OPERATIONAL EVALUATION OF THE ARTS II RADAR ALPHANUMERIC DISPLAY SUBSYSTEM (RADS)

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FINAL REPORT

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A programmable, nontracking beacon Automated Radar Terminal System (ARTS II A) was installed in a TRACON configuration at the National Aviation Facilities Experimental Center. The operational suitability of the Radar Alphanumeric Display Subsystem (RADS) was evaluated. The RADS displays were evaluated over a 2-week period through the collection of subjective data obtained from controller questionnaires. It was concluded that the RADS consoles are suitable for use in air traffic control facilities. Modifications to the FOCUS control, MAP ILLUM control, A/N GAIN control, and Data Block Offset Switch are recommended.  

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PREFACE

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INTRODUCTION

PURPOSE.

The purpose of this project was to provide a comprehensive determination of the operational suitability of the Radar Alphanumeric Display Subsystem (RADS) for use in air traffic control facilities.

BACKGROUND.

As a result of the Automated Radar Terminal System (ARTS II) evaluation in the Knoxville, Tennessee, Terminal Radar Approach Control Facility (TRACON), a contract (DOT FA72WA-3073) was issued for a prototype automated radar terminal system, suitable for use at terminal radar facilities with low traffic density. This system was installed in a Type B Terminal Radar Approach Control Cab (TRACAB) configuration at the Wilkes-Barre/Scranton Tower, Avoca, Pennsylvania, during December 1972 by Lockheed Electronics Co., Inc. (LEC), Plainfield, New Jersey. Subsequently, a 6-week field evaluation was conducted by the National Aviation Facilities Experimental Center (NAFEC) personnel. In the Type B (TRACAB) configuration, radar and alphanumeric information was displayed in the tower cab through the use of a Bright Alphanumeric Subsystem (BANS). The further evaluation of ARTS II was conducted upon the Data Entry and Display Subsystem (DEDS) portion of the same basic system in a Type A (TRACON) configuration at NAFEC, Atlantic City, New Jersey. Radar and alphanumeric information was displayed through the use of the RADS in a TRACON environment located in Building 149, (LAB E) NAFEC (Figure 1).

DISCUSSION

The ARTS II A configuration (Figure 2) is a nontracking beacon alphanumeric system, utilizing standard terminal radar and beacon subsystems. ARTS II A, like ARTS II B, is composed of the LEC MAC-16 Data Processing Subsystem (DPS), and the Data Acquisition Subsystem (DAS) (Figure 3).

Both configurations are functionally identical. The basic ARTS II system and its functions have been previously described in detail in the Interim Report, "The Field Evaluation of ARTS II B (TRACAB)," (Report Number FAA-RD-73-119). The main difference between Type A and Type B configurations lies with the DEDS, therefore, no further description of the system, except for the DEDS, will be offered.

ARTS II A DEDS consists of single-console assemblies, associated alphanumeric keyboards, and Positional Entry Modules (PEM), manufactured by the International
FIGURE 1. RADS TRACON ENVIRONMENT
FIGURE 2. ARTS II A (TRACON) CONFIGURATION - BLOCK DIAGRAM
FIGURE 3. DATA PROCESSING SUBSYSTEM AND DECODING DATA ACQUISITION SUBSYSTEM
Telephone and Telegraph Company, Fort Wayne, Indiana. Figure 4 depicts a typical RADS console with associated keyboard, Beacon Display, and Code Select Panels. The following basic elements are included as part of the console:

- Cathode Ray Tube (CRT), 16-inch, and deflection system;
- Radar video interface and processor;
- Range mark generator;
- Computer Input/Output interface;
- Format generator;
- Alphanumeric character generator;
- Leader generator;
- Radar alphanumeric time-sharing switching;
- Data entry devices; and
- Radar and alphanumeric controls.

The RADS consoles are capable of accepting normal and Moving Target Indicator (MTI) radar video, radar pretrigger, and radar antenna positional data from standard Airport Surveillance Radar (ASR) systems, video map, and beacon inputs.

The RADS CRTs are manufactured with a combination of P-11 and P-33 type phosphor which, when excited at different intensities, cause the radar sweep to appear bluish-purple in color; range marks, video map and targets appear orange; and alphanumerics appear pink. ARTS II is capable of driving up to six displays in any combination of BANS or RADS consoles. During this evaluation three RAD consoles were utilized to display normal and MTI radar video from the Eastern Region’s ASR-4 Radar Site at NAFEC. A typical RADS console presentation is depicted in Figure 5.

**METHOD OF APPROACH**

The RADS consoles were evaluated through the collection of subjective data obtained from questionnaires. These were completed after 3-hour periods of system usage by qualified Air Traffic Control Specialists (ATCS) familiar with alphanumeric subsystems and displays. Test subjects were selected from the Air Traffic Services Branch, ANA-250 and from the Systems Test Branch, ANA-110. The evaluation was conducted in two phases:

**PHASE I - RANDOM TARGET INPUTS.** The purpose was to train test subjects in the use of ARTS II and the RADS, and to observe display qualities through the association of aircraft identity with random beacon targets of 4096 Mode 3/A transponder-equipped aircraft.

**PHASE II - SURVEILLANCE APPROACHES.** The purpose was to determine the adequacy of control/display relationship and to observe display qualities while vectoring a NAFEC test aircraft for surveillance approaches.
FIGURE 5. RADS CONSOLE PRESENTATION
CONTROLLER TRAINING.

Training was conducted during Phase I through the use of display control adjustments, briefing by Test Directors, and use of ARTS II training scripts. Initially, all display controls were turned to full counterclockwise position, forcing controllers to adjust the display to their satisfaction while observing the reaction of the controls. After the display was adjusted for a satisfactory presentation, controllers were briefed on ARTS II system functions. They then observed display qualities while executing ARTS II training scripts.

ATC PROCEDURES.

Standard procedures and facility operating instructions were used. Separation was not applied between digital target symbols, or between a digital target symbol and a primary or secondary radar target. All approaches were conducted during Visual Flight Rules (VFR) weather conditions and under the monitoring of Atlantic City Approach Control.

DATA COLLECTION.

Questionnaires (see Appendix) were administered to each controller after the test periods. During the 5 days of Phase I testing, 37 controllers from both ANA-250 and ANA-110 were rotated daily through the laboratory. Questions 12 and 32 were not completed since they dealt with surveillance approaches.

During the 3 days of Phase II testing eight qualified, medically-certificated controllers from ANA-250 were rotated through the laboratory. Twenty-five surveillance approaches with a NAFEC test aircraft (Grumman Gulfstream) were executed to various runways at NAFEC. It was during this phase that Questions 12 and 32 were completed.

Throughout Phase I and II of the data collection, problems were encountered with the alignment of the video map. It was for this reason that responses to Question 6 were not requested. Also, with the exception of one test period in Phase I, weather clutter was not encountered during data collection, and thus, responses to Question 16 were not requested.

DISCUSSION OF RESULTS

In the compilation of the controllers' questionnaires, which were used to evaluate the ARTS II RADS, the responses received to all questions except 3, 11, and 21 reflected a decisive majority (80 percent or better).

In response to Question 3, comments were received concerning the distortion of the RADS presentation due to weather. This distortion was only evident during periods of heavy-clutter breakthrough and radar interference. On the three RAD consoles utilized during the evaluation, this heavy-clutter break-
through and radar interference resulted in a decreased high-voltage recovery constant time. This decrease caused the high-voltage regulator to fluctuate, resulting in the shifting out in range of all radar and alphanumeric information. The fourth console, located in the maintenance area, was unaffected since it had been modified at the factory prior to shipment. Subsequent to the 2-week evaluation period this condition was also eliminated on the other consoles by modification of the high-voltage regulator cards. The Test Directors and other qualified ATCS then reassessed the display qualities of the modified consoles during periods of heavy weather clutter and radar interference. As a result, it was determined that the distortion had been eliminated and that radar separation could be provided between targets operating in areas affected by weather clutter.

In response to Question 11, comments reflected that the positioning of digital target symbols was too far away from the primary and secondary target. This distance (registration error) was observed in some cases to be excessive and did vary with the range and position of the alphanumericics on the display. This registration error was attributed to a contractor evaluation to determine the period of time required for the adjustment to drift that was in progress during the RADS evaluation. During Phase II of the evaluation this effort was terminated and accurate registration was demonstrated to the satisfaction of both the controllers and the Test Directors.

A more disturbing occurrence, within the same general area, was the distracting movement of data blocks when display range settings were reduced. Although not a specific requirement during the execution of the surveillance approaches, alphanumeric association was retained with the test aircraft on the 10-mile range setting. The alphanumericics would jump from the center of the broadband target to either the left or right edge of the target. This alphanumeric jump was attributed to the operational program attempting to position alphanumericics in the center of a wide target. On this range setting, as in the case of all radar displays when utilized on the lower range settings, the target size increased as the range setting decreased. This condition occurs on the increased range settings, but is not as noticeable since target size is smaller.

In response to Question 21, comments were received that better access to the DATA BLOCK OFFSET Switch, and a separate control for PEM dot intensity, would be desirable. Comments were also received about the unsatisfactory interaction between radar sweep intensity and alphanumeric leader intensity. Although eight data block offset directions are available, only one of the two sets of four may be used at any one time. The choice of either the set of cardinal points or the set of 45° counterpoints is dependent upon a switch setting. This switch is located beneath the console shelf and behind a panel among display logic boards. Thus it is not readily available to the operator.

In the case of the PEM dot and leader intensities, when a desirable intensity for the display and alphanumericics was achieved, the PEM dot and the leaders were normally not visible. Leader intensity was found to be a function of the radar SWEEP INTENSITY control, and PEM dot intensity is a function of the
A/N GAIN control. Normally the controllers preferred to operate the ARTS II system at reduced alphanumeric intensity settings.

Although the responses to rapidity and accuracy of the operator controls were decisively affirmative, the operation of the FOCUS and MAP ILLUM controls was found to be undesirable. The FOCUS control, although accomplishing its function, performed more like an ON/OFF switch. Full counterclockwise rotation produced an out-of-focus presentation. Clockwise rotation of the control produced not a gradual, but an almost instant refocus at the full-clockwise position. When rotating the MAP ILLUM control full-counterclockwise, the map illumination could not be turned OFF if desired. Although all controls were adequately labeled and lighted, it was observed that the PUSH-TO-TURN operating instruction on the tips of the DECENTER controls was not visible in the reduced lighting of the laboratory environment.
SUMMARY OF RESULTS

A complete compilation of the questionnaires from both phases of data collection is presented in the Appendix. It is from these that the results were obtained. Observations made by the Test Directors are included in the Discussion of Results of this report.

A majority of responses received concurred that:

1. The focus of targets displayed on the RADS was sharp and clear.

2. There was no distortion observed on the RADS presentation, except during periods when weather clutter and radar interference existed. This was subsequently eliminated by console modification.

3. There was sufficient contrast between targets and other features on the RADS presentation.

4. The resolution of the RADS presentation was satisfactory under all conditions.

5. Target size could be reduced to a satisfactory minimum on the RADS presentation to provide the accuracy required for conducting surveillance approaches.

6. The stability of the RADS presentation was satisfactory.

7. Observation of the RADS presentation did not cause any physical discomfort or fatigue.

8. The response to the operation of the controls was rapid and accurate.

9. The controls provided on the console were necessary for operational use of the RADS.

10. The quality of the alphanumerics was satisfactory.

11. The color of the sweep, alphanumerics, range marks, and video map was satisfactory.

12. The overall quality of the display was good.

13. The RADS presentation was satisfactory for use in conducting surveillance approaches to an airport.
CONCLUSIONS

From the results of this evaluation it is concluded that:

1. The RADS consoles are suitable for use in air traffic control facilities.

2. Interaction between the SWEEP INTENSITY control and the intensity of the alphanumeric leaders was not satisfactory.

3. The FOCUS and MAP ILLUM controls should be modified to better perform their intended functions.

4. Positioning of ARTS II alphanumerics, in relation to the center of the broadband targets, was very distracting when operating on reduced range settings.

5. PEM dot intensity was not satisfactory when the A/N GAIN was reduced.

6. The location of the DATA BLOCK OFFSET Switch was not satisfactory.
RECOMMENDATIONS

The following recommendations must be accomplished to improve the operational suitability of the RADS consoles:

1. Modify the FOCUS control to allow for a gradual change in display focus.

2. Make the intensity of the leader a function of the A/N GAIN control.

3. Modify the MAP ILLUM control to provide for turning OFF the map illumination.

4. Improve the method for positioning the alphanumerics in relation to the center of the broadband targets.

5. Provide an individual gain control for PEM dot intensity or intensify the PEM dot to a level of brightness greater than that of the alphanumeric characters.

6. Relocate the DATA BLOCK OFFSET Switch to the front of the display console.
APPENDIX

SUMMARY OF CONTROLLER RESPONSES TO ARTS II
RADS CONTROLLER QUESTIONNAIRES

In this Appendix the bracketed numbers following
the responses indicate the number of times the
comments were made.
RAD CONTROLLER QUESTIONNAIRE

1. Was the focus of targets displayed on the RAD sharp and clear? YES 100% NO 0%
   COMMENT: Trouble establishing sharp sweep focus. (1)
   TOTAL RESPONSES: 37

2. Does the FOCUS control adequately perform the function for which it was intended? YES 97% NO 3%
   COMMENT: Acts like OFF/ON switch. (1)
   TOTAL RESPONSES: 37

3. Was any distortion observed on the RAD presentation? YES 32% NO 68%
   COMMENT: Evident after looking at display for some time. (1) Due to weather. (6) No more than a good ASR-4 (1)
   TOTAL RESPONSES: 37

4. Was it necessary to readjust the focus of the RAD after satisfactory initial adjustments had been completed? YES 3% NO 97%
   COMMENT: Attempted to focus sweep many times. (1)
   TOTAL RESPONSES: 37

5. Was the quality of the video map satisfactory for operational use of the RAD? YES 94% NO 6%
   COMMENT: Not satisfactory on 10-mile range. (1)
   TOTAL RESPONSES: 36

6. Was the accuracy of the video map and range marks on the RAD satisfactory in relation to permanent echoes and aircraft position reports? YES NO
   COMMENT: (NOTE: Responses not requested.)

7. When the RAD range scale was changed did it affect the quality of the display? YES 19% NO 81%
   COMMENT: Momentarily (1) Lower ranges video map distorted. (1) Beacon slashes too wide on 30-mile range. (1) No more than a good ASR-4. (1)
   TOTAL RESPONSES: 37

8. Were any additional control adjustments required after changing range scales on the RAD? YES 8% NO 92%
   COMMENT: Had to reduce map gain after range change. (1)
   TOTAL RESPONSES: 36

9. Was there sufficient contrast between targets and other features on the RAD presentation? YES 89% NO 11%
   COMMENT: Leader too bright. (4) Sweep intensity should only adjust sweep. (1) No problem after watching scope a while. (1) Very good contrast targets, video map and alphas. (1)
   TOTAL RESPONSES: 37

A-1
10. Was the resolution of the RAD presentation satisfactory under all conditions? YES 89% NO 11%
COMMENT: Leader and data block intensity should be one control. (1) Weather could cause bad resolution. (2) No, but as good as most systems in operation. (1)
TOTAL RESPONSES: 36

11. Was the positioning of the digital target symbols with relation to the primary targets satisfactory? YES 66% NO 34%
COMMENT: LEC in process of determining degradation. (1) Hard to see. (1) Too much distance between them. (5) Varied from end of target to center. (1) Varied up to two miles. (2) Varied with range. (1)
TOTAL RESPONSES: 35

12. Can target size be reduced to a satisfactory minimum on the RAD to provide the accuracy required for conducting surveillance approaches? YES 100% NO 0%
COMMENT:
TOTAL RESPONSES: 8

13. Was the target trail adequate? YES 83% NO 17%
COMMENT: Maybe 3 target trails would be an improvement. (1) Needs more retention. (3)
TOTAL RESPONSES: 35

14. Was the bracket video adequate for control purposes? YES 97% NO 3%
COMMENT: No double bloomer 31/77/76. (1)
TOTAL RESPONSES: 34

15. Was the stability of the RAD satisfactory? YES 100% NO 0%
COMMENT: Short term at least. (1)
TOTAL RESPONSES: 37

16. When using the RAD can radar separation be provided between targets operating in areas affected by weather clutter? YES__ NO __
COMMENT: (NOTE: Responses not requested.)

17. Did observation of the RAD cause any physical discomfort or fatigue? YES 6% NO 94%
COMMENT: Not certain how coloring of CRT would affect vision of controller after an 8-hour period. (2) Harder on eyes, but target stands out better. (1)
TOTAL RESPONSES: 36

18. Did the illumination of the RAD operating area have any affect on the radar presentation? YES 11% NO 89%
COMMENT: Lighting was OK, but not varied. (3) Not with lighting used. (1) Too much ambient light derogated quality. (1)
TOTAL RESPONSES: 37
19. Was the response to operation of the controls rapid and accurate?
YES 97% NO 3%
COMMENT: Focus didn't respond as expected. (1)
TOTAL RESPONSES: 37

20. Are the controls provided on the console necessary for operational use of the RAD? YES 100% NO 0%
COMMENT: A separate leader intensity control is needed. (1)
TOTAL RESPONSES: 36

21. Were there any controls not readily accessible to you that should have been? YES 35% NO 65%
COMMENT: Separate control for PEM & intensity (1) North/South data block offset. (5) Leader intensity. (1) Leader length. (1)
TOTAL RESPONSES: 37

22. Were the alphanumeric controls satisfactory? YES 84% NO 16%
COMMENT: Reference leader intensity. (5) Size should be in lesser increments. (1) PEM dot hard to find. (3) Prefer rheostat control. (1)
TOTAL RESPONSES: 37

23. Was the quality of the alphanumerics satisfactory? YES 95% NO 5%
COMMENT: Very good. (1) Leader intensity too bright. (1) PEM too weak. (1)
TOTAL RESPONSES: 37

24. Were the Filter Switches satisfactory? YES 95% NO 5%
COMMENT:
TOTAL RESPONSES: 37

25. Were the Field Inhibit Switches satisfactory? YES 100% NO 0%
COMMENT:
TOTAL RESPONSES: 37

26. Were the Quick Look Switches satisfactory? YES 97% NO 3%
COMMENT:
TOTAL RESPONSES: 37

27. Was the color of the sweep satisfactory? YES 95% NO 5%
COMMENT: I prefer green. (1)
TOTAL RESPONSES: 37

28. Was the color of the alphanumerics satisfactory? Yes 100% NO 0%
COMMENT: Could be hard on eyes after prolonged observance. (1)
TOTAL RESPONSES: 37
29. Was the color of the range marks satisfactory? **YES 100% NO 0%**

   COMMENT:
   TOTAL RESPONSES: 37

30. Was the color of the video map satisfactory? **YES 100% NO 0%**

   COMMENT:
   TOTAL RESPONSES: 35

31. What was your opinion of the overall quality of the display? **GOOD 100% BAD 0% MARGINAL 0%**

   COMMENT: Brightness could be a factor. (1)
   TOTAL RESPONSES: 37

32. Is the RAD presentation satisfactory for use in conducting surveillance approaches to an airport? **YES 88% NO 12%**

   COMMENT:
   TOTAL RESPONSES: 8

33. In your estimation, what could be done to improve the utility of the RAD?

   COMMENT: Improve focus. (1) Improve registration. (1) Improve PEM dot intensity. (1) Sweep intensity adjust only sweep, not A/N. (2)

34. Please indicate any other comment you wish: Nice piece of equipment. (1) PEM dot too weak. (3) Dislike having to adjust sweep intensity to adjust leader. (1) Should have independent leader intensity. (2) Beacon targets in close proximity to weather appear to bend, range marks bend and alphanumeric jump. (1) Correct problems encountered during precipitation. (1) Correct interaction of sweep and A/N intensity. (1) Check fatigue factor of pink versus green color. (1)