual polarization capability for the NSSL WSR-88D (KOUN). Polarimetry data are being collected from KOUN, and a validation of engineering design, data accuracy and potential operational issues is underway. In November 2003, the NEXRAD agencies will decide whether to proceed with full scale development and implementation. If development and funding proceed satisfactorily, dual polarization could be implemented on NEXRAD in the 2007-2008 period.

2.4 FAA Radar Data

The FAA operates four radar systems that include channels with capabilities for processing and distributing weather 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. The NWS is planning to begin incorporating FAA data from selected sites in late 2003. 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 [8]:

- Complementary coverage for closer or unobstructed views of particular storms,
- Coverage in case of NEXRAD outages,
- Multiple radar wind field calculations,

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WSR-88D Software Releases: Contents and Schedules Targets (April 2003, Rev 10, Post SREC of Apr 8-9)																																	
Firm Dates		Development R&D, POC				Specification Baseline Prototyping				Implementation Baseline SW Coding				Field Test New Science				Integration Prepare Baseline				Deployment ROC											
Target Dates		CY 2002				CY 2003				CY 2004				CY 2005				CY 2006				CY 2007				CY 2008							
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
DEPLOYED	ORPG	ROC B2 NCEP Super OB, Rainfall Bias Table, REC - Clutter Likelihood, High Resolution VIL, BZIP2 Product Compression Capability																															
DEPLOYED	ORPG	NWS/FAA ROC B3 User Selectable Layer Reflectivity, Digital Storm Total Precipitation, Data Quality Assurance, Histogram from VWP, Enhanced High Resolution VIL, Solans 8, Distributed Processing, Improved Error Reporting, Common Compiler, Blockage Algorithm																															
DEPLOYED	AWPS	NWS AWPS OB1 AWPS Hi Res V display option for SRM																															
Mesocyclone Rapid Update	ORPG	NWS ROC B4 Mesocyclone Algorithm output after each elevation angle																															
Enhanced Echo Tops		FAA ROC B4																															
HR VIL Improvements		ROC B4																															
Infrastructure Enhancements		PC Port, Improve RP Data Management, Product Removal, Error Reporting, Library SVC-compression for Intermediate Late Products, Comm Manager Improvement, Merge Field Adaptation Edits																															
PPS Enhancement		NWS ROC Modify Rate Accumulation to handle faster VCPs, Residuals Correction																															
PPS New VCP REC Phase1		NWS-ROC Conduct field testing at selected sites before national baselining																															
FAA Radars: TDWR, ARSR-4	AWPS	NWS AWPS OB3 Supplemental Radar Products Generator (SPG) will feed AWPS directly for FAA products																															
VCP 12	ORPG	NWS ROC B5 Better vertical resolution at longer ranges; 4.1 minutes																															
PPS New VCP REC Phase2		Includes EPRE integration; applies REC output to rainfall products																															
Tomado Rapid Update		Tomado Detection Algorithm output after each elevation angle																															
Meso Detect Alg Phase 1		Radar data only, retain current Meso & MRU																															
MPDA		Reduce range folding - primarily for stratiform events																															
Infrastructure Enhancements		ORPG Changes for ORDA, BDDS Archive II Compression & Data Manager for Central Collection, Break Out MSCF into CPC1, Digital Comms, AWPS One Time Requests via WAN Phase I																															
FAA Radar: ASR-11	AWPS	NWS NWS NWS AWPS OB4 AWPS SPG (Supplemental Product Generator) architecture; BZIP2 Decoding																															
ORDA Initial Capability	ORDA	Vendor RSIS ROC B6 First sites with Build 6, later sites with latest Build																															
Meso Detect Alg Phase 2	ORPG	NWS ROC B6 Add near storm environment, rapid update, alerting, data array product																															
Snow Accumulation Algorithm		ROC B6																															
MGFA Phase I		Gust front detections at 2 sensitivity levels																															
Infrastructure Enhancements		Support for ORDA, Zib, RPG/C algorithm lib, Adaptation data improvements, Archive III Status Product, AWPS WAN OTR Phase II?																															
1/4 Km Reflectivity Data	ORDA/ORPG	NSSL NWS ROC-NWS ROC B7 Forecast positions of gust fronts																															
Range Oversampling Phase I		Remove onsite Level II, Generic product format, Remove legacy meso alg																															
Enhanced SCIT		ROC B7																															
DQA Improvements		FAA ROC B7																															
MGFA Phase II		Forecast positions of gust fronts																															
Infrastructure Enhancements	ORDA/ORPG	ROC ROC ROC B8 S-Z Phase Coding for lowest elevation angles																															
R/V Ambiguity Mitigation	ORDA	NSSL-NCAR-NSSL NWS ROC-NWS ROC B8 Slaggered PRT for higher elevation angles																															
R/V Ambiguity Mitigation		Interactive selection of points for processing																															
Full Spectrum Processing Phase I	ORDA/ORPG	NSSL-ROC NWS ROC-NWS ROC B8																															
1/2 Degree Radial Sampling		ROC B8																															
Index Base Data Angles		ROC B8																															
Multiple Base Data Streams		ROC ROC B8																															
Infrastructure Enhancements		ROC ROC B8																															
Doppler Processing 2nd Trip	ORDA/ORPG	NSSL-NCAR-ROC NWS ROC-NWS ROC B8/10 Extend velocity info by 50 km																															
Full Spectrum Processing Phase II		Automatic tomado pattern recognition																															
Range Oversampling Phase II	ORDA	ROC B8/10 Add Whitening																															
Infrastructure Enhancements	ORDA/ORPG	ROC B8/10																															
Under Final Development. Build Not Yet Targeted.																																	
PPS Range Correction Alg	ORPG	NWS NWS NWS NWS Mitigate bright band and long range impacts, includes Convective Stratiform Separation algorithm																															

Figure 1. Planning for NEXRAD Functionality Enhancements.

- AP and clutter mitigation.

3. SCIENTIFIC OPPORTUNITIES

3.1 Early ORPG Enhancements

The initial ORPG enhancements included full resolution reflectivity and velocity data array products, and a LAN-to-LAN connection to the NWS Advanced Weather Interactive Processing System (AWIPS) for high speed transmission of products to forecasters. Future enhancements will include:

- Clutter and anomalous propagation identification,
- High resolution Vertically Integrated Liquid water,
- User defined layers of maximum Composite Reflectivity,
- New Volume Coverage Patterns,
- Enhanced Mesocyclone Detection,
- Snow Accumulation,

- Multi-scale echo tracker and boundary detection.

3.2 Early ORDA Enhancements

When deployed, the DSP capability of the ORDA will immediately support the implementation of a number of enhancements that will provide better data for scientific algorithms. Some enhancements [10] have already been specified, and will be developed for early, follow on releases after initial ORDA deployment. These early enhancements will include:

- Range - Velocity ambiguity mitigation,
- Radial sampling at 1/2 degree intervals,
- Reflectivity data at 1/4 km range resolution,
- Algorithm-specific application of SNR (Signal to Noise Ratio) thresholds,
- Doppler processing to end of 2nd trip.

The expanded base data will be available in the ORPG to be utilized to improve current algorithms, and to support improved science.

3.3 Dual Polarization Benefits

Dual Polarization takes advantage of ways in which the transmitted wave's polarization affects the backscattering of hydrometeors. With a radar with polarization diversity, information related to both the horizontal and vertical dimensions of the observed scatterers 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.

3.4 FAA Data Use

FAA radar data will initially be used to generate base reflectivity and velocity image products similar to those produced for the WSR-88D. More sophisticated use of FAA data will involve multiple Doppler wind field analyses, merging the data with WSR-88D data to produce 'best' radar data mosaics, retrieval of vertical wind profiles, and more. The scientific algorithms needed for optimum use of FAA data remain to be developed, offering opportunities for innovative developers.

3.5 Weather Systems Synthesis

With the implementation of ORPG and its high speed link to AWIPS, one of the original goals of the NPI program is within reach. To date, the ORPG algorithms have largely been radar data specific, with only minimal, user entered environment information utilized. Now, synergistic algorithms can be implemented that would combine the NEXRAD data with the full range of observational and model data available on AWIPS. Applications exploiting meso scale and storm scale models are now practical. It is envisioned that university and laboratory research community innovative development will provide major contributions to improving the operational benefits of the new infrastructure.

3.6 Software Development Tools

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 the operational WSR-88D. This project, termed CODE (Common Operations and Development Environment), is designed to provide an Application Programming Interface, underlying software modules, program layout and documentation support, and other tools that are compliant with the operational system [5, 6, 7]. One expected benefit of CODE is that the integration

of new science into operational systems will be eased, leading to a shorter time period between approval of an algorithm and its operational use. CODE is now the primary development tool for NWS and FAA programmers producing ORPG compliant implementations of new algorithms.

The NWS is working with UCAR/Unidata to offer CODE to the broader radar development community. The NWS plans to implement an electronic dissemination of base data in near real time. Unidata is currently collaborating with the University of Oklahoma to test such a capability with the Collaborative Radar Acquisition Field Test (CRAFT) project [9]. Under CRAFT, data from a number of WSR-88D sites are being distributed over the Internet using the Unidata Local Data Manager (LDM) software. One of the features of CODE is the ability to incorporate an LDM interface and ingest data from any of the LDM WSR-88D sites for developing and testing algorithms.

4. SUMMARY

In summary, the NEXRAD infrastructure enhancements, dissemination of base data, and development of radar application development tools have combined to offer a heretofore unmatched environment for radar science development and operational implementation.

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