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NPSEC-94-002

AD-A283 263

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Monterey, California

PERFORMANCE COMPARISON
AN/FRD-10 vs. PUSHER

by

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February 1994

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Prepared for: Naval Security Group Command
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Washington, DC 20393-5220

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
February 1995

3. REPORT TYPE AND DATES COVERED
Interim Report

4. TITLE AND SUBTITLE
PERFORMANCE COMPARISON
AN/FRD-10 vs. PUSHER

5. FUNDING NUMBERS

6. AUTHOR(S)
Wilbur R. Vincent and Richard W. Adler

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Postgraduate School
Monterey, CA 93943-5000

8. PERFORMING ORGANIZATION REPORT NUMBER
NPSEC-94-002

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Naval Security Group Command
Code G43
3801 Nebraska Avenue NW
Washington DC 20393-5220

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
The views expressed in this report are those of the authors and do not reflect the official policy or position of the Department of Defense or the United States Government.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release;
distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
The possibility of replacing some of the AN/FRD-10 Circular Disposed Antenna Array (CDAA) facilities with lower cost PUSHER type of CDAA is an option available to planners. It is generally assumed that the ability of the PUSHER to receive signals of interest (SOI) is only slightly less than that of the larger AN/FRD-10 and AN/FLR-9 types of CDAA. However, no specific analysis of the actual difference in performance is known to exist. This report provides a preliminary performance analysis of the two types of facilities.

Detailed performance-related measurements have been made at a number of AN/FRD-10 CDAA sites. These measurements were made as a part of the U.S. Navy's Signal-to-Noise-Enhancement Program (SNEP). The objective of the SNEP is to identify and mitigate all factors that degrade the ability of receiving sites to recieve SOI and process data from them. Similar measurements have also been made at PUSHER sites, although complete data is available from only a single PUSHER site. This report uses data accumulated from the AN/FRD-10 sites and from one measured PUSHER site to examine the differences in their ability to receive SOI.

The performance Evaluation Technique (PET) developed by the Naval Postgraduate School was used to evaluate the performance of each kind of CDAA. To simplify this initial analysis, the assumption was made that an AN/FRD-10 site containing an RFSS type of RF switch would be replaced with a PUSHER. Only the technical properties of the two types of CDAA were considered. The additional adverse impact of internal and external sources of man-made noise on performance was not included. It was assumed that the impact of EMI would be the same for both types of systems. In addition, the effect of nighttime overloading and saturation of the RF-distribution systems (RFD) from the relatively high levels of total signal power collected by the antenna elements were not considered in this preliminary analysis.

14. SUBJECT TERMS
EMI/RFI, high frequency direction finding, CDAA, signal to noise enhancement project

15. NUMBER OF PAGES
17

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18

INTRODUCTION

The possibility of replacing some the AN/FRD-10 Circular Disposed Antenna Array (CDAA) facilities with the lower cost PUSHER type of CDAA is an option available to planners. It is generally assumed that the ability of the PUSHER to receive signals of interest (SOI) is only slightly less than that of the larger AN/FRD-10 and AN/FLR-9 types of CDAA. However, no specific analysis of the actual difference in performance is known to exist. This memorandum provides a preliminary performance analysis of the two types of facilities.

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BASIS FOR ANALYSIS

Measured gains and losses of the RFD of a typical AN/FRD-10 CDAA and a PUSHER are provided in Table 1. Values of loss are provided in increments of 2.5 MHz over the frequency band of 2 to 30 MHz. These values are provided in Columns 2 and 3 of the table. Other differences between the two systems must also be taken into account. For example, the antenna gain of the PUSHER is estimated to be about 3-dB less than that of the AN/FRD-10. This is shown in Column 4. The PUSHEP. uses RG-8 coaxial cable from each element to its center hut whereas the AN/FRD-10 uses large low-loss cable. The calculated difference in cable loss is shown in Column 5. The total RF loss of the PUSHER is shown in Column 6.

Table 1
Signal Loss Values

Frequency MHz	AN/FRD-10 RFD Loss dB	PUSHER RFD Loss dB	PUSHER Antenna Loss dB	PUSHER Cable Loss dB	PUSHER Total Loss dB
2.5	4.4	19.0	3.0	1.0	23.0
5.0	3.6	14.0	3.0	1.0	21.0
7.5	3.8	7.0	3.0	1.0	11.0
10.0	0.0	11.0	3.0	1.0	15.0
12.5	0.0	13.0	3.0	2.0	18.0
15.0	0.0	8.0	3.0	2.0	14.0
17.5	0.0	22.0	3.0	2.0	27.0
20.0	0.0	10.0	3.0	2.0	15.0
22.5	1.1	22.0	3.0	3.0	28.0
25.0	1.5	17.0	3.0	3.0	23.0
27.5	2.3	11.0	3.0	3.0	17.0
30.0	0.5	22.0	3.0	3.0	28.0

The noise floor of active elements of the RFD in both the AN/FRD-10 and the PUSHER determine the lowest level signal that can be received. The noise floors of the RFD of both types of systems has been measured using a 3-kHz-wide gaussian-shaped measurement bandwidth. The values of noise floor for each system are provided in Table 2.

Frequency MHz	AN/FRD-10 Noise Floor dBm	PUSHER Noise Floor dBm
2.5	-124	-116
5	-124	-116
7.5	-124	-116
10	-124	-116
12.5	-124	-116
15	-124	-116
17.5	-124	-116
20	-124	-116
22.5	-124	-116
25	-124	-116
27.5	-124	-116
30	-124	-116

Table 2
Noise Floor

PERFORMANCE EVALUATION

Signal loss between the antenna and a receiver decreases the amplitude of signals provided to that receiver. Signals that fall below the RFD noise floor measured at the input to a receiver will not be detected. These factors are routinely measured by SNEP teams to identify operational problems within a CDAA site. Data accumulated over a number of years was used as the basis for the comparison of the PUSHER to the AN/FRD-10 CDAA.

The signal loss and noise floor values in Tables 1 and 2 provide the basis to compare the underlying capabilities of each type of CDAA to receive SOI. A specific type of SOI located within the primary coverage zone of a mid-latitude site was selected for the analysis of the performance of each type of CDAA. The SOI used a transmitter power of 1 kW and a dipole antenna. It was assumed that the SOI employed modulation that could be detected by a receiver at a 0-dB (S+N)/N. A log-normal amplitude distribution was used for the comparison.

Figure 1 shows the result of the comparison. Row 1 (blue) of the presentation shows the performance level of the AN/FRD-10. The small decrease in performance below 8 MHz was the result of an older model low-band multicoupler. The replacement of this multicoupler with a newer model will improve the low-band performance capability of that system.

Row 2 (yellow) shows the effect of only the RFD signal loss on the ability of the PUSHER to receive the same SOI. RFD loss seriously degrades the ability of this type of system to receive SOI. This result indicates that every effort should be made to decrease the RFD signal loss in existing and future PUSHER systems.

Row 3 (red) shows the overall performance of a complete PUSHER system. The loss of the RG-8 coaxial cable from the PUSHER's antenna elements to its center hut is added to the RFD loss in this line. A cable length of 100 feet was used which may be shorter than that used in most PUSHER installations. The exact cable lengths were not available at the time of this preliminary analysis.

The results indicate that a PUSHER installation side-by-side with an AN/FRD-10 will receive less than half the number of SOI received by the AN/FRD-10. This assumption assumes that both systems have the same internal and external man-made noise levels. The susceptibility of the two systems to man-made noise problems is not considered in this preliminary evaluation.

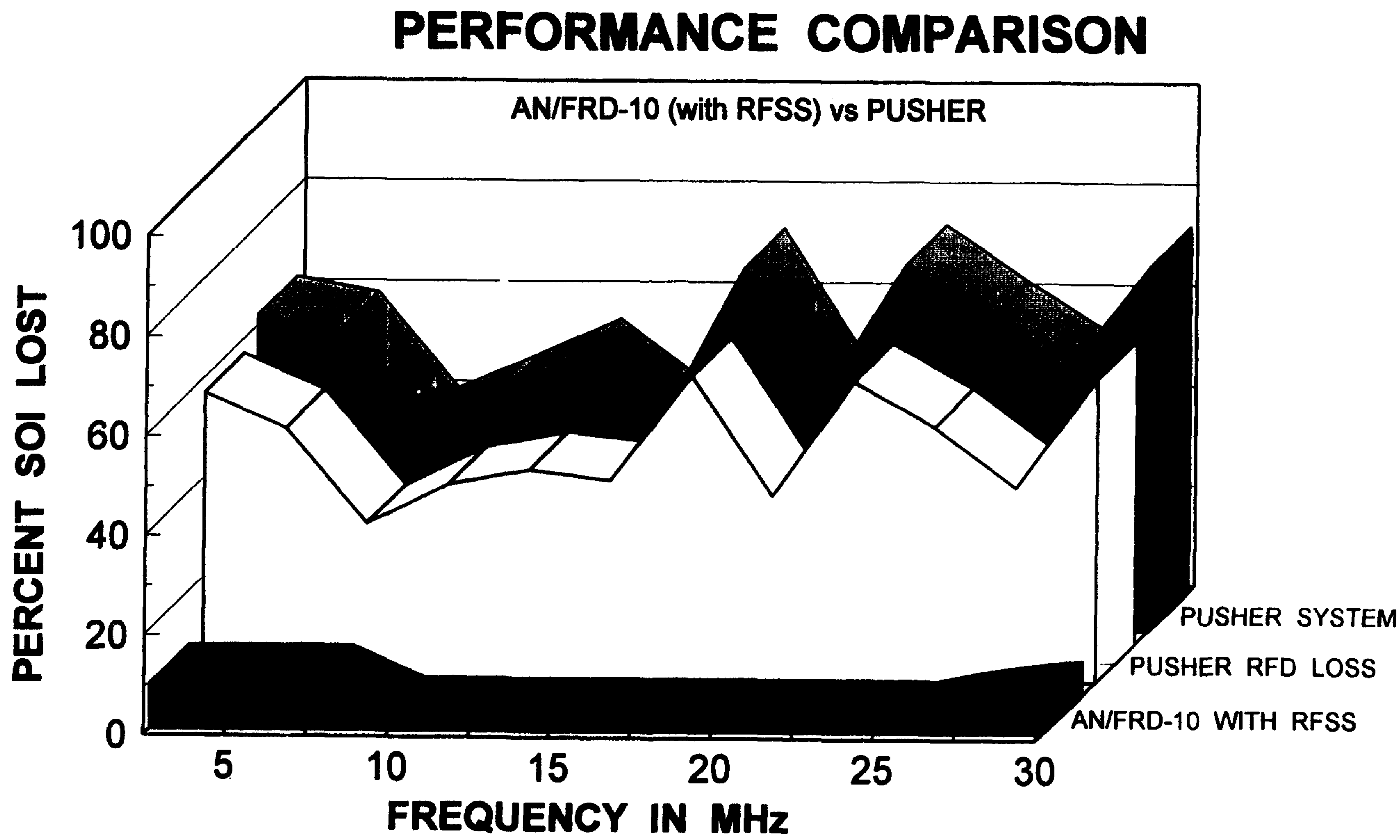

Figure 1
Performance Comparison

Unfortunately, the SOI missed by the PUSHER will not be a random sampling of the incoming signals. The lost SOI will be those below a specific field strength level. SOI that are very strong in amplitude will be received equally well by both CDAA systems. Since each kind of SOI will be received with a distribution of amplitudes ranging from modest down to very weak, a receiver using the PUSHER will not detect many of the SOI that are collected by its antenna. There is no class of SOI that the PUSHER will receive as well or better than the AN/FRD-10.

The data base available for the analysis of the performance of the AN/FRD-10 CDAA is extensive; however the data base for the PUSHER is limited. While the data used for the analysis of the PUSHER CDAA appears to be normal and in general agreement with limited samples of data from other PUSHER sites, more data from additional sites would be useful.

CONCLUSIONS

The initial comparison of the performance of the AN/FRD-10 CDAA with a PUSHER CDAA has provided rather surprising results. These results do not agree with the conventional view of the two systems which suggest that only small antenna-related differences in performance exist. The following summarize the findings and conclusions.

- Excessive signal loss and excessive noise floor of the RFD of the PUSHER CDAA are major reasons for the large difference in performance of the PUSHER when compared to an AN/FRD-10 CDAA. These two factors allow the PUSHER to receive only about one half as many SOI as an AN/FRD-10.

- The use of RG-8 cable to carry signals from the PUSHER antenna elements to the center hut adds to the RFD loss and further degrades its ability to provide detectable signals to receiving systems. This factor can be corrected by changing the antenna element cables to a low-loss type of cable.

- The smaller antenna aperture of the PUSHER over the AN/FRD-10 also adds to its lower level of performance, however this factor is of lower importance that the signal loss and noise floor factors.

- The correction of the signal loss and noise floor problems in a PUSHER will require a major and costly redesign of the RFD system for that type of CDAA.

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