technical note technical note

Final Report for the ATC Evaluation of the Prototype Airport Surveillance Radar Wind Shear Processor (ASR-WSP) at Orlando International Airport

Radame' Martinez

March 1993

DOT/FAA/CT-TN92/48

Document is on file at the Technical Center Library,
Atlantic City International Airport, N.J. 08405

U.S. Department of Transportation
Federal Aviation Administration

Technical Center
Atlantic City International Airport, N.J. 08405

NOTICE

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The United States Government assumes no liability for the contents or use thereof.

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the objective of this report.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/CT-TN92/48		

4. Title and Subtitle	5. Report Date
FINAL REPORT FOR THE ATC EVALUATION OF THE PROTOTYPE AIRPORT SURVEILLANCE RADAR WIND SHEAR PROCESSOR (ASR-WSP) AT ORLANDO INTERNATIONAL AIRPORT	March 1993
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Radame' Martinez	DOT/FAA/CT-TN92/48
9. Performing Organization Name and Address Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405	13. Type of Report and Period Covered Technical Note
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report presents the results of the FAA's air traffic control (ATC) operational evaluation of an Airport Surveillance Radar Wind Shear Processor (ASR-WSP) which operated at Orlando International Airport (MCO) during the summer of 1992. The evaluation was conducted in order to obtain reaction to the ASR-WSP weather products and displays.

It was concluded that the system is capable of meeting ATC operational needs and in general was rated as very useful. However, the accuracy of the gust front algorithm and to a lesser extent, the accuracy of the microburst algorithm are two features that the controllers/supervisors agree need some improvement.

17. Key Words	18. Distribution Statement
Airport Surveillance Radar Wind Shear Processor (ASR-WSP) Wind Shear Aviation Weather	Document is on file at the Technical Center Library, Atlantic City International Airport, NJ 08405

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	20	

Form DOT F 1700.7 (8-72) *Reproduction of completed page authorized*

TABLE OF CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

The Airport Surveillance Radar Wind Shear Processor (ASR-WSP), also known as Airport Surveillance Radar-9 (ASR-9) modification for low altitude wind shear detection, is a production ASR-9 with an expanded weather channel for added processing capabilities. The primary mission of the ASR-WSP is to enhance the safety of air travel through the timely detection and reporting of hazardous wind shear in and near the terminal approach and departure zones of the airport. It will also improve the management of air traffic (AT) in the terminal area through the forecast of precipitation, and ultimately the detection of other hazardous weather phenomena. The ASR-WSP may be used as a stand-alone system at airports without a Terminal Doppler Weather Radar (TDWR) or Enhanced-Low Level Wind Shear Alert System (E-LLWAS), or in an integrated mode with either or both the TDWR and E-LLWAS.

An operational evaluation of a prototype ASR-WSP, developed by Massachusets Institute of Technology Lincoln Laboratories (MIT/LL), was conducted at the Orlando International Airport (MCO) in Orlando, Florida, during the period June 29, 1992, to August 31, 1992. The objective of the evaluation was to obtain Federal Aviation Administration (FAA) air traffic controller reaction to the prototype ASR-WSP weather data and display equipment. The displays (used during the prior TDWR testing) consisted of one Geographical Situation Display (GSD), two large (15" x 15" x 6") Ribbon Display Terminals (RDT), and one small (12" x 11.25" x 6") RDT located at the tower cab; one GSD and one large RDT located in the Terminal Radar Approach Control (TRACON) room; and a GSD and large RDT located in the training room. Questionnaire forms were used to obtain responses from supervisors and controllers relative to the operational suitability of the displays and data.

The following are highlights of the evaluation: (1) the ASR-WSP is very useful when making runway configuration changes, (2) the ASR-WSP is not perceived to be as accurate as the prototype TDWR, (3) the gust front prediction feature is not reliable, and (4) the information provided on both the RDT and the GSD is very useful.

Generally, the participants favor the system. However, there was a feeling that the system needs to be refined and the gust front feature needs more work. It is recommended that more testing be performed in the future.

INTRODUCTION

PURPOSE.

The purpose of this evaluation was to obtain Federal Aviation Administration (FAA) air traffic controller feedback to the weather products generated by the Massachusets Institute of Technology Lincoln Laboratories (MIT/LL) prototype Airport Surveillance Radar Wind Shear Processor (ASR-WSP). The input obtained from this evaluation is intended to be incorporated into the ASR-WSP specification. The evaluation was conducted by the FAA Technical Center's Weather/Primary Radar Division, ACW-200. The plan for this evaluation is detailed in the Air Traffic Operational Evaluation Plan for the Prototype ASR-WSP at Orlando International Airport in Orlando, Florida, dated July 1992.

BACKGROUND.

Since 1986, the ASR-9 program office (ANR-200) has sponsored Lincoln Laboratory (LL) to evaluate the low-altitude wind shear detection capabilities (such as microbursts and gust fronts) of the ASR-9. This capability may be achieved by means of a relatively low cost modification to the weather channel of existing ASRs which would allow them to detect low-altitude wind shear without interfering with their primary function of aircraft detection and tracking. An ASR-WSP testbed operated in Huntsville, Alabama, in 1987 and 1988; Kansas City, Missouri, in 1989; and most recently in Orlando, Florida, in 1990 and 1991. The 1992 demonstration was basically a continuation of the demonstrations started in the summers of 1990 and 1991.

The testbed, established by MIT/LL, was used to collect experimental data, establish operational algorithms, and provide user friendly products to the displays used by the supervisors/controllers in the Air Traffic Control Tower (ATCT) and the Terminal Radar Approach Control (TRACON). During the demonstration, the ASR-WSP utilized the Terminal Doppler Weather Radar (TDWR) display devices, providing essentially the same type of products as those provided by the TDWR.

METHOD

PARTICIPANTS.

Four supervisors, 1 air traffic assistant, and 19 controllers participated in the evaluation. An Orlando ATCT Plans and Procedures Specialist (PPS) administered the questionnaires to the participants.

TRAINING.

The MIT/LL provided training to ATCT and TRACON personnel before the demonstration started. They were taught to use and understand the ASR-WSP products provided on the Geographical Situation Display (GSD) and Ribbon Display Terminal (RDT). The PPS gave the participants a briefing prior to the administration of the questionnaire. A Technical Center representative was present to answer questions the first day the questionnaires were administered.

EQUIPMENT.

The following equipment (also used during TDWR testing) was used to present the weather products: (1) one GSD, two large RDTs, and one small RDT located at the tower cab, (2) one GSD and one large RDT located in the TRACON room, and (3) one GSD and one large RDT located in the training room.

Ribbon Display Terminal (RDT). The RDTs function as integrated readout devices retaining the LLWAS runway threshold and center field wind data, and providing alarms on ASR-WSP microburst detections near or on the runways, and in the approach and departure areas. This information is provided to air traffic control (ATC) in alphanumeric format. Two sizes were used; a 12" x 11.25" x 6" (small size) and a 15" x 15" x 6" (large size).

The alert warning messages were displayed on the RDTs in the following form:

Runway ID	Wind shear type	Expected loss/gain	Location 1st encounter	Threshold

For example:

19D	MBA	50K	2MD	320	14

is read as: runway 19 departure, microburst alert (MBA), expect 50 knot loss, encounter at 2 miles on departure, runway threshold winds at 320 degrees at 14 knots.

Geographical Situation Display (GSD). The GSD uses a Sun work station to display weather information to ATC supervisors and controllers. It functions as a situation display monitor and as an air traffic (AT) planning tool for runway management. This color work station provides graphical representation of the location and intensity of precipitation, microbursts (MB) and gust fronts (GF), as well as estimates of the speed and direction of motion for precipitation cells and GFs.

EVALUATION QUESTIONNAIRE.

In order to obtain feedback from the users, ACW-200 developed a questionnaire (appendix A). The questionnaire was divided into specific areas regarding the RDT and GSD as well as some general aspects of the system. The questionnaire was structured to obtain the evaluation of the prototype ASR-WSP by rating a statement about each feature/function on a five-point scale ranging from very good to very poor, plus a do not know category for controllers who did not see a specific feature working. Comments were encouraged. Open-ended questions were also asked in order to obtain more feedback on specific features.

PROCEDURE.

The prototype ASR-WSP evaluation took place at the Orlando International Airport (MCO) ATCT. On June 15, 1992, two representatives of the FAA Technical Center met with Orlando Tower representatives and it was agreed that the PPS would administer the questionnaires during the daily briefing for 7 consecutive days.

The FAA Technical Center provided the Orlando PPS with adequate copies of the questionnaires. The PPS distributed and collected these questionnaires during the daily briefings in August and then returned them to the FAA Technical Center for analysis.

ANALYSIS.

The questionnaire responses were assigned numerical values (-2 = very poor to 2 = very good and ? = do not know) and the mean response and standard deviation was computed for each questionnaire item. The means and standard deviations were analyzed to determine whether the controllers felt that the equipment and weather products provided by the ASR-WSP met their operational suitability needs. The responses to open-ended questions and comments were analyzed for content and to provide additional controller feedback (appendix B).

RESULTS AND DISCUSSION

Twenty-four persons participated in the evaluation: 4 supervisors, 1 air traffic assistant and 19 controllers. The mean, standard deviation, and number of respondents for the RDT and GSD sections of the questionnaire are presented in tables 1 and 3. The RDT responses and GSD responses are presented in tables 2 and 4, respectively.

RIBBON DISPLAY TERMINAL (RDT).

Table 1 contains the number of respondents, mean value and standard deviation for the RDT responses. The mean value for every feature fell in the good category, with the accuracy of the displayed MB information having the lowest mean rating at 0.947 (standard deviation = 0.999) and the clarity of the displayed information, the highest at 1.330 (standard deviation = 0.720). The following scale was used to rate features from very poor to very good: very poor = -2, poor = -1, fair = 0, good = 1, and very good = 2. Table 2 shows clearly that most of the respondents rated every feature good or better. An impressive 50 percent of the participants rated the usefulness of the displayed MB information as very good and 43 percent did the same with completeness of displayed information. On the other hand only 24 percent thought that the accuracy of the displayed GF information was very good although 52 percent thought it was good. The GF algorithm has always been thought as the least reliable feature of the ASR-WSP and a weakness of this system especially the GF prediction. Two examples of controllers' comments that reflect that feeling are: (1) gust front prediction is not accurate and, (2) the quality of the gust front prediction needs to be brought to the TDWR standard.

Number of respondents, mean and standard deviation on question No. 1 of the RDT.

TABLE 1. QUESTION NO. 1 ON THE RDT

QUESTION NO. 1	NUMBER OF RESPONDENTS	MEAN	STANDARD DEVIATION
A. Completeness of the displayed information	23	1.260	0.847
B. Accuracy of the displayed microburst information	22	0.947	0.999
C. Accuracy of the displayed gust front information	21	1.050	0.760
D. Timeliness of the displayed information	22	1.270	0.750
E. Usefulness of the displayed microburst information	24	1.300	0.910
F. Usefulness of the displayed gust front information	22	1.280	0.770
G. Clarity of the displayed information	21	1.330	0.720
H. Aptness of message abbreviations	22	1.230	0.730

TABLE 2. RDT RESPONSES

Total RDT responses and ratings for question No. 1

QUESTION NO 1						
	Very Poor -2	Poor (-1)	Fair (0)	Good (1)	Very Good (2)	Do not know
A.	0	2	0	11	10	0
B.	0	3	1	9	6	3
C.	0	1	2	11	5	2
D.	0	1	1	11	9	0
E.	0	2	1	8	12	1
F.	0	1	1	10	9	1
G.	0	1	0	11	9	0
H.	0	1	1	12	8	0

GEOGRAPHICAL SITUATION DISPLAY (GSD).

The number of respondents, mean value and standard deviation for the GSD responses are presented in table 3.

Overall, the mean values, although slightly lower than the RDTs, also fell in the good category. Accuracy of the displayed GF information received a low 0.69 mean rate (standard deviation = 0.810) and accuracy of displayed MB information a 0.86 (standard deviation = 1.100). Both ratings fell between the fair and good category. There is a feeling that the GSD MB and GF information, although very useful, is not as accurate as it should be. On the other hand, 11 of 24 respondents thought that the completeness of the displayed information was very good and 9 rated it as good. It was also made clear by the participants, especially supervisors, that the GSD is an extremely useful tool for runway management. Comments like very useful, good lead time and you have a better lead time for runway changes are two examples of good reviews given by two supervisors.

Number of respondents, mean and standard deviation on question No. 1 of the GSD section.

TABLE 3 QUESTION NO. 1 ON THE GSD

QUESTION NO. 1	NUMBER OF RESPONDENTS	MEAN	STANDARD DEVIATION
A. Completeness of the displayed information	24	1.210	0.910
B. Accuracy of the displayed microburst information	24	0.860	1.100
C. Accuracy of the displayed gust front information	24	0.690	0.810
D. Timeliness of the displayed information	24	1.080	0.760
E. Usefulness of the displayed microburst information	24	1.040	0.940
F. Usefulness of the displayed gust front information	24	1.000	0.760
G. Usefulness of wind shift prediction	23	1.130	0.800

TABLE 4. GSD RESPONSES

QUESTION NO 1						
	Very Poor -2	Poor (-1)	Fair (0)	Good (1)	Very Good (2)	Do not know
A.	0	2	2	9	11	0
B.	1	2	3	9	7	2
C.	0	2	6	12	3	1
D.	0	1	3	13	7	0
E.	0	3	1	12	8	0
F.	0	1	4	13	6	0
G.	0	1	3	11	8	0

GENERAL.

Forty percent of the participants thought the ASR-WSP is very useful, especially the GSD, for runway management. The remaining 60 percent rated the usefulness for runway management as good.

When asked if they see the ASR-WSP as a help or a hindrance in their jobs of controlling traffic, only 9 percent thought that it does not make any difference. Fifty-four percent see the ASR-WSP as great help, 36 percent as some help.

Thirty-five percent of the participants would like to see the system installed as it is for operational use, 52 percent thought few changes are still needed, and two individuals thought that the system is unsuitable for operational use, one going as far as saying that the entire concept is inappropriate.

CONCLUSIONS

The evaluation of the Massachusetts Institute of Technology Lincoln Laboratories (MIT/LL) prototype Airport Surveillance Radar Wind Shear Processor (ASR-WSP) by the Orlando International Airport controllers and supervisors provided significant input on the operational suitability of the Ribbon Display Terminal (RDT) and Geographical Situation Display (GSD) and usefulness of the weather products provided by the system in an operational environment. Some of the significant findings are:

1. In general, the system is very useful.

2. The completeness, timeliness, and usefulness of the displayed information for both gust fronts (GF) and microbursts (MB) (RDT and GSD) and the clarity of the displayed RDT information are good.

3. Supervisors found the GSD very helpful in making runway configuration changes prior to weather events.

4. The general feeling is that the system still produces a slightly high amount of false alarms, especially GFs.

RECOMMENDATIONS

The Orlando, air traffic control (ATC) personnel have accepted the prototype Airport Surveillance Radar Wind Shear Processor (ASR-WSP) as a functional radar system capable of meeting their operational needs. However, there are some features that need improvement. It is Orlando's ATC opinion that the gust front (GF) prediction feature needs to be refined. The system is still generating several false alarms. The controllers also feel that the GF and microburst (MB) detection accuracy could be improved. It is recommended that more testing be performed in the future and this feature be corrected.

ACRONYMS AND ABBREVIATIONS

ASR-9	Airport Surveillance Radar No. 9
ASR-WSP	Airport Surveillance Radar Wind Shear Processor
AT	Air Traffic
ATC	Air Traffic Control
ATCT	Air Traffic Control Tower
E-LLWAS	Enhanced Low Level Wind Shear Alert System
FAA	Federal Aviation Administration
GF	Gust Front
GSD	Geographical Situation Display
MBA	Microburst Alert
MCO	Orlando International Airport
MB	Microburst
MIT/LL	Massachusetts Institute of Technology Lincoln Laboratories
PPS	Plans and Procedures Specialist
RDT	Ribbon Display Terminal
TDWR	Terminal Doppler Weather Radar
TRACON	Terminal Radar Approach Control

APPENDIX A

EVALUATION QUESTIONNAIRE

Tower____ Tracon____ Controller____ Supervisor____ (8/92)

GEOGRAPHICAL SITUATION DISPLAY (GSD)

Please answer question 1 using the following scale:
-2=very poor -1=poor 0=fair 1=good 2=very good ?=do not know.
If you did not work with a specific piece of equipment please skip the corresponding section.

1. Rate the following ASR-WSP features: (Please circle one)

a. completeness of the displayed information	-2	-1	0	1	2	?
b. accuracy of the displayed microburst information	-2	-1	0	1	2	?
c. accuracy of the displayed gust front information	-2	-1	0	1	2	?
d. timeliness of the displayed information	-2	-1	0	1	2	?
e. usefulness of the displayed microburst information	-2	-1	0	1	2	?
f. usefulness of the displayed gust front information	-2	-1	0	1	2	?
g. usefulness of wind shift prediction	-2	-1	0	1	2	?

2. Please state instances (if any) of wind shear that the system did not display:_____

3. Do you consider the rate of false alarms for microbursts acceptable? ____YES ____NO If NO explain. _____

4. Do you consider the rate of false alarms for gust fronts acceptable? ____YES ____NO If NO explain. _____

5. Provide comments on any rating of 0 or lower and/or any other comments on the role of the GSDs._____

6. Supervisors only: Was the GSD useful in making runway configuration changes prior to weather events? YES____ NO___. Please explain. _____

_____

_____

_____

RIBBON DISPLAY TERMINAL (RDT)

1. Rate the following features: (Circle one using the following scale: - 2 = very poor - 1 = poor 0 = fair 1 = good 2 = very good ? = do not know)

a.	completeness of the displayed information	-2	-1	0	1	2	?
b.	accuracy of the displayed microburst information	-2	-1	0	1	2	?
c.	accuracy of the displayed gust front information	-2	-1	0	1	2	?
d.	timeliness of the displayed information	-2	-1	0	1	2	?
e.	usefulness of the displayed microburst information	-2	-1	0	1	2	?
f.	usefulness of the displayed gust front information	-2	-1	0	1	2	?
g.	clarity of the displayed information	-2	-1	0	1	2	?
h.	aptness of message abbreviations	-2	-1	0	1	2	?

2. Please state instances (if any) of wind shear that the system did not display:_____

_____

_____

_____

3. Provide comments on any rating of 0 or lower and/or any other comments on the role of the RDTs._____

_____

_____

_____

_____

_____

GENERAL

1. Rate the usefulness of the ASR-WSP for runway management. (Circle one.) -2 -1 0 1 2 ?

2. Do you see the ASR-WSP as a help or a hindrance to you in your job of controlling local traffic ? (Circle one)

a. great help b. some help c. neither help nor hindrance
d. hindrance e. great hindrance f. do not know
Any comments? _____
_____
_____

3. What benefits do you see from the ASR-WSP?

_____
_____
_____
_____

4. What problems do you see with the ASR-WSP?

_____
_____
_____
_____

5. Based on your present knowledge, please rate the ASR-WSP's suitability for widespread operational use in the field. Please circle one of the letters.

a. suitable, install and use, do not make any changes.
b. suitable, install and use but some changes beneficial.
c. unsuitable, do not install, some changes necessary prior to installation.
d. unsuitable, do not install, good concept but extensive redesign necessary.
e. unsuitable, do not install, entire concept inappropriate.
f. do not know.

If you think that changes are necessary please list them.

_____
_____
_____
_____
_____

Please list here any other comments you have.

_____
_____
_____
_____

Your input is valuable, thank you for your cooperation.

APPENDIX B

RESPONDENTS COMMENTS

RIBBON DISPLAY TERMINAL (RDT)

2. Please state instances (if any) of wind shear that the system did not display.

"None observed"
"None noted"
"It usually happened the other way. I.E. ghost shear"
"None"

3. Provide comments on any rating of 0 or lower and/or any other comments on the role of the RDTs.

"Get rid of the ghosts"
"Again several cases where MBA of 40 kts or greater with pilot reports to the contrary"
"None"
"Smaller RDT's are great"
"No way to verify accuracy"

GEOGRAPHICAL SITUATION DISPLAY (GSD)

2. Please state instances (if any) of wind shear that the system did not display.

"None observed"
"Unknown"
"None noted"
"None"
"Don't know of any"
"None"
"Couple of times on rwy but they were 10 kts or below"
"7/17/92 indicated gust front and no weather activity was displayed-indicated 50 kt gust front for 5 mins then went to 10 kts LLWAS wind indicated 1210, WSP indicated WSA +15 kts - same day ASR-9 displayed level 3 weather 1 nm south of Orlando, WSP showed nothing"

3. Do you consider the rate of false alarms for microbursts acceptable?

"Marginally"
"Did not know of any false alarms"
"Numerous alarms of windshear +50 kts, +30 kts, etc., airborne aircraft plus other aircraft with wind direction equipment reported no windshear"
"There were several instances of MBA when pilot reports were to the contrary"
"There should be no false alarms"
"Don't have a good method to crosscheck"

4. Do you consider the rate of false alarms for gust fronts acceptable?

"Marginally"
"Did not know of any false alarms"
"There should be no false alarms"
"No way of verifying alarms"

5. Provide comments on any rating of 0 or lower and/or any other comments on the role of the GSDs.

"We average one error a week to a week and a half. Accuracy for a production with this kind of costs and development should be much better"
"Saw one instance of storm motion showing storms moving north but in actuality they moved northeast"
"Gust front prediction not accurate"
"The quality of the gust front prediction needs to be brought up to the TDWR standard"
"Need better display of wind shear and gust front"
"Accuracy has to be taken for granted no way to crosscheck from our position"

6. Supervisors only: Explain if the GSD was useful in making runway configuration changes prior to weather events.

"Gust front, storm motion"
"Based on gust front projection-storm movement"
"You have a better lead time for runway changes"
"Very useful, good lead time"

GENERAL

3. What benefits do you see from the ASR-WSP?

"Better planning and runway use, wx info to pilots"
"Real time display, change flow accordingly"
"Able to anticipate weather and answer questions"
"The obvious"
"Many"
"Runway changes"
"Helps to plan traffic flows"
"Managing runway changes"

4. What problems do you see with the ASR-WSP?

"None"
"None"
"Lack of speed"
"N.A."
"Cost overruns"
"Wrong readouts, useless information that was not accurate plus the inability of operator personnel from advising if the readouts were valid"
"Solve false alerts"
"None"
"Extra work - put displays in airplanes so people who really need the info get it"
"Sometimes trying to give us more information than needed"
"Ensuring alerts are accurate and pertinent information is displayed"

5. If you think that changes are necessary please list them.

"Insure speeds and projection lines are intact"
"Use doppler, more accurate system"
"Only changes to adapt to individual airports and bring the gust front up to the same standard as TDWR"
"Test reliability, verify accuracy"

List any other comments you have.

"TDWR appears somewhat better but more costly"
"Very good equipment"
"Hurry and get it on line"
"My use of the system is limited because I work ground control only"