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NMFS-SEFC-13

EVALUATION OF A QUARTERWAVE STUB ANTENNA FOR TIROS SATELLITE APPLICATION

LAWRENCE B. STOGNER

June 1980
U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Center
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U.S. DEPARTMENT OF COMMERCE
Philip M. Klutznick, Secretary
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Richard A. Frank, Administrator
National Marine Fisheries Service
Terry L. Leitzell, Assistant Administrator for Fisheries

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SUMMARY

The capability of a marine mammal transmitter to provide data to a satellite receiver to calculate accurate position information was demonstrated using the NIMBUS random access measurement system (RAMS). However, NIMBUS is nearing the end of its design life, and emphasis is being shifted to TIROS which has a similar acquisition system but will require modifications to the transmitter package. The NIMBUS sensor requires 980 m sec to complete an up-link, while the TIROS system will require only 360 m sec, which should improve system performance because of the uncertain dolphin breathing cycle.

The TIROS-N quarter-wave stub antenna communicated accurate position locations during low power level operations based on data processed by the Local User's Terminal (LUT) and Service ARGOS. This style of antenna is essential for use with a small, portable package, and is ideally suited for use on the marine mammal transmitter package. The antenna gain and radiation pattern (3.5 dBi gain from approximately 30° above the horizontal plane) and vertical polarization enhance the applicability. However, for marine mammal transmitter applications, a spring at the base of the antenna is required to provide flexibility and protection to the animal, and the antenna must serve as a seawater sensor requiring it to be insulated from the seawater environment except at the sensory location. These problems appear to have been solved for the NIMBUS system, and the TIROS system will be designed accordingly.

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INTRODUCTION

A cooperative program involving the National Fisheries Engineering Laboratory (NFEL), Southwest Fisheries Center (SWFC), National Data Buoy Office (NDBO), and National Aeronautics and Space Administration (NASA) was initiated in FY 1977 to develop a satellite-linked dolphin tracking system. A prototype system was designed to operate through the random access measurement system (RAMS) aboard NIMBUS-6 for up to one year. Subsequent test and evaluation activities indicated the concept was feasible.

The NIMBUS-6 system is nearing the end of its design life, and potential users are being directed toward the TIROS-N acquisition system operated by the French Service ARCOS. This has been known since the inception of the program, and the objective of transmitting through TIROS-N has been documented. Modifications to the transmitter and antenna assemblies are required to facilitate use with the TIROS system. This report documents the evaluation of a quarterwave stub antenna for use on the marine mammal transmitter and its compatability with TIRO-N requirements.

One side benefit to be derived from the conversion from NIMBUS to TIROS is that the data transmit period will be reduced from 980 m sec to 360 m sec. This will aid data acquisition because the normal breathing cycle of the animals has been determined to be less than optimal for completing data up-links with the NIMBUS-6 system.

Development of a marine mammal transmitter requires consideration be given to a system design that does not impair normal behavioral patterns of the animal, can operate efficiently in the ocean environment, and can satisfy operational requirements. The objective of this evaluation was to assess the quarterwave stub antenna to determine its operational limits when operated under conditions similar to the expected environment.

BACKGROUND

The Southwest Fisheries Center has overall responsibility for the porpoise tracking project and assumed the responsibility of corresponding with the French Service ARGOS for authorization to transmit over the TIROS-N satellite system and for data processing by Service ARGOS. Four platform identifications were issued by Service ARGOS to the Southwest Fisheries Center; two of which *were* used during the antenna evaluation.

On December 10, 1979, NFEL sent a Telex message to M. Roland of Service ARGOS in Toulouse, France, stating that NFEL intended to put two transmitter packages on the air, using the assigned platform ID's. On December 13, 1979, a Telex was received from Service ARGOS which stated that no transmissions could be made through the satellite with transmitters that had not been type-certified. The transmitters had been type-certified by the NOAA Data Buoy Office for use during the FGGE project; however, the particular serial numbers had not been registered with Service ARGOS. The platforms were manufactured by the American Electronic Laboratories, Inc., and were type-certified on January 31, 1978 as DCP-III type. Registration forms for the two platforms were completed and sent to Service ARGOS on December 19, 1979.

NFEL made an overseas call on January 2, 1980, to Service ARGOS to determine the status of the request since permission had not been received. Verbal permission was granted at that time. Earlier, on December 12, 1979, a request was sent to the U.S. Coast Guard's Oceanographic Unit seeking assistance in receiving and processing data on their Local User Terminal (LUT). On January 3, 1980, a letter was received from the U.S. Coast Guard, offering assistance. The evaluation experiment started on January 7, 1980.

ANTENNA SELECTION

The antennas were fabricated and tested by Comant Industries, Inc., of Santa Monica, California. Comant built the antennas to operate on the TIROS-N assigned frequency of 401.65 MH_z in a vertical polarized quarter-wave configuration. A ground plane was provided by Comant that resembles the two-tube package configuration currently used for the NIMBUS version of the marine mammal transmitter.

Antenna radiation pattern tests performed by Comant used three rotational planes. A radiation pattern for an antenna is established by radiating RF energy at a known power level from an isotopic reference antenna. The reference signal is received by the test antenna at some RF power level. The measured RF power level is recorded in dBi (decibels) which is a logarithmic ratio of received signal level to the isotopic reference signal. The attitude of the reference antenna to the antenna being tested affects the actual amount of RF energy that is received by the test antenna. In each pattern plane, the test antenna is rotated 360° through one of the rotational attitudes.

Figure 1 depicts the test antenna aligned perpendicularly to the reference antenna; i.e, the source antenna is directly overhead. The received power level measurements are obtained at incremental points (every 5 degrees of rotation) as the test antenna is rotated in a pitch attitude. Figure 2 is a plot of signal levels received, and indicates a gain of 3.5 dBi. The plot shows that as the antenna is rotated, it causes the receiving element and ground plane to be rotated through the field of view of the isotopic reference antenna. This is indicated on the plot which shows a maximum gain of 3.5 dBi when the receiving element has an unobstructed view of the reference antenna to levels approaching zero when the ground plane blocks the view

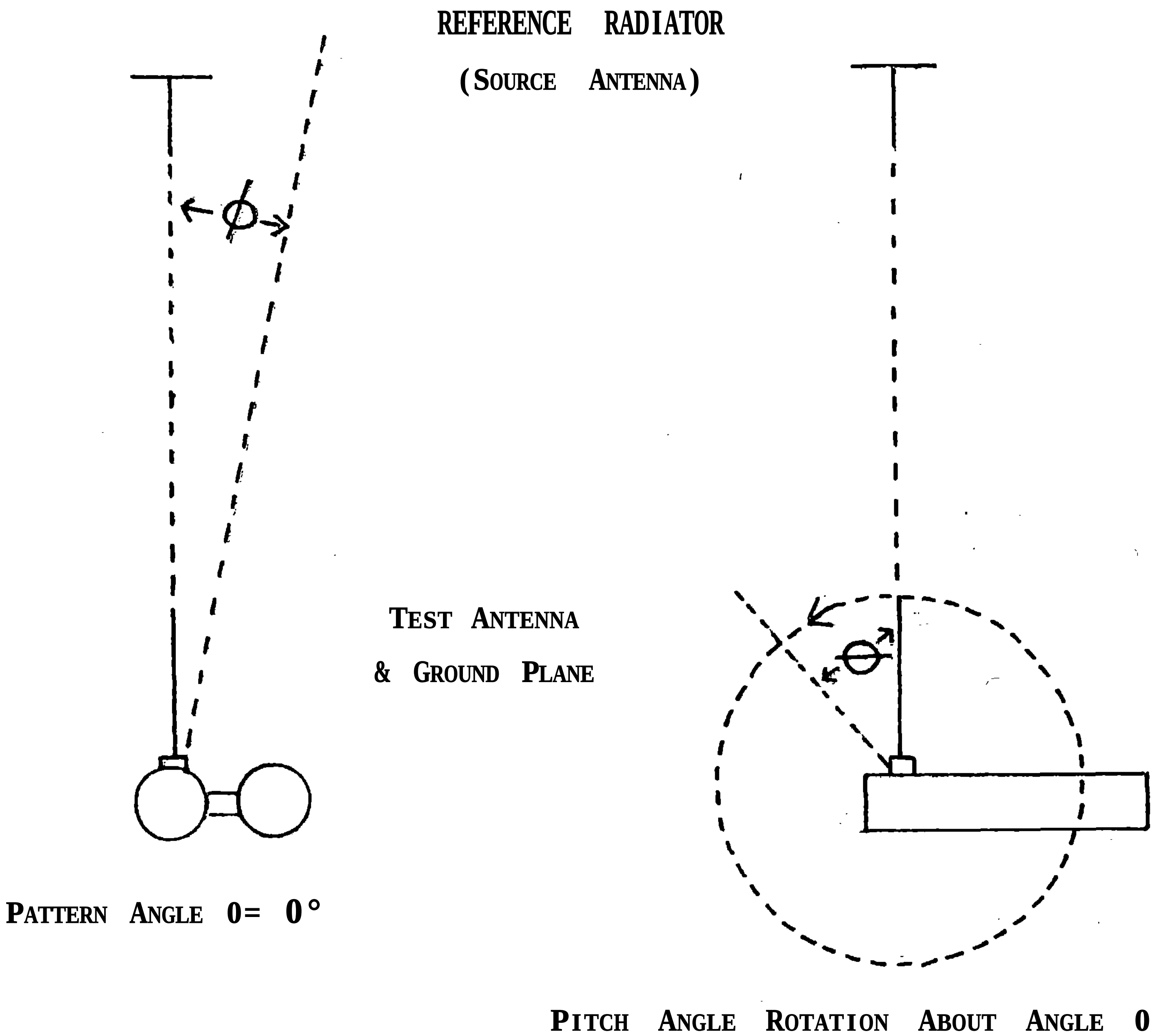
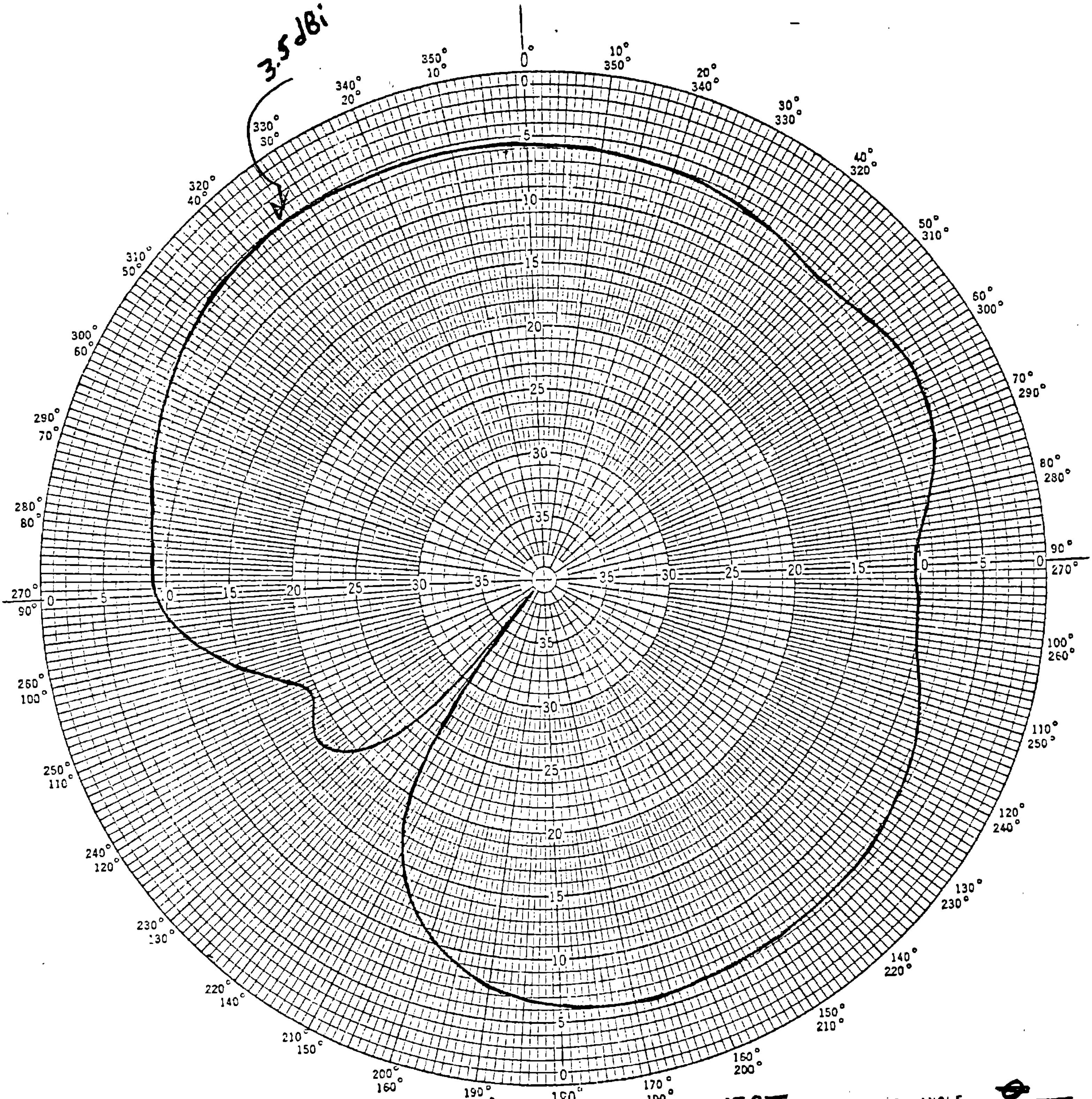


FIGURE 1. RADIATION TEST SETUP FOR PATTERN ANGLE 0= 0° WITH PITCH ROTATION ABOUT ANGLE 0

TRANSCO® PRODUCTS, INC.



ANTENNA TEST ANTENNA

SCALE ______ FREQUENCY 401.65

OPERATOR ______ DATE 2-11-79

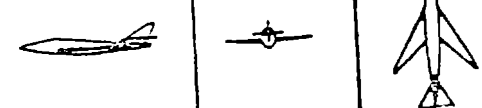
PE NO. ______ FILE NO. ______

POLARIZATION VERT VARIABLE ANGLE θ

PATTERN PLANE $\phi=0°$ GROUND PLANE ______

AIRCRAFT PATTERN PLANE ______

PITCH (✓) ROLL ( ) YAW ( )



between the receiving element and the reference antenna. The area behind or below the ground plane level is not used as a receiving element. The ground plane, however, is required as part of the overall receiving or transmitting antenna design, and its physical configuration contributes to the gain characteristics of the antenna. It serves as a reflector for the RF signal and intensifies, either positively or negatively, the RF signal level.

Figure 3 depicts the test antenna pitched forward 20° and rotated through the receiving antenna's plane. Figure 4 is the polar plot of the measured RF signal level as received by the test antenna. As in the pitch rotational plane, a gain of 3.5 dBi was obtained. This gain is reflected in the side lobes shown on the plot. The gain is diminished from approximately 30° to 150° as shown on the plot. The reduced gain in this region is reflective of the relative position of the ground plane as viewed from the reference antenna.

Figure 5 depicts the reference antenna at a right angle (90°) displacement to the test antenna. The test antenna in this pattern configuration was rotated in the roll plane about the center axis of the antenna. Figure 6 is the polar plot of the measured RF signal level received by the test antenna. This particular pattern and rotational plane, as expected, produced the least desired gain characteristics. The gain reflected in the side lobes was -1.5 dBi.

These are typical antenna pattern tests and represent what can be expected of the antenna in an operational configuration. If a three dimensional plot where constructed for this antenna, one might visualize the upper half as a mushroom and the lower half side lobes as a doughnut with the hole in the center representing zero power level.

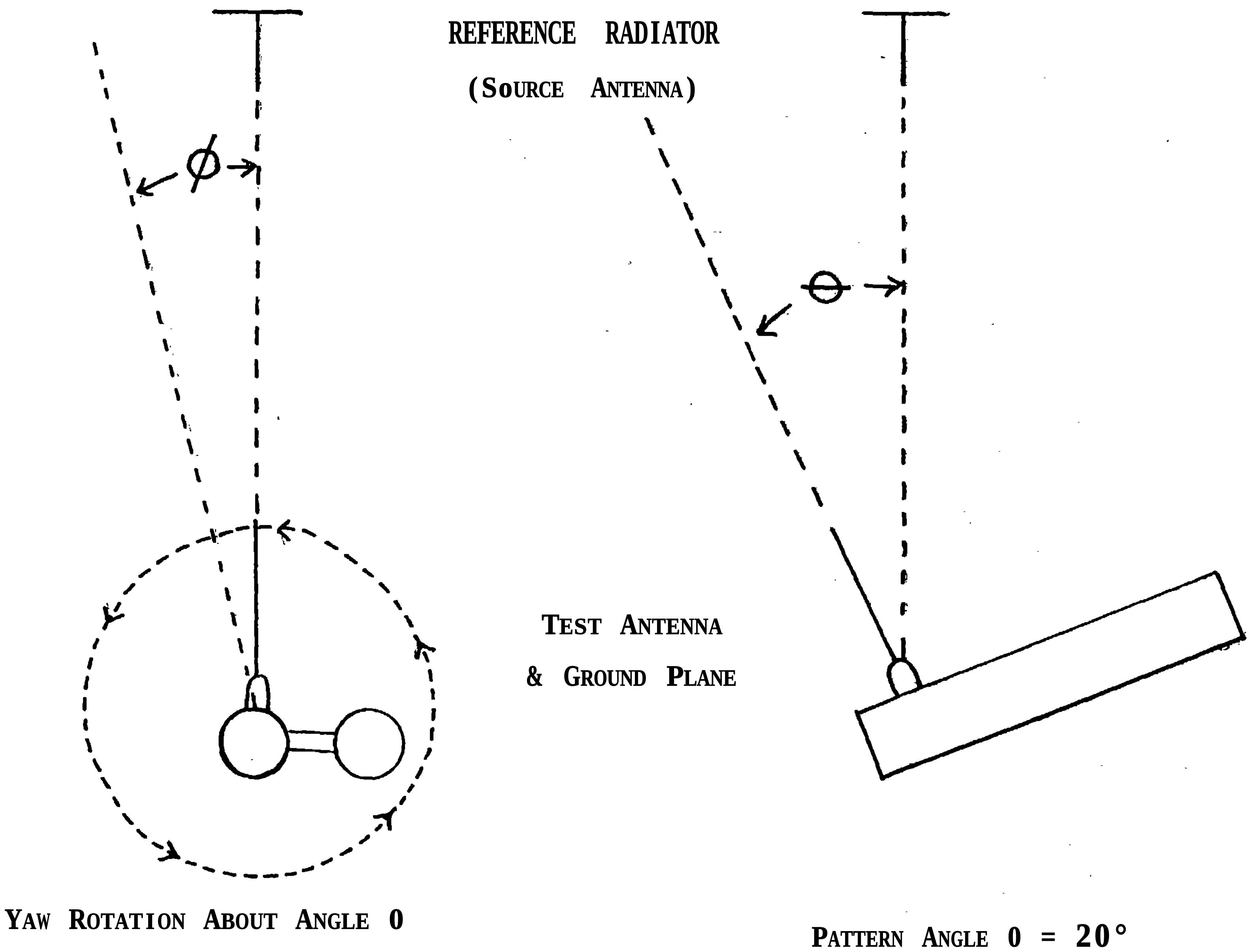
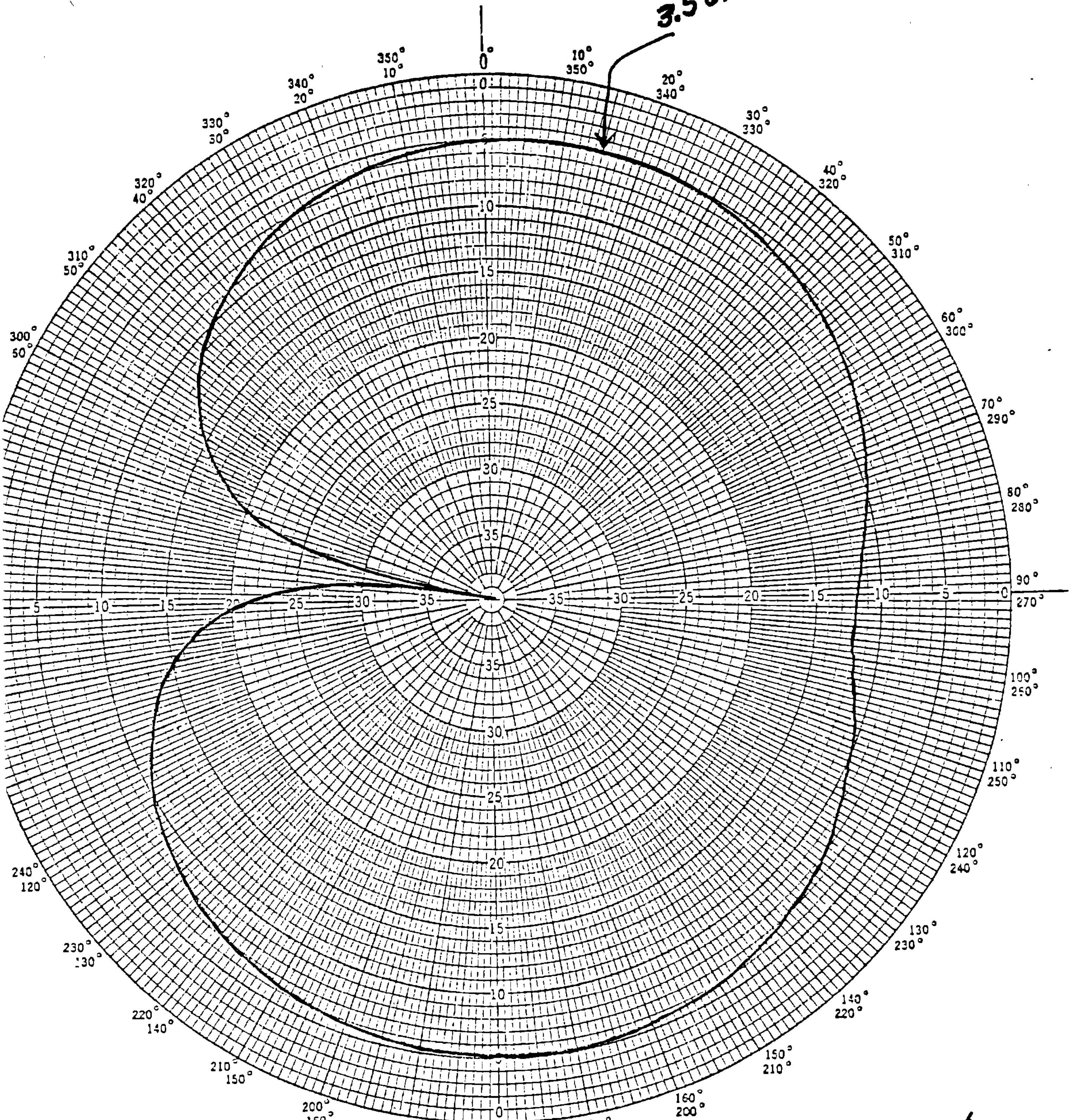


FIGURE 3. RADIATION TEST FOR PATTERN ANGLE 0 = 20° WITH YAW ROTATION ABOUT ANGLE 0.

TRANSCO PRODUCTS, INC.



ANTENNA TEST ANTENNA

FREQUENCY 401.65

DATE 2-11-79

FILE NO.

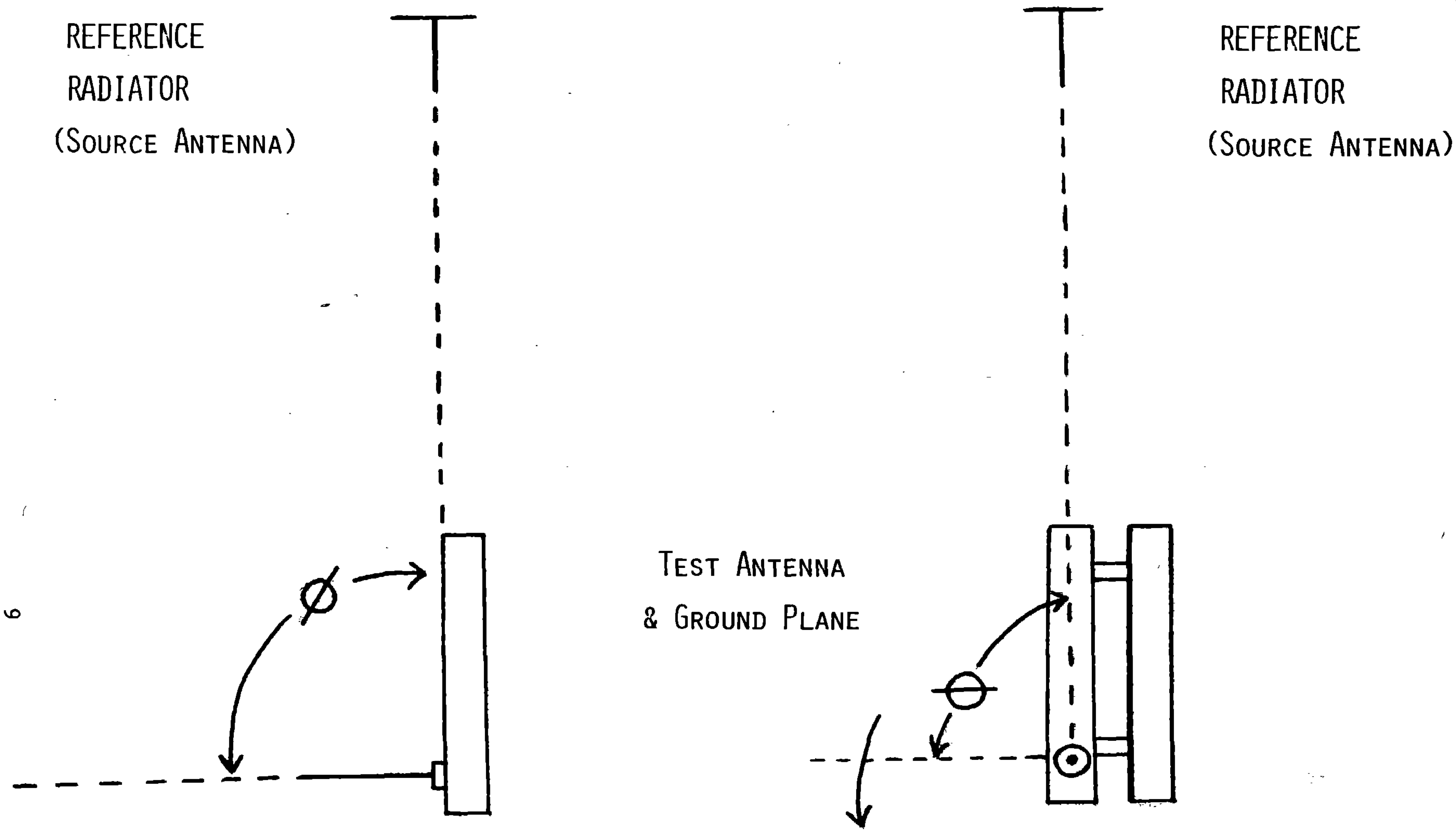
POLARIZATION VERT VARIABLE ANGLE ϕ

PATTERN PLANE θ=20° GROUND PLANE

AIRCRAFT PATTERN PLANE

PITCH ( ) ROLL ( ) YAW (✓)

FIGURE 4.

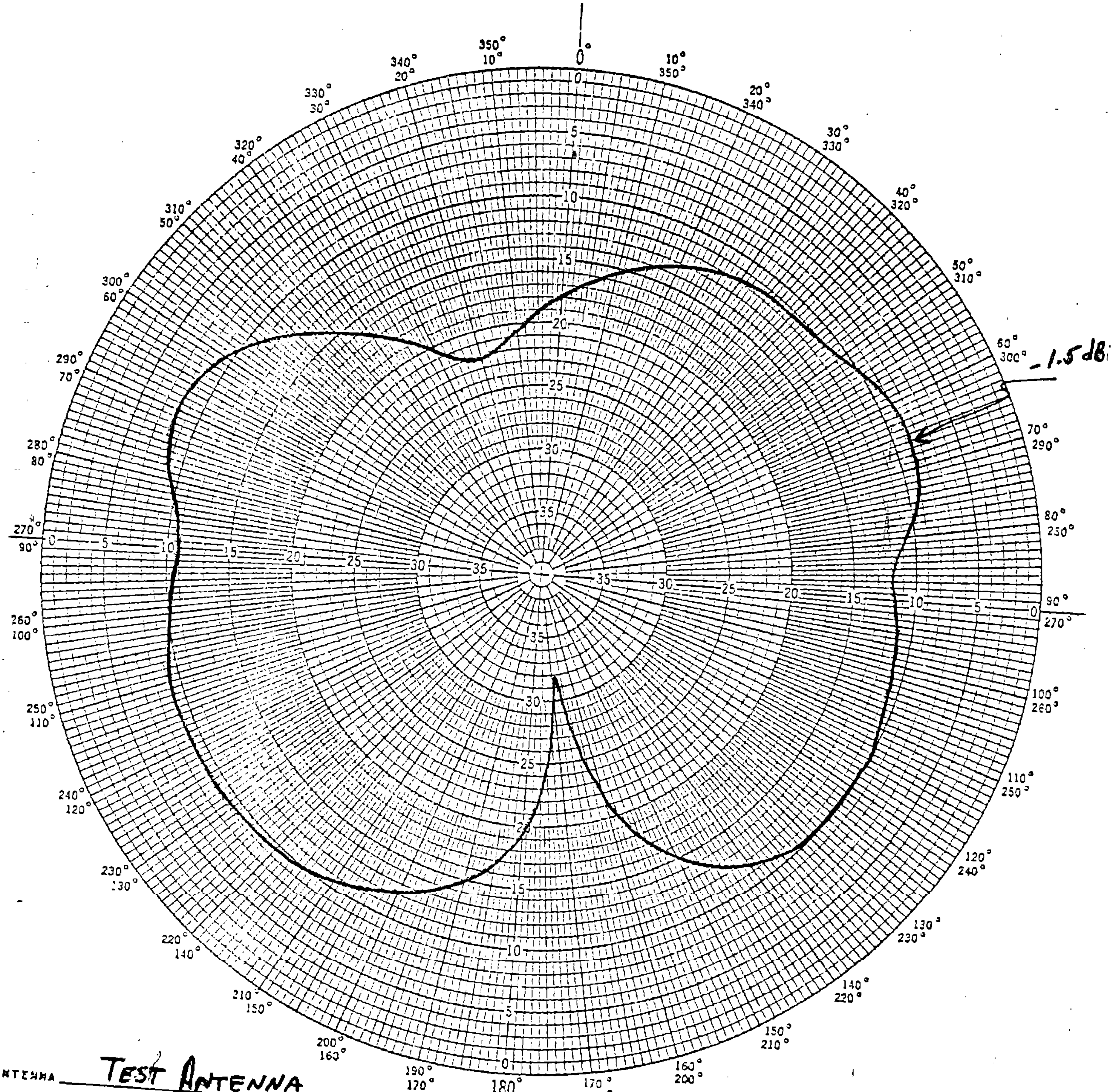


PATTERN ANGLE $\phi = 90^\circ$

ROLL ROTATION ABOUT ANGLE θ

FIGURE 5. RADIATION TEST SETUP FOR PATTERN ANGLE $\phi = 90^\circ$ WITH ROLL ROTATION ABOUT ANGLE θ

TRANSCO PRODUCTS, INC.



ANTENNA Test Antenna

SCALE ______ FREQUENCY 401.65 MHz

OPERATOR ______

PE NO. ______ DATE 2-11-79

FILE NO. ______

POLARIZATION VERT

PATTERN PLANE Ø=90°

VARIABLE ANGLE θ

GROUND PLANE ______

AIRCRAFT PATTERN PLANE ______

PITCH ( ) ROLL (✓) YAW ( )

Figure 6.

EVALUATION PLAN

The tests were performed at the National Space Technology Laboratories (NSTL) using the two American Electronics Laboratory (AEL) Data Collection Platforms (DCP's) as the transmitters for the evaluation study. Table 1 provides the device serial numbers, type certification, and assigned Service ARGOS identification codes.

DEVICE MFG.	DEVICE SERIAL NO.	CERTIFICATION	COMPUTER CODE	DEVICE HEX CODE
AEL	1 0 3	DCP-III	03201	3204C
AEL	108	DCP-III	03200	3201F

TABLE 1. TRANSMITTER IDENTIFICATION

Each DCP was equipped with identical quarterwave stub antennas, fabricated by Comant Industries. During this series of tests, one DCP, Service ARGOS computer code 03201, was established as the reference unit. The antenna for this DCP was mounted on a type N RF connector located in the center of an aluminum ground plane that measured approximately 18 inches square. The type N connector was terminated into a 50-ohm coax cable to facilitate the interface to the DCP transmitter. Transmitter power output from the reference unit was set at 33 dBm and remained at that level throughout the test period. The second DCP(ID 03200) was used as the test unit. The antenna for the test unit was mounted on one of two parallel aluminum tubes to simulate the TIROS-N version of the marine mammal transmitter system. The two tubes were one and one-half inches in diameter, ten inches in length, and were one inch apart along their parallel length. A type N RF bulkhead connector was located one inch from the end of one of the tubes. The type N connector was terminated into a 50-ohm coax to facilitate the interface to the DCP transmitter.

Figures 7 & 8 show the test setup as it appeared on the roof of Building 8201 at NSTL. The battery (a 12-volt automobile battery) and the two DCP's were uncovered during calibration and alignment procedures (Figure 7). The operational configuration used during the evaluation test is shown in Figure 8. The battery and both DCP's are covered with a waterproof box that is held in place by a heavy ladder. This configuration was required to allow easy access when required to make equipment modifications. For example, the power attenuation pads were changed every 5 to 6 days. Building' 8201 is located at the following grid coordinates: 30.378 North Latitude; 89.559 West Longitude.

Tests were initiated with both units operating at identical power output levels. The test unit remained at a given output level for 5 to 6 days before being lowered to a new power output. A total of four power levels were used during the course of the evaluation. The purpose of the tests were to determine if good positioning up-links to the satellite could be maintained with the transmitter operating below 0.5 watts (27 dBm) power output.

Data transmitted to the satellite were processed by Service ARGOS and the Coast Guard's Local User Terminal (LUT). Generally, data received and processed by the LUT. were available on a daily basis, while data processed by Service ARGOS took several weeks to obtain. Positioning accuracy could be determined at all transmitted power levels for both systems.

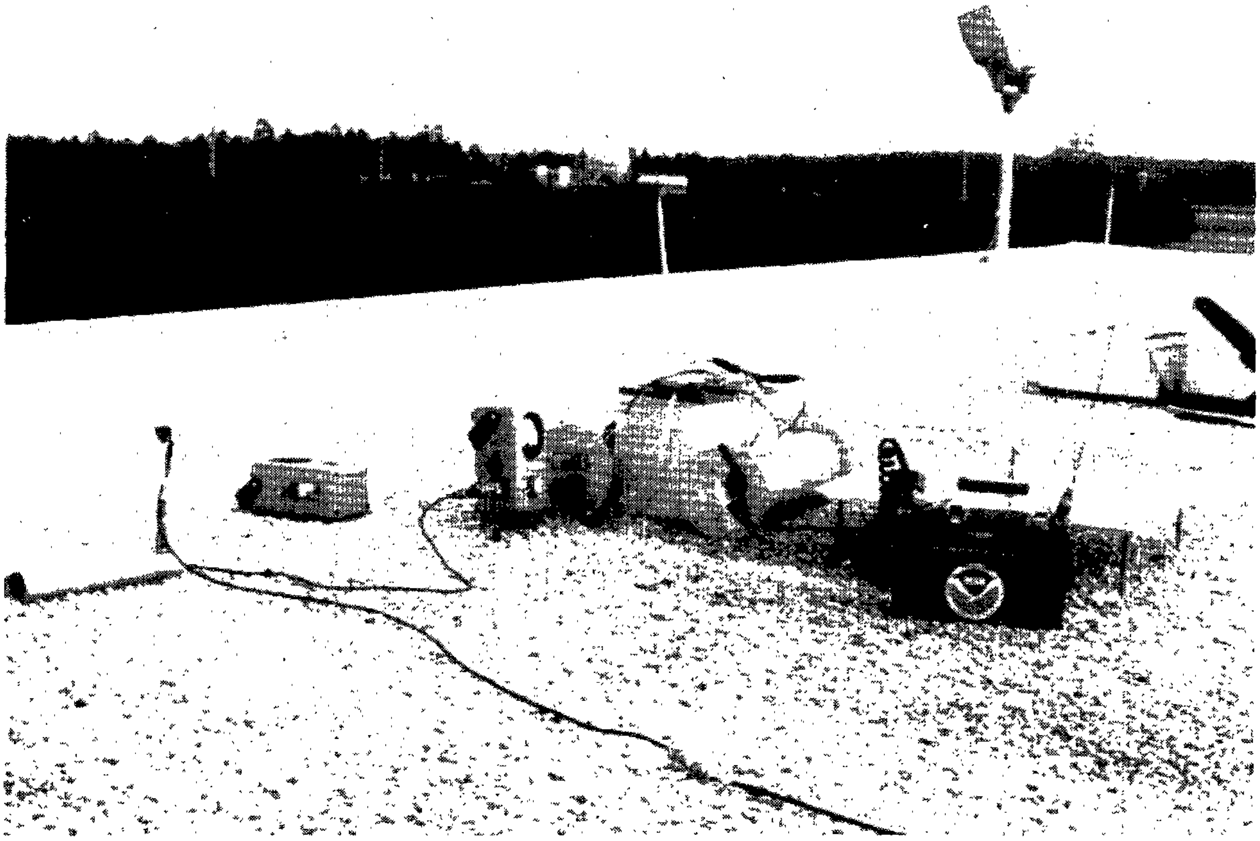


Figure 7. Alignment and checkout on roof of building 8201.

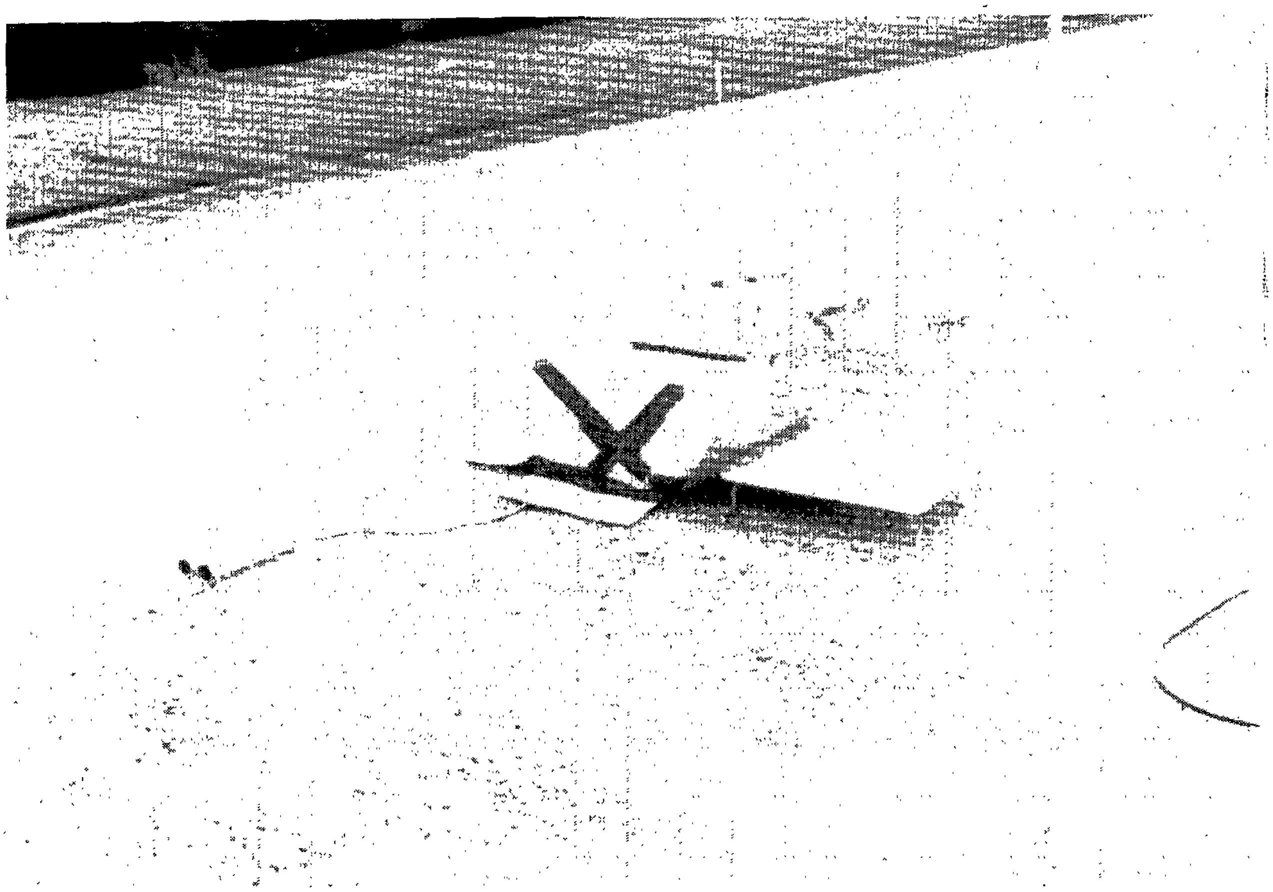


Figure 8. Operational setup on roof of building 8201.

EVALUATION RESULTS

Several minor problems occurred in the early test phases that prevented the system from functioning properly. In one incidence, one DCP was not programmed with the correct I/D and in another case, the DCP was not powered on. And, the Coast Guard had problems with the LUT's tracking antenna. These problems were resolved. The Coast Guard did experience other antenna failures during the course of the test period, however, no data were lost due to system down time,

The usual mode of operation was that the platforms were allowed to transmit at a given power level for several days. When data were received and processed by the LUT system, the information was phoned to NSTL. If data were missed because of problems, the system platforms were allowed to continue transmitting at the current power level until sufficient data had been obtained.

Data received and processed by the Local User Terminal (LUT) are shown in Tables 2 and 3. The data shown are a chronological listing of position fixes resolved by the TIROS-N satellite from transmitted signals received from both the reference platform (I.D 3201) and the test platform (I/D 3200). Table 3 shows that the data received from platform 3201 on l/31/80 diverged. Divergence occurs when the transmitted signal cannot be resolved by the down-link computer system. If the down-link station has a high quality reference signal with low residuals and the data received from the satellite has low residuals, then the down-link computer system generally has no problems converging the data and producing a high quality data point.

Time of reception is shown in Greenwich Mean Time or "z" time. The column labeled "Data Streams" indicates the number of data up-links received and processed by the satellite. The column labeled "Position Location"

TABLE 2. LOCAL USER TERMINAL DATA: TEST PLATFORM DCP 3200

DATE	TIME	PLATFORM I/D	DATA STREAMS	POSITION LOCATION	DEVIATION ERROR (feet)	POWER OUTPUT dBm	/ watts
1/16/80	0753Z	3200	6	30.38N 89.60W	687	33.8	2.4
1/17/80	0922Z	3200	11	30.38N 89.60W	687	33.8	2.4
1/19/80	0900Z	3200	12	30.38N 89.60W	687	33.8	2.4
1/18/80	1846Z	3200	8	30.39N 89.60W	3804	33.8	2.4
1/20/80	0849Z	3200	12	30.38N 89.60W	687	33.8	2.4
1/23/80	1357Z	3200	8	30.38N 89.60W	687	29.29	0.85
1/25/80	1312Z	3200	7	30.38N 89.62W	7386	29.29	0.85
1/27/80	1230Z	3200	6	30.38N 89.59W	3312	29.29	0.85
1/27/80	1410Z	3200	7	30.36N 89.62W	9316	29.29	0.85
1/27/80	2350Z	3200	10	30.37N 89.59W	4129	29.29	0.85
1/28/80	2328Z	3200	9	30.38N 89.60W	687	27.78	0.6
1/29/80	2307Z	3200	6	30.37N 89.60W	2559	27.78	0.6
1/30/80	0047Z	3200	8	30.38N 89.60W	687	27.78	0.6
1/31/80	0025Z	3200	No data received.				
2/1/80	0004Z	3200	4	30.38N 89.59W	3312	20.79	0.12
2/28/80	0015Z	3200	5	30.38N 89.60W	687	20.79	0.12
2/28/80	1234Z	3200	7	30.38N 89.60W	687	20.79	0.12
3/12/80	0032Z	3200	5	30.38N 89.60W	687	20.79	0.12

TABLE 3. LOCAL USER TERMINAL DATA : REFERENCE PLATFORM DCP 3201

DATE	TIME	PLATFORM I/D	DATA STREAMS	POSITION LOCATION	DEVIATION ERROR (feet)	POWER OUTPUT dBm	watts
1/19/80	1846Z	3201	5	30.37N 89.60W	2559	33.8	2.4
1/23/80	1357Z	3201	8	30.38N 89.61W	3874	33.8	2.4
1/25/80	1312Z	3201	6	30.38N 89.62W	7387	33.8	2.4
1/27/80	1230Z	3201	9	30.38N 89.60W	687	33.8	2.4
1/27/80	1410Z	3201	8	30.35N 89.62W	11533	33.8	2.4
1/27/80	2350Z	3201	13	30.37N 89.59W	4129	33.8	2.4
1/28/80	2328Z	3201	9	30.38N 89.60W	687	33.8	2.4
1/29/80	2307Z	3201	7	30.38N 89.60W	687	33.8	2.4
1/30/80	0047Z	3201	10	30.37N 89.60W	2559	33.8	2.4
1/31/80	0025Z	3201	14	Data diverged			
2/1/80	0004Z	3201	13	30.38N 89.59W	3312	33.8	2.4
2/28/80	0015Z	3201	10	30.38N 89.60W	687	33.8	2.4
2/28/80	1234Z	3201	10	30.38N 89.60W	687	33.8	2.4
3/12/80	0032Z	3201	11	30.38N 89.60W	687	33.8	2.4

indicates the position of the transmitting platform as determined by the satellite's on board electronics, using the doppler information derived from the transmitted signals from the platform and the satellite's ephemeris data. The column labeled "Deviation Error" indicates in feet how far the satellite's computed platform position location is from the actual location. The column labeled "Output Power" indicates the transmitted power output level for each of the platforms and is shown in dBm and watts.

Table 3 summarizes the data received and processed by the LUT over an eight-week period beginning January 15, 1980, and continuing through March 12, 1980. As previously stated, there were operational down times that necessitated longer operational periods at specified power output levels.

The LUT data for platform ID 3200 (the test unit) were processed and plotted as a distribution of satellite computed locations for latitude and longitude (Figure 9). The actual location of the platform is indicated by the "X". Note that the distribution chart has only eight locations plotted. Of the 17 locations resolved, ten are for the same position and have the least distance error. The average distance error is repeated for further clarification in Table 4, which also indicates that 88 percent of the resolved locations are less than a mile from the actual location. By similar comparison, 58.8 percent were only 687 feet from the actual location. These data are from the test system that produced transmissions at 0.12 watts.

Figure 10 shows of a plot of the 13 satellite computed locations for latitude and longitude for platform ID 3201 as received and processed by the LUT. Again, the actual location is indicated by the "X". Seven individual locations are plotted, since six are for the same position. Table 5 shows that 84.6 percent of the resolved locations are less than one mile from the actual location. Similarly, 61.5 percent were less than half a mile away, and 46.2 percent were only 687 feet from the actual location.

TABLE 4. SUMMARY OF LUT DATA.

TEST UNIT 3200		REFERENCE UNIT 3201	
No. Readings	Position	No. Readings	Position
9	30.38/89.60	6	30.38/89.60
2	30.38/89.59	3	30.38/89.59
1	30.38/89.61	1	30.38/89.61
1	30.38/89.62	2	37.37/89.60
1	30.37/89.59	1	30.37/89.59
1	30.39/89.60	1	30.35/89.63
1	30.36/89.62		
1	30.37/89.60		
Avg.	30.378/89/601	Avg.	30.376/89.60
Number of Passes	17	Number of Passes	14
Number of Data Streams	131	Number of Data Streams	133
Avg. No. of Data Streams Per Pass	7.7	Avg. No. of Data Streams Per Pass	9.5
Max. No. of Data Streams	12	Max. No. of Data Streams	14
Min. No. of Data-Streams	4	Min. No. of Data Streams	5

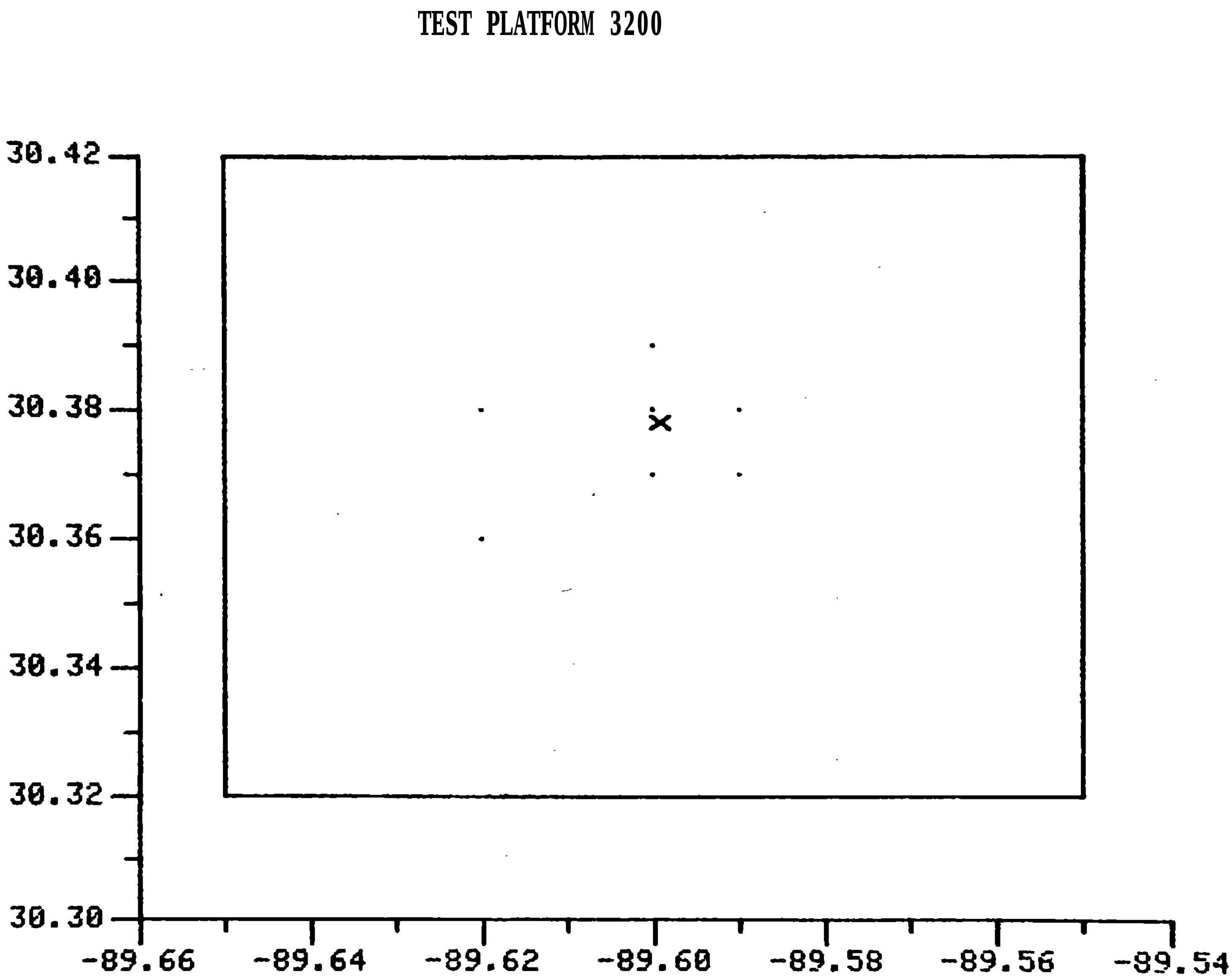


FIGURE 9. USCG USER TERMINAL DATA: DISTRIBUTION OF RESOLVED POSITION FIXES (ACTUAL POSITION IS MARKED AT 'X').

TEST PLATFORM 3200

AVERAGE DISTANCE ERRORS FOR 1/16/80-3/12/80

DATE	ERROR IN MILES	ERROR IN FEET
1/16/80	.130120	687.0350
1/17/80	.130120	687.0350
1/19/80	.130120	687.0350
1/19/80	.720391	3803.6640
1/20/80	.130120	687.0350
1/23/80	.130120	687.0350
1/25/80	1.399039	7386.9241
1/27/80	.627228	3311.7636
1/27/80	1.764447	9316.2788
1/27/80	.781918	4128.5262
1/28/80	.130120	687.0350
1/29/80	.484677	2559.0950
1/30/80	.130120	687.0350
2/ 1/80	.627228	3311.7636
2/28/80	.130120	687.0350
2/28/80	.130120	687.0350
3/12/80	.130120	687.0350

TABLE 5. USCG LOCAL USER TERMINAL DATA: AVERAGE DISTANCE ERRORS OF RESOLVED POSITION FIXES FROM ACTUAL POSITION,

REFERENCE PLATFORM 3201

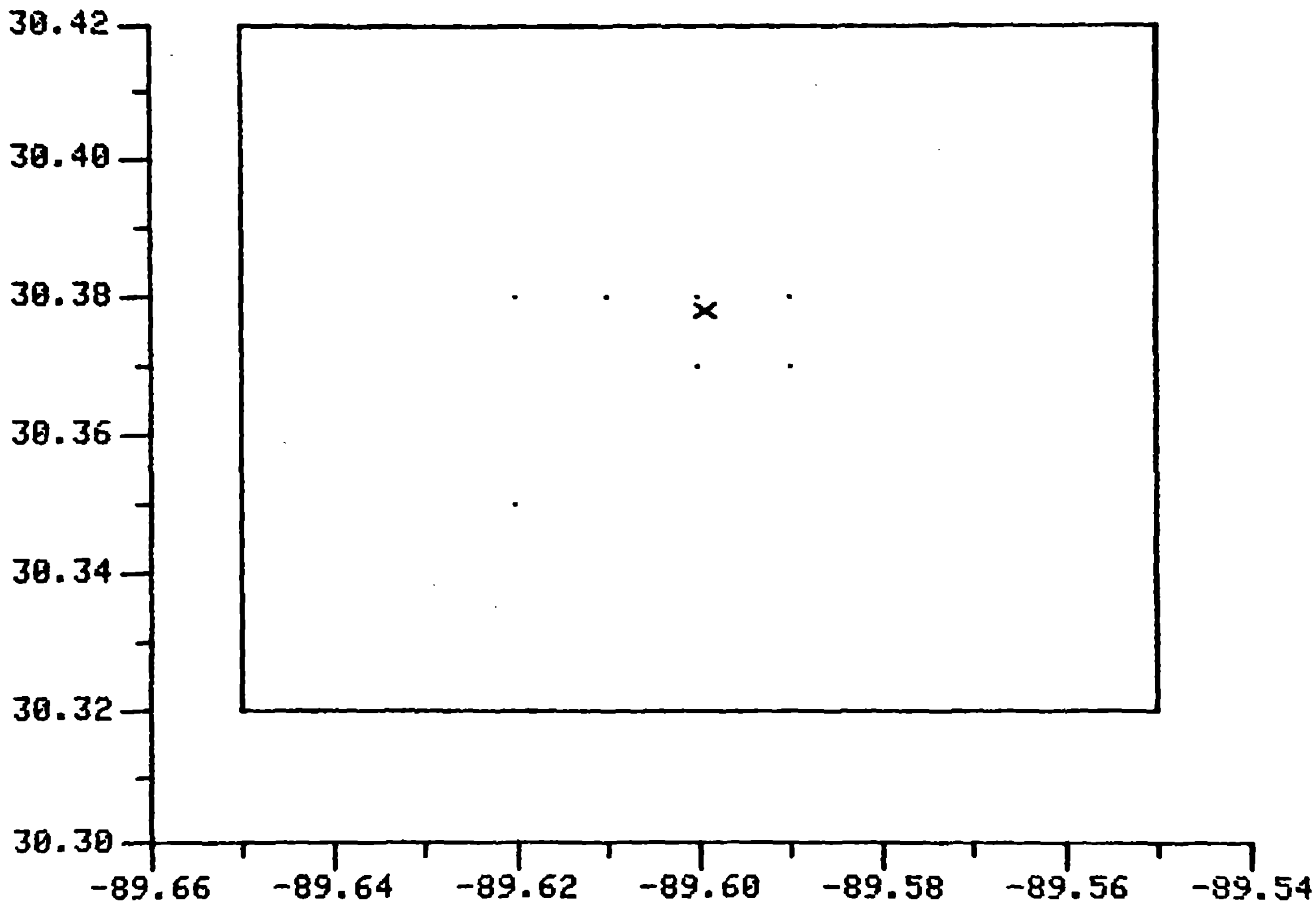


FIGURE 10. CSCG LOCAL USER TERMNAL DATA: DISTRIBUTION OF RESOLVED POSITION FIXES (ACTUAL POSITION IS MARKED AT 'X').

REFERENCE PLATFORM 3201

AVERAGE DISTANCE ERRORS FOR 1/19/80-3/12/80

DATE	ERROR IN MILES	ERROR IN FEET
1/19/80	.484677	2559.0950
1/23/80	.733619	3873.5061
1/25/80	1.399039	7386.9241
1/27/80	.130120	687.0350
1/27/80	2.184320	11533.2092
1/27/80	.781918	4128.5262
1/28/80	.130120	687.0350
1/29/80	.130120	687.0350
1/30/80	.484677	2559.0950
2/ 1/80	.627228	3311.7636
2/28/80	.130120	687.0350
2/28/80	.130120	687.0350
3/12/80	.130120	687.0350

TABLE 6. USCG LOCAL USER TERMINAL DATA: AVERAGE DISTANCE ERRORS OF RESOLVED POSITION FIXES FORM ACTUAL POSITION,

Due to operational problems during the early stages of the evaluation, there were less data transmitted from the reference unit. However, data that were transmitted, received and processed were of high quality and data missed during the early phases of the test did not alter the overall outcome of the evaluation. The critical period for both transmitters to be on the air was when the test unit (3200) transmitted at lower output power levels. During these periods, both transmitters were operational.

The Service ARGOS data shows similar results. Tables 7 and 8 are dialy summaries of the platform transmissions as received by the satellite during passes over the transmitter location. Service ARGOS received all data that the satellite had seen and stored on board during the daily passes over the platform location. Examination of the data indicates the orbital path of the satellite over the platform location varied from day to day. Since this test was active for approximately 2½ months, there were enough data samples to determine which day and which orbital pass during that day was more directly over the platform location.

The position location for each of the platforms was averaged on a daily basis. For tracking purposes, a daily location fix would supply sufficient information for plotting the migration of a marine mammal.

Table 9 is a summary of the total number of transmit days from platform 3200 for each of the four transmitted power levels (mean average only). Transmissions were not made at the averaged level.

TABLE 9. SERVICE ARGOS DATA: SUMMARY/DCP 3200.

	No. of Days	No. of Passes	Avg. Passes Per Day	No. of Up Links	Avg. No. of Up Links/Pass	Avg. Lat. Pos.	Avg. Long. Pos.	Power dBm	Output watts
	10	71	7.1	907	12.8	30.379	89.599	33.8	2.4
	5	23	4.6	309	13.4	30.379	89.601	29.29	.85
	6	23	3.8	144	6.3	30-378	89.597	27.78	.6
	47	285	6.1	1812	6.4	30-378	89.600	20.79	.12
Avg.	68	402	5.9	3172	7.9	30-378	89.600	28.95	.55

TABLE 7: PLATFORM ID 3200, DAILY AVERAGE OF SERVICE ARGOS DATA,

DATE	NUMBER OF PASSES PER DAY	NUMBER OF UPLINKS (TOTAL)	AVERAGE NUMBER OF UPLINKS PER PASS	AVERAGE LATITUDE LOC	AVERAGE LONGITUDE LOC	TRANSMITTED POWER LEVEL dBm / Watts
1-13	1	14	14	30.377	89.599	33.8/2.4
1-14	10	92	9.2	30.380	89.598	"
1-15	9	97	10.8	30.380	89.598	"
1-16	10	140	14	30.381	89.597	"
1-17	11	165	15	30.377	89.599	"
1-18	10	130	13	30.379	89.600	"
1-19	6	64	10.7	30.379	89.602	"
1-20	4	67	16.8	30.379	89.600	"
1-21	4	58	14.5	30.379	89.601	"
1-22	6	80	13.3	30.379	89.599	"
1-23	5	58	11.6	30.378	89.599	29.29/0.85
1-24	4	45	11.3	30.380	89.605	"
1-25	4	67	16.8	30.380	89.604	"
1-26	5	77	15.4	30.378	89.599	"
1-27	5	62	12.4	30.377	89.598	"
1-28	6	57	9.5	30.378	89.597	27.78/0.6
1-29	3	35	11.7	39.379	89.600	"
1-30	1	1	1	30.378	89.597	"
2-01	5	23	4.6	30.378	89.596	"
2-02	5	11	2.2	30.378	89.596	"
2-03	3	17	5.7	30.378	89.596	"
2-04	4	23	5.8	30.377	89.602	20.79/0.12
2-05	5	34	6.8	30.377	89.602	"
2-06	5	33	6.6	30.378	89.599	"
2-07	6	30	5	39.377	89.596	"
2-08	6	42	7	30.377	89.596	"
2-09	8	63	7.9	39.379	89.598	"
2-10	9	61	6.8	39.379	89.598	"
2-11	6	39	6.5	39.378	89.596	"
2-12	6	24	4	39.379	89.595	"
2-13	1	12	12	39.378	89.601	"
2-14	1	5	5	30.378	89.601	"
2-15	4	33	8.3	30.378	89.601	"
2-16	6	42	7	30.378	89.601	"
2-17	7	48	6.9	39.376	89.606	"
2-18	5	26	5.2	30.378	89.605	"
2-19	9	52	5.8	30.378	89.605	"
2-20	6	35	5.8	30.382	89.594	"
2-21	4	23	5.8	30.382	89.594	"
2-22	6	37	6.2	30.379	89.601	"
2-23	4	37	9.3	30.378	89.598	"
2-24	9	58	6.4	30.377	89.595	"
2-25	7	46	6.6	30.378	89.600	"
2-26	7	43	6.1	30.380	89.601	"
2-27	8	64	8	30.378	89.599	"
2-28	7	53	7.6	30.379	89.595	"
2-29	8	53	6.6	30.378	89.595	"
3-01	6	29	4.8	30.379	89.602	"
3-02	7	44	6.3	30.378	89.604	"
3-03	4	32	8	30.378	89.600	"
3-04	6	37	6.2	30.378	89.600	"
3-05	6	39	6.5	30.379	89.602	"
3-06	7	47	6.7	30.380	89.602	"

TABLE 7: PLATFORM ID 3200 CONT'D

DATE	NUMBER OF PASSES PER DAY	NUMBER OF UPLINKS (TOTAL)	AVERAGE NUMBER OF UPLINKS PER PASS	AVERAGE LATITUDE LOC	AVERAGE LONGITUDE LOC	TRANSMITTED POWER LEVEL dBm / Watts
3-07	6	41	6.8	30.378	89.599	33.8/0.12
3-08	8	71	8.9	30.380	89.597	"
3-09	8	53	6.6	30.377	89.598	"
3-10	6	28	4.7	30.380	89.600	"
3-11	4	20	5	30.380	89.607	"
3-12	6	42	7	30.378	89.605	"
3-13	8	47	5.9	30.378	89.600	"
3-14	6	23	3.8	30.378	89.600	"
3-15	6	33	5.5	30.379	89.599	"
3-16	7	42	6	30.379	89.599	"
3-17	7	43	6.1	30.377	89.602	"
3-18	6	38	6.3	30.378	89.598	"
3-19	5	18	3.6	30.378	89.598	"
3-20	6	33	5.5	30.379	89.603	"
3-21	6	36	6	30.379	89.602	"

TABLE 8: PLATFORM ID 3201 DAILY AVERAGE OF SERVICE ARGOS DATA,

DATE	NUMBER OF PASSES PER DAY	NUMBER OF UPLINKS (TOTAL)	AVERAGE NUMBER OF UPLINKS PER PASS	AVERAGE LATITUDE LOC	AVERAGE LONGITUDE LOC	TRANSMITTED POWER LEVEL dBm / Watts
1-02	4	38	9.5	30.377	89.596	33.8/2.4
1-03	8	119	14.9	30.378	89.597	"
1-04	9	147	16.3	30.378	89.598	"
1-05	12	167	13.9	30.378	89.598	"
1-06	12	159	13.3	30.378	89.598	"
1-07	10	155	15.5	30.378	89.600	"
1-08	10	155	15.5	30.379	89.598	"
1-09	11	156	14.2	30.379	89.597	"
1-10	10	137	13.7	30.379	89.600	"
1-11	8	106	13.3	30.377	89.598	"
1-12	7	121	17.3	30.378	89.597	"
1-13	9	145	16.1	30.378	89.598	"
1-14	6	88	14.7	30.379	89.598	"
1-17	1	14	14	30.380	89.601	"
1-18	10	147	14.7	30.379	89.598	"
1-19	5	68	13.6	30.379	89.600	"
1-20	4	33	8.3	30.377	89.600	"
1-21	4	75	18.6	30.378	89.600	"
1-22	4	68	17	30.378	89.598	"
1-23	6	91	15.2	30.379	89.600	"
1-24	6	88	14.7	30.379	89.599	"
1-25	6	55	9.2	30.379	89.599	"
1-26	4	82	20.5	30.379	89.599	"
1-27	5	80	16	30.377	89.598	"
1-28	6	88	14.7	30.380	89.599	"
1-29	6	89	14.8	30.380	89.600	"
1-30	5	78	15.6	30.377	89.598	"
1-31	8	138	17.3	30.378	89.599	"
2-01	9	141	15.7	30.380	89.600	"
2-02	10	116	11.6	30.379	89.600	"
2-03	9	119	13.2	30.378	89.603	"
2-04	7	25	13.6	30.377	89.601	"
2-05	11	137	12.5	30.379	89.599	"
2-06	9	106	11.8	30.380	89.597	"
2-07	11	145	13.2	30.381	89.598	"
2-08	8	122	15.3	30.380	89.598	"
2-09	8	159	19.9	30.382	89.602	"
2-10	10	168	16.8	30.379	89.599	"
2-11	11	167	15.2	30.379	89.596	"
2-12	10	145	14.5	30.378	89.599	"
2-13	3	30	10	30.378	89.601	"
2-14	1	18	18	30.378	89.598	"
2-15	6	97	16.2	30.378	89.597	"
2-16	11	129	11.7	30.380	89.601	"
2-17	9	141	15.7	30.378	89.601	"
2-18	5	83	16.6	30.377	89.600	"
2-19	10	153	15.3	30.376	89.595	"
2-20	14	173	12.4	30.378	89.598	"
2-21	13	177	13.6	30.377	89.597	"
2-22	11	144	13.1	30.376	89.599	"
2-23-	6	102	17	30.377	89.598	"

TABLE 8: PLATFORM 3201 CONT'D

DATES	NUMBER OF PASSES PER DAY	NUMBER OF UPLINKS (TOTAL)	AVERAGE NUMBER OF UPLINKS	AVERAGE LATITUDE LOG	AVERAGE LONGITUDE LOG	TRANSMITTED POWER LEVEL dBm / Watts
2-24	12	166	13.8	30.378	89.599	33.8/2.4
2-25	11	170	15.5	30.377	89.602	"
2-26	10	150	15.0	30.378	89.598	"
2-27	8	152	19	30.378	89.598	"
2-28	9	140	15.6	30.378	89.598	"
2-29	10	157	15.7	30.379	89.596	"
3-01	12	161	13.4	30.376	89.595	"
3-02	11	177	16.1	30.377	89.600	"
3-03	6	83	13.8	30.377	89.597	"
3-04	10	127	12.7	30.382	89.600	"
3-05	10	135	13.5	30.380	89.598	"
3-06	10	152	15.2	30.380	89.598	"
3-07	8	148	18.5	30.378	89.602	"
3-08	9	152	16.9	30.379	89.598	"
3-09	12	199	16.6	30.378	89.597	"
3-10	12	175	14.6	30.378	89.600	"
3-11	10	143	14.3	30.378	89.598	"
3-12	10	172	17.2	30.384	89.597	"
3-13	11	160	14.5	30.379	89.597	"
3-14	10	139	13.9	30.378	89.597	"
3-15	10	153	15.3	30.378	89.596	"
3-16	8	133	16.6	30.381	89.599	"
3-17	8	124	15.5	30.383	89.598	"
3-18	11	140	12.7	30.378	89.596	"
3-19	4	62	15.5	30.379	89.597	"

A summary of 76 days of transmissions from platform 3201 operating at an output power level of 33.8 dBm is shown in Table 10.

TABLE 10. SERVICE ARGOS DATA: SUMMARY/DCP 3201

No. Of Days	No. of Passes	Avg. Passes Per Day	No. of Up Links	Avg. No. of Up Links/Pass	Avg. Lat. Pos.	Avg. Long. Pos.	Power output
76	640	8.4	9354	14.6	30.3796	89.5985	33.8 dBm (2.9 watts)

The Service ARGOS data are shown in Figure 11 in a distribution of resolved fixes (52) plotted in latitude and longitude for platform 3200. The actual platform location is indicated by the "X". The distribution chart shows 31 plotted locations. Of the 52 resolved locations, all are less than one-half mile from the actual location. Table 11 indicates average distance errors of the resolved locations for platform 3200. Examination of the data reveals that the average location for the resolved positions to be less than one-quarter mile (900.6 feet) from the actual location.

Figure 12 is a distribution plot of the Service ARGOS resolved position fixes (75) in latitude and longitude for platform 3201. The distribution chart shows 31 plotted locations. Of the 75 resolved locations, all are less than one-half mile from the actual location. Table 12 indicates the average distance errors for the resolved locations for platform 3201. All but one resolved position location is less than one-third of a mile from the actual location, and the average distance error for all resolved position fixes was 717.1 feet.

The resolved position fixes processed by Service ARGCS are more accurate than those processed by the U.S. Coast Guard's LUT. The following information is included to provide an understanding of the basic differences between the data received and processed by the LUT versus data received and processed by Service ARGOS. Table 12 presents technical data relative to the TIROS-N system.

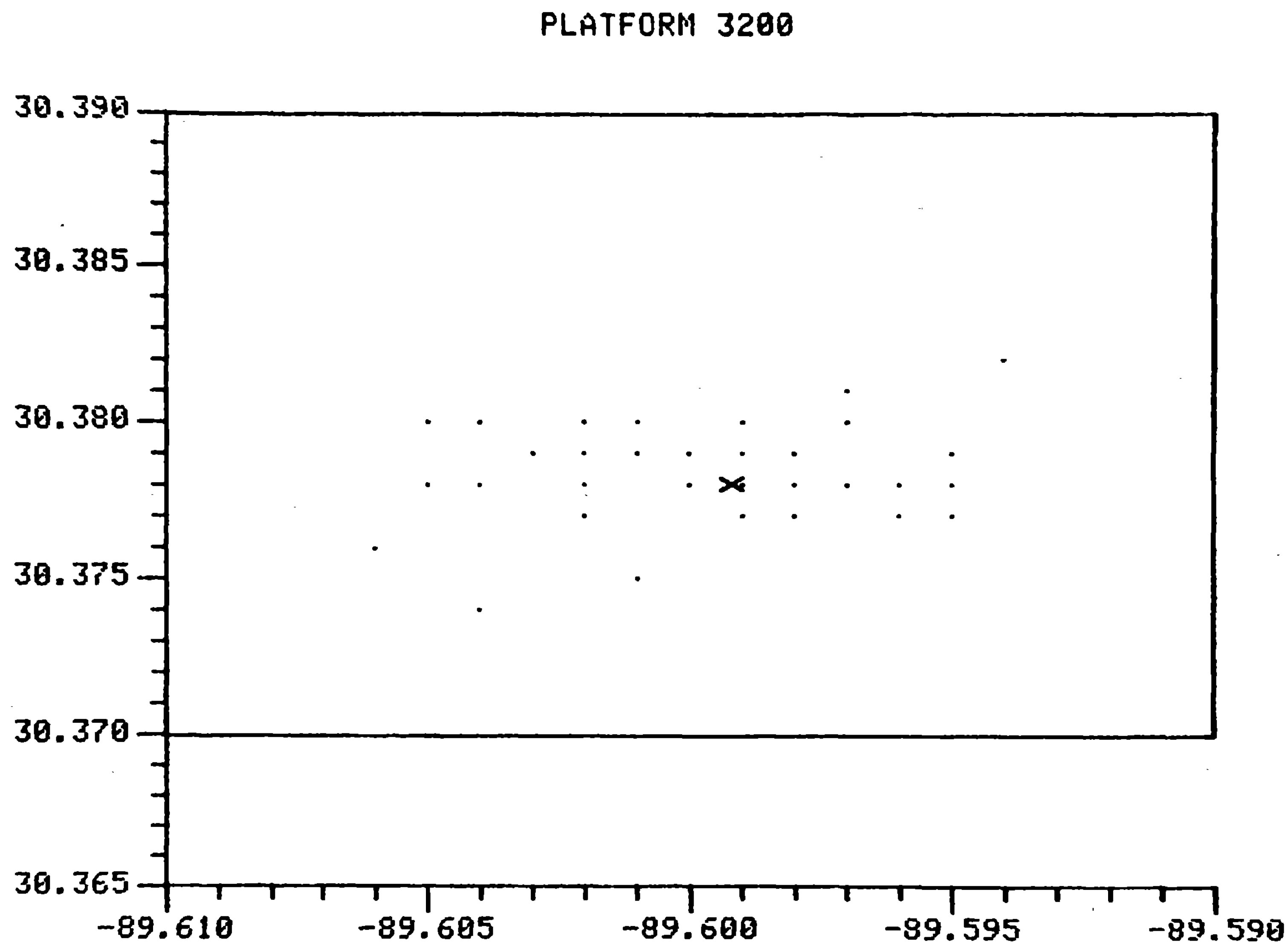


FIGURE 11. SERVICE ARGOS DATA: DISTRIBUTION OF RESOLVED POSITION FIXES. (ACTUAL POSITION IS MARKED AT 'X')

PLATFORM 3200

AVERAGE DISTANCE ERRORS FOR 1/1/80-2/18/80

DATE	ERROR IN MILES	ERROR IN FEET
1/14/80	.062991	332.5908
1/15/80	.119069	628.6850
1/16/80	.231103	1220.2230
1/17/80	.062991	332.5908
1/18/80	.079542	419.9794
1/19/80	.134352	709.3788
1/20/80	.054081	285.5487
1/21/80	.134352	709.3788
1/22/80	.059775	315.6112
1/23/80	.013075	69.0351
1/24/80	.402615	2125.8051
1/25/80	.343099	1811.5623
1/26/80	.013075	69.0351
1/27/80	.100991	533.2346
1/28/80	.146970	776.0038
1/29/80	.079542	419.9794
1/30/80	.146970	776.0038
2/ 4/80	.197892	1044.8672
2/ 6/80	.013075	69.0351
2/ 7/80	.222689	1175.8001
2/ 9/80	.099018	522.8125
2/10/80	.099018	522.8125
2/11/80	.213995	1129.8916
2/12/80	.286947	1515.0797
2/13/80	.218268	1152.4570
2/17/80	.471974	2492.0232
2/18/80	.389003	2053.9380

TABLE 11. SERVICE ARGOS DATA: AVERAGE DISTANCE ERRORS OF RESOLVED POSITION FIXES FROM ACTUAL POSITION.

PLATFORM 3200 CONT'D

AVERAGE DISTANCE ERRORS FOR 2/19/80-3/21/80

DATE	ERROR IN MILES	ERROR IN FEET
2/20/80	.421783	2227.0129
2/22/80	.134352	709.3788
2/23/80	.080015	422.4788
2/24/80	.287634	1518.7076
2/25/80	.054081	285.5487
2/26/80	.169278	893.7856
2/27/80	.013075	69.0351
2/28/80	.286947	1515.0797
2/29/80	.280956	1483.4493
3/ 1/80	.196891	1039.5870
3/ 2/80	.322041	1700.3762
3/ 5/80	.196891	1039.5870
3/ 6/80	.222195	1173.1904
3/ 7/80	.013075	69.0351
3/ 8/80	.188698	996.3237
3/ 9/80	.100991	533.2346
3/10/80	.406608	2146.8909
3/12/80	.188054	992.9233
3/13/80	.054081	285.5487
3/15/80	.059775	315.6112
3/16/80	.059775	315.6112
3/17/80	.197892	1044.8672
3/18/80	.080015	422.4788
3/20/80	.261600	1381.2495
3/21/80	.196891	1039.5870

TABLE 11. CONT'D

PLATFORM 3201

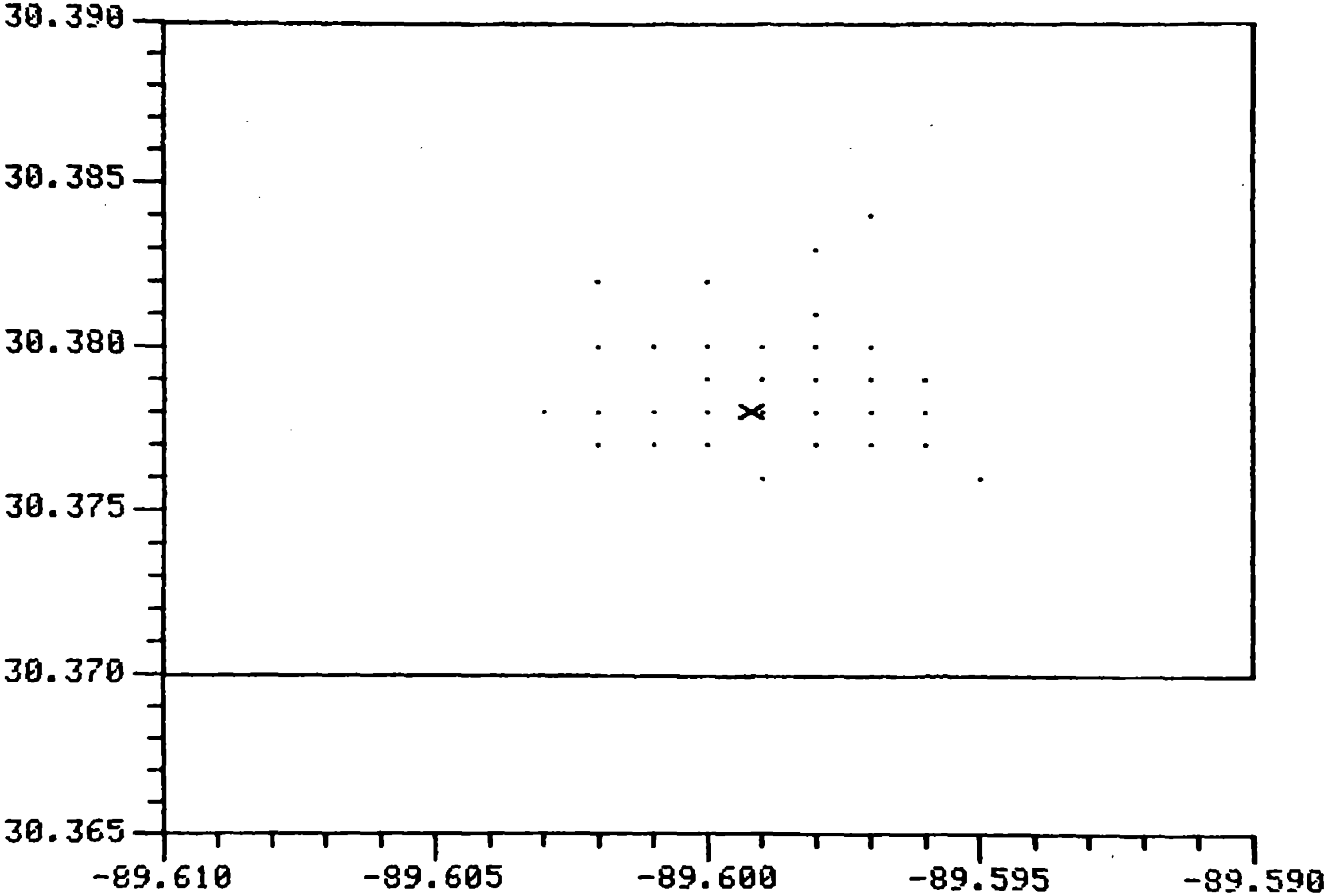


FIGURE 12, **SERVICE ARGOS DATA:** DISTRIBUTION OF RESOLVED POSITION FIXES
(ACTUAL POSITION IS MARKED AT 'X")

PLATFORM 3201

AVERAGE DISTANCE ERRORS FOR 1/2/80-1/30/80

DATE	ERROR IN MILES	ERROR IN FEET
1/ 2/80	.222689	1175.8001
1/ 3/80	.146970	776.0038
1/ 4/80	.146970	776.0038
1/ 5/80	.080015	422.4788
1/ 6/80	.080015	422.4788
1/ 7/80	.080015	422.4788
1/ 8/80	.099018	522.8125
1/ 9/80	.158121	834.8811
1/10/80	.158121	834.8811
1/11/80	.100991	533.2346
1/12/80	.146970	776.0038
1/13/80	.146970	776.0038
1/14/80	.099018	522.8125
1/17/80	.169278	893.7856
1/18/80	.099018	522.8125
1/19/80	.079542	419.9794
1/20/80	.081986	432.8843
1/21/80	.054081	285.5487
1/22/80	.080015	422.4788
1/23/80	.079542	419.9794
1/24/80	.059775	315.6112
1/25/80	.059775	315.6112
1/26/80	.059775	315.6112
1/27/80	.100991	533.2346
1/28/80	.119069	628.6850
1/29/80	.130120	687.0350
1/30/80	.100991	533.2346

TABLE 12. SERVICE ARGOS DATA: AVERAGE DISTANCE ERRORS OF RESOLVED POSITION FIXES FROM ACTUAL POSITION.

PLATFORM 3201

AVERAGE DISTANCE ERRORS FOR 1/31/80-2/26/80

DATE	ERROR IN MILES	ERROR IN FEET
1/31/80	.013075	69.0351
2/ 1/80	.130120	687.0350
2/ 2/80	.079542	419.9794
2/ 3/80	.255015	1346.4790
2/ 4/80	.135813	717.0945
2/ 5/80	.059775	315.6112
2/ 6/80	.188698	996.3237
2/ 7/80	.195475	1032.1097
2/ 8/80	.142860	754.2992
2/ 9/80	.303600	1603.0089
2/10/80	.059775	315.6112
2/11/80	.221801	1171.1105
2/12/80	.013075	69.0351
2/13/80	.121031	639.0413
2/14/80	.080015	422.4788
2/15/80	.146970	776.0038
2/16/80	.222195	1173.1904
2/17/80	.121031	639.0413
2/18/80	.081986	432.8843
2/19/80	.306158	1616.5135
2/20/80	.080015	422.4788
2/21/80	.159365	841.4468
2/22/80	.122340	645.9565
2/23/80	.100991	533.2346
2/24/80	.013075	69.0351
2/25/80	.197892	1044.8672
2/26/80	.080015	422.4788

TABLE 12. CONT'D

PLATFORM 3201

AVERAGE DISTANCE ERRORS FOR 2/27/80-3/19/80

DATE	ERROR IN MILES	ERROR IN FEET
2/27/80	.080015	422.4788
2/28/80	.080015	422.4788
2/29/80	.221801	1171.1105
3/ 1/80	.306158	1616.5135
3/ 2/80	.081986	432.8843
3/ 3/80	.159365	841.4468
3/ 4/80	.244405	1290.4568
3/ 5/80	.142860	754.2992
3/ 6/80	.142860	754.2992
3/ 7/80	.188054	992.9233
3/ 8/80	.099018	522.8125
3/ 9/80	.146970	776.0038
3/10/80	.054081	285.5487
3/11/80	.080015	422.4788
3/12/80	.387321	2045.0555
3/13/80	.158121	834.8811
3/14/80	.146970	776.0038
3/15/80	.213995	1129.8916
3/17/80	.308887	1630.9209
3/18/80	.213995	1129.8916
3/19/80	.158121	834.8811

TABLE 12. CONT'D

TABLE 13. TIROS-N TECHNICAL DATA:

Altitude:	830 ± 18km
Inclination:	98° polar orbit, during each orbit the satellite "sees" both the North and South poles.
Period:	101 minutes

Latitude	Cumulative visibility time over 24 hours	Number of passes in 24 hours Min.	Mean	Max.	Mean Pass duration
± 0°	40 min.	3	3.5	4	
± 15°	44 min.	4	4	4.5	
± 30°	50 min.	4	4.5	6	
± 45°	64 min.	5	5.5	6	10 min.
± 55°	85 min.	8	8	9	
± 65°	123 min.	10.5	11	11.5	
± 75°	161 min.	14	14	14	
± 90°	192 min.	14	14	14	

Since the Local User Terminal (LUT) can obtain data only during the given pass when it can see the satellite, it cannot obtain data for satellite pass over the test platforms. The test platforms, however, transmitted to the satellite during each pass over the platform location. This is why, when analyzing the received LUT data for the platforms, there are only 1 or 2 passes received and processed. On the other hand, the data processed by ARGOS is for all data transmitted during the daily orbital passes. As shown in Table 13, the probability of the satellite receiving data transmitted by the platforms during a given pass, is a direct function of its latitude pass, although the satellite can see pole to pole in a 5000 km swath or circle in the east/vest direction encompassing the earth. At each orbit, this swath covers both the North and South Poles (polar orbits). For the satellite, the swath is displaced by 25° (i.e. 2800 km) at the Equator as a result of the rotation of the earth. Thus, collection performance, which is determined by orbit geometry, is a function of latitude. Such factors, as type of antenna, antenna orientation and transmitted power output, all contribute to the quality of the data up-link, and in the probability of an up-link being received and processed by the satellite.

APPLICATION TO MARINE MAMMAL TRACKING

The TIROS quarterwave stub antenna was evaluated for the sole purpose of determining the feasibility of using an antenna so configured to transmit at low power to the orbiting TIROS satellite. Results of the evaluation conclude in a very positive way that an antenna of that configuration can transmit data at low power to the satellite. Its application on a Marine Mammal Transmitter device for migration tracking is more suitable to the porpoise than the NIMBUS version. The average breathing period for the porpoise is approximately 700 m seconds. The NIMBUS data message requires 980 m seconds, and the TIROS data message requires 360 m seconds. It is, therefore, obvious that a TIROS system requiring just 360 m seconds for its data message can operate within the 700 m second porpoise breathing period. Having demonstrated the low power capabilities and requiring just 360 m seconds for transmission the TIROS transmitter and quarterwave stub antenna possess significant qualifications that must be considered in future applications for marine mammal tracking projects.

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