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EVALUATION OF THE MASER-EQUIPPED RADAR SET AN/MPS-34 AND AREA PRECIPITATION MEASUREMENT INDICATOR

Report No. 2

Contract No. DA 28-043 AMC-01257(E)

DA Project No. 1V0.25001.Al26

SECOND QUARTERLY PROGRESS REPORT

1 July 1965 to 30 September 1965

Sponsored by
U. S. Army Electronics Command
Port Monmouth, New Jersey

Illinois State Water Survey
Atmospheric Sciences Section
at the
University of Illinois
Urbana, Illinois

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To evaluate the MASER-equipped AN/MPS-34 radar and Area Precipitation Measurement Indicator (APMI) for their meteorological usefulness to the Army.

Prepared by

R. E. Rinehart
Assistant Project Meteorologist

and

D. M. A. Jones
Project Meteorologist

G. E. Stout
Project Director

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PURPOSE

The purpose of this contract is to evaluate the capability of the MASER-equipped weather radar set AN/MPS-34 and the Area Precipitation Measurement Indicator (APMI) to operate as a highly sensitive meteorological sensing device and as a system for rapidly measuring, integrating, and displaying areal precipitation; determine what meteorological phenomena not detectable by other radar may now be detected, measured, and displayed by this equipment; and determine the general utility of these units for meteorological purposes.

ABSTRACT

Difficulties encountered with the APMI and progress in overcoming these problems are discussed briefly.

The MASER-equipped MPS-34 radar was operated during August near Magdalena, New Mexico, and 49-3/4 hours of data were collected of which 18 hours were on MASER mode. Nearly 700 feet of radar film collected on 19 days of operations are available for analysis. The MASER operation was limited by the occasional lack of helium, and for a short period by trouble with the pump klystron circuits.

An addition was made to the elevation control system to provide smoother scanning in the RHI mode and to permit the RHI mode to be photographed through the same indicator system as the PPI mode.

Analysis of data collected during August in New Mexico was limited to unusual echoes which appeared as coherent targets up to 42 db below full gain without the MASER operating. The conclusion is that these targets were birds.

PUBLICATIONS, LECTURES, REPORTS, AND CONFERENCES

On 31 July 1965 the AN/MPS-34 radar was shipped from the University of Illinois Airport at Savoy, Illinois, to Adam's Ranch located 10.5 miles SW of Magdalena, New Mexico, for a month of data collection in association with Mr. Charles B. Moore and Dr. Bernard Vonnegut of Arthur D. Little, Inc. E. A. Mueller and R. E. Rinehart maintained and operated the radar in New Mexico during August. The radar was returned to Illinois on 1 September.

On 17 August R. L. Robbiani visited the Meteorological Laboratory of the Illinois State Water Survey in Savoy, Illinois.

Between 20-27 August, R. L. Robbiani was in New Mexico for consultation with the operating personnel on the MASER operations.

INTRODUCTION

The activities of this quarter are divided into four groups: repair and preparation of the radar for data collection; data collection in New Mexico; preliminary analysis of data; and resumption of work on the Area Precipitation Measurement Indicator (APMI). The radar was prepared for data collection in July. The New Mexico

operation was carried out in August. During September analysis of data was initiated and additional work performed on the APMI. Because the recent work on the APMI is essentially unrelated to the other three phases, it is discussed first.

APMI OPERATIONS

During the last two weeks of September, work was resumed on the alignment and operation of the APMI in preparation for its connection with the MPS-34 radar. The various circuits contained in the APMI were inspected completely, and their proper functioning with the system as a whole was checked.

A camera has been mounted to photograph the tube display, and this installation is ready for film exposure tests. Focusing tests have been completed.

Plans to attach the APMI to the CPS-9 radar during the absence of the MPS-34 radar did not materialize, since the engineering staff of the Survey was involved in field projects at remote locations.

A number of difficulties were located and corrected in the APMI system. Triggering from the radar was erratic and unreliable because of improper polarity of the trigger, and this was corrected by adding a buffer amplifier. TWO disconnected diodes were found and repaired. At present the APMI is running properly on PPI mode, but not on the offset or B-scan modes.

It would seem that the original design of the APMI, which uses a 465.611 kc clock which is not synchronized to the radar transmitter, places an uncertainty of ±0.2 mile in the position in range of any integrating cell. The result is a smearing of the echo between cells. This has been noted with a signal generator input on the shorter ranges, but not on the longer ranges.

MPS-34 OPERATIONS

Preparation

One of the major preparatory activities during July was the addition of data-recording facilities to the MPS-34. These include a stepgain control with 10 gain steps, a VE Repeater-Indicator, and a 35-mm camera with control. The camera has a built-in data section which has lights to indicate the gain setting by the binomial number system, a 24-hour clock, a frame counter, and an area for written data. The system was tested and some data were taken before departure for New Mexico (without the MASER operating, however).

The MASER was put in operating condition just before departure to New Mexico. It is now standard tuning procedure to align the MASER magnet with respect to the MASER rubies. This is probably the primary cause of poor masering in the past, as well as in later operations.

The 30-liter liquid helium Dewar arrived in time to allow for initial testing and precooling before filling it. It was filled and then shipped in the MPS-34 van to provide helium in New Mexico until liquid helium became available there.

New Mexico Operation

Transporting of the MPS-34 radar van for New Mexico started 31 July, and it arrived at the site on Adam's Ranch 10.5 miles southwest of Magdalena on 3 August. By 6 August the radar was set up and the MASER aligned.

The MASER operated a total of 18 hours on 9 days while there. On 10 days without the MASER operating, 31-3/4 hours of data were collected. In general, the periods of data collection with the MPS-34 were limited to the periods of operation when Arthur D. Little, Inc., personnel were recording supplemental data. Table 1 shows the days on which data were collected with and without the MASER, and the hours of data collected each day. Nearly 700 feet of radar film were exposed in New Mexico.

Table 1. Time-Lapse Data Collection in New Mexico

Date (1965)	On-time (MST)	Off-time (MST)	Total on-time (hr;min)	MASER On
9 August	1125	1259	1:34	No
10 August	1148	1303	1:15	No
11 August	1402	1425	0:23	Yes
13 August	1130	1603	2:57	No
14 August	1230	1725	4:55	Yes
16 August	1020	1625	6:05	Yes
17 August	1017	1605	5:48	Yes
18 August	1050	1347	2:57	No
19 August	0937	1528	5:51	No
20 August	1220	1620	4:00	No
25 August	1220	1310	0:50	Yes
26 August	(Radar calibration using aluminum sphere)			Yes
28 August	1138	1423	2:45	No
29 August	1103	1521	5:l8	No
30 August	0805	1300	4:10	No
31 August	0933	1032	0:59	No

The use of the MASER was limited primarily by two causes: (1) days without liquid helium and (2) one period of trouble with the pump klystron circuits.

The helium shipped with the radar lasted only long enough for the initial tuning and aligning on 5-6 August. The first 100 liters of helium supplied by A. D. Little, Inc., lasted from 11 to 18 August, and the second 100 liters from 20 to 29 August. The first 100-liter Dewar provided five complete fills of the MASER Dewar, whereas the second provided eight. This difference probably can be attributed to the fact that liquid nitrogen was used to precool the MASER Dewar with the second 100 liters, but not with the first.

On 20 August the MASER failed to operate properly. After some checks on the system the pump klystron became suspect, but the problem proved to be a broken lead in the cable between the power supply and chassis of the pump klystron. This cable broke at least five times in the course of the repairs. Once the cable was repaired and a capacitor in the klystron power supply replaced, the klystron operated properly. The MASER was inoperative for about 4-1/2 days, including alignment time.

Even without the MASER operating, the MPS-34 was sensitive enough to detect ground clutter targets well above their actual heights, primarily because of the side lobe pattern of the antenna. Although the summit of South Baldy was geometrically at 8 statute miles range, 90° azimuth, and +6° tilt, it was detectable at tilt angles up to 20°. To reduce the effects of the antenna's side

lobes, a billboard-like obstruction was built and placed adjacent to the radar van so that it would block the direct view of South Baldy from the radar antenna. The upper 6 feet of its 10-foot width (total height about 20 feet from ground level) was covered with aluminum foil to block completely the passage of any microwave energy. The choice of position of the billboard in azimuth was governed primarily by the fact that the region of principal interest for the early detection of precipitation echoes was over the well-instrumented facilities of South Baldy.

One addition to the data collection facilities was completed in New Mexico. A selsyn motor, driven by a reversible direction motor, was connected to the MPS-34's elevation data system in such a way that it may be used to drive both the antenna and the selsyn in the VE Repeater-Indicator. RHI photographs are now possible using the VE either by (l) manually raising and lowering the antenna with the elevation hand crank, or by (2) using the motor-driven selsyn to adjust the antenna. The latter method provides smoother scanning than is possible with hand tilting, but the scanning at present is slower than desirable and this overexposes the film somewhat. Because this system is time-consuming to use, few RHI frames have been taken this way. It does, however, add considerable information about the vertical structure of the echoes.

Research Facilities

Other facilities besides the MASER-equipped MPS-34 radar were present in New Mexico for measurements of various types. Personnel

of the White Sands Missile Range had two experimental installations at the Adam's Ranch site. One was an M-33 radar equipped with a tunnel diode RF amplifier. The other was an acoustical network designed primarily for measuring various characteristics of the audio results of lightning. Both were in operation throughout the period of MPS-34 operations.

On Mount Withington, A. D. Little, Inc., (ADL) had instruments set up for recording and telemetering lightning information. On South Baldy, the control center for ADL operations and the location of the Langmuir Laboratory of the New Mexico School of Mines, numerous instruments were available for measuring most standard meteorological parameters as well as many parameters related to atmospheric electricity and lightning. Both ADL and the School of Mines had radars operating, the latter's also having a tunnel diode front-end.

ADL had cameras set up at three different locations, with one l6-mm and one 8-mm at each location. These were aimed at Mt. Withington and South Baldy to take time-lapse photographs of the cloud development over these mountain ranges during the daylight hours.

In addition to the fixed-site facilities, two types of airborne data collectors were being utilized by ADL. Balloons, although little used for data collection, were used for flying aluminum spheres for calibration purposes. One such flight on 26 August 1965 was used as a system calibration check for the

MPS-34. The second type of data collector was the two twin-engine Queenairs, supplied by the National Center for Atmospheric Research, Boulder, Colorado, which were equipped primarily for various atmospheric electricity measurements but took other standard meteorological measurements also.

Data collected at the other installations are to be made available for use with the data taken on the MPS-3[1]!-, if this should be desirable. These arrangements are also reciprocal.

Data Analysis

On 20 August very unusual echoes were noted on the radar scope for the first time. They appeared as many small echoes generally within 5 miles of the radar. They had a specular appearance and were given the descriptive name "speckles." They were fairly dense in number, appeared to be coherent targets, and some were fairly strong, remaining visible on the third gain step (42 db below full gain). When questioned, the Baldy Control personnel confirmed that these were on their radar also and that the echo characteristics were similar.

Visual observations revealed nothing unusual about the atmosphere. The skies were nearly clear with just a few clouds, mainly over the mountains. The personnel at the White Sands acoustic site noted nothing very unusual, except slightly more low frequency noise than normal and a 4° F temperature drop between 1200 MST and 1335 MST.

possible explanations of the echoes include small-scale turbulence, birds, and insects. 20 August was one of the few days when many insects were observed while personnel were working on top of the MPS-34 van.

The appearance, motion, and density of the speckles on the first day of observation, as well as upon subsequent days, has led to the tentative conclusion that these echoes are from birds. Mr. Frank Bellrose, Aquatic V/aterfowl Specialist with the Illinois State Natural History Survey, who is currently conducting research in the radar tracking of birds, agreed with the conclusion. He stated that the density of the echoes is in agreement with his observations that the number of birds observed by radar is greater than would be expected from visual observations from the ground.

Several speckles were tracked through use of radar film data. The results of the movements of nine of the speckles on 20 August 1965 are given in Table 2. It should be emphasized that the speckles chosen for analysis were probably the exceptional ones in terms of speeds and directions. That is, some were chosen because of their obviously slow or fast speeds; others were chosen to show that the speckles moved in various directions rather than a uniform direction. Thus, the values given in Table 2 should not be taken as representative or averages but only as examples. The range of speeds from 3.3 to 38 mph is entirely within the range possible by birds in the area. Speckles at heights of up to 15,000 feet, as measured from the RHI photographs taken on the

film, are also explainable as birds. Even the seemingly high densities of up to 36 speckles per square mile (at an average height in this case of 5,500 feet above the radar) can be accounted for by birds.

Perhaps one reason for the detection of such an abundance of birds was the relatively high tilt angles that were being used to avoid ground clutter. Data were taken near 15° tilt generally. In less mountainous terrain where blocking is not a problem and low tilt angles may be used for long-range target detection, the possibility of the detection of bird targets at the ranges beyond ground clutter is less likely. For instance, the maximum slant range of detection for the speckles during the New Mexico operational period was 5-8 miles; the normal ground clutter range for the AN/CPS-9 at the Meteorological Laboratory in Illinois is about 25 miles. It will be interesting to determine whether bird targets will be detectable beyond the 25-mile range in Illinois with the MASER in the system of the MPS-34. Higher tilt angles will also be employed for a comparison with the New Mexico observations. It may be that there actually were more birds to be detected in the immediate area in New Mexico than in other areas of radar observation, because the local terrain may have been channeling updrafts carrying the insects upon which the birds feed into a preferred area near the radar.

Table 2. Time-Distribution and Movement of Selected Speckles on 20 August 1965

Speckle number	Time of detection (MST)	Time of disappearance (MST)	Duration (min:sec)	Speed (mph)	Direction (degrees of azimuth)
1	1347:10	1358:40	11:30	4*	130 at start 90 at end
2	1352:40	1400:30	7:50	8	136
3	1353:40	1356:55	3:15	22	290
4	1402:05	1408:50	6:45	18	286
5	1407:40	1409:15	1:35	3	54
6	1408:50	1419:00	10:50	5	184
7	1420:00	1422:50	2:50	23	118
8	1421:55	1426:10	4:15	7	166
9	1427:40	1429:30	1:50	38	218

*This speckle curved; the speed given is between end points.

CONCLUSIONS

The MASER-equipped MPS-34 is now capable of automatic data collection in the PPI mode of operation and of manual data collection in the RHI mode. Upon completion of work on the APMI circuitry and data recording system, the APMI will be attached to the MPS-34.

The New Mexico operations, while not allowing for continuous MASER data collection, did provide a reasonable amount of data taken with and without the MASER. Addition of the data taken by Arthur D. Little, Inc., should augment the usefulness of the data obtained.

Although some additional time may be spent in the analyses of speckle echoes, it is concluded that the speckles detected by the MPS-34 were birds. From the radar data the speeds, directions of travel, height, and densities of the birds are readily determined.

PROGRAM FOR NEXT INTERVAL

Data collection will be one of the primary goals during the next quarter. The APMI should be ready shortly and will be used for comparisons, both with step-gain radar data and with raingage network data. Several modes of operation will be tried to obtain various combinations of data from the APMI, MPS-34, and/or MASER-equipped MPS-34. Because of the field trip to New Mexico, the period of intensive operations planned for the Second Quarter will be carried out during the Third Quarter.

Analysis of the bulk of the New Mexico data will probably take place after receipt of the supplementary data from other groups operating there during August. Some further analysis of the speckles will be done to complete this phase.

As Illinois data become available, analysis will be carried on during slack periods of data collection.

A complete listing of personnel engaged during the first and second quarters is as follows:

Name and Title	Starting date	Hours Worked 1st Qtr.	Hours Worked 2nd Qtr.	Terminated
G. E. Stout Project Director	4/1/65	24	40	
E. A. Mueller Project Engineer	4/1/65	60	127	
D. M. A. Jones Project Meteorologist	4/1/65	40	160	
R. E. Rinehart Assistant Project Meteorologist	4/26/64	380	510	
D. W. Staggs Electrical Engineer	4/1/65	120	280	
Morton L. Epstein Meteorological Aide II	6/22/65	40	510	
Bradley C. Halter Research Assistant	5/3/65	370	245	8/16/65

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