NOAA Technical Memorandum NWS WR-174

ARAP TEST RESULTS

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Western Region Headquarters
Salt Lake City, Utah
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UNITED STATES DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary /
National Oceanic and Atmospheric Administration
John V. Byrne, Administrator /
National Weather Service
Richard E. Hallgren, Director

This publication has been reviewed and is approved for publication by Scientific Services Division, Western Region.

L. W. Snellman

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CONTENTS

TABLES

ARAP TEST RESULTS

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I. Conception of ARAP

The development of the ARAP (AFOS Radar Processor) system began in June, 1979 when a low-cost experiment was performed with a NOVA 312 computer system. The purpose of the experiment was to determine if it was possible to provide realtime radar information on AFOS for under $10,000. At the end of the three month experiment, a test had been performed at both Las Vegas and Los Angeles with good results. The equipment used for the test included a NOVA 312 computer with 16KW memory, two floppy disk drives, and a special radar interface board developed during that summer. The system would take observations at only one level every few minutes and would produce an echo intensity map. Refer to WRTM-148 for more details on this system.

Since the summer experiment was successful, a decision was made early in 1980 to build a more versatile radar processor. At this time, the RADAP system development was progressing at NWSH. Since the RADAP system exceeded our requirements and was suffering budget constraints, we felt that a system could be developed for less money with only the bare essentials. Computer hardware was purchased for the task and was scheduled to arrive in June, 1980. During the four month wait, software block diagrams were developed using the current D/RADAX and proposed RADAP systems as models. The cost of the Western Region radar processor was estimated to be about $15,000 per unit (the actual cost today is $23,500). Even though there was some duplication of effort, we continued our efforts since we felt the need for an inexpensive automated radar processor for use in both emergency (flash flood) and routine (pilot briefing) operations.

II. Development of ARAP

The computer system consisting of a NOVA 4/C with 32KW memory, floppy drive, 12.5MB Winchester disk arrived in June, 1980. By this time the specifications for the Western Region radar processor and the basic software block design to meet the requirements were completed and software development began immediately. Some initial tests involving ground-clutter rejection were performed at Las Vegas using a high-speed analog-to-digital converter to calculate signal variability. It was soon decided that the subtraction method of ground-clutter rejection was both best and most efficient. It was also realized that the NOVA 4/C computer did not have the slot capacity required for this project and a NOVA 4/X computer with 64KW memory was purchased.

The software development effort proceeded in four stages:

A. System Skeleton Design - completed September, 1980.
Development of the basic skeleton structure including system tables and outgoing communication routines.

B. Keyboard Communication Routines - completed December, 1980.
Development of the interactive keyboard command system. Currently the system has over 65 available commands ranging from system and product status to message composition.

C. Observation Subsystem Routines - completed February, 1981.
Development of the routines to schedule the observation at a specified interval, take the observation, perform ground-clutter suppression, and grid the processed data.

D. Product Subsystem Routines - completed April, 1981.
Development of the routines to create the meteorological products from the XY grid data which involved writing graphics routines, alpha grid formatters, and other specialized routines. The available products at the end of April were:

1. Echo Intensity Map
2. 1-Hr. Precipitation Accumulation Map
3. Long-Term Precipitation Accumulation Map
4. Echo Tops Map
5. Echo VILs Map
6. Echo Movements
7. Areal Coverage vs. Time Plots

III. ARAP Systems Test

Version 1.00 of the ARAP software was ready for testing in April, 1981. Las Vegas WSO was chosen as the test site because of the frequency of spring thunderstorms and the willingness of the staff to participate. An instruction manual was prepared in draft form for the system test. The purpose of the test was to ensure that the ARAP software was stable and the interaction between the WSR-74C radar, ARAP, and the AFOS system were compatible.

After a week of checking out the hardware, calibrating the antenna controller, connecting cables, and fine-tuning the software, the system test began on April 29, 1981. After the system was operational for several days, several suggestions were made by the OIC at Las Vegas and the ARAP test coordinator on how to improve it. The various software modifications were made and Version 1.01 was installed May 12. The following updates were made:

a. Improved ground-clutter rejection (multiple-pass initialization).
b. New message composition commands (editing functions).
c. Archive skip function (only archive certain versions of products).
d. Automatic system log archive (keeps permanent record of operations).
e. New display command (allows display of previous product versions).
f. Top/VIL products available on the hour.

The system test continued until May 27, 1981. During the test several significant precipitation events occurred which allowed the Las Vegas staff to use the various ARAP products in an "operational" sense. The system test was very successful--only three hangs and three crashes occurred in the entire month.

A report containing suggestions and comments regarding the ARAP test was submitted by Las Vegas to WRH. The suggestions were considered and work began on Version 1.02.

IV. Preparation for the "Operational" Test

Two months of software development and documentation occurred between the system test at Las Vegas (May 1981) and the planned "operational" test at Billings, Montana, in July 1981. Using the suggestions from the Las Vegas test report, the instruction manual was revised and printed as a Technical Memorandum (WRTM-167). Programs were written to create ARAP specialized map backgrounds such as city/county, range circles, FAA air-routes, and MDR grid boxes. The following improvements emerged from Version 1.02 in August:

a. Improved software stability.
b. Reduced resolution Top/VIL maps (to lessen a system workload).
c. Addition of auto-alarm threshold increase subsystem (to automatically change the product alarm warning thresholds to avoid repeated warnings).
d. Eliminated preformats for more reliable software.
e. Addition of error code change commands (allowing the operator to only log and/or alert certain system messages).

V. "Operational" Test - Part I

The second major test of the ARAP system was the "operational" test. The objective of this test was to determine the operational usefulness of the ARAP system for both warning and routine situations. Billings, Montana, was chosen to be the test site since it has the most active convective activity in the region during August and September. Several stations in the Western and Central Regions were asked to participate in the test by examining and using the charts in an operational mode. They were asked to submit a comprehensive report on the reliability, timeliness, and usefullness of the various products. The participating stations were:

Western Region
- a. Billings WSO
- b. Helena WSO
- c. Great Falls WSFO

Central Region
- a. NSSFC
- b. Bismarck WSFO
- c. Williston WSO

The test began the end of July and was scheduled to end September 1. Several serious crash problems surfaced quite soon after the system was installed. About every two to three hours the system would hang and stop all processing. After two weeks of this recurring problem the ARAP system was temporarily removed for software reworking. During this period of time the AFOS Demonstration Test was in progress and the ARAP system was shut down.

VI. "Operational" Test Interim Period

For a one month period (August 15 - September 15, 1981) between the removal and reinstallation of ARAP at Billings, intensive software debugging and rewrites occurred. The stability was increased from one crash every three hours to one crash every week. In addition, the following software improvements were made:

a. Automatic increase and decrease of alarm threshold settings for each of the five catgories.
b. Changes in the command formats.
c. Addition of time set and special observation commands.

It was also necessary to reconfigure the ARAP Antenna Controller Sybsystem from a passive to an active controller. The passive method of using solid-state control transformers was not sufficiently sensitive to position the antenna elevation within 0.1 degrees. The active method of using digital-to-analog converters to control the velocity of the antenna allowed the software to position the antenna more accurately.

Due to the number of software and hardware changes made in developing Version 1.03, an update to the ARAP User's Guide was printed.

VII. "Operational" Test -- Part II

The second part of the "operational" test at Billings began on September 28, 1981, and continued through October 23, 1981.

A. System Reliability:

Table I, "ARAP Observation Attempts Reliability", lists the number of observations that were attempted to be taken during the test. The table shows that the ARAP system was operational 81.3% of the test period. The only major problem was the failure of the Winchester disk drive. A blown fuse caused the drive to lose power. The system was down for three days since the ARAP test coordinator could not be reached by phone. Since it only took one hour to replace the fuse the numbers are juggled in the last column to reflect a one hour down period due to the disk drive failure. Under these circumstances the ARAP system would have been operating 97.5% of the test period.

The other problems that caused ARAP outages were radar maintenance (2.0%), commercial power failure (0.4%), and an apparent software hang (0.06%).

The ARAP system was used extensively as a meteorological tool during the test. Three of the test reports received indicated that the system was used for pilot briefings (23 at Williston, ND). No warning situations occurred during the test period but it was mentioned in the reports that the system would be useful for warning situtations. Almost all of the reports stated that the data was easy to read and timely.

	OBSERVATION ATTEMPTS		OBSERVATION ATTEMPTS ASSUMING NO DISK FAILURE*	
	NUMBER	%	NUMBER	%
Total Observations Attempted	2828	81.3	3390	97.5
Disk Drive Failure	567	16.3	5	.1
Radar Maintenance	70	2.0	70	2.0
Apparent Software Hang	2	0	2	0

*A blown fuse caused the disk drive to lose power. The staff at Billings was instructed not to attempt to fix it until the test coordinator could be reached. Three days later the fuse was replaced and ARAP was working again. It took only one hour to replace the fuse. The figures have been adjusted to reflect this one hour outage.

ARAP Observation Attempts Reliability
Table 1

	OBSERVATIONS		OBSERVATIONS ASSUMING NO RADAR TIMEOUTS*	
	NUMBER	%	NUMBER	%
Successful	2699	95.4	2806	99.2
Radar Timeout	107	3.8	0	0
Operator Interrupt	15	.5	15	.5
Software Problems	7	.3	7	.3

*Radar Timeout occasionally occurs when the antenna is rotating in a counterclockwise direction. This is because the WSR-74C hysteresis latch prevents the exact azimuthal position from being transmitted to ARAP. This problem can be prevented without affecting the radar operation by removing and jumping over the hysteresis cards. The calculations in column two reflect the expected percentages with this modification.

ARAP Observational Reliability
Table 2

Several suggestions were made:

1. Instruction Manual

   Billings, Montana, and NSSFC commented that the instruction manual should be improved. "The ARAP System should have two distinct handbooks, an operator's guide, and a user's guide. Time after time users and operators were thoroughly confused using NOAA Technical Memorandum NWS WR-167 (ARAP User's Guide)". In response to this suggestion, the User's Guide will be changed to separate the operator's and user's section. In addition, a separate guide to commands and procedures, "POCKET GUIDE TO ARAP COMMANDS AND PROCEDURES", has been developed.

2. Time/Date Group Relocation

   Great Falls commented on the date/time group: "...date and time group was hard to read; i.e., numbers too small...date and time group should be in a lower corner." The current legend contains not only the date/time group, but also the legend value equivilent. The date/time in future revisions will be in the lower left corner in large print. The remainder of the legend will remain in the upper left corner.

3. DVIP Intensities/Precipitation Accumulations

   The accuracy of the data was discussed by Billings: "...precipitation accumulation charts overestimated the amounts of precipitation that were received by reporting stations." ARAP uses the Marshall-Palmer ZR law to calculate precipitation rate and derive precipitation accumulation. Without any method of ground-truth in this test, accumulation values could have been off by a large amount. Some of the precipitation events consisted of snow and the ZR law doesn't apply for this case. Ground-truth is necessary, especially in dry climates, to more accurately calculate precipitation accumulation.

4. Clarity of Products

   Only NSSFC had negative comments about the clarity of products. "At the 1:1 zoom setting, the digital values overlapped and were unreadable...horizontal lines also partially obscured the numbers...". NSSFC was also concerned about overwhelming the AFOS RDC circuits. Their comments are somewhat conflicting. In previous versions of ARAP software the alphanumeric digits "1" through "9" were used. In the current version, horizontal lines are used for intensity one, and digits for values two through nine. This has resulted in a graphic size reduction of 60%. The present configuration optimizes the graphic size and the amount of data presented. The graphic (on a 1:1 zoom setting) provides an image with shading that closely resembles the radar screen. When the graphic is zoomed the numbers become legible and the actual data value can be determined. NSSFC also commented that "reduction in the plotting density ... possibly at all (zoom) settings..." would decrease the RDC loading. This is true; however, to do so would decrease the effectiveness of the ARAP system for small-scale pattern recognization. There are plans to reduce RDC loading by storing the ARAP data either locally or sending it only to surrounding sites.

VIII. Future Plans for ARAP

ARAP is currently (December, 1981) undergoing software modifications. Version 1.04 is expected to be ready for testing in January, 1982. It will contain the following improvements or changes:

A. Revised ARAP User's Guide including more detailed sections on:
   1. Remote access to ARAP data
   2. Error code explanations

B. Pocket Guide of ARAP Commands and Procedures.

C. Status printout on the hour if in standby mode.

D. Ability to specify the number of versions to archive of each product. If properly set, it could eliminate the need to change the archive floppy every twelve hours. The archive disk could then conceivably contain several weeks of data.

E. Antenna controller calibration value changable by field personnel. In Version 1.03 the software had to be changed to perform a calibration.

F. Specifiable device for main and auxilary archive. Currently the floppy is the main archive device (DP4) and the Winchester disk is the auxilary archive (ARC). This software change would permit other devices to act as archive.

In January, 1982, Version 1.04 will be ready for testing. Three sites, Las Vegas, Phoenix, and Portland, have been chosen for this multi-purpose test. The following items will be investigated:

A. Long-term stability - Is the software stable enough to be used operationally regardless of meteorological conditions?

B. Documentation - Is the documentation for the following catagories adequate for operational use:
   1. ARAP User's Guide
   2. Quick Reference Guide
   3. Hardware Schematics
   4. Software Block Diagrams and Coding

C. Versatility - Can the software be tailored to any site with different requirements?

D. Other Agencies - Can other agencies use the data? Non-AFOS sites can access the data using the remote terminal ports.

E. Integrating Other Programs - Can other programs such as Teletext, rain-gage networks, front-end processors, be integrated into the ARAP system?

F. Development of Interface Board to Connect ARAP to the Radar Serial Data Distribution Equipment. This will enable the ARAP system to be connected to local warning radars, network radars, and ARTCC radars.

The three site's ARAP systems will be brought up a month apart. With three sites participating in this test, and various people evaluating the system, the suggestions and following improvements should produce an operational system that meets the radar data requirements of many meteorologists. At the end of this test a formal request will be made to NWSH to allow ARAP to become a recognized, operational meteorological tool.

APPENDIX

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE
Rm. 212, Admin. Bldg.
Logan International Airport
Billings, MT 59101

Date : November 16, 1981

Reply to Attn. of: MIC
FTS 585-6335

To : WFW3, WRH, Mark Mathewson

From : Bert L. Nelson, MIC

Subject: ARAP Test Report

A. General: The ARAP Nova/4 Computer Software worked very well during the test period. Only one hardware problem was encountered. The AFOS products generated by ARAP were timely and of good quality.

1. DVIP Intensities: The Echo Intensity Maps were very useful. Echo Intensity Maps were used by the Billings Flight Service Station to brief pilots. In rain and snow situations the DVIP Level 2 area was slightly larger on the Echo Intensity Map than on the WSR-74C Radar Scope.

2. Precipitation Accumulations: Both the one hour and 24 hour precipitation accumulation charts overestimated the amounts of precipitation that were received by reporting stations. In dry climates the precipitation accumulation rates may have to be drastically reduced for DVIP Levels 1 and 2 or correlated to the available precipitable water.

3. Echo Tops Maps: Echo tops maps were of a limited value due to the time period of the test. During the July-August 1981 ARAP run the tops maps were very useful with thunderstorm activity. During the September-October test the echo tops maps were subject to the limitations of the WSR-74C in detecting actual tops. Due to the minimum descernable signal of the radar, the radar echo tops are generally quite unreliable during the cooler months of the year.

4. Overall the ARAP system performed very well. The software load for this test period performed much better than the software load during the July-August test run.

B. Impact on station operations.

1. The ARAP system had a minimum impact on routine station duties and the operation of the radar.

2. Too much equipment was located in the Radar Room (WSR-74C radar console, two NWR consoles and the NOVA4/X Computer). Room temperatures ranged from 80 to 85 degrees. In future tests the NOVA4/X Computer should be located in an adjacent room with a remote control panel in the Radar Room.

C. Specific Recommendations:

1. The ARAP System is a good means of providing radar data on AFOS in graphic form.

2. The ARAP System should have two distinct handbooks, an operators guide and a users guide. Time after time users and operators were thoroughly confused using NOAA Technical Memorandum NWS WR-167.

3. During the start (first week) of the test an ARAP expert should be available to provide guidance and solutions to the operators and the users.

cc: MIC WSFO GTF

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE

WSFO, Great Falls, M T

November 3, 1981

TO: Director, Western Region
WSRO, Salt Lake City, UT
ATTN: WFW3

FROM: David E. Olsen
Meteorologist in Charge

SUBJECT: Billings ARAP Test

Unfortunately, during the ARAP test, most of the convective activity was on the wane. Nevertheless, Frank Kieltyka, Met. Intern, had these comments which speak for all of us:

"I used the radar information from Billings mainly to see where the echoes were located with respect to the BIL airport. Before ARAP, I would have to call BIL which was time consuming for both myself and the person in BIL. The radar plots are easy to read and the charts were updated at a good frequency.

I have two minor complaints. The first is that the date and time group was hard to read; i.e., numbers too small. The second complaint is that the date and time group should be in a lower corner."

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE

October 28, 1981

TO: National Weather Service
P. O. Box 11188, Federal Building
Salt Lake City, UT 84147
Attn: Mark Mathewson, SSD, WFW3

FROM: Donald E. Stoltz, MIC/AM, WSFO, Bismarck, ND

SUBJECT: ARAP (AFOS Radar Processor) Test at Billings, MT

During the test the following graphics were available on a real time basis:

Background	Data
B21 County Area	T20 Echo intensity
	T21 Area coverage calculations
	T22 1 Hour Precip. accumulation map
	T23 24 Hour Precip. accumulation map
	T24 Echo height map
	T25 Vert. Int. liquid water content

The test period was void of significant convective precipitation events and there were no warning situations. However, this did not distract from the tremendous potential this system has. Our antiquated SD system is too time consuming and provides limited data, even for network radars, and almost completely prohibits the distribution of radar data from local warning radars. The ARAP system could be the answer to these problems.

This office found the data very useful, timely and the graphics were clear and accurate. The presentations would be extremely helpful during warning situations, reviewing storm paths and locating areas of heavy rains for hydrologic purposes.

I would like to see the ARAP program tested in an area that has more frequent and intense convective precipitation events such as North Dakota, and I would volunteer the NWS facility at Bismarck for that test.

I believe the National Weather Service should totally commit itself to a program such as ARAP. We can no longer afford the man hours needed to code up SD reports. The time saved could be better spent in the detection of severe storms through more detailed analysis of radar data and distribution of the information to the public.

cc: WFC
WFC41

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE

October 26, 1981

TO: Director, Central Region
Attn; WFC41

FROM; MIC WSO Williston, ND

SUBJECT: ARAPS test (September 28-October 23)

During the period of the test the following graphics were available on a real time basis:

Background		Data	
B21	county area	T20	echo intensity
B22	airways	T21	area coverage calculations
B23	radial distance	T22	a 1 hour precip. accumulation map
B24	MDR grid	T23	a 24 hour precip. accumulation map
		T24	echo height map
		T25	vert. int. liquid water content.

The loop and animate programs were not available here.

During the test period there were no warning situations.

During the test period the data presentation was very useful, giving radar information previously not available. The graphics were easy to read and on a real time basis. The data was used for pilot briefing (23 briefings) and for local forcasting.

The reliability was good with only one major outage.

It appears to be a excellant system to utilize remote data from WSR 74C radars and AFOS.

cc: WSFO Bismarck, ND

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Severe Storms Forecast Center
Room 1728 Federal Building
601 E. 12th Street
Kansas City, Missouri 64106

November 2, 1981

TO: Chief, SSD - WFW3

THRU: Director, NSSFC

THRU: Acting Director, CRH (WFC41)

FROM: Richard A. Kerr
NSSFC, AFOS FP

SUBJECT: BIL ARAP Test Sept 28 through Oct 23, 1981

Delay in starting the test, and non-conformity of AFOS product headers with those specified in the ARAP instruction manual hindered evaluation of this office of the BIL products during periods of severe or heavy thunderstorm activity, so we are unable to provide a detailed evaluation of the ARAP AFOS graphics.

At the 1:1 zoom setting, the digital values overlapped and were unreadable, requiring use of a higher zoom setting, and thus the loss of a portion of the display, usually including the legends. Some people raised the question of how many of these radar charts it would take an hour to completely overwhelm the RDC, if the program was expanded to additional WSR74C stations. Thus a reduction in the plotting density would appear to be desirable, at least at the lower zoom settings, and possibly at all settings to reduce RDC loading. The horizontal lines also partially obscured the numbers at 4:1 zoom setting, and probably should be eliminated.

The areal coverage calculations were not useful in this office. Evaluation of the 24-hr precipitation chart was not done, due to invalid data during the early part of the test when precipitation was in the area.

A better evaluation by this office would require episodes of heavy thunderstorm activity, which would have been more likely in the summer. The system does have potential, if it does not overwhelm the capabilities of the RDC to function satisfactorily.

The manual should have a separate part for remote AFOS with the specific AFOS headers to be used plainly stated. Changes in test dates and AFOS products should be sent the field users well ahead of such changes.

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NOAA SCIENTIFIC AND TECHNICAL PUBLICATIONS

The National Oceanic and Atmospheric Administration was established as part of the Department of Commerce on October 3, 1970. The mission responsibilities of NOAA are to assess the socioeconomic impact of natural and technological changes in the environment and to monitor and predict the state of the solid Earth, the oceans and their living resources, the atmosphere, and the space environment of the Earth.

The major components of NOAA regularly produce various types of scientific and technical information in the following kinds of publications:

PROFESSIONAL PAPERS — Important definitive research results, major techniques, and special investigations.

CONTRACT AND GRANT REPORTS — Reports prepared by contractors or grantees under NOAA sponsorship.

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