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RADAP II, AN INTERIM RADAR DATA PROCESSOR

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1. INTRODUCTION

The National Weather Service (NWS) presently has a primary radar network comprised of 51 WSR-57 and 5 WSR-74S weather radars. Supplemented by a number of WSR-74C local warning radars, this network provides nearly blanket radar coverage over the eastern two-thirds of the United States. The full potential of the operational application of data from these weather radars has been limited because the data from most of these sites are presented to the user in video output form that requires manual processing if the data are to be used numerically to derive quantitative estimates (Greene, 1971). Faced with these shortcomings in the real-time quantitative application of radar data, the NWS began in 1971 the Digitized Radar Experiment (D/RADEX) with the goal of using automatic computer processing to enhance the usefulness of radar data. In D/RADEX, selected network WSR-57 radars were equipped with digitizing hardware including a minicomputer, and programs were developed to process the digital data into various products having applications to both meteorology and hydrology (Bigler et al., 1970, McGrew, 1971).

In 1976, when the experiment officially ended, the NWS decided to convert the D/RADEX sites from experimental to quasi-operational status and to run in this mode as long as spare parts and available maintenance would allow. At present, four of the five D/RADEX sites are still operational. These sites are Kansas City, Mo., Monett, Mo., Oklahoma City, Okla., and Pittsburgh, Pa. In the summer of 1981, a new WSR-74S radar equipped with a D/RADEX type processor was installed at Jackson, Ky.

2. NETWORK EXPANSION

For 5 years, 1976 through 1980, the NWS proceeded toward the procurement of new automatic RAdar DAta Processor (RADAP) systems for operational implementation at all network radar sites and some of the local warning radar sites (Shreeve, 1980). RADAP was planned to replace the aging D/RADEX equipment and to expand automatic radar data processing capabilities to cover most of the continental U.S. In mid-1980, the RADAR procurement was cancelled due to higher priority projects. Elimination of RADAP made it critical that alternatives for at least a minimum capability be considered for some of the NWS radar sites in the interim period until the implementation of the Next Generation Weather Radar (NEXRAD) systems. It was decided that the best alternative would be to maintain the present automatic digital processing capabilities at the D/RADEX sites and to extend these capabilities to several other sites to fulfill the digital radar data requirements during this interim pre-NEXRAD period. To partially meet these needs, the RADAP II system (a follow-on of D/RADEX) was developed by the NWS.

In the current plan, the number of NWS sites equipped with data processors will be increased from five to ten during 1983 (see Figure 1). This will be accomplished by installing new RADAP II systems on NWS radars at Charleston, W. Va., Amarillo, Tex., Garden City, Kans., Wichita, Kans., and Limon, Colo., and by "upgrading" the five existing D/RADEXs to be compatible with the new systems.

Current and future users of the RADAP II data include:

1) Meteorologists, hydrologists, and technicians at the Weather Service Forecast Offices (WSFOs) the Weather Service Offices (WSOs), and the River Forecast Centers (RFCs) -- The Pittsburgh, Oklahoma City, and Topeka WSFOs are particularly active in the use of D/RADEX data and will use RADAP II data routinely.

2) The System Development Office's (SDO's) Techniques Development Laboratory which uses the data for development of short-range prediction models and procedures.

3) The Hydrologic Research Laboratory's Radar Hydrology Group (RHG) which is using the data for their Hydrologic Rainfall Analysis Project (HRAP). HRAP is aimed toward improving the accuracy and timeliness of flood forecasts and is highly dependent upon the availability of high quality digital radar data.

4) The National Flash Flood Program which is developing and testing a multistate hydrologic data network, including digital radar data collected at Jackson, Ky.

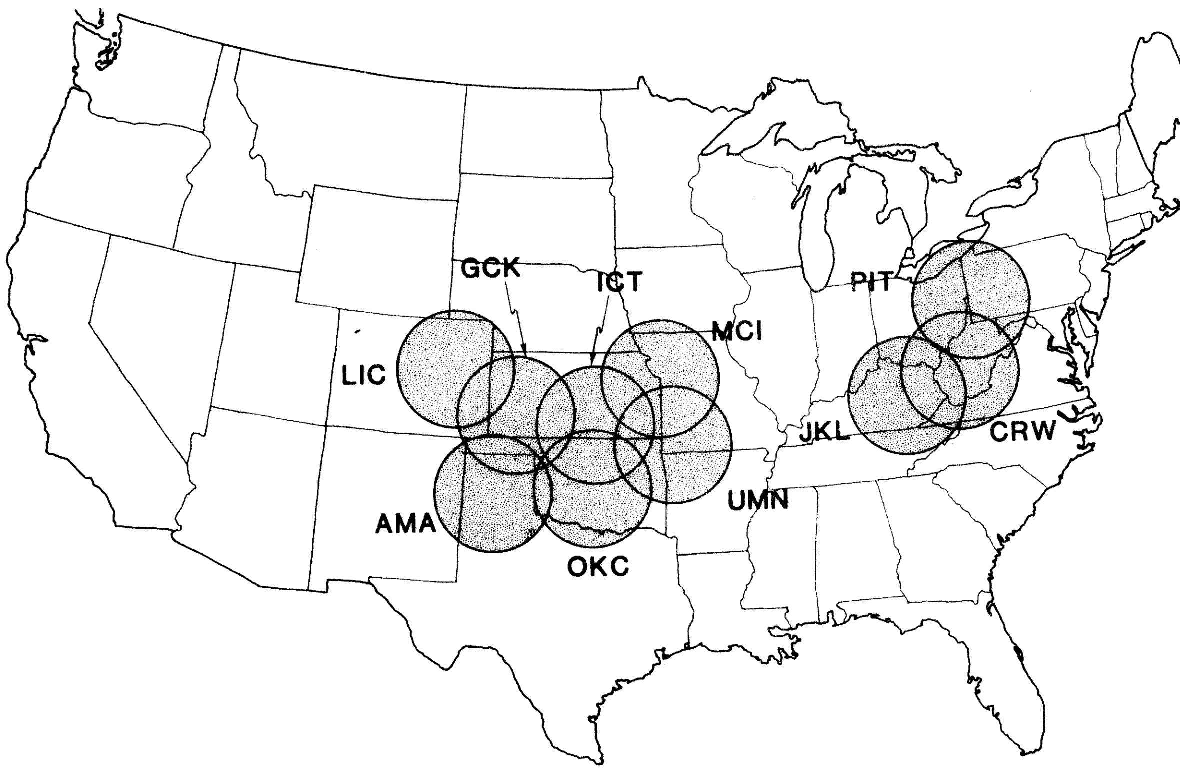

Figure 1. RADAP II Network.

5) The Tulsa RFC -- Although D/RADEX demonstrated that rainfall estimates based on digital radar data have great potential for hydrologic applications, the full potential for applications of these data to river stage forecasting have not been realized since no RFC has had more than 40 percent of their area of responsibility covered by digital radar data (the Tulsa RFC currently has 40 percent coverage, most of which is provided by the Monett and Oklahoma City radars). For radar data to play an integral part in the operational forecast system, these data must be available from a high percentage of the RFC's area. With the expanded RADAP II network, the Tulsa RFC will have digital radar-rainfall estimates from 90 percent of their area of forecast responsibility.

6) NEXRAD -- Recognizing that the weather radars being operated by the NWS and USAF to obtain information about hazardous weather are becoming obsolete, the Department of Commerce (DoC), Department of Defense (DoD), and the Department of Transportation (DoT) have proposed a common new weather radar system (NEXRAD). Procurement of NEXRAD is being managed by a Joint System Program Office (JSPO). Plans are to begin deployment of these replacement radar systems by FY 1988, with eventual completion by FY 1990-91 (NEXRAD, 1980).

An important part of NEXRAD is the development of graphical display systems. To accomplish development in this area and others, the NEXRAD JSPO is establishing an Interim Operational Test Facility (IOTF) at Norman, Okla. The IOTF, as well as the RHG, plans to make extensive use of digital radar reflectivity data collected from the Midwest test bed (parts of Colorado, Kansas, Texas, Oklahoma, and Missouri) for the development of the future display systems and as a test bed for developing applications software for NEXRAD.

7. The National Meteorological Center which will use the data as input to regional and/or national composites such as the National Radar Summary Chart, HRAP rainfall analyses, FAA radar mosaics, quantitative precipitation forecast products, etc.

3. SYSTEM CAPABILITY, OPERATIONAL REQUIREMENTS AND HARDWARE

a. Capability

The RADAP II digital processor was designed within the following constraints:

1) The computer system had to be software compatible with D/RADEX. This was necessary so that existing D/RADEX system software that were developed and improved during the last eight years could be implemented into the new interim processors without a major expenditure of resources.

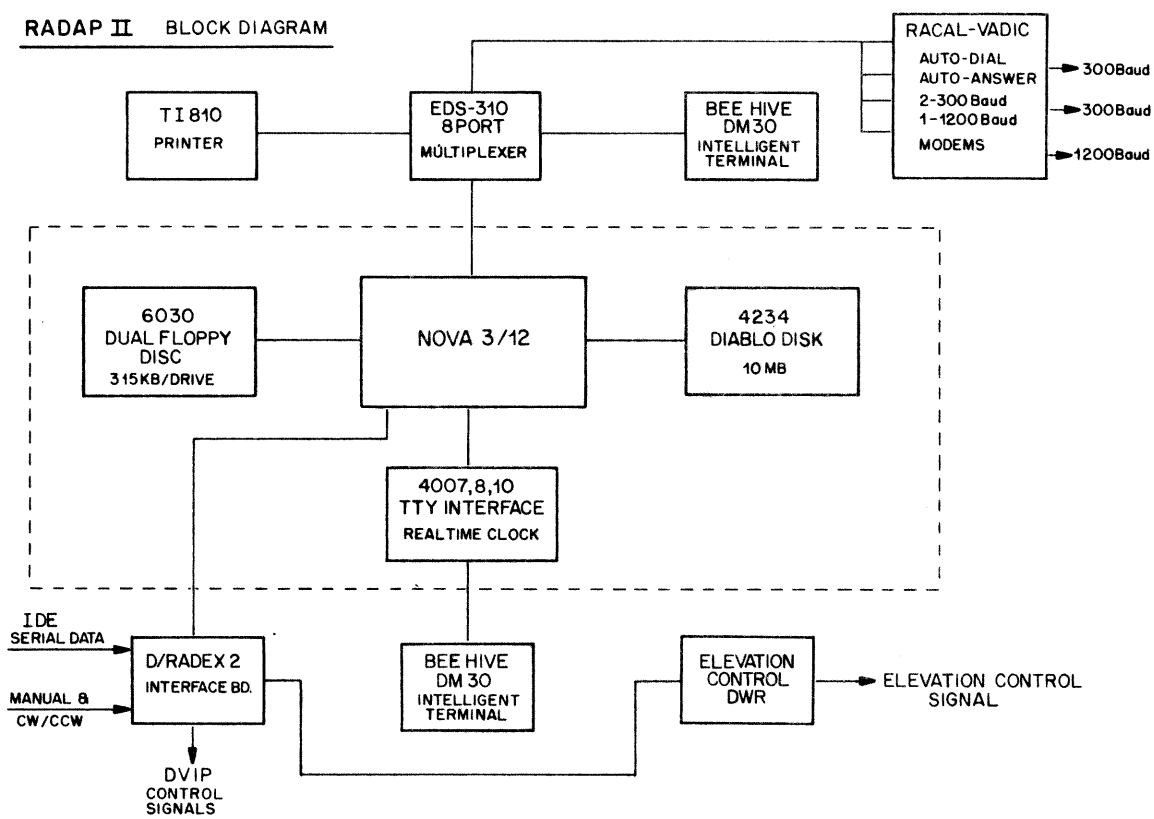

Figure 2. Display of all the hardware components in RADAP II. The dashed area includes components contained in the Data General computer.

2) Graphics display capability should be available for certain sites. An important part of NEXRAD is the development of graphical display systems. Experience gained through the operational use of RADAP II will be extremely beneficial to the ultimate development of the future NEXRAD display systems. The ability to examine radar data by means of a graphics device will be a major selling point toward a fuller acceptance of digital radar data by the radar operator as well as the operational forecaster. As we learn through the operational use of the interim system, more useful displays and/or a series of displays or animated loops will be developed and implemented, thus providing a natural bridge to the use of NEXRAD display products.

b. Hardware

The heart of the RADAP II processing system is the Data General NOVA 3* minicomputer. The computer receives radar data from the Digital Video Integrator and Processor (DVIP) and translates it into internal D/RADEX levels ranging from 0 to 15. It then processes the data into various forms, archives it, and outputs it either automatically or on command. Data can be accessed remotely by telephone hookup using a 300/1200 baud terminal. Through multiplexing, RADAP II is capable of simultaneously handling two incoming requests for data plus automatically transmitting data to preselected users.

Description. The RADAP II hardware was designed with three constraints. First, the system had to use existing Data General assembly language software products. Second, the system was to operate using the new Isolation Distribution Equipment (IDE) installed at every radar site (NWS, 1980). Third, the hardware should use state of the art electronics and have a cost ceiling of 25K per system.

In order to use Data General assembly language products and stay within budget requirements we purchased reconditioned NOVA 3 computer systems. These computers consist of a NOVA 3 with 32K word core memory, hardware multiply and divide, I/O card, real-time clock and disk controller. Also included in the system is a 10 megabyte hard disk and 630K byte dual floppy disk. The NOVA 3 and disks were installed in a 6 foot rack with space available for the remaining RADAP II hardware. The remainder of the RADAP II system consists of three Racal-Vadic modems with auto-answer/auto-dial capability (two 300 baud, one 1200 baud), an elevation control drawer, and a Radar Interface and Multiplexer Card installed within the NOVA 3 chasis. External to the RADAP II cabinet are a local and remote KCRT as well as a printer. A block diagram of the RADAP system is shown in Figure 2.

* The mention of manufacturer's name should not be interpreted as Government sanction of this particular product nor as the indication of preference over some other manufacturer.

Operation. The RADAP II system receives radar data in serial digital form from the IDE. All Weather Service radars will have an IDE with isolated output available for external users. Direct connection to the radar will not be permitted. The IDE data consists of a 0.1 degree radar radial at a resolution of 8 bits per Km. Each radial also contains radar azimuth and elevation as well as radar status information. The data is transmitted asynchronously from the IDE at 1.8 MHZ bits per second. The serial bit stream from the IDE is demodulated by the Radar Interface and Multiplexer card which includes a microprocessor that preprocesses selected 1 or 2 degree radials and controls the Direct Memory Access (DMA) into the NOVA 3 computer. The radar radials are then used in the application programs for generating the various RADAP II products. Whenever tilt sequences are required the RADAP II system must take control of the radar elevation circuits. The NOVA 3 sends elevation position data to the Elevation Control Drawer. The Elevation Control Drawer converts the digital elevation position information to an analog error signal that replaces the radar drive signal and permits RADAP II to control radar elevation.

Communications hardware for RADAP II consists of two 300 baud modems and one 1200 baud modem. These modems can operate in both auto-dial and auto-answer mode and can be connected directly to the telephone company jacks. The KCRTs have the capability of storing 4 pages of data that can be incrementally scrolled. The local KCRT is used for system control as well as display of RADAP products. A high quality printer is used for a permanent record of RADAP II products.

4. IMPLEMENTATION SCHEDULE

The RADAP II installation schedule is given in table 1. Initial plans were to "upgrade" the five existing D/RADEXs before installing the five new sites. However, because WSR-74 IDE problems must be resolved before "upgrading" the system at Jackson, Ky., this system, along with the new system at the WSR-74 at Charleston, W. Va., will be implemented last. In addition to the ten operational sites, new systems will be installed at the NWS Training Center in Kansas City, Mo. and at NWS Headquarters in Silver Spring, Md. for maintenance and operation training and system development and testing.

Table 1. Schedule of RADAP II Retrofits (R) and New Installations (N)

Site	Completion Date
(R) Pittsburgh, PA	12/4/82
(R) Oklahoma City, OK	2/25/83
(R) Monett, MO	4/29/83
(R) Kansas City, MO	6/8/83
(N) NWS Training Center	6/8/83
(N) NWS Headquarters	6/24/83
(N) Limon, CO	7/13/83
(N) Garden City, CO	7/13/83
(N) Amarillo, TX	7/29/83
(N) Wichita, KS	7/29/83
(N) Charleston, WV	8/19/83
(R) Jackson, KY	9/16/83

5. PRODUCTS

Initially, the RADAP II system will generate the same products as were generated with D/RADEX. These are described in the D/RADEX manual (NWS, 1982) and include the following:

- B-scan
- Radar Code Intensity Map
- Accumulated Rainfall (previous & current 1 hour, 3 hour, 24 hour, and storm totals
- Critical Rainfall Accumulations
- Echo Tops Map
- Vertically Integrated Liquid Water (VIL)
- System Movement Vector
- Forecast Zero Tilt Reflectivity Patterns
- Severe Weather Probability

Until recently, the graphical output of these products was limited to alphanumeric printers and cathod ray tube (CRT) terminals. In the summer of 1982, the NEXRAD JSPO funded a short test of operational forecaster interactions with color graphics radar displays. This test, conducted at the Pittsburgh WSFO, utilized the products available from a D/RADEX system. An Interactive Color Radar Display (ICRAD) system was developed to display selected D/RADEX products to the forecasters in color (NEXRAD, 1983). The NEXRAD JSPO has funded an expanded test of full operational use of automated color displays for radar observations and severe weather warnings.

This test will be conducted at the Oklahoma City, WSFO during the spring/summer of 1983 and it is hoped that the color graphic capabilities will be implemented operationally once the test is completed.

In addition to improving the graphics capabilities to more nearly match those envisioned for NEXRAD, we believe that, within the constraints imposed by the RADAP II system, an effort should be made to upgrade the software where possible to more closely match plans for NEXRAD reflectivity based products.

6. SUMMARY

Full production of the NEXRAD system will not begin until 1988. Until then, RADAP II will extend digital processing capabilities to include ten network sites. RADAP II will permit the maintenance and extension of the state-of-the-art real-time operational applications developed in D/RADEX. A significant reason why the use of digital radar data has not moved forward faster than it has is because of a lack of comprehensive and versatile applications software to analyze and quality control the data effectively. RADAP II will be used for the continued development and testing of applications software to provide feedback on the operational usefulness of the software which will be critical to the successful design and development of the NEXRAD system.

7. ACKNOWLEDGEMENTS

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