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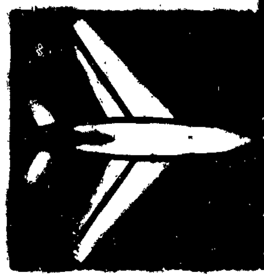
FINAL REPORT

Project No. 531-1S



RADAR QUALITY CONTROL FEASIBILITY EXPERIMENT

JANUARY 1963

FEDERAL AVIATION AGENCY
Systems Research & Development Service
SYSTEMS MANAGEMENT DIVISION
WASHINGTON, D.C.

FINAL REPORT

RADAR QUALITY CONTROL FEASIBILITY EXPERIMENT

PROJECT NO. 531-1S

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Performance Assurance Area

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This report has been approved for general distribution.

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ABSTRACT

The objective of this effort was to determine, by a relatively short experiment, the feasibility of utilizing user aircraft for the purpose of continuously monitoring the performance of primary radar systems. The experiment was designed to permit a technical and economic comparison between the user aircraft method of monitoring and the present periodic flight inspections.

The data collection portion of the experiment was performed at the Norfolk, Virginia, combined center and tower facility on the modified ASR-2 and the FPS-8 radar systems for a period of 30 days.

An analysis of the data collected indicated that it is both technically and economically feasible to perform radar flight inspection by utilizing user aircraft. It is estimated that approximately the same information presently being collected by periodic flight inspection could be collected with user aircraft for approximately one-fourth to one-third of the cost. Conversely, for the same cost as the present periodic flight inspection, approximately three to four times the information could be obtained by making use of the user aircraft technique. In addition, since the user data would be collected on a daily basis, degraded performance would be recognized earlier.

It is recommended that plans be made for the trial implementation of radar quality control flight checks by utilizing user aircraft. A parallel effort should be established to determine the optimum methods for analyzing the data and establishing limits of acceptable performance. The practicality of collecting and analyzing the data by automatic or semiautomatic means should also be investigated.

I. INTRODUCTION

1.1 This report presents the design, implementation, results and conclusions of an experiment which was performed to investigate the feasibility of flight checking air traffic control (ATC) surveillance radars by using radar echoes of user aircraft. This experiment has been called a "Radar Quality Control Feasibility Experiment," designated as "RQCFE."

1.2 This concept of quality control flight checking of radar facilities was initially established under the technical and administrative cognizance and direction of the Systems Performance Branch (RD-309) of the Systems Research and Development Service (see report prepared by Operations Research, Incorporated, entitled "Techniques for the Evaluation of Surveillance Radar Systems"). After the initial review of this concept, the Systems Performance Branch was requested to design, implement and analyze the results of a short, intensive feasibility experiment in this area. A total of 75 days was allotted, of which 30 days were to be used for actual data collection.

1.3 The following section presents an explanation of the purposes, objectives and criteria of the RQCFE. Section III briefly discusses implementation, and references the implementation plan formulated prior to running the experiment and the procedures and data forms used during the experiment. Section IV presents an analysis of the data obtained during the month of data collection, and makes a comparison with the present radar periodic flight inspection. Section V examines the technical and economic feasibility of performing flight inspection by using the radar quality control technique. Finally, conclusions concerning the experiment and recommendations regarding implementation and additional work required are presented.

II. OBJECTIVES OF THE EXPERIMENT

PURPOSE

2.1 The overall purpose of the RQCFE was to determine the feasibility of flight checking surveillance radar facilities by making use of target echo returns from the normal flow of user air traffic. This type of day-to-day flight checking has been called a "quality control flight check."

A PERSPECTIVE

2.2 The point of view maintained throughout the design of the experiment and the analysis of the resulting data was that of comparing the quality-control type of flight check with present periodic flight checks. It was believed that unless such a comparison could be made, it would be impossible to truly assess the value of the quality control flight check. Hence, the technique chosen for this feasibility study, although not considered optimal by independent considerations, was designed to have the advantage of being able to provide all the significant information obtained during periodic flight checks and, in addition, important information which present periodic flight checks do not provide.

OBJECTIVES

2.3 One of the objectives of the experiment was to determine two types of repeatability:

(i) Repeatability in the sense of being able to correlate the results of a single user run with those of present periodic flight checks with a DC-3 when both flights were performed at approximately the same time, in the same location.

(ii) Statistical repeatability in the sense that valid coverage patterns would emerge from the statistical analysis of data taken over an extended period of time.

The former determination took the form of reference flight checks between a DC-3 and a Gulfstream, the results of which are reported in Section IV, paragraphs 4.3 through 4.5. The latter determination is presented in many graphs and tables of the same section.

2.4 The major hypothesis leading to the concept of quality control flight checks was that radar performance varies from day to day, and even from hour to hour. Based upon this hypothesis, it is clearly not possible to assure continuous accurate operation of the radar facilities by checking at 120-day intervals. To prove this hypothesis, simulated user runs with a Gulfstream were performed at the beginning and at the end (an interval of 30 days) of the user aircraft data collection period. Results of these simulated user runs are presented in Section IV, paragraphs 4.6 through 4.8.

Periodic Flight Checklist

2.5 As indicated previously, it was considered important to determine how well the quality control flight check could provide the information called for in the present periodic flight checklist. The summarized results of this comparison are presented in Section IV, paragraphs 4.70 through 4.83.

Capability for Dynamic Performance Monitoring

2.6 The quality control flight check was examined, in general, for its capability in providing dynamic performance monitoring of surveillance radar facilities. This included not only the items of the checklist mentioned above, but additional factors influencing performance such as weather effects, overall equipment effects, the location and multiplicity of holes in coverage, intermediate and high altitude route structure coverage, and the effects of different types of aircraft. It was believed that by correlating radar degradation with existing conditions at the same time, an indication of possible causes of degradation could be determined. By noticing and analyzing trends, a first order approximation to prediction of possible future radar degradation could be ascertained. Results of this attempt are likewise presented in Section IV.

Technical and Economic Feasibility

2.7 Finally, the examination of each of the preceding items was to be considered from the point of view of overall technical and economic feasibility. The results of this determination are shown in Section V of this report.

III. IMPLEMENTATION OF THE EXPERIMENT

3.1 Implementation of the RQCFE, based upon the implementation plan presented in Appendix I, was executed through the joint efforts of the Systems Performance Branch, RD-309; Experimentation Division, RD-45; Supporting Services Division, RD-70; center and tower personnel at Norfolk, Virginia; Flight Inspection personnel, Eastern Region; and members of Operations Research, Incorporated. Briefings were held with all participating controllers during the last week of March 1962. At that time, forms for data collection were distributed and procedures for the experiment were discussed.

3.2 Both a general and a detailed set of procedures for the feasibility experiment were written and distributed. These sets of procedures, together with the data forms, are shown in Appendix II. A number of data collection techniques were examined prior to the start of the experiment. The technique selected was the one felt to give the maximum amount of consistent data that could be reduced and analyzed for the purpose of this experiment. A suggestion by FS-235 that a finer grain target rating technique be used was investigated. It was determined that, if used, it would result in the data being reduced in volume by about 50 per cent for the experiment. In addition, the indications received from controller personnel were that consistent data would not be obtained from one controller to another, thus making it impractical to reduce and analyze such data to obtain additional information beyond that obtainable with the technique selected for the experiment. It should be pointed out, however, that this suggestion is not without merit if the data were to be collected by automatic or semiautomatic means.

3.3 The data collection program was carried out on the modified ASR-2 (referred to herein as ASR-2/4) and the FPS-8 radar systems at the Norfolk, Virginia, combined center and tower facility. Data were collected 16 hours per day, 7 days per week, for a period of 30 days on one ASR-2/4 indicator display and one FPS-8 indicator display set up for this purpose.

3.4 It should be emphasized that this experiment was intended as a short time period effort to determine the feasibility of radar flight inspection by utilizing user aircraft. The limitation of 30 days of data collection did not allow sufficient time for feedback and optimizing of the test. However, it was recognized in advance that this limitation did exist and that further work would be necessary to make recommendations for final implementation.

IV. DATA COLLECTION AND ANALYSIS

4.1 This section of the report presents an analysis of the data obtained during the RQCFE. These data were taken for both the ASR-2/4 and the FPS-8 and were recorded by the controllers on the prescribed data forms (Appendix II). The data were then transcribed to work sheets (some of which are summarized in this section) and operated upon to yield the tables and plots herein presented. The methods used in analyzing the DC-6 tracks with the ASR-2/4 and the FPS-8 for this experiment reflect the necessity for meeting two immediate requirements:

(i) To determine the feasibility of using echo returns from normal air traffic to flight check the radars.

(ii) To perform this feasibility analysis in the prescribed interval of 75 days.

A number of methods for data analysis are considered in this section of the report. Several of these methods yield limited information; however, they have been presented for the purpose of showing the different types of sorts and the type of information that can be obtained from each. For example, sort No. 1 of the basic data sorts represents the averaging of all maximum range data regardless of the altitude, route, time of day, and date on which the data were taken for the 30-day period. It is difficult to see where this sort would have much value for a facility. It might be, however, that this information would be of value to a regional office as a gross method of monitoring the performance of radar facilities. In general, it is believed that the normalized data sorts, plotted with respect to the determined average performance, will yield the most information on the performance of a facility on a daily basis.

4.2 The remainder of this section describes, first, the results of the reference flight check runs with the DC-3 and Gulfstream. This is followed by the results of the simulated user runs by the Gulfstream. Both sets of data were taken at the beginning (April 2 and 3) and end (May 1 and 2) of the RQCFE. Data for tracks of the DC-6 aircraft, for which the greatest number of samples was obtained, are then sorted and analyzed for both radars. This is followed by a general discussion of the effects of different aircraft and high altitude route structure. A brief comparison of the data obtained during the RQCFE and the periodic flight checklist is made.

REFERENCE CHECKS

4.3 Reference checks were run under normal periodic flight inspection conditions between the DC-3 and a Gulfstream from NAFEC simulating user aircraft. Two sets of these runs were performed: one on April 2 and 3, and the other on May 1 and 2. For both checks, the DC-3 flew at 10,000 feet on a 235°-055° radial, while the Gulfstream flew 10,000 feet on V1-194 south airway which is in proximity. Target strengths were read out in levels of from 0 through 4 for both aircraft. In addition, the Gulfstream data were recorded in accordance with the procedure established for recording user aircraft data (Appendix II).

ASR-2/4

4.4 Figure 4.1 summarizes the data obtained for the ASR-2/4 on April 2 and May 1. The actual target strength readouts are indicated for both the DC-3 and the Gulfstream. For the outbound run on April 2, the Gulfstream maximum range was 80.5 per cent of the DC-3 maximum range. For the outbound run on May 1, the Gulfstream maximum range was 79.6 per cent of the DC-3 maximum range. Runs on a given day were separated by no more than 20 minutes in time and were performed with the same equipment. The figures of 80.5 and 79.6 per cent indicate correlated differences between results obtained with the DC-3 and the Gulfstream, noting the fact that both sets of runs were kept in time proximity allowing little chance for the radar or weather characteristics to change in the interval between checks. The existence of holes prior to reaching maximum range for both aircraft should also be noted.

FPS-8

4.5 Figure 4.2 summarizes the data obtained for the FPS-8 on April 3 and May 2. For the inbound run on April 3, the Gulfstream maximum range was 86.8 per cent of the DC-3 maximum range. For the inbound run on May 2, the Gulfstream maximum range was 66.1 per cent of the DC-3 maximum range. This would indicate that the Gulfstream, flying in the vicinity of and during the time of the flight of the DC-3 flight inspection aircraft, does not maintain a correlated difference. A plot of the DC-3 flight inspection vertical coverage data in Fig. 4.3, however, indicates that the loss of the DC-3 aircraft was a result of shielding (note that data points are only about 0.1° above the radio horizon and that the pattern cuts back approximately 18 decibels within 0.1°). Since the FPS-8 vertical coverage flight check using a DC-3 does not appear to properly measure performance variation of the facility, it is not possible to prove the validity of the use of user aircraft for this purpose by comparison to it as was done for the ASR-2/4. However, there is no reason to assume that the validity of utilizing user aircraft for flight inspection, as established for the ASR-2/4, is not also valid for the FPS-8. It is believed that the difference in Gulfstream coverage between the two dates was due to atmospheric anomalies that existed within the coverage area of the FPS-8, however, in the case of the DC-3 this variation was covered up by the shielding effect.

SIMULATED USER FLIGHTS WITH GULFSTREAM

4.6 A Gulfstream aircraft performed simulated user flights at the beginning (April 2 and 3) and end (May 1 and 2) of the RQCFE. Data were taken on both the ASR-2/4 and the FPS-8. A discussion of the results of these runs is presented below.

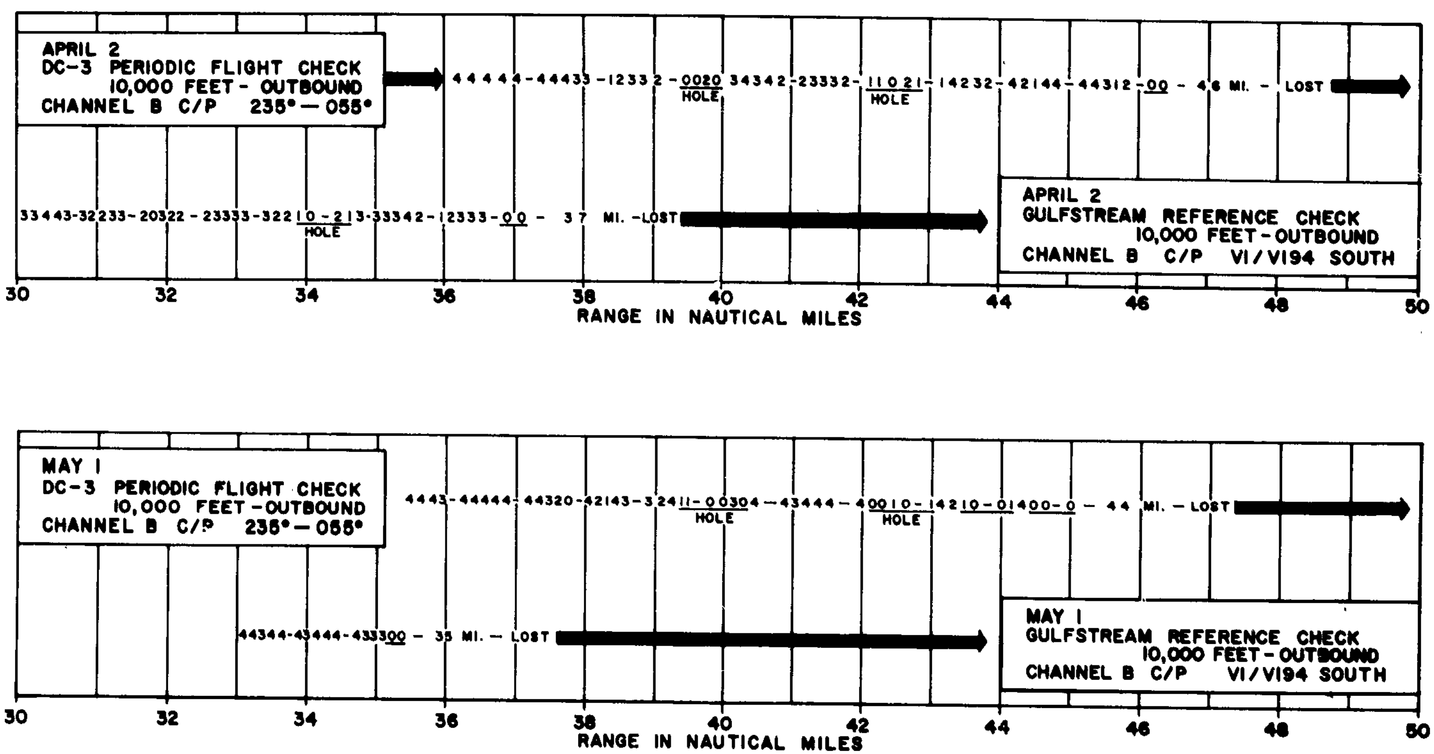

FIG. 4.1 REFERENCE CHECKS FOR ASR-2/4 RADAR

ASR-2 Modified

4.7 The results of the Gulfstream simulated runs for the ASR-2/4 are shown in Table 4.1. This table shows the altitude, route and direction of the run and compares the maximum ranges obtained on both April 2 and May 1. The maximum ranges for May 1 vary from -30.0 to +15.6 per cent of those obtained for April 2. This wide variation shows, by example, that maximum range (as one indication of radar performance) is a fluctuating parameter and that data taken with a separation in time by one month appear not to be repeatable in a deterministic (nonprobabilistic) sense. It should be noted that the choice of maximum range is the last range at which the target was usable for control purposes. Some of the tracks shown in the raw data indicate holes in coverage prior to these ranges, separated by periods of strong signal returns constituting usable targets.

FPS-8

4.8 The results of the Gulfstream simulated runs for the FPS-8 are shown in Table 4.2. As with the ASR-2/4, this table shows the altitude, route and direction of the run and compares the maximum ranges obtained on both April 3 and May 2. The maximum ranges for May 2 vary from -14.6 to +22.0 per cent of those obtained for April 3. As with the ASR-2/4, it can be concluded that maximum range may vary substantially with time, on a given route at a given altitude with a particular aircraft. It should be noted that these results show a need for more frequent flight inspection, if the actual continuous performance of the facilities is to be known.

ANALYSIS OF DC-6 USER FLIGHTS

4.9 The majority of data taken for the RQCFE was for DC-6 flights in the Norfolk area. These data have been compiled separately and are presented below.

ASR-2/4 - General

4.10 Data compiled for the ASR-2/4 for DC-6 aircraft are shown in Table I, Appendix III. This table shows the date on which the flight was tracked, time, maximum range, altitude of the aircraft at that range, route of flight, whether the flight was inbound or outbound, additional comments pertinent to the flight, and the presence and locations of holes in coverage.

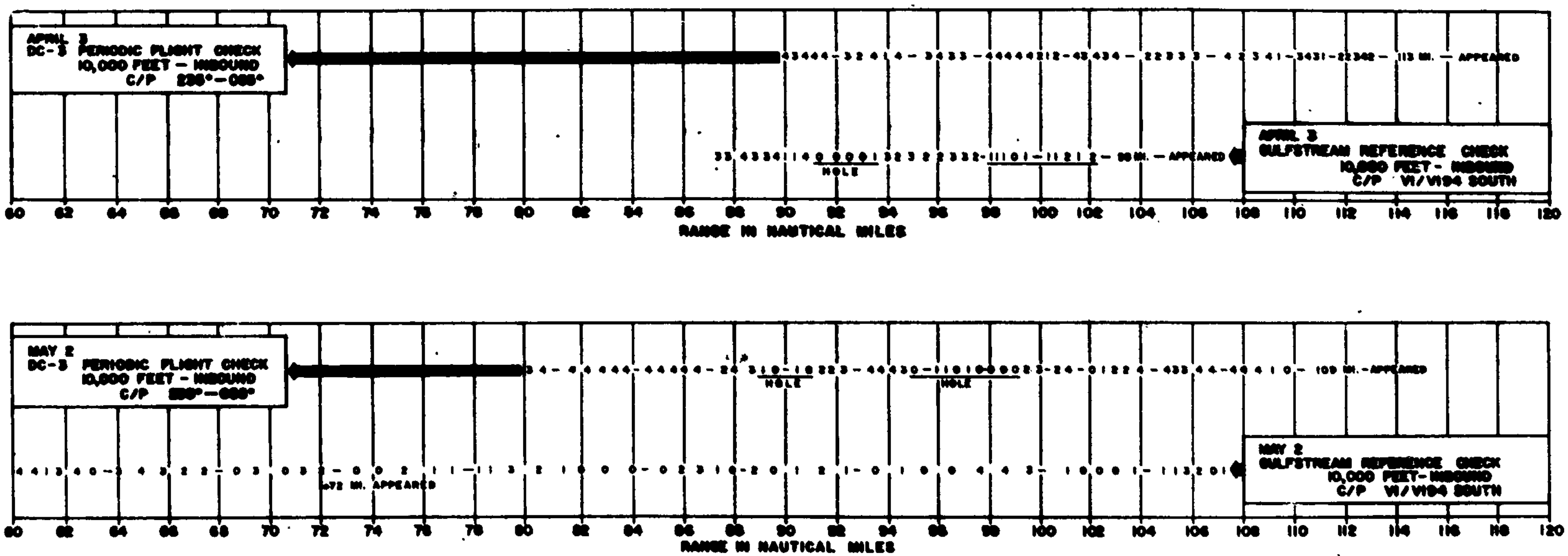

FIG. 4.2 REFERENCE CHECKS FOR FPS-8 RADAR

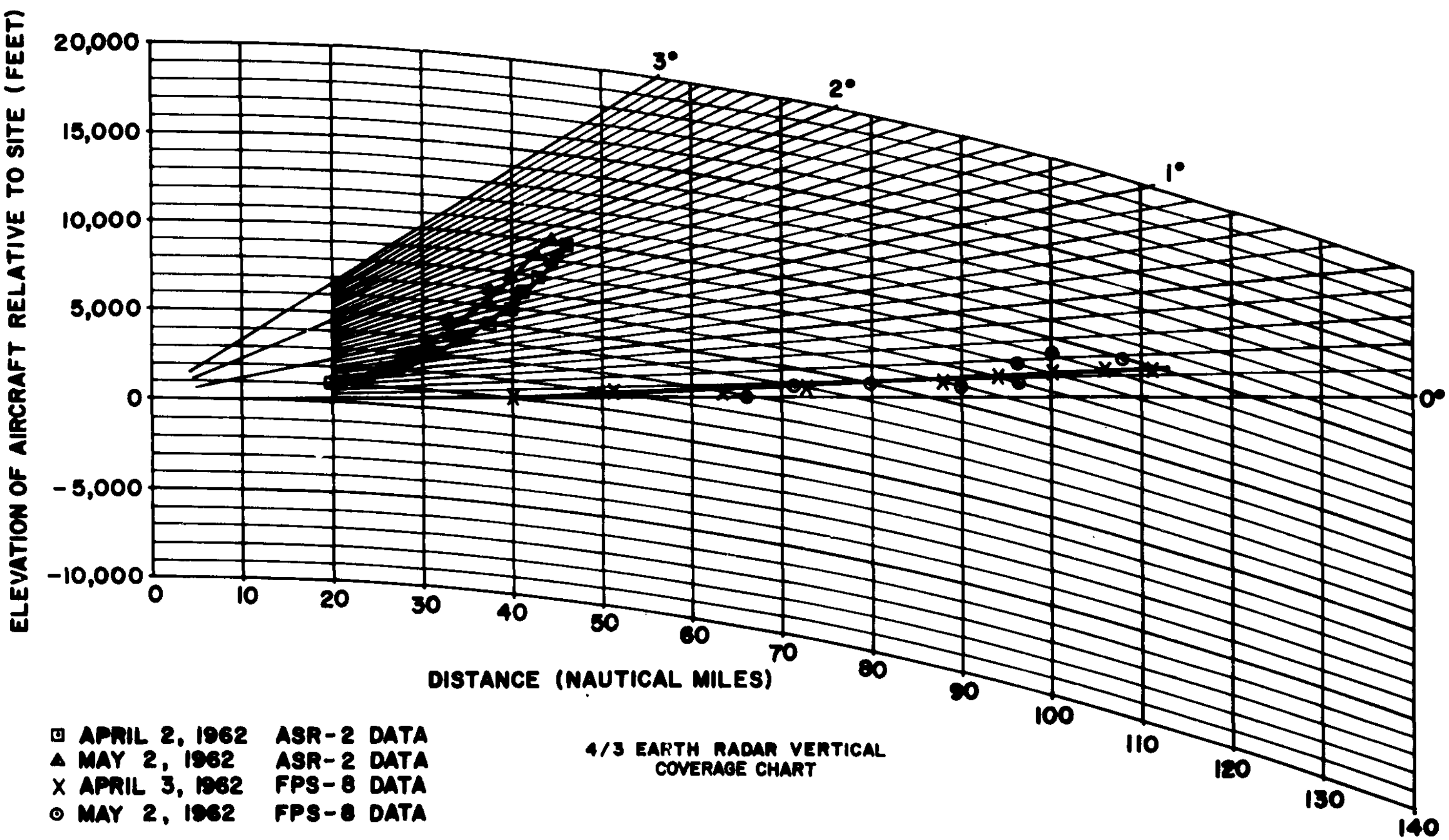

FIG. 4.3 VERTICAL COVERAGE FLIGHT INSPECTION FOR ASR-2/4 AND FPS-8 RADARS WITH DC-3 AIRCRAFT (APRIL 3 AND MAY 2, 1962)

TABLE 4.1

ASR-2/4 RADAR - SIMULATED USER FLIGHTS WITH GULFSTREAM

Altitude (ft.)	Route	Inbound or Outbound	Time (Zebra)[1] April 2, 1962	Maximum Range (NM) April 2, 1962	Time (Zebra) May 1, 1962	Maximum Range (NM) May 1, 1962
3,000	V1-194	O	1645	30	1445	21
3,000	V1-194	I	1700	27	1500	24
10,000	V1N[2]	O	2227	32	1315	37
10,000	V1N	I	2245	30	1330	32
7,000	V194	O	2255	30	1355	33
7,000	V194	I	2315	31	1415	29
4,000	V260	O	2335	28	1515	24
4,000	V260	I	2350	26	1530	22

[1] Time Zebra = Eastern Standard Time + 5 hours.

[2] N = northern section of route with respect to Norfolk.

TABLE 4.2

FPS-8 RADAR - SIMULATED USER FLIGHTS WITH GULFSTREAM

Altitude (ft.)	Route	Inbound or Outbound	Time (Zebra)[1] April 3, 1962	Maximum Range (NM) April 3, 1962	Time (Zebra) May 2, 1962	Maximum Range (NM) May 2, 1962
10,000	V1N[2]	O	2142	91	1206	85
10,000	V1N	I	2214	89	1230	92
15,000	1503S[3]	O	2015	82	2000	100
15,000	1503S	I	2039	110	2021	96
15,000	1503N	O	2055	97	1905	99
15,000	1503N	I	2120	81	1929	98
25,000	J79VN	O	2140	105	1329	102
25,000	J79VN	I	2200	86	1400	82
25,000	J79VS	O	2215	96	1808	82
25,000	J79VS	I	2230	97	1844	92
10,000	V286	O	2235	82	1250	76
10,000	V286	I	2250	83	1310	73

[1] Time Zebra = Eastern Standard Time + 5 hours.

[2] N = northern section of route with respect to Norfolk.

[3] S = southern section of route with respect to Norfolk.

4.11 The data shown in Table I, Appendix III, were taken directly from the original data sheets which were completed by the controllers. Approximately 6 per cent of the total tracks of DC-6 aircraft for the ASR-2/4 was not used for the Nos. 1, 2, 3, 4, and 5 basic data sorts since, for these tracks, weather conditions or misadjustment of the radar equipment were noted as having interfered with the track, thus affecting the maximum range point. For example, a common case ocurred when the aircraft moved directly into a large and heavy duct over Cape Charles Peninsula and thereafter could not be tracked. Because the first five sorts are thought of as presenting the average performance of the facility, these data were not included. (However, the data have been included in the No. 9 basic data sort and the normalized data sorts plotted on Figs. 4.9 and 4.10, since the intent of these sorts is to show variations in performance whether due to normal or abnormal conditions.)

4.12 Data Sorts. Table 4.3 shows a list of 12 sorts of data that could be presented from the compiled data. For example, sort No. 1 represents the averaging of all maximum range data, regardless of the altitude, route, aircraft aspect, time of day, and date on which the data were taken. Under the heading of "ASR-2/4 Basic Data Sort," there are 12 different sorts of the data. The first four sorts represent average conditions over the 30 days of data collection; sorts Nos. 5 through 8 present variations in performance with time of day averaged over 30 days; and the last four sorts show variation in performance on a daily basis over the test period. The analysis of the results of tracking DC-6 aircraft with the ASR-2/4 radar presents different sorts which can be obtained from the basic data. These types of sorts, although informative for the purpose of the experiment and for historical data on the performance of the radar, are not necessarily optimum for implementation where daily decisions on performance are to be made based on a relatively few samples. It is possible, however, to normalize some of this data with respect to a particular independent parameter whose characteristic has been established by measurement, such as a vertical coverage pattern, or to an average expected range for a given route at each elevation based on the measurement of a number of flights for the aircraft type being monitored. These techniques permit all data collected to be compared, and provide a basis for a decision as to whether overall performance is down or just performance at a given altitude or route. Examples of both these normalizing techniques of data reduction are discussed under the heading of "ASR-2/4 Normalized Data Sorts."

ASR-2/4 Basic Data Sorts

4.13 Sort No. 1. All the maximum range data compiled in Table 4.3 has been averaged and a standard deviation has been calculated. The

TABLE 4.3

POSSIBLE SORTS OF COMPILED DATA
FOR ASR-2/4 RADAR WITH DC-6 AIRCRAFT

Sort No.	All Data	Altitude	Route	Time	Date	Results Presented in:
1	X					Paragraph 4.13
2		X				Figure 4.4
3			X			Table 4.4
4		X	X			Figure 4.5
5	X			X		Figure 4.6
6		X		X		Not Presented
7			X	X		Not Presented
8		X	X	X		Not Presented
9	X				X	Figure 4.7
10		X			X	Not Presented
11			X		X	Not Presented
12		X	X		X	Not Presented

Maximum range is the dependent variable.

average range for DC-6 aircraft on the ASR-2/4 is 35. 0 nautical miles (NM) with a standard deviation of 7. 5 NM. The number of samples is 163 tracks. It is to be noted that the average of 35. 0 NM contains unequal proportions of flights at different altitudes. However, since the choice of aircraft with respect to altitude was random, the number of samples at each altitude is representative of the expected density of traffic at these altitudes. The same observation is true of route choices. The exact proportion of samples at each altitude and route can be seen from the following sorts.

4. 14 Sort No. 2. This sort is a presentation of maximum range data for different altitudes independent of route, aircraft aspect, time of day, and date. A plot of average maximum range against altitude is presented in Fig. 4. 4. Individual averages at the various altitudes are shown with the number in parentheses, representing the number of samples averaged. It is noted that the pattern is quite regular and meaningful, as shown by the vertical coverage pattern obtained during the April 2 periodic flight check with a DC-3. (The periodic flight check data are presented in Appendix IV.)

4. 15 A comparison of the periodic flight check data with the curve of Fig. 4. 4 indicates not only the regularity of the user aircraft data, but at first glance it shows the DC-3 to be a "better" target than the DC-6. This can be interpreted as follows: The criterion used in the RQCFE for coverage is that the aircraft should be usable for control purposes. Thus, the RQCFE results reflect the capability of the radar in the hands of the people who use it, namely, the controllers. As such, the results indicate usable radar performance under normal and representative operating conditions and possible deviations therefrom. However, flight checking is performed under such fairly nonrepresentative conditions as visual-flight-rule (VFR) weather, and a radar set which, although perhaps not peaked, is not representative of normal operating conditions.

4. 16 Sort No. 3. If the data are sorted by route, independent of altitude, time of day and date, an indication of the degree of symmetry in azimuth can be obtained. The calculations of average maximum range for different routes are shown in Table 4. 4. Routes are listed in an order which corresponds to a counterclockwise rotation about Norfolk.

4. 17 The results of this sort likewise require interpretation. The data shown in Table 4. 4 provide average maximum ranges for different routes, but are averaged over nonuniform sets of altitudes. For example, the average range of 42. 0 NM for V156 was obtained for only two samples which were at arbitrary altitudes. The problem of normalizing, or weighting, this data with respect to the altitudes at which they were taken is considered in a later portion of this chapter.

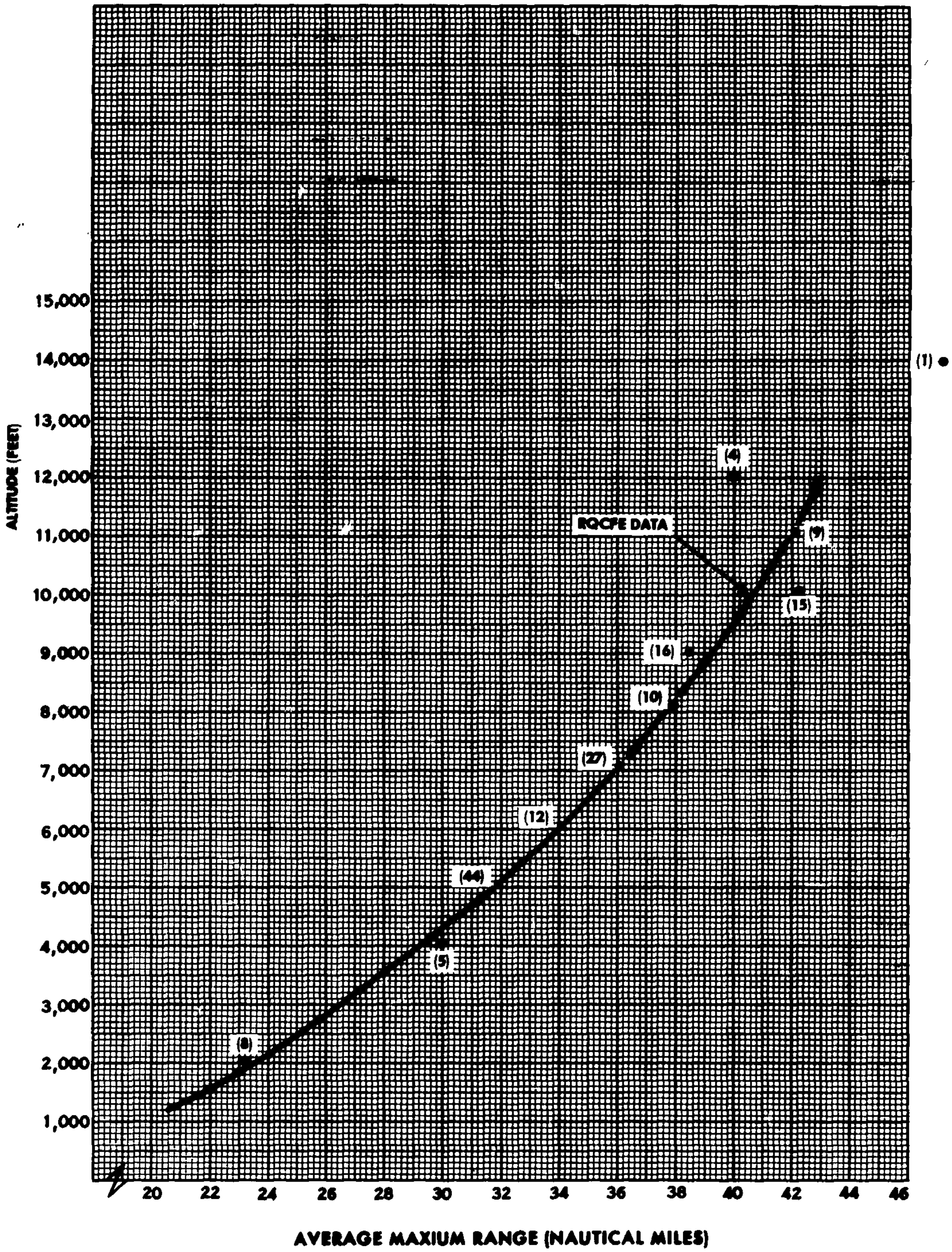

FIG. 4.4 DATA SORT NO. 2 FOR ASR-2/4 RADAR WITH DC-6 AIRCRAFT - RANGE VERSUS ALTITUDE

TABLE 4.4

DATA SORT NO. 3 FOR ASR-2/4 RADAR WITH DC-6 AIRCRAFT
AVERAGE MAXIMUM RANGE VERSUS ROUTE

Route	Average Maximum Range (NM)	Number of Samples
V139	37.4	5
V1N[1]	35.6	27
V194	30.6	45
V286	44.7	18
V156	42.0	2
PHF[2]	30.9	33
V260	38.5	8
V266	37.0	3
V1-194	38.9	20
V194S[3]	36.5	2

[1] Victor One North

[2] Patrick Henry

[3] Victor 194 South

4.18 Furthermore, some of the data obtained can be misleading in the following sense: Note that the average maximum range for V286 is 44.7 NM, the largest average calculated. Most of these data were taken on flights from Norfolk on V194 to V286. The intersection of these two routes is at a range of approximately 35 N.M. Therefore, results indicated for V286 contained no samples less than 35 NM and accounts for the rather large average maximum range on this route. There are also indications that due to the broadside nature of this route a greater target size was obtained, and that a small percentage was loss due to shielding.

4.19 Sort No. 4. This sort will provide information which can be used to construct vertical coverage patterns on various routes. However, because of the relatively few (163) total samples, after the data are sorted both by route and altitude, only a few samples exist for each route and altitude. For example, Fig. 4.5 shows a vertical coverage pattern for the Patrick Henry (PH) area. As before, the number of samples at each altitude is shown in parentheses. Note that with only a total of 33 samples for this route, it is difficult to construct a meaningful vertical coverage pattern although a definite regularity is indicated. However, Fig. 4.4 shows that an increase in number of samples by a factor of approximately 5 (from 33 to 163) seems to provide enough information to be able to construct a more meaningful vertical coverage pattern. The samples can be obtained by selection of aircraft on certain routes which are representative of certain sectors around Norfolk; for example, V194 and V286 might represent coverage to the north, PHF and V260 might represent coverage to the west, and V1-194 and V194S might represent coverage to the south.

4.20 Sort No. 5. The fifth sort provides information to show the fluctuation of radar coverage during the day. Figure 4.6 shows a plot of average maximum range as a function of time of day. Data were not taken during certain hours, namely, between 9 and 10 p.m. and between midnight and 7 a.m. The number of samples averaged is shown in parentheses.

4.21 If the one sample of 44 NM between 9 and 10 a.m. is discarded as being statistically insignificant, the trend of the graph indicates increasing performance (coverage) during the morning hours (from 7 a.m. to noon) and decreasing performance in the afternoon (from noon to 6 p.m.). It should be remembered, however, that these averages are over all altitudes and contain unequal numbers of samples at different altitudes. A normalized curve with respect to altitude (Fig. 4.8) shows similar results although they are not as pronounced.

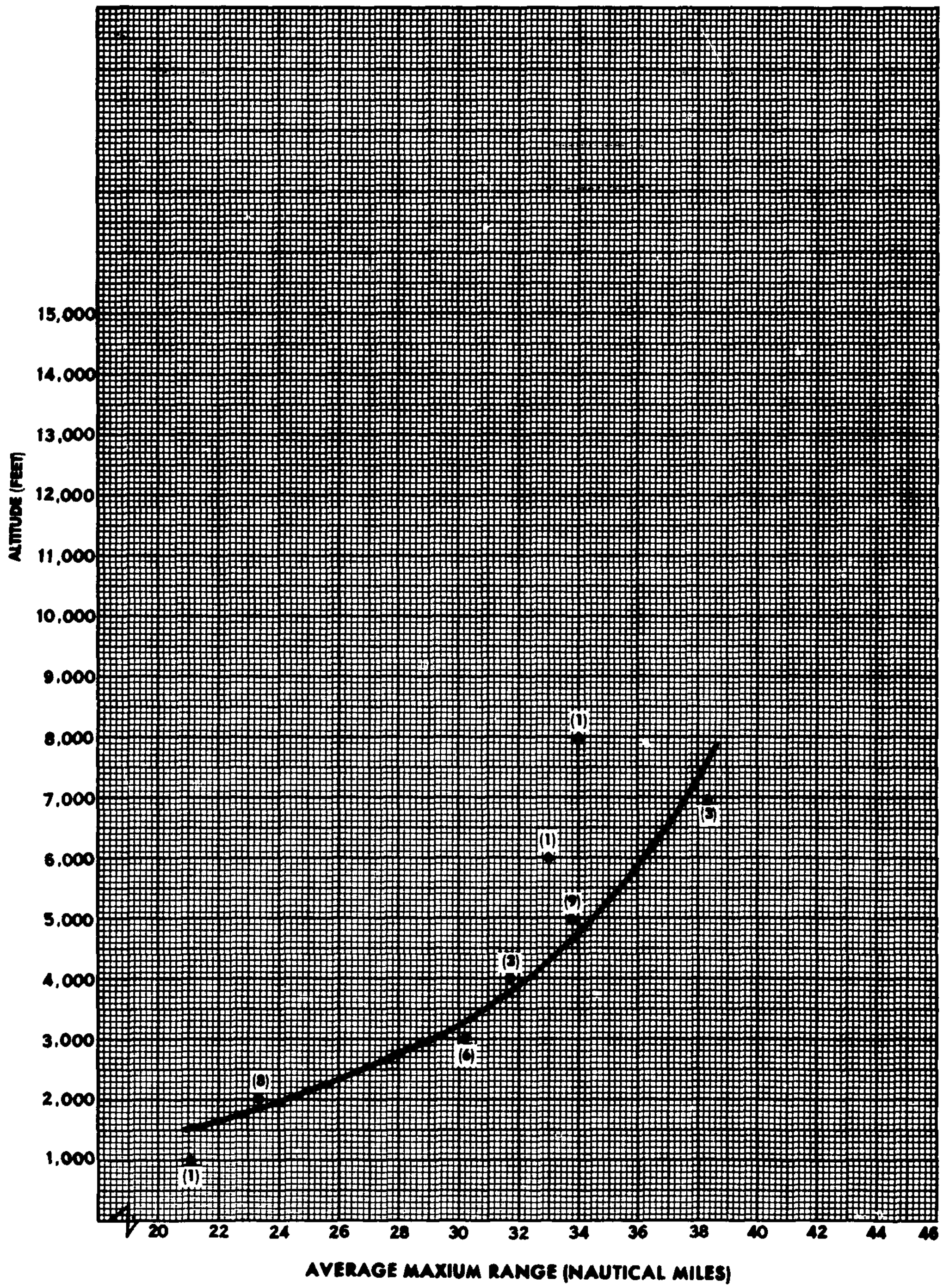

FIG. 4. 5 DATA SORT NO. 4 FOR ASR-2/4 RADAR WITH DC-6 AIRCRAFT - RANGE VERSUS ALTITUDE AT PHF

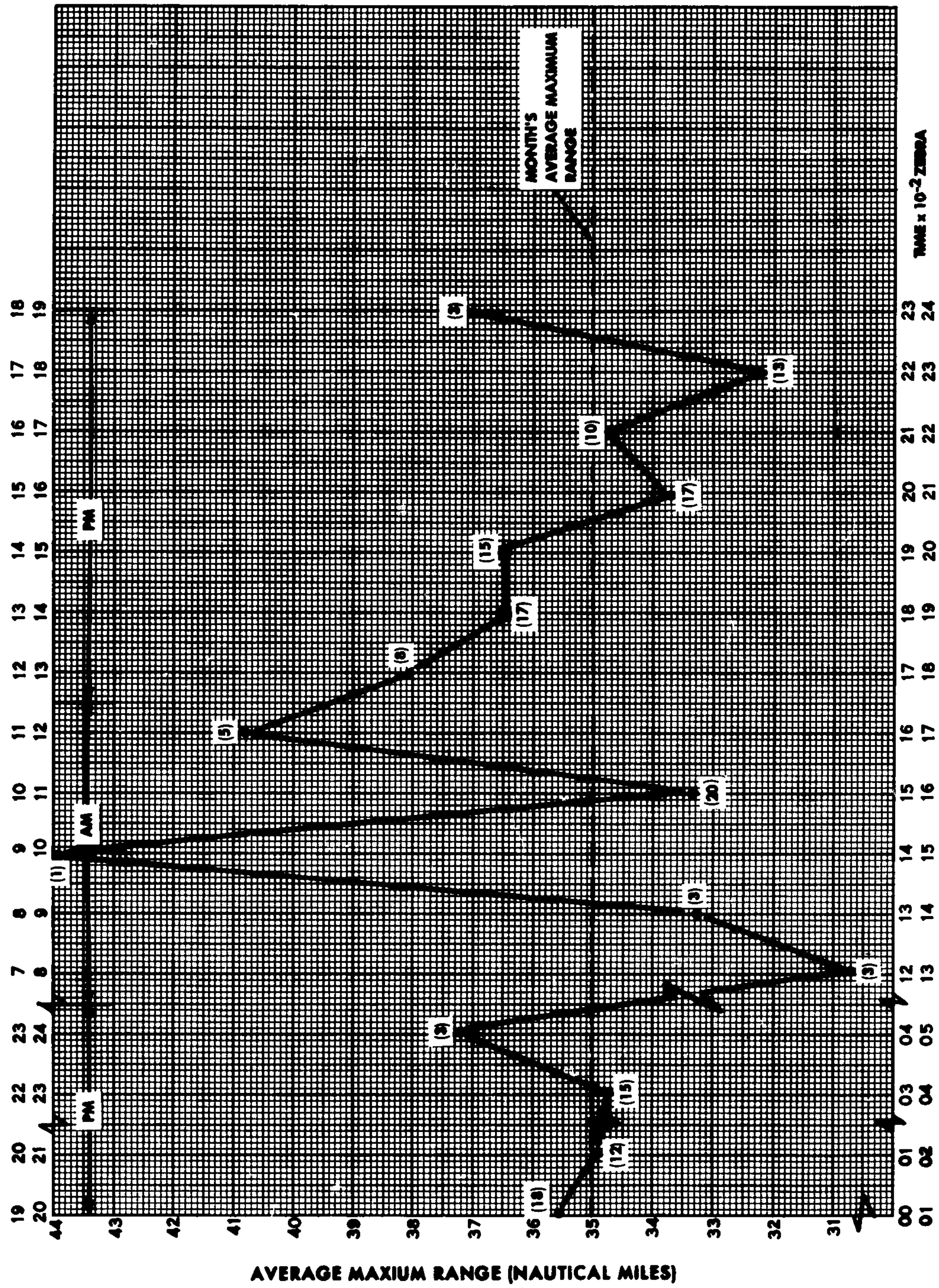

FIG. 4.6 DATA SORT NO. 5 FOR ASR-2/4 RADAR WITH DC-6 AIRCRAFT - RANGE VERSUS TIME

4.22 Sorts Nos. 6, 7 and 8. These sorts have not been analyzed due to the relative dearth of samples within each category.

4.23 Sort No. 9. The analysis of sort No. 9 is shown in Fig. 4.7 which is a plot of average maximum range as a function of date. Note again that the averages presented are over all altitudes, routes, times of day, and headings of the aircraft. Therefore, what appears to be a loss of coverage on a particular date might, in fact, be the result of all samples chosen having been at a low altitude, or a particularly unfavorable route (from the point of view of coverage), and so forth. (Figure 4.9 eliminates dependence on what appears to be the most important variable, namely, altitude.) This is done by a normalizing process and shows that the coverage on April 23 was, in fact, degraded performance. This point is discussed further in paragraph 4.32. It is emphasized that when considering data analysis for a possible field implementation, the normalizing procedure should be considered, from which direct action on the part of the flight check analyst can easily and quickly be inferred.

4.24 Sorts Nos. 10, 11 and 12. These sorts have not been analyzed due to the relative dearth of samples within each category.

ASR-2/4 Normalized Data Sorts

4.25 The previous analyses of the results of tracking DC-6 aircraft with both radars present different sorts which can be made with the basic data. It is possible, however, to normalize some of these data with respect to a particular independent parameter to negate the influence of that parameter on the results. For example, Figs. 4.6 and 4.7 for the ASR-2/4 could be normalized, given an appropriately large sample size, with respect to both route (azimuth) and altitude to make these graphs representative of true radar coverage variation with time, with no implicit dependence on azimuth or altitude.

Reference of Maximum Ranges to a Given Altitude

4.26 There are many ways by which it is possible to normalize the data. For example, assume that some number of samples is obtained on a particular route over a wide range of altitudes. If the number of samples at each altitude is not sufficient to generate a regular distribution, then one may make use of a prior knowledge of the probable structure of the vertical coverage pattern, based upon physical considerations, to "smooth"

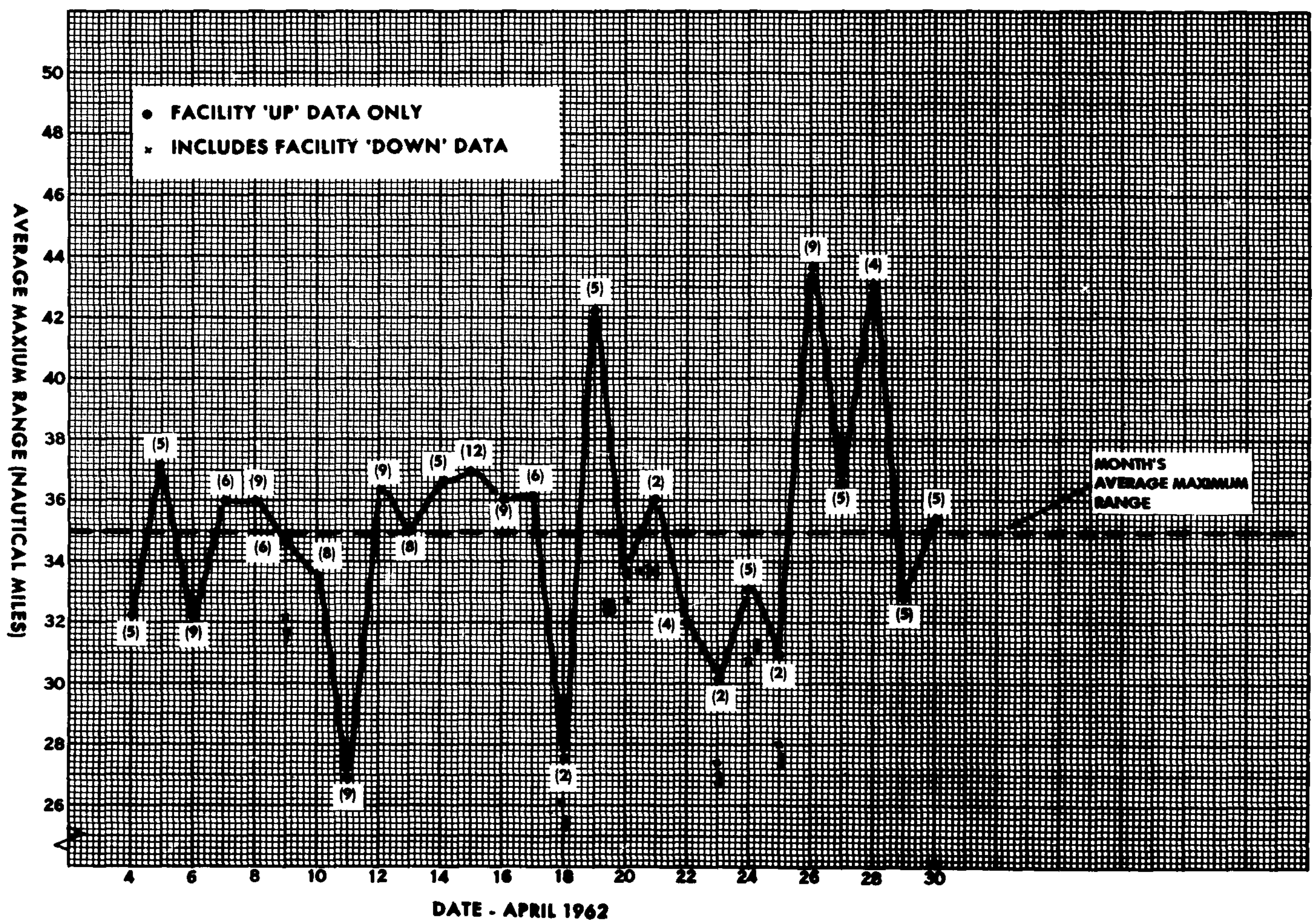

FIG. 4.7 DATA SORT NO. 9 FOR ASR-2/4 RADAR WITH DC-6 AIRCRAFT - RANGE VERSUS DATE

a curve through the given sample points. Then the average maximum range at each altitude may be normalized or "referred" to the average maximum range at a conveniently chosen altitude. To describe this process mathematically, let

R_{ij} = the i^{th} maximum range at the j^{th} altitude.

Then

$\overline{R}_j$ = average maximum range at the j^{th} altitude

where

$$\overline{R}_j = \frac{1}{n_j} \sum_{i=1}^{n_j} R_{ij}$$

and

n_j = number of maximum range samples at the j^{th} altitude.

Now let

ρ_j = smoothed maximum range at the j^{th} altitude, obtained from a vertical coverage interpolation.

Then define

$C_{kj} = \frac{\rho_j}{\rho_k}$ = weighting constant to refer the smoothed maximum range at k^{th} altitude to the smoothed maximum range at the j^{th} altitude.

Then $R_{ik} \times C_{kj}$ represents the value of the i^{th} range sample obtained at the k^{th} altitude, referred to the j^{th} altitude. In other words, this represents the maximum range that would have been obtained if the sample had been drawn from the j^{th} altitude instead of the k^{th} altitude. If this is done for all samples at all altitudes, a series of maximum range points is obtained which can be interpreted as the maximum ranges that would have been obtained if all samples were drawn from the j^{th} altitude. The individual referred values can then be compared to the average value and standard deviation limits obtained by operating on all the referred samples.

4.27 By way of indicating how this can be done, the data obtained for DC-6 aircraft for the ASR-2/4 have been operated on in the manner described above. However, since the number of samples at each route is not sufficient to describe a regular vertical coverage pattern, the vertical coverage pattern over all routes (Fig. 4.4) has been used to establish the C_{kj} weighting constants. It is emphasized that with the appropriate vertical coverage pattern for each route, the same method may be used on each route.

4.28 If j = 5, corresponding to an altitude of 5000 feet, a table of weighting constants C_{ki} is shown in Table 4.5. The referred range samples then represent the maximum ranges that would have been obtained had all maximum range samples been taken at an altitude of 5000 feet. The average value of these referred ranges has been calculated as 32.1 NM.

4.29 If the referred average maximum range samples are then normalized with respect to the overall monthly average, the fluctuation about that average can be illustrated. This is shown in Figs. 4.8 and 4.9, the former being derived from the data of Fig. 4.6 and the latter from Fig. 4.7.

4.30 It was noted, in the discussion of Figs. 4.6 and 4.7, that the cases of abnormally high and low average maximum range could be attributed, in part, to the fact that the samples were at high and low altitudes, respectively. However, in Figs. 4.8 and 4.9, altitude is not a factor, since all data have been referred to an altitude of 5000 feet.

4.31 In Fig. 4.8, it is noted that range coverage has fallen below two standard deviations from the mean for the data recorded between 7 and 8 a.m. If it is assumed that the data are normally distributed, one can expect samples below two standard deviation limits only 2.3 per cent of the time. If deviation below 2σ is established as a cause for alarm in terms of the capability of controlling aircraft (in this case a 2σ degradation corresponds to a range 90.4 per cent of the average), then maintenance should be alerted to this degradation and should check for degraded equipment.

4.32 In Fig. 4.9, it is significant to note that range coverage falls below the 2σ limits on April 23. The plot of Fig. 4.7 does not show this situation. Returning to the original data in Table I, Appendix III, it is noted that there are two maximum range samples in question on that date; one out to 31 NM at 12,000 feet, and the other out to 29 NM at 11,000 feet. Figure 4.9 correctly indicates the fact that these are abnormally poor values, for at these high altitudes, coverage should be considerably greater (note Fig. 4.4). Hence, the value of the referring of data to a specific altitude can be seen. As before, maintenance personnel would be alerted to the abnormally low coverage obtained on April 23.

TABLE 4.5

C_{k5} WEIGHTING CONSTANTS FOR DIFFERENT ALTITUDES FOR ASR-2/4 RADAR WITH DC-6 AIRCRAFT

Altitude (ft.)	k	$C_{kj} = C_{k5}$
1000	1	1.59
2000	2	1.35
3000	3	1.20
4000	4	1.08
5000	5	1.00
6000	6	.93
7000	7	.88
8000	8	.84
9000	9	.81
10000	10	.78
11000	11	.76
12000	12	.74

Weighting constants derived from Fig. 4.4.

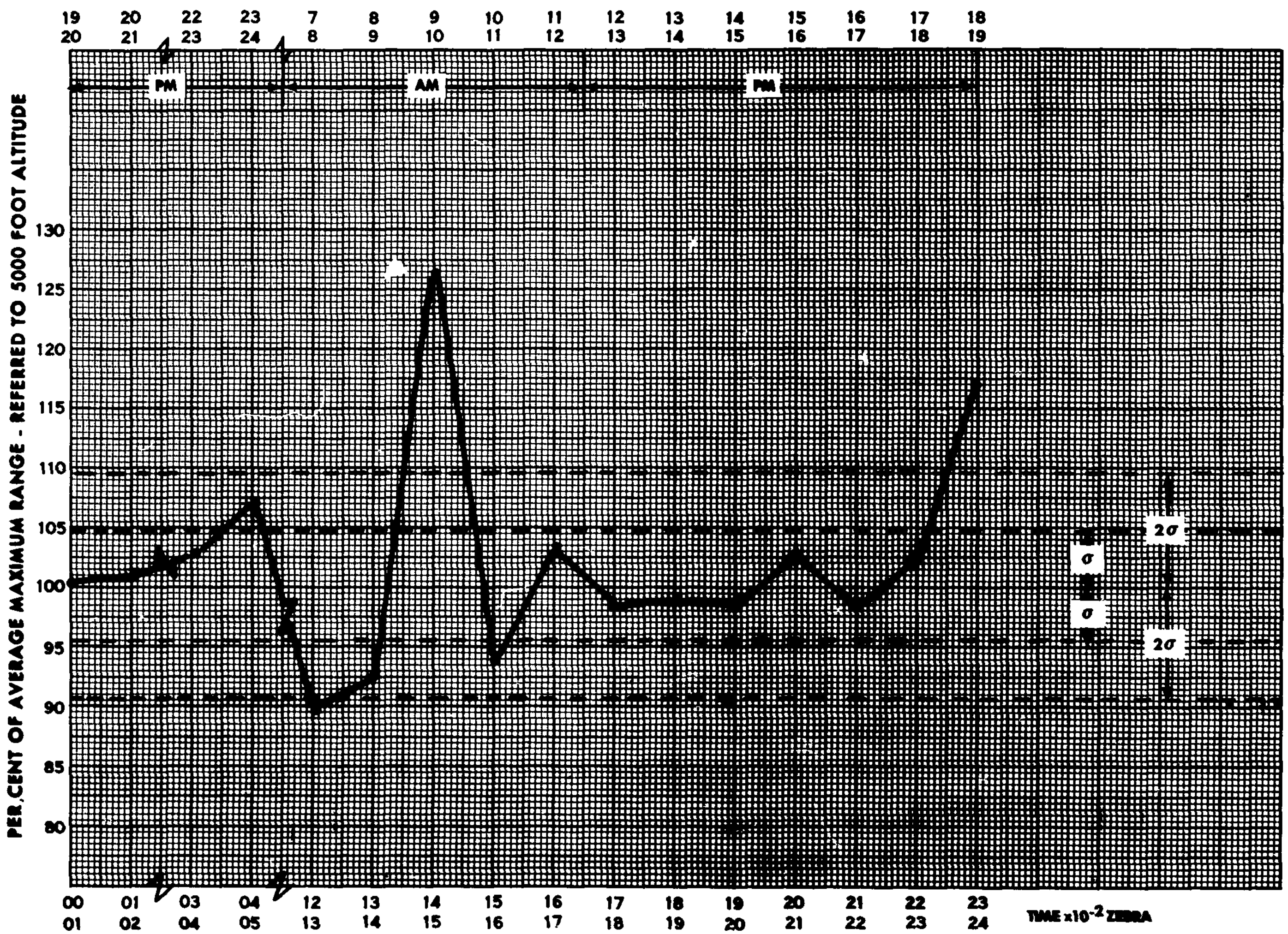

FIG. 4.8 PER CENT OF REFERRED AVERAGE MAXIMUM RANGE VERSUS TIME USING ASR

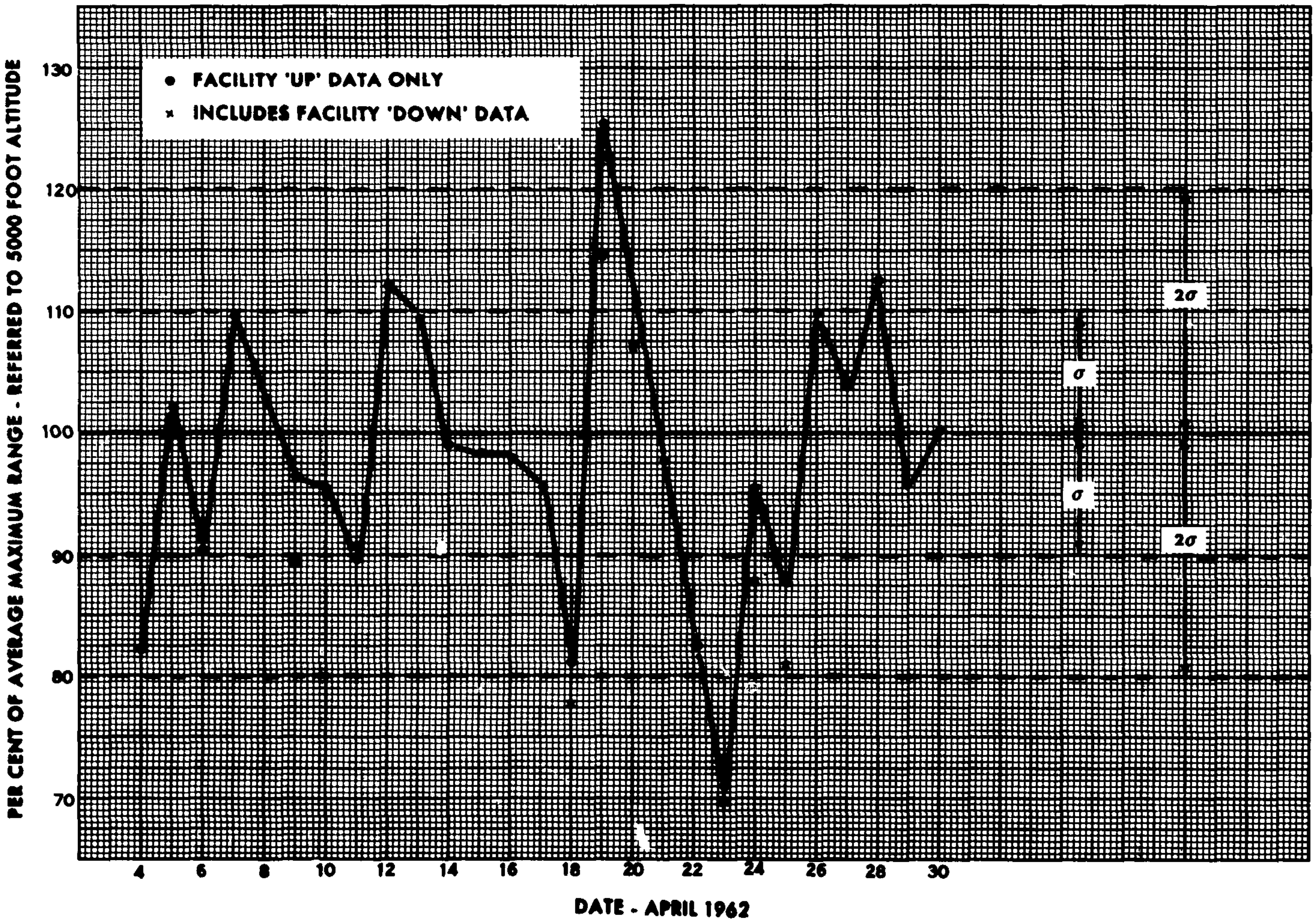

FIG. 4.9 PER CENT OF REFERRED AVERAGE MAXIMUM RANGE VERSUS DATE USING ASR-2/4 RADAR WITH DC-6 AIRCRAFT

Reference of Samples to Each Altitude

4.33 If the number of samples at each altitude is sufficient, then an average expected range for a given route at each altitude can be established. It is then possible to rate each aircraft's maximum range for a given run as a percentage of the average expected range for that route and altitude. By so doing, a plot can be made of percentage of range with respect to the average expected (100 per cent) range. The following paragraphs present an example of this type of data reduction. This method indicates true radar (coverage) performance and does not have the disadvantage (as do some of the graphs of the previous section) of containing the implicit effects of variables which require further, and often nontrivial, interpretation.

4.34 The collection of data is restricted, initially, to one route, one aircraft type, and one particular direction of flight. To illustrate the method of analysis, DC-6 departure traffic on V194 to V286 in the Norfolk area was chosen for this example. Sixty-three such flights were tracked during the RQCFE and the basic data for them is presented in Table I, Appendix III. Although this route combination was chosen because of the relatively large number of samples, it has the disadvantage of having an abrupt change in direction. This factor has a tendency to cause a discontinuity in the data. Route V194 is essentially a radial route with respect to the radar; however, as soon as the aircraft makes the turn onto route V286, it tends to present a broadside target thus giving a return considerably above threshold for several additional miles beyond that which would be expected if the aircraft were to continue on a radial course. The result is to give a wider variance of maximum ranges and, in turn, make it necessary to have wider tolerance limits if the false alarm rate is not to be increased. It is thus apparent that a radial route for the complete run is most desirable, since the aircraft aspect will remain essentially constant. If this is not possible, the second best choice is one that has no abrupt changes in direction. However, for the purpose of this example, it is felt that route V194-286 is satisfactory to explain the technique.

4.35 If the data on departure route V194-286 is sorted by altitude, an average maximum range point can be calculated <u>for each altitude.</u> Each maximum range point obtained can then be converted to a percentage of the average maximum range at each altitude. The standard deviation, in percentage of the average maximum range for each altitude, is shown in Fig. 4.10 (A, B and C) for each of the samples taken during the 30-day period. No DC-6 departures on V194-286 were recorded on April 12 and 23, and the one sample on April 26 has been discarded in order to simplify the display. Note, also, that the locus of single standard deviations is plotted for samples indicated in Fig. 4.10.

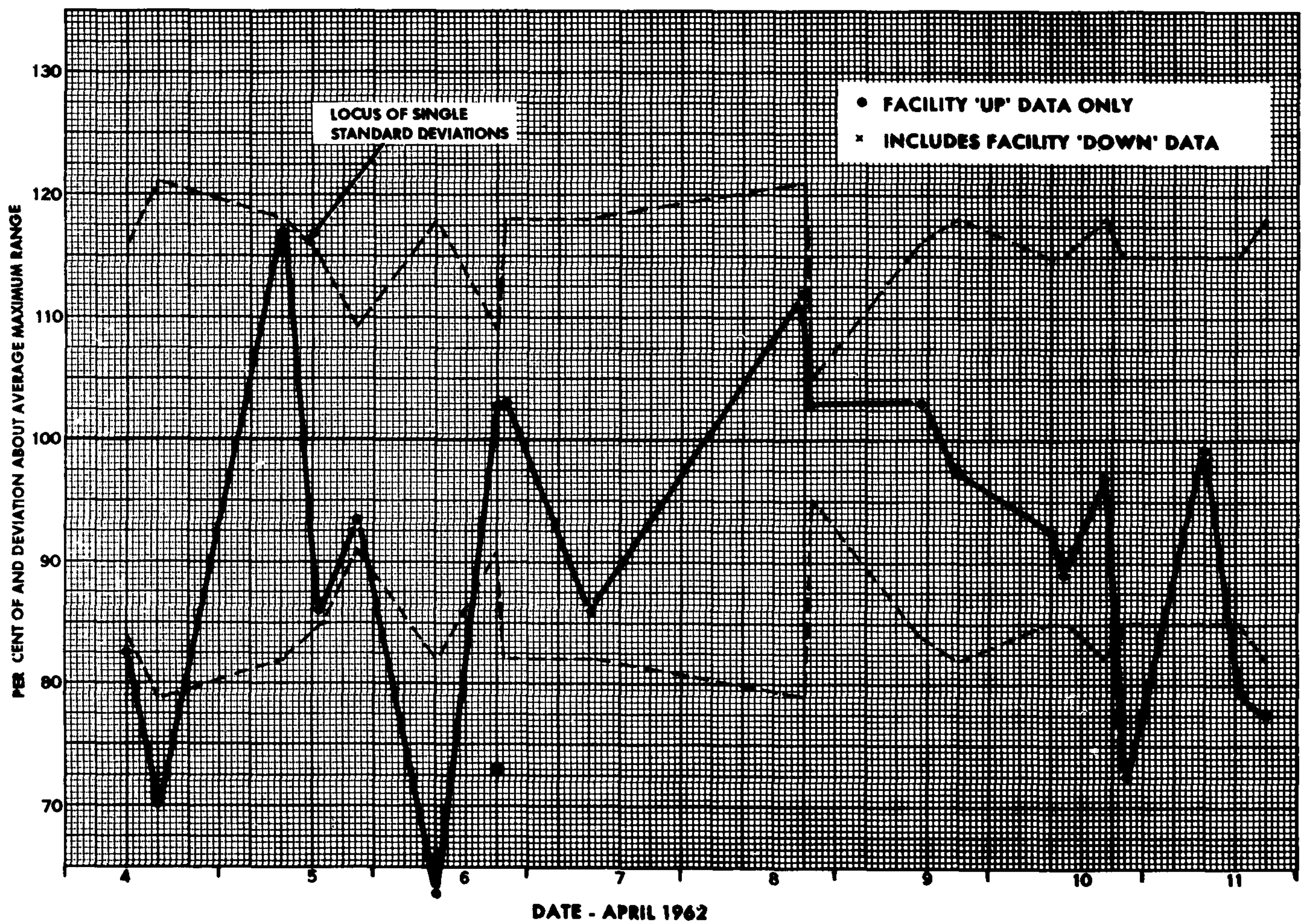

FIG. 4.10A FLUCTUATION OF RADAR COVERAGE WITH TIME DEPARTURES ON V194-286 USING ASR-2/4 RADAR WITH DC-6 AIRCRAFT (APRIL 4 THROUGH APRIL 11, 1962)

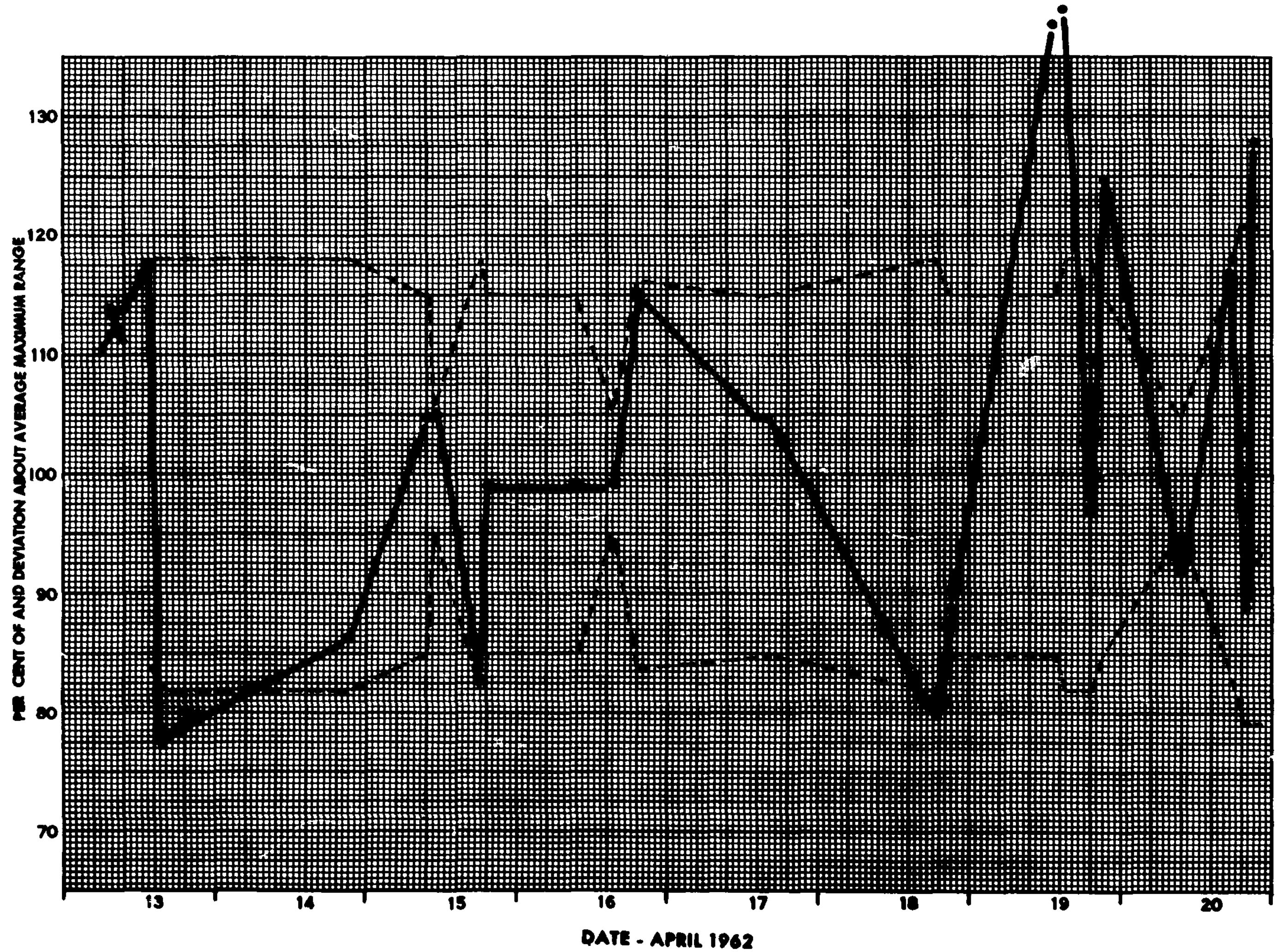

FIG. 4.10B FLUCTUATION OF RADAR COVERAGE WITH TIME DEPARTURES ON V194-286 USING ASR-2/4 RADAR WITH DC-6 AIRCRAFT (APRIL 13 THROUGH APRIL 20, 1962)

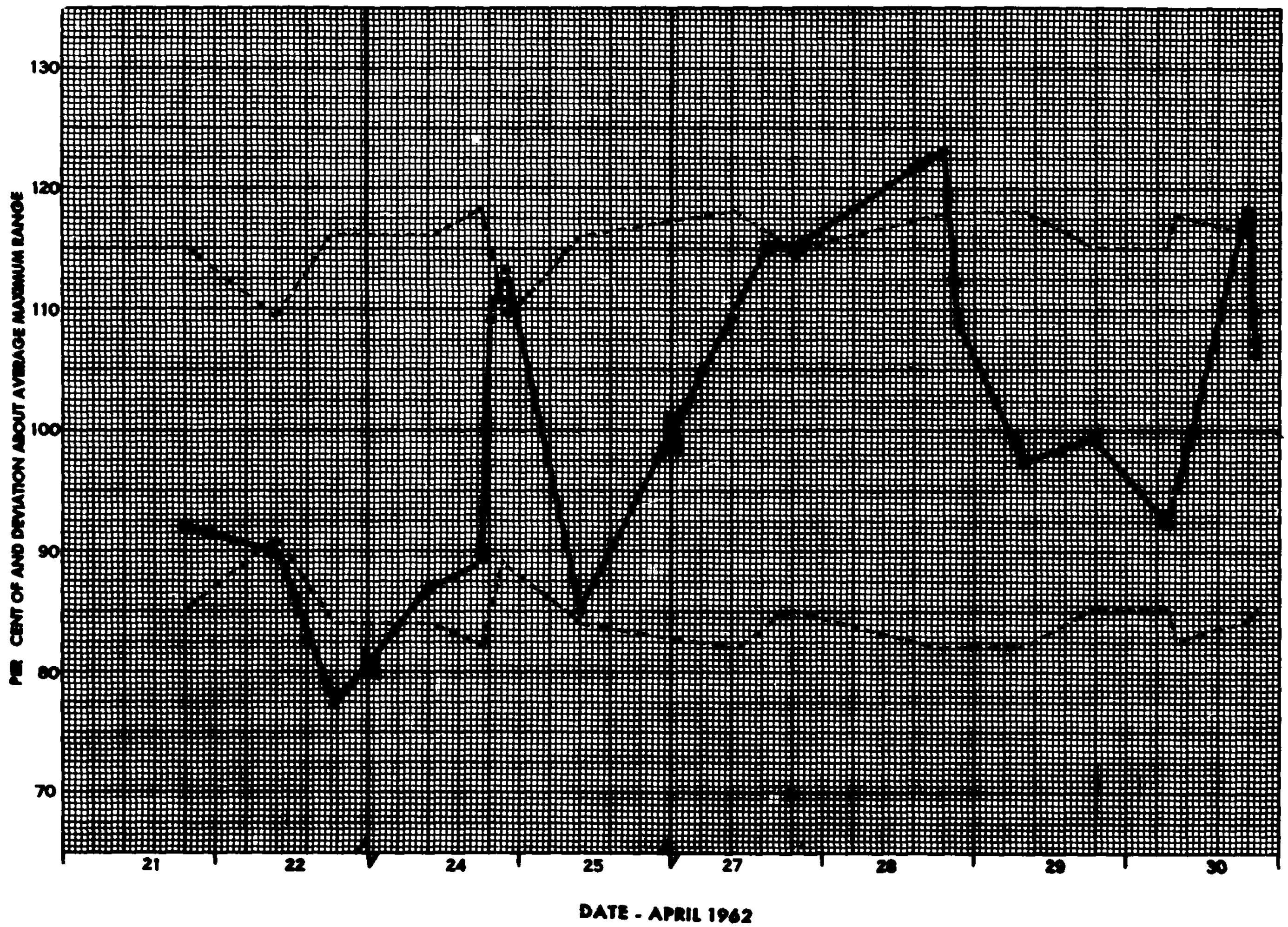

FIG. 4.10C FLUCTUATION OF RADAR COVERAGE WITH TIME DEPARTURES ON V194-286 USING ASR-2/4 RADAR WITH DC-6 AIRCRAFT (APRIL 21 THROUGH APRIL 30, 1962)

4.36 Figure 4.10, then, represents the true fluctuation of radar coverage as a function of time, since comparisons of maximum range points are made on a given route for departing DC-6 aircraft at the same altitudes. This type of chart can easily be plotted from day to day at each radar site.

4.37 As more and more data are collected on a daily basis, more samples will be obtained for each altitude, providing greater confidence in the comparison with past performance and the decision to investigate possible causes of degraded performance. The sample size for each altitude, although small (seven samples, on the average, per altitude) is still seven times greater than that obtained during present periodic flight inspections for the example above.

Tolerances and False Alarm Rates

4.38 There are a number of ways to establish acceptable tolerances below which degradation in performance would require an investigation as to cause and corrective maintenance or procedural action to be taken depending on the cause. One approach would be to establish a compromise tolerance of a quantity of decibel (db) degradations with respect to a preestablished level of performance. This would be similar to the present periodic flight inspection tolerance of 4 db below the commissioning level. For example, a similar technique could be applied to the No. 4 basic data sort which establishes the average vertical coverage pattern of a given route over a preselected sampling period. (Approximately 150 samples are estimated as being sufficient to establish an accurate pattern.) The reference commissioning level for the user type aircraft selected could be established by making correlation runs with a flight inspection DC-3 aircraft or, alternately, the allowable tolerance might be referenced to the upper 2σ level for the sample size used to establish the initial average vertical coverage pattern with no equipment or atmospheric anomalies existing.

4.39 Another approach to the problem of establishing acceptable tolerances would be on a completely statistical basis. This would have particular application to the normalized data sort, described in paragraphs 4.33 through 4.37, which is intended to permit decisions on performance level to be made on a daily basis. If the variance for maximum range on a given route at each elevation is established based on data obtained only under "up" conditions of the equipment and atmosphere, and the data at each elevation are normally distributed (this remains to be proven but appears to be a reasonable assumption), then a tolerance of 2σ based on each run would represent a 2.3 per cent false alarm rate (that is, this condition would occur 2.3 per cent of the time for up conditions of the equipment and atmosphere). This false alarm rate could be reduced by widening the tolerance; for example; a 3σ tolerance would reduce the false alarm rate to .13 per cent. It could also be reduced by basing a decision on more than one sample; for example, the false alarm rate based on two consecutive samples with variances of 2σ or greater would be a maximum of .05 per cent.

4.40 If a tolerance of 2σ is felt to be too wide from an operational standpoint as a basis for determining abnormal performance of a facility, a decision can be made on a larger number of samples, thus reducing the tolerance without affecting the false alarm rate; for example, if the false alarm rate is selected as 2.3 per cent and a decision is to be based on two consecutive samples instead of one, the tolerance is reduced from 2σ to 1.035σ.

4.41 The above approaches to establishing tolerances are intended only to give an idea of the possible approaches to this problem or, perhaps, for initial use in a pilot implementation program. More extensive statistical testing can be applied to the data, and should be investigated further and correlated directly to equipment performance capabilities and operation requirements for the facilities. These areas should be considered so that an effective trade off between complexity of analysis, cost, and capability for almost real-time monitoring is achieved.

4.42 Effects of Weather. Of the 170 DC-6 flights with the ASR-2/4, 18 provided indications of the prominence of weather on the scope. This represents 10.8 per cent of the tracks. The data also indicated that rather severe ducting and clutter often appear on the scope over the Cape Charles Peninsula which is about 20 miles north/northeast of Norfolk. The controllers indicate that they try to avoid vectoring aircraft in this area. If necessary, however, they vector aircraft around the clutter. Also, prevailing winds in the Norfolk area are toward the northeast and when heavy precipitation appears in the southwest sector, it can be predicted that the motion of the precipitation, and subsequent scope clutter will be obliquely across the scope in the northeasterly direction. This motion usually takes units of hours.

4.43 Existence of Holes. A loss of target for at least one scan during the track prior to reaching the maximum range point was indicated on 58.3 per cent of the tracks compiled in Table I, Appendix III. In some of these cases, reasons for such losses were indicated by the controllers. For example, when the aircraft was within the moving target indicator (MTI) gate setting and was turning, its radial velocity was zero and thus the target was lost. In other cases, weather on the scope blocked the track (prior to the maximum range point) or ducting may have caused a refraction and trapping of rays. In still other cases, intermittent targets at long range may be attributed to reflected ground signals cancelling out the direct path signal.

4.44 With respect to the number of consecutive scans the target was lost on each track, Fig. 4.11 shows a plot of the percentage of tracks for which the target was lost at least 1, 2, ... up to 8 consecutive scans during the track. In cases where the loss of target was indicated in mileage rather than numbers of scans, taking an average speed of 220 knots for the DC-6 and an antenna rotation speed of 13 revolutions per minute (rpm), the loss of a target for 1 mile corresponds to approximately 3 1/2 scans. This figure indicates the prevalence of holes under normal user aircraft control conditions. For about 10 per cent of the tracks, the target was lost for at least 7 consecutive scans; that is, approximately 30 seconds for a DC-6 or 2 miles of space.

4.45 Equipment Effects. An attempt was made to correlate loss of coverage with degradation in equipment. This was difficult to do since the normal control operation has a self-regulatory effect on the status of equipment. That is, when the controllers notice unusual losses of targets or misalignment in normal traffic, they call it to the attention of maintenance personnel who, in turn, check on the status of the equipment. In only two cases on the ASR-2/4 were abnormal equipment conditions noted which existed while RQCFE tracks were being recorded. On April 20, a DC-6 was tracked out to only 22 miles at 9,000 feet on V1N. The controller noted that the intermediate frequency (IF) gain had been reduced prior to this run. Also, on April 24, a DC-6 was tracked out to only 18 miles at 5000 feet on V1N. In this case, the IF gain setting was noted as being too low.

4.46 Flight Direction Effects. Over five times as many tracks were recorded for outbound flights as for inbound flights for the ASR-2/4 with DC-6 aircraft. The analysis thus far presented has not differentiated between inbound and outbound flights. Therefore, it contains averages over both, with the outbound flights weighted about five to one as compared to the inbound flights except in the case of the normalized sort plotted on Fig. 4.10 where only outbound traffic on route V194-286 was used. All other sorts therefore contain averages over both inbound and outbound flights, with the outbound flights weighting five to one as compared to the inbound flights.

4.47 The inbound and outbound flights have been sorted by altitude (similar to sort No. 2) and the various average maximum range points are

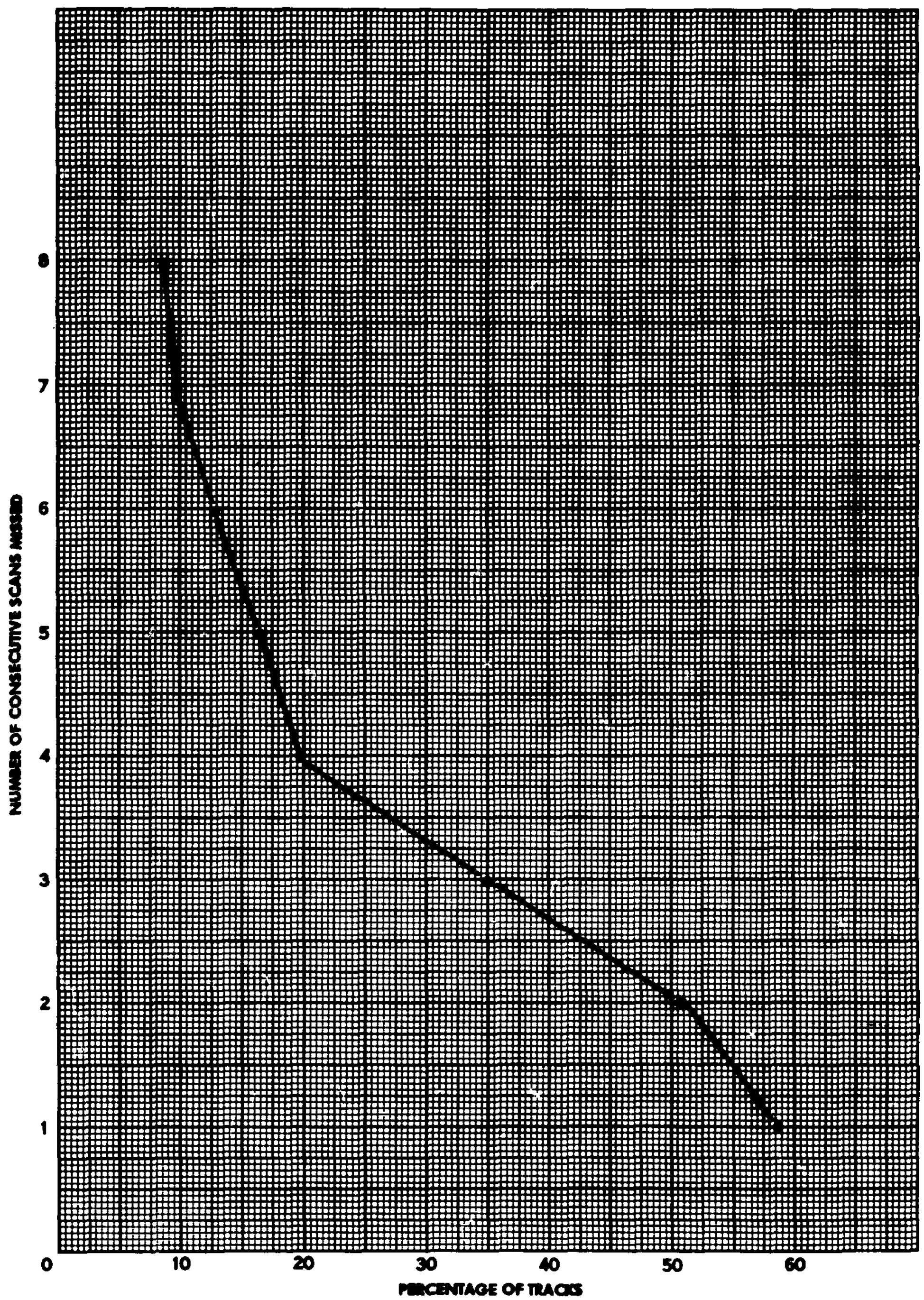

FIG. 4.11 PERCENTAGE OF TRACKS FOR WHICH TARGET LOST AT LEAST THE ORDINATE NUMBER OF CONSECUTIVE SCANS USING ASR-2/4 RADAR WITH DC-6 AIRCRAFT

plotted in Fig. 4.12. Arrows between points indicate the differences between average maximum ranges for inbound and outbound flight. It can be noted that most of the inbound points lie to the right of the outbound points, indication that the inbound flights could be detected at longer range, on the average, than the outbound flights. The data are not statistically conclusive but it appears that the inbound flights can be detected, on the average, from 2 to 4 NM farther than the outbound flights.

FPS-8 - General

4.48 Less data were obtained for DC-6 traffic on the FPS-8 than on the ASR-2/4. The FPS-8 data, compiled from the data forms for DC-6 aircraft, are shown in Table II, Appendix III. As with the ASR-2/4, this table shows the date on which the aircraft was tracked, time, maximum range, altitude of the aircraft at that range, route of flight, whether the flight was inbound or outbound, additional comments pertinent to the flight, and the presence and locations of holes in coverage. Approximately 4 per cent of the total tracks of DC-6 aircraft for the FPS-8 was not used for the Nos. 1, 2, 3, 4, and 5 basic data sorts since, for these tracks, weather conditions or equipment malfunctioning were noted as having interfered with the track thus affecting the maximum range point. Since the first five sorts are thought of as presenting the average performance of the facility, these data were not included. However, these data have been included in the No. 9 basic data sort since the intent of this sort is to show variations in performance whether due to normal or abnormal conditions.

4.49 Data Sorts. Given a large sample size, Table 4.6 shows a list of 12 sorts of data that could be presented from the compiled data. The sorts that appear in this report, which are meaningful and consistent with the sample size obtained during the RQCFE, are discussed in the following paragraphs. Due to the time limitations of this experiment, no attempt was made to analyze the data to present the normalized sorts for the FPS-8 as was done for the ASR-2/4. The discussion for the ASR-2/4 on tolerances and false alarm rates contained in paragraphs 4.38 through 4.41 is equally applicable to the FPS-8.

FPS-8 Basic Data Sorts

4.50 Sort No. 1. The average maximum range, considering all data compiled over different altitudes and routes for DC-6 aircraft, is 91.8 NM with a standard deviation of 13.2 NM. The number of samples is 97 tracks.

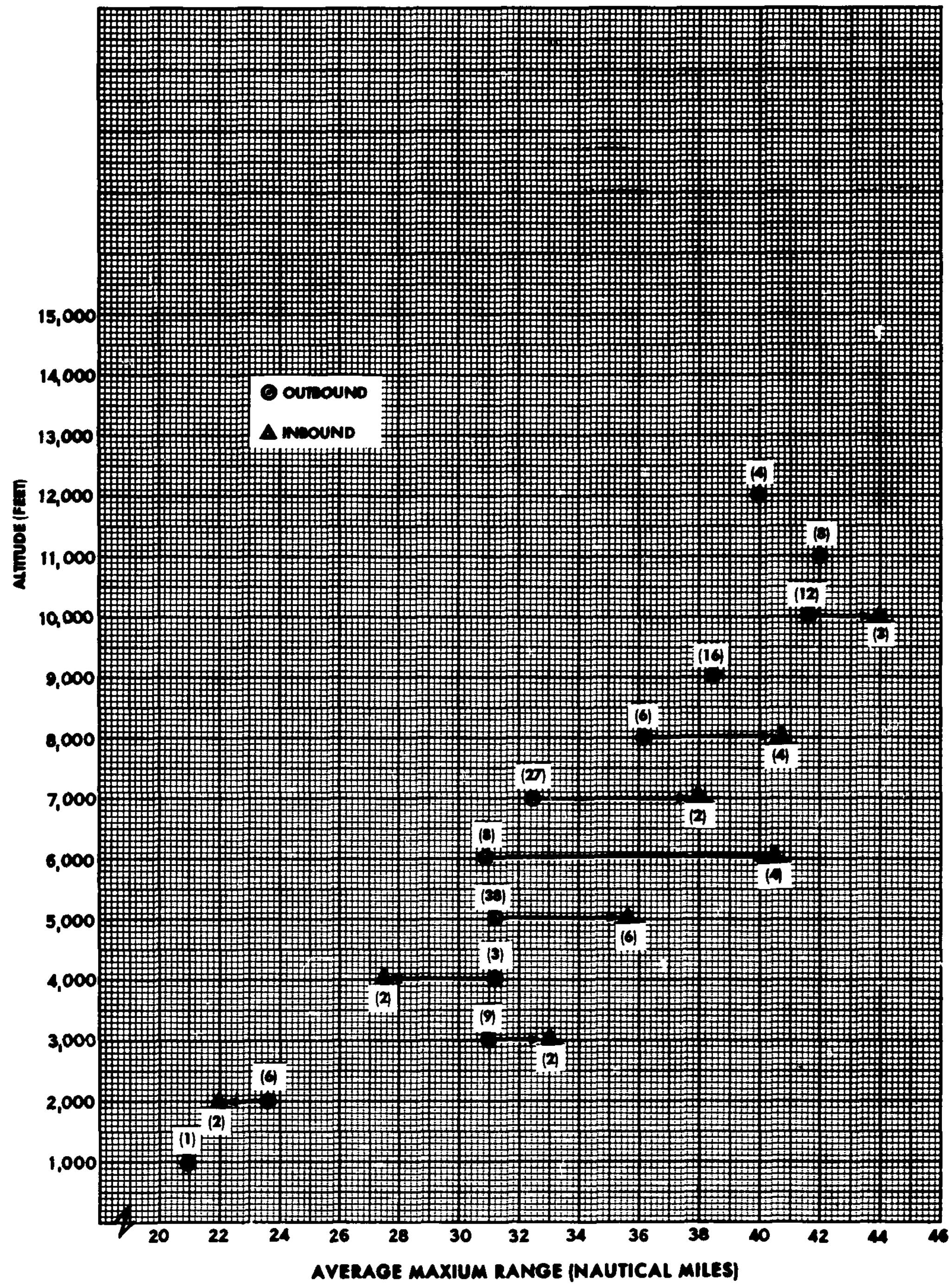

FIG. 4.12 RANGE VERSUS ALTITUDE FOR INBOUND AND OUTBOUND FLIGHTS USING ASR-2/4 RADAR WITH DC-6 AIRCRAFT

TABLE 4.6

POSSIBLE SORTS OF COMPILED DATA FOR FPS-8 RADAR WITH DC-6 AIRCRAFT

Sort No.	All Data	Altitude	Route	Time	Date	Results Presented in:
1	X					Paragraph 4.50
2		X				Figure 4.13
3			X			Table 4.7
4		X	X			Figure 4.14
5	X			X		Figure 4.15
6		X		X		Not Presented
7			X	X		Not Presented
8		X	X	X		Not Presented
9	X				X	Figure 4.16
10		X			X	Not Presented
11			X		X	Not Presented
12		X	X		X	Not Presented

Maximum range is the dependent variable.

4.51 Sort No. 2. A vertical coverage pattern for the data sorted by altitude is shown in Fig. 4.13. The data extend in altitude to 19,000 feet,, or approximately twice the altitude coverage obtained during periodic flight checks. The results are consistent with those determined for the ASR-2/4, namely, that the DC-6 does not appear to be as good a target as the flight inspection DC-3 (the periodic flight check data are presented in Appendix IV). The reasons for the differences have been discussed in paragraph 4.15.

4.52 Sort No. 3. The radar coverage on various routes, averaged over all altitudes, times and days, is indicated in Table 4.7. This table shows the effect of altitude for the intermediate altitude route 1503 at which the average maximum ranges are over 100 NM, as compared to average ranges for basic altitude routes which are below 100 N.M. Note also the preponderance of data on V286. This is a much used route for DC-6 aircraft for flights between Norfolk and Washington, D. C.

4.53 Sort No. 4. The route at which the greatest number of samples was obtained is V286 on which 42 DC-6 aircraft were tracked. This number of samples is one-third to one-fourth of the number of samples which constituted a reasonably regular vertical coverage pattern for the ASR-2/4 (Fig. 4.4). Hence, the 42 samples on V286 do not suffice to define a very consistent vertical coverage pattern, as shown by Fig. 4.14 in which a rough fairing of data was performed.

4.54 Sort No. 5. If the data are sorted by time of day, independent of route, altitude and date, a plot of average maximum range as a function of time of day can be obtained as shown in Fig. 4.15. Both samples shown from 9 to 10 p.m. were taken at 18,000 feet on route 1503 and thus account for the large value of average maximum range. Of the six samples for the lowest maximum range of 78 NM between 7 and 8 p.m., four were at 9000 feet and one each at 7000 and 11,000 feet.

4.55 Sorts Nos. 6, 7 and 8. These sorts have not been analyzed due to the relative dearth of samples within each category.

4.56 Sort No. 9. A plot of average maximum range as a function of date is shown in Fig. 4.16, representing data accumulated from sort No. 9. The large values of average maximum range on April 7 and 14 are due mostly to the fact that three of the four samples were at the high altitudes of 17,000 and 14,000 feet. The low value of average range on April 10 was comprised of two samples; one at 5000 and the other at 7000 feet. Even at

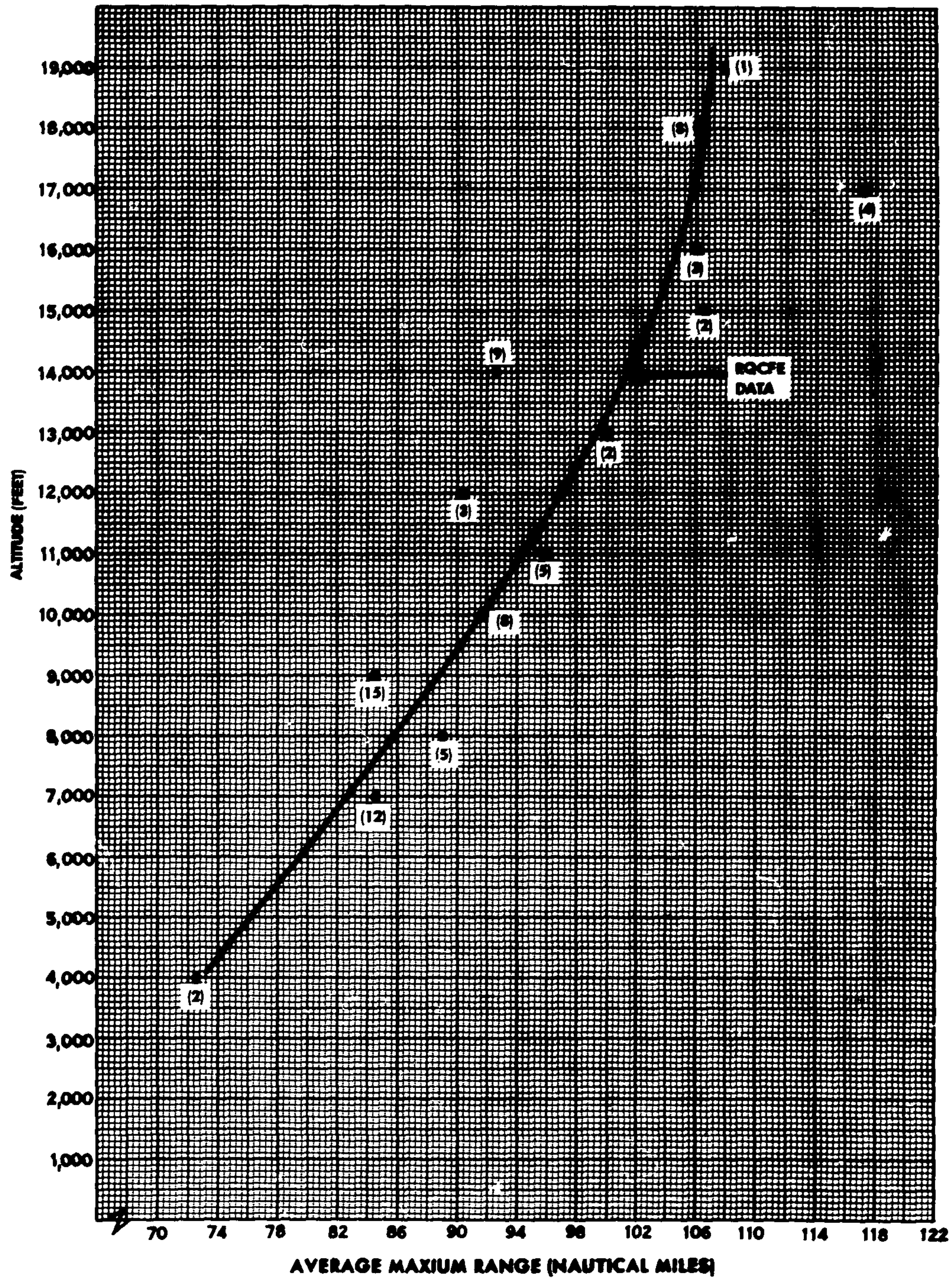

FIG. 4.13 DATA SORT NO. 2 FOR FPS-8 RADAR WITH DC-6 AIRCRAFT - RANGE VERSUS ALTITUDE

TABLE 4.7

DATA SORT NO. 3 FOR FPS-8 RADAR WITH DC-6 AIRCRAFT - AVERAGE MAXIMUM RANGE VERSUS ROUTE

Route	Average Maximum Range (NM)	Number of Samples
1503 N[1]	112.6	9
V139	96.3	3
V1N	93.2	11
V286	85.0	42
V157	84.0	2
V156	85.0	2
PHF[2]	90.0	1
V266	93.0	1
1503 S[3]	105.0	9
V1-194[4]	90.9	17

[1] Route 1503 North

[2] Patrick Henry

[3] Route 1503 South

[4] This compilation includes V1, V194 and V229. There was only one sample on V229.

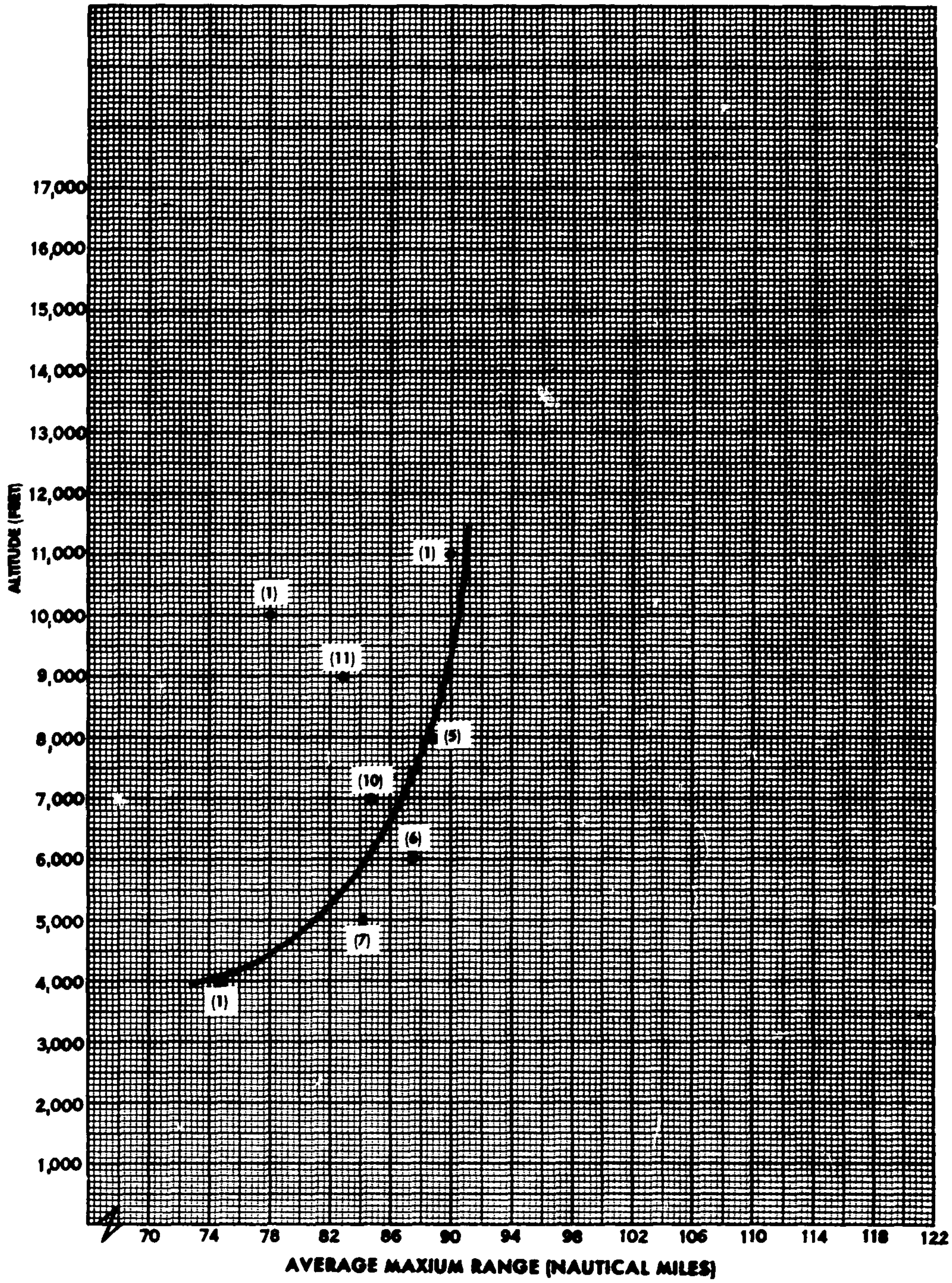

FIG. 4.14 DATA SORT NO. 4 FOR FPS-8 RADAR WITH DC-6 AIRCRAFT - RANGE VERSUS ALTITUDE ON V286

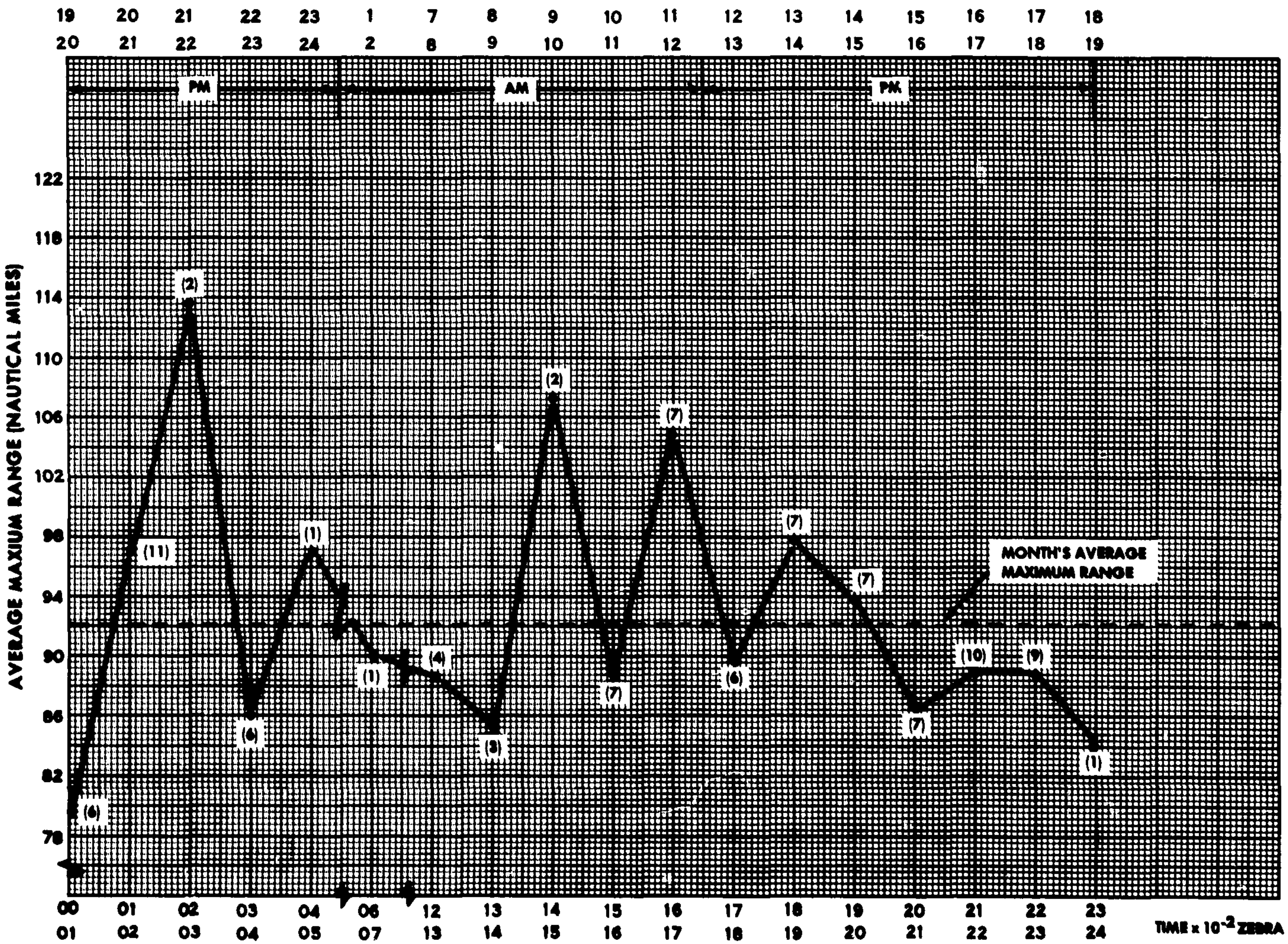

FIG. 4.15 DATA SORT NO. 5 FOR FPS-8 RADAR WITH DC-6 AIRCRAFT - RANGE VERSUS TIME OF DAY

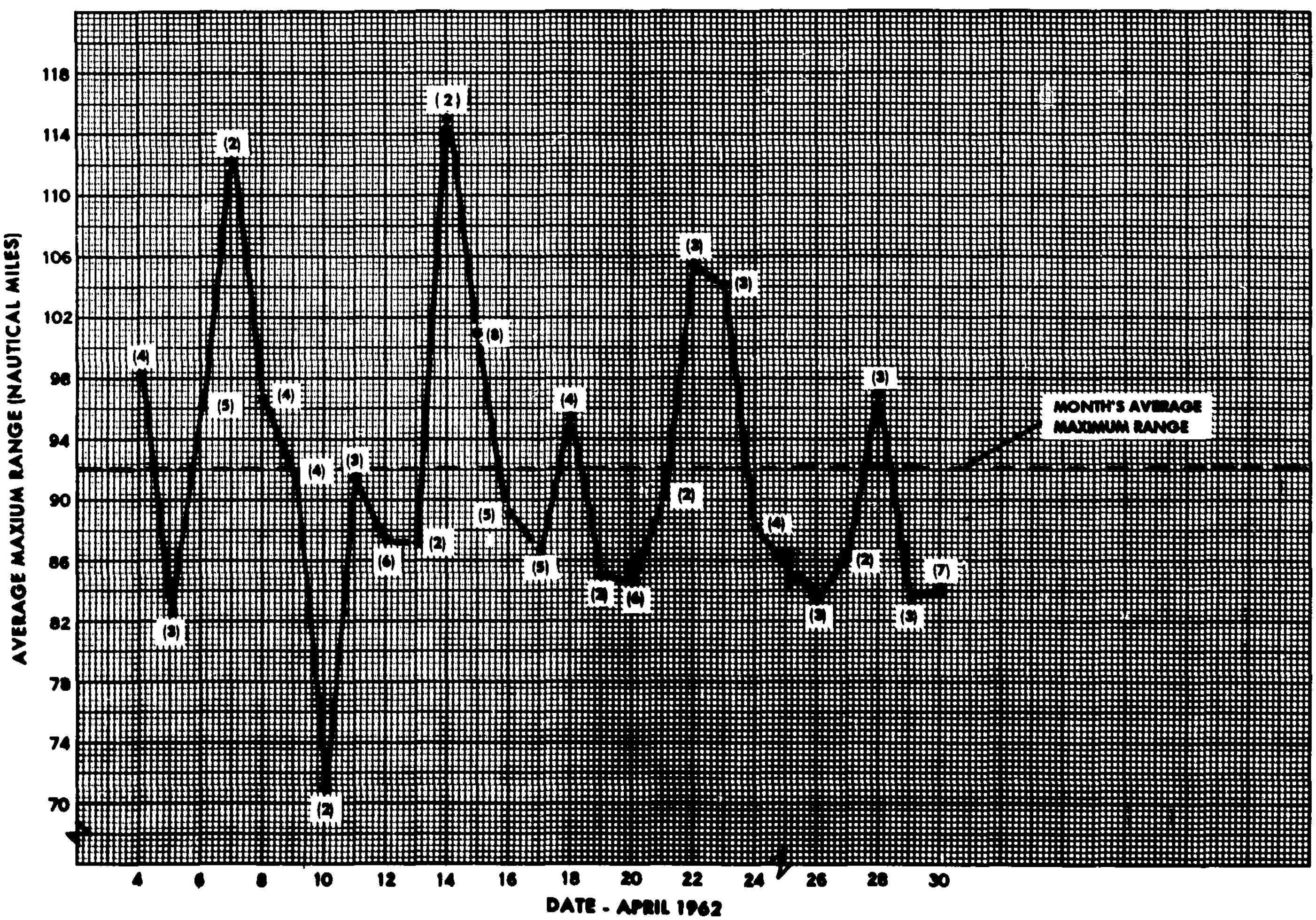

FIG. 4.16 DATA SORT NO. 9 FOR FPS-8 RADAR WITH DC-6 AIRCRAFT - RANGE VERSUS DATE

these altitudes, however, the maximum range values are low, indicating degraded coverage. The graph of Fig. 4.16 breaks at April 25 since no tracks of DC-6 aircraft were obtained on that date.

4.57 Sorts Nos. 10, 11 and 12. These sorts have not been analyzed due to the relative dearth of samples within each category.

4.58 Effects of Weather. Of the 101 DC-6 flights with the FPS-8, 22 provided indications of the prominence of weather on the scope. Additional overall weather effects and observations have been presented in paragraph 4.42.

4.59 Existence of Holes. A loss of target for at least one scan during the track prior to reaching the maximum range point was indicated on 46.5 per cent of the tracks compiled in Table II, Appendix III. Figure 4.17 shows the percentage of total tracks for which the number of consecutive misses was 1, 2, . . . up to 8 scans.

4.60 Equipment Effects. Observations regarding the effects of equipment are similar to those already discussed in paragraph 4.45.

4.61 Flight Direction Effects. Over four times as many tracks were recorded for outbound flights as for inbound flights for the FPS-8 with DC-6 aircraft. As for the ASR-2/4, no attempt was made to differentiate between these tracks in the data sorts presented in Table 4.6. A plot of average maximum range as a function of altitude for inbound and outbound headings is shown in Fig. 4.18. With the small sample size of only 19 total inbound tracks spread over altitudes from 4000 to 18,000 feet, the data show the outbound target better (on the average) at 11,000 feet and less, and the inbound target (on the average) at 13,000 feet and above.

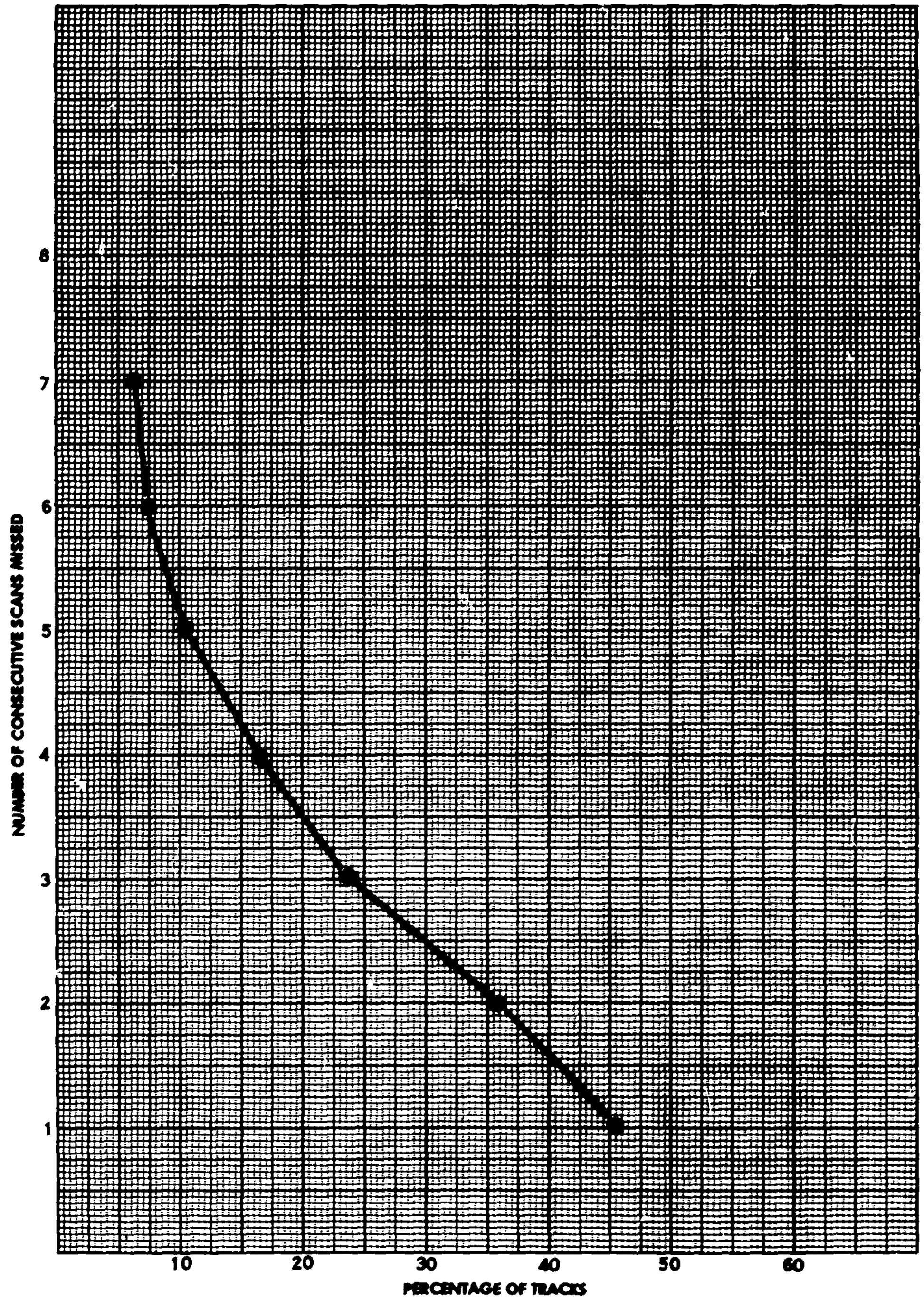

FIG. 4.17 PERCENTAGE OF TRACKS FOR WHICH TARGET LOST AT LEAST THE ORDINATE NUMBER OF CONSECUTIVE SCANS USING FPS-8 RADAR WITH DC-6 AIRCRAFT

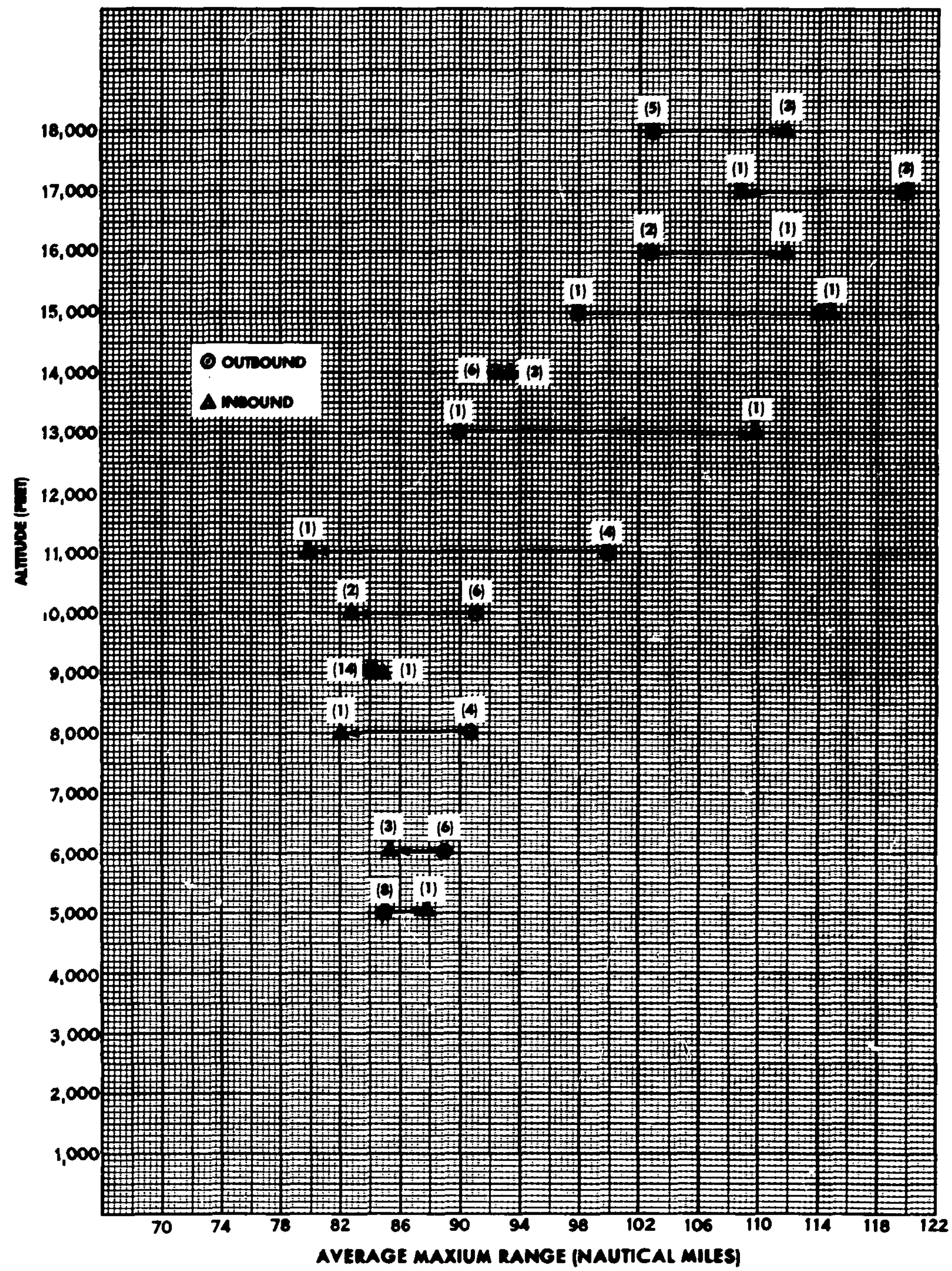

FIG. 4.18 RANGE VERSUS ALTITUDE FOR INBOUND AND OUTBOUND FLIGHTS USING FPS-8 RADAR WITH DC-6 AIRCRAFT

THE EFFECT OF DIFFERENT AIRCRAFT

General

4.62 Since the DC-6 was chosen as the aircraft for which the greatest amount of data would be collected (Appendix II, Procedures - Flight Check Experiment), data on other types of aircraft are rather sparse. In spite of this dearth of data, the results are reasonably consistent and regular. This is probably due, in part, to the fact that during instrument-flight-rule (IFR) weather, there was no lack of DC-6 aircraft filing flight plans. Therefore, under these conditions, DC-6's were tracked. During VFR conditions, however, flight strips (and thus altitude information) of DC-6's were not always available; therefore, other aircraft were tracked. Hence, on other than DC-6 tracks, one of the most important variables, namely weather, tends to remain fairly consistent.

ASR-2/4 - DC-3 Types

4.63 Medium-sized, twin-engined aircraft have been plotted as a group. The radar cross sections of the DC-3, Convair 340, and P2V are evidently similar enough that had any one of these aircraft been considered singly, similar vertical coverage patterns would have been obtained. Figure 4.19 compares the DC-3 vertical coverage pattern with the DC-6 pattern and with the pattern established for the total of DC-3 type aircraft; that is, Convair 340, P2V, and DC-3. As noted above, the DC-3 in "good weather" appears to be a better target than the DC-6 "average weather."

FPS-8 - DC-3 Aircraft

4.64 Only four DC-3's were tracked and recorded with the FPS-8 radar. Although the range appeared reasonable (more than 95 per cent of the range of the DC-6's taken during the same period), there were not enough samples to make a comparison over the complete vertical coverage.

ASR-2/4 - Viscount

4.65 Figure 4.20 compares the Viscount average maximum range to that of the DC-6, for the ASR-2/4. Even though head-on and tail-on maximum ranges over all azimuths were combined, the pattern, with these few samples, shows an average deviation of only approximately 5 per cent.

FPS-8 - Viscount

4.66 The maximum range of the FPS-8, averaged over all routes, time and direction of flight, is presented in Fig. 4.21. Analysis of

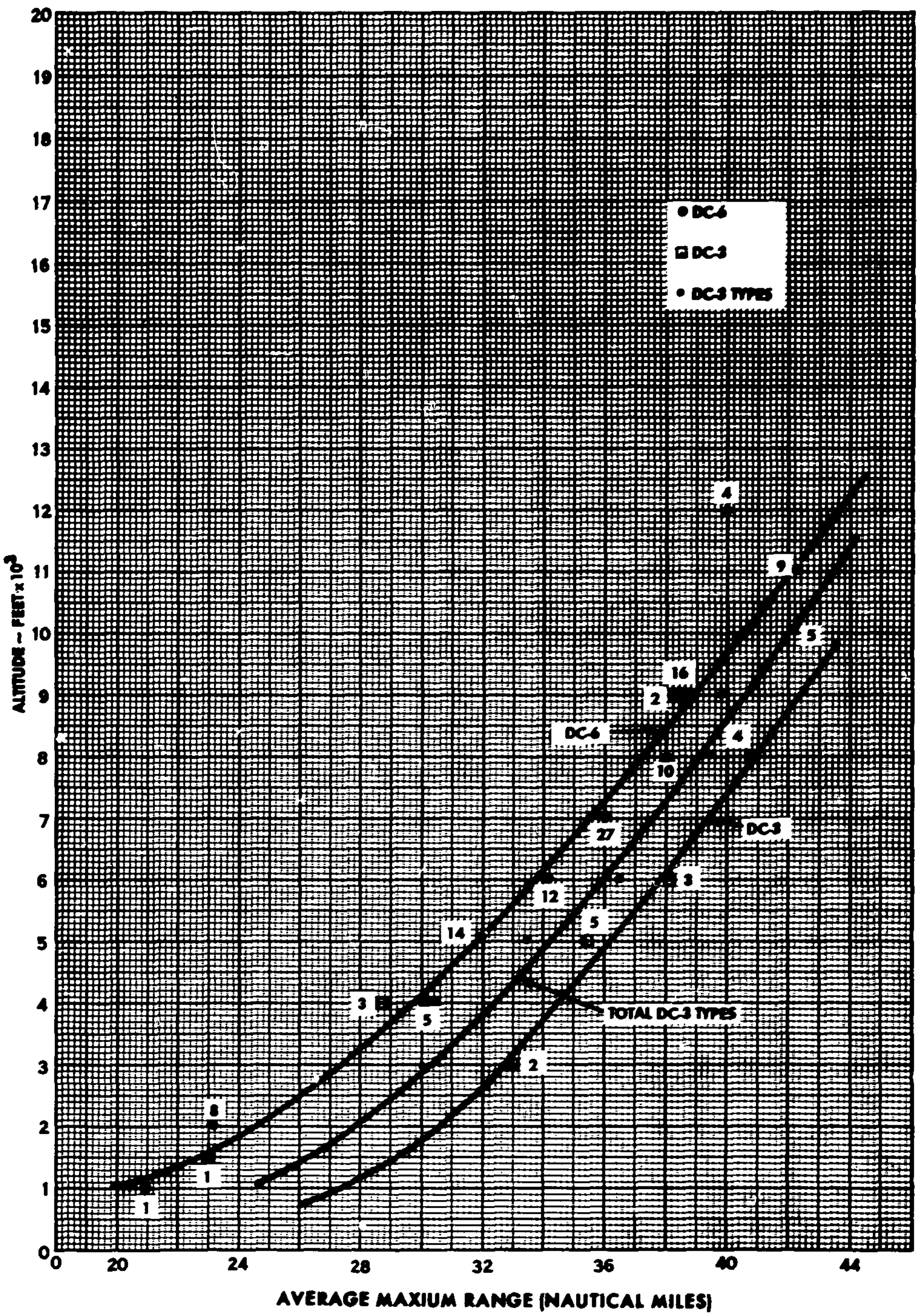

FIG. 4.19 DC-3 VERTICAL COVERAGE FOR ASR-2/4 RADAR

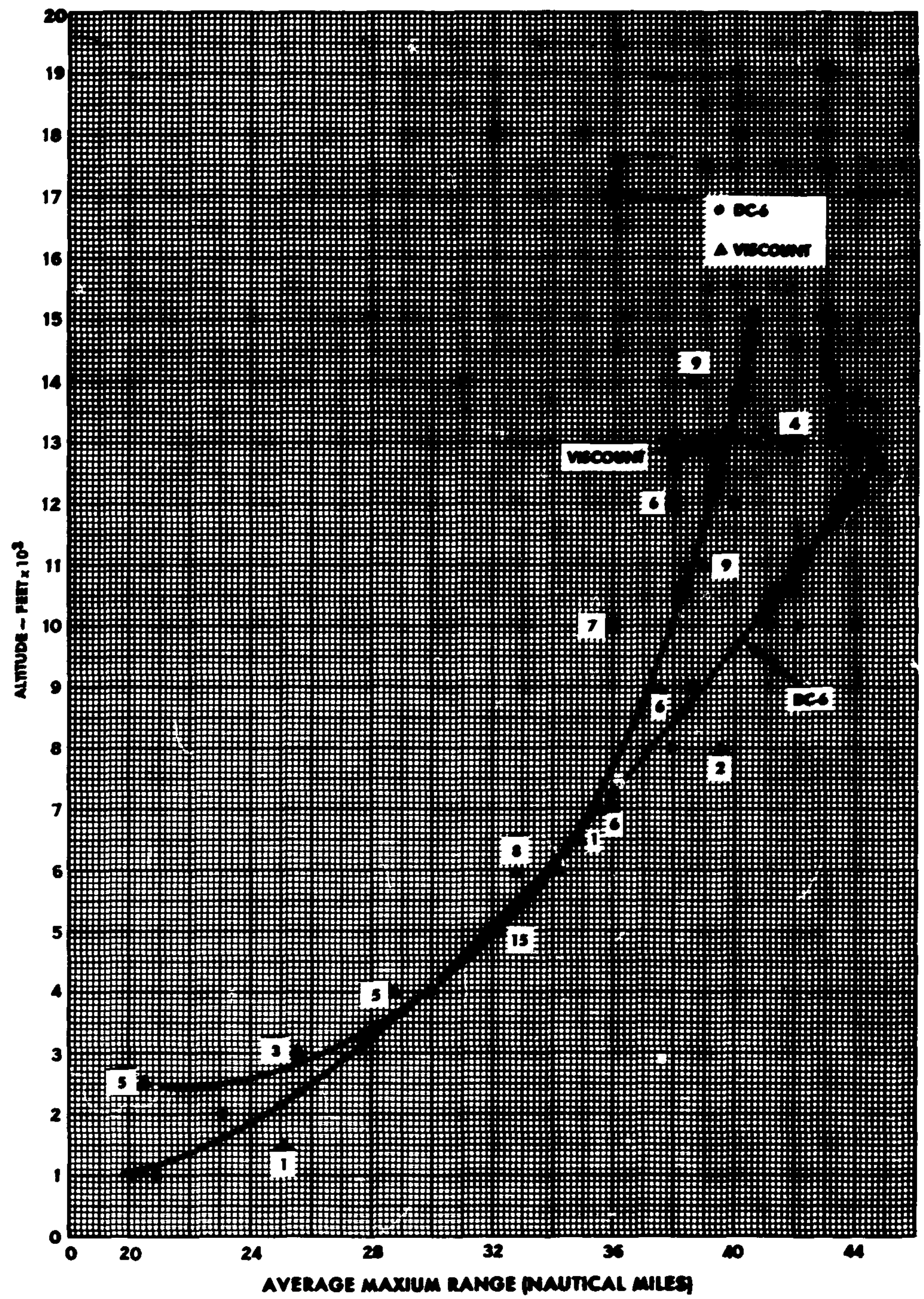

FIG. 4.20 VISCOUNT VERTICAL COVERAGE FOR ASR-2/4 RADAR

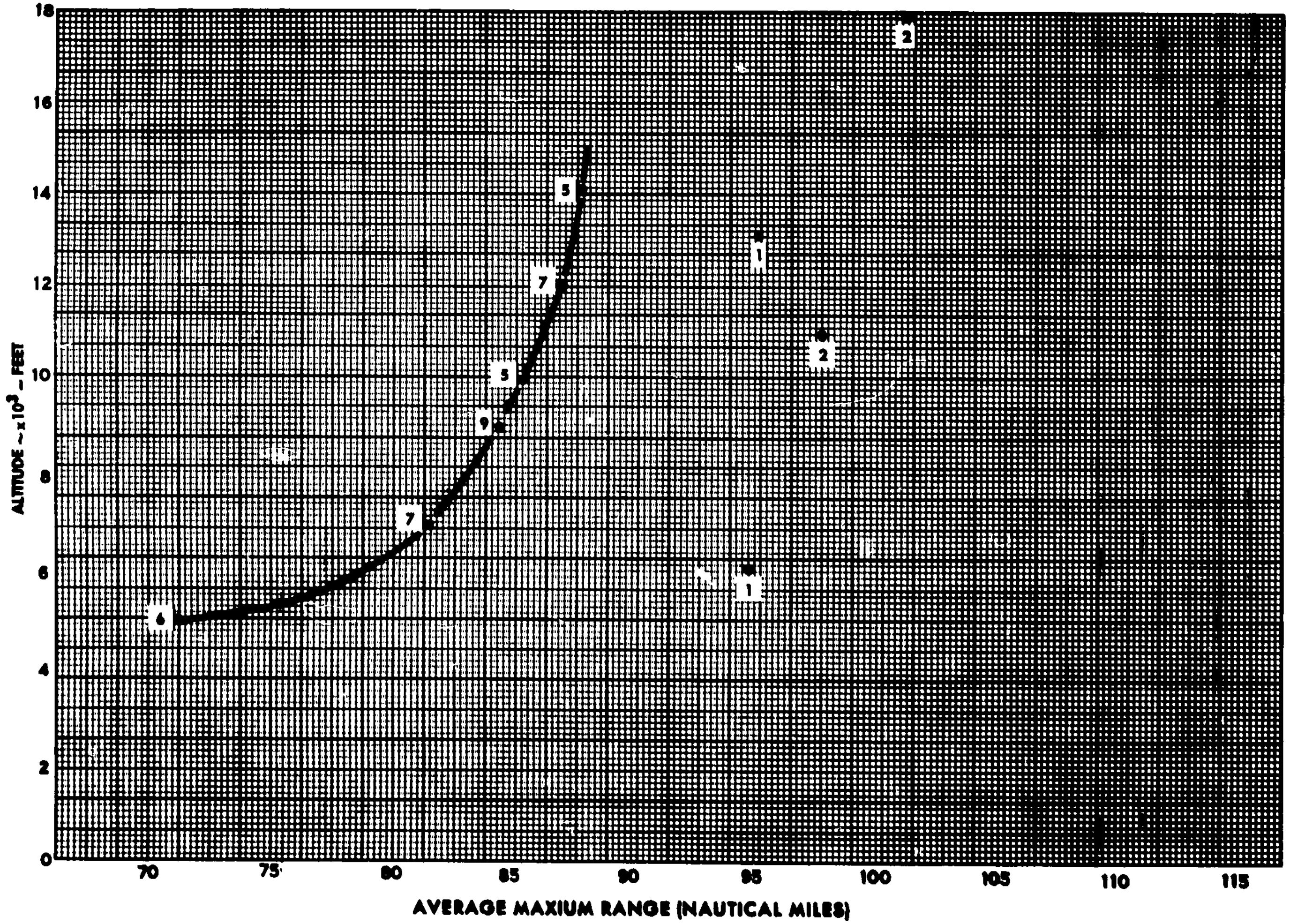

FIG. 4.21 VISCOUNT VERTICAL COVERAGE FOR FPS-8 RADAR

the maximum range data for the Viscount indicates how a small amount of data, taken over an extended period of time, are likely to appear. The average of the data taken at altitudes for which there were more than two samples appears quite regular. However, unusually good weather and equipment performance can make a single track appear "out of line." In most cases, this good vertical coverage is almost 15 per cent better than the average coverage. "Bad weather" or equipment performance is noted on the original data forms and these tracks were excluded from the computation of average maximum range. For example, the 45 tracks presented were the result of a total of 50 tracks taken during the test; 3 had to be discarded because of weather effects which interfered with the maximum range determination, and 2 were discarded because the altitude at maximum range was not known. Figure 4.22 shows a condensed version of the vertical coverage of Fig. 4.21, but includes also the inner fringe pattern.

Other Aircraft Types

4.67 ASR-2/4. Between 1 and 15 tracks were made of approximately 20 other types of aircraft. These varied from extremely small, poor targets (T33 or TV2) to very large, good targets (C130). The results were similar to those of other aircraft in the sense that fairly regular vertical coverage patterns emerged as soon as a few tracks accumulated at a range of altitudes.

4.68 FPS-8. The same general features apply to the miscellaneous types of aircraft tracked on the FPS-8. On both radars, if aircraft were combined into generic classes (that is, four-engine prop driven, two-engine prop driven, single place jet, and so forth), the vertical coverage patterns became regular and approached values which could be expected. For example, the various four-engine types showed slightly better range than the DC-6's, presumably because of the presence of large military cargo aircraft which are discussed in the following paragraphs on high altitude structure.

High Altitude Structure

4.69 General. Since, as stated previously, one of the primary purposes of this experiment was to reproduce the vertical coverage of the basic altitude structure, detailed study of the high altitude structure is not included. Perhaps the most promising area for direct correlation of equipment performance with the maximum range of a radar track is in the high altitude tracks. Tracks taken in close succession appeared to be highly correlated both in maximum range and position of holes. Also,

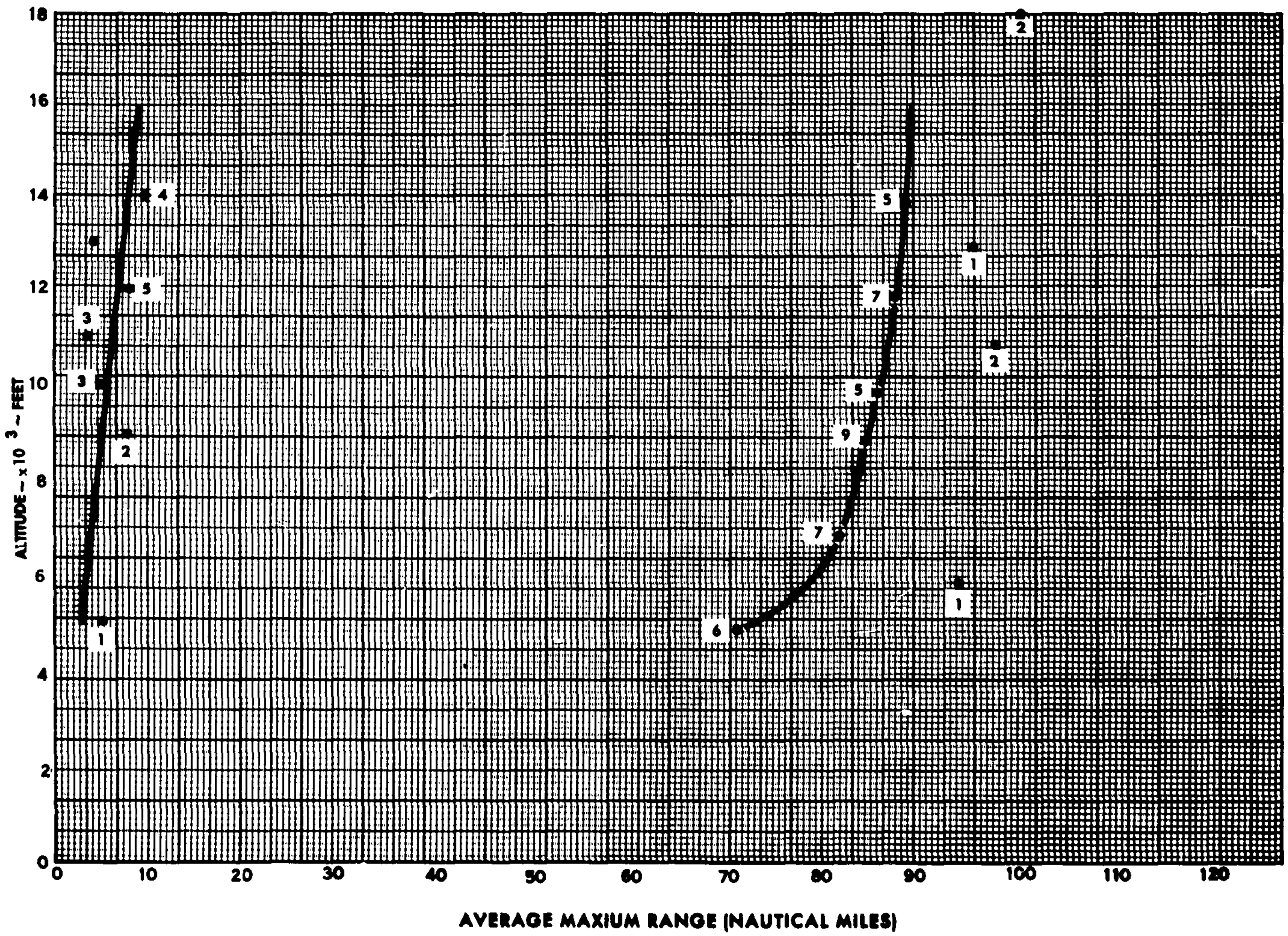

FIG. 4.22 VISCOUNT VERTICAL COVERAGE INCLUDING INNER FRINGE FOR FPS-8 RADAR

during this test, the controllers mentioned an apparent strong correlation between maximum range at high altitude, and coverage at low altitude. Figure 4.23 shows the average maximum range of the FPS-8 radar for 123 DC-8 tracks. Table 4.8 indicates that the DC-8, 720 and 880 give very similar radar returns and have similar head-on versus tail-on characteristics. This table also indicates the regularity of data acquired in the high altitude structure. Figure 4.23 also shows the average maximum range for all turbojet high altitude traffic; that is, 707, 720, 880, and DC-8.

COMPARISON WITH RADAR PERIODIC FLIGHT CHECKLIST

Coverage

4.70 Vertical. A vertical coverage pattern up to 10,000 feet is obtained at one azimuth, three times a year, during periodic flight checks. From data obtained during the RQCFE, vertical coverage patterns were constructed for the ASR-2/4 and FPS-8 across all routes (Figs. 4.4 and 4.13), and for single routes (Figs. 4.5 and 4.14). Subsequent data can be continuously compared to the coverage indicated on an hourly and daily basis. In addition, the RQCFE showed that data can be obtained for different types of aircraft and can be used to ascertain the coverage patterns at altitudes above 10,000 feet, including both intermediate and high altitude route structures. (As previously mentioned in paragraph 4.5, the present flight inspection of ARSR-type facilities does not appear to properly measure performance variations of the facility due to the loss of the aircraft target as a result of shielding by the radio horizon.)

4.71 Route. Coverage on two routes (one in addition to the vertical coverage check) at minimum instrument altitude is obtained during periodic flight checks. During the RQCFE, route coverage over a wide range of altitudes for routes V1, V139, V194, V286, V156, V260 and V266 in the Norfolk area with DC-6 aircraft was obtained. In addition, coverage on intermediate route 1503 and high altitude route J79V was obtained. The latter was for high altitude jet "flythrough" traffic. The RQCFE information was obtained daily.

4.72 Fix. Coverage over a minimum of two fixes at an altitude which provides the minimum acceptable target return (Strength 2) on the minimum instrument altitude is checked during periodic flight checks. During the RQCFE, coverage at various altitudes over fixes was checked under the normal routine of flight following the aircraft. In addition, on April 18, fix coverage on the FPS-8 was checked for two DC-6 aircraft: one at 9000

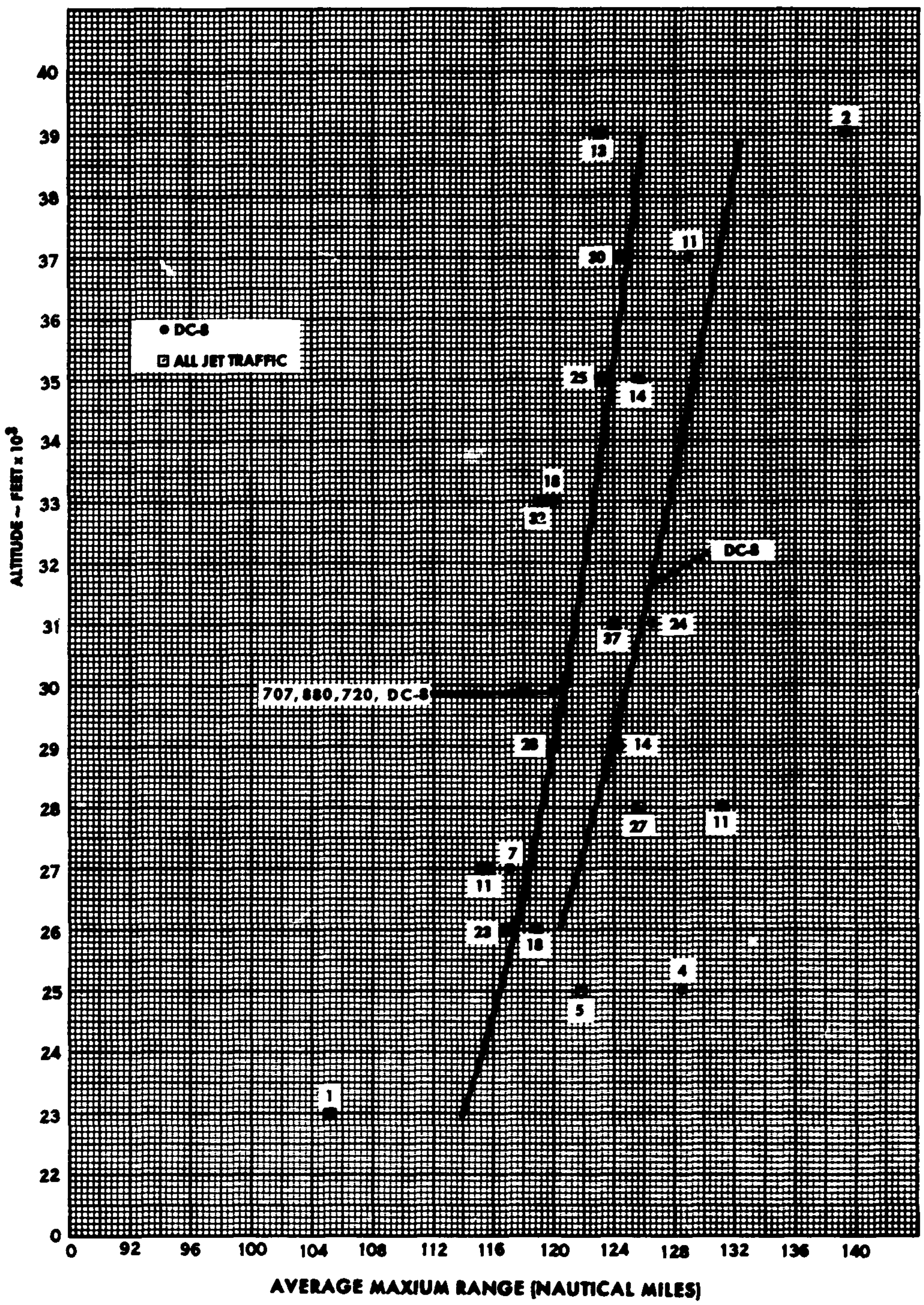

FIG. 4.23 JET TRAFFIC VERTICAL COVERAGE ON ROUTE J79V FOR FPS-8 RADAR

TABLE 4.8

RELATIONSHIP BETWEEN AVERAGE MAXIMUM RANGES

FOR JET TRAFFIC ON J79V

Aircraft	$\overline{R}_{max}$ OUT / $\overline{R}_{max}$ IN (per cent)	$\overline{R}_{max}$ 220° / $\overline{R}_{max}$ 030° (per cent)	$\overline{R}_{max}$ @31,000 Ft. (NM)
DC-8	97.1	92.6	126.3
720	98.3	95.8	120.2
880	99.4	91.2	116.7

feet out of Norfolk on VI and the other, 1 hour 36 minutes later, at 5,000 feet out of Patrick Henry to V286. A DC-6 flight out of Norfolk to 14,000 feet on V260 was checked on the FPS-8 for fix coverage on April 26. In all cases, fix coverage was reported to be satisfactory. Fix coverage was also reported as satisfactory for the ASR-2/4 on April 23 for a DC-6 flight out of Norfolk on VI to an altitude of 11,000 feet.

Video and Fixed Map Accuracy

4.73 Accuracy of the fixed and video maps is checked at selected points at minimum instrument altitude during periodic flight checks. The video map (for the FPS-8) and fixed map (for the ASR-2/4) were checked using the returns from fixed targets whose geographical position have been established and were recorded as satisfactory or unsatisfactory for the tracks (with some exceptions) recorded during the RQCFE. Over the period of approximately 30 days of tracking user aircraft, 481 flights were tracked on the ASR-2/4 and 427 on the FPS-8. Limited communciation with the pilot of the user aircraft would permit checks of the map beyond the area of fixed target returns.

Moving Target Indicator Blind Speed

4.74 The periodic check, called "MTI blind speed" is somewhat of a misnomer since what is actually required by the flight inspection manual is to check that there is a minimum loss of signal of any speed except the blind speed. During the RQCFE, tracks were normally recorded within the MTI gate setting (usually about 30 NM out) to check MTI performance with user aircraft. In addition, in approximately 3 per cent of the tracks, targets were lost within the MTI gate setting during turns when their radial velocities to the radar were zero, thus permitting a check of the velocity shaping response.

Surveillance Approaches

4.75 Surveillance approaches are performed during each periodic flight check. For example, during the flight check on April 2, 1962, approaches were flown to runways 1, 4, 13, 19, 22 and 31 using MTI, circular polarization (C/P) and staggered PRF. Accuracy was found satisfactory and good coverage was obtained throughout the approaches. During the RQCFE, a surveillance approach with a Colt to runway 4 was performed. It was reported that good targets appeared throughout the approach. In addition, radar approach controllers are required to conduct a minimum number of practice radar approaches each month. This, together with the surveillance approach performed during the RQCFE, is evidence of the feasibility of performing surveillance approaches with user aircraft. Any error in the approach course displayed would be apparent by the deviation of the aircraft from the displayed course in making a landing or by the aborting of a landing with the associated pilot comments indicating that he was not properly aligned with the runway even though so indicated by the radar display.

Strobe Line

4.76 The direction finder (DF) strobe line feature, if installed, is checked during periodic flight checks. The strobe line was checked on the ASR-2/4 and recorded as satisfactory or unsatisfactory for some of the tracks during the RQCFE.

Fixed Target Identification

4.77 Fixed targets are checked, when necessary, as part of the periodic flight check. No fixed targets were checked during the RQCFE, since a ground rule of the experiment was that no communications would be conducted with the user aircraft for the purpose of obtaining data. If occasional communications (less than four per year) could be permitted for this purpose, then this information could be obtained from a user aircraft.

Controller Proficiency

4.78 Controller proficiency is checked during each periodic flight check, although this was not done during the RQCFE. Controller proficiency can be checked by monitoring the control operation at selected intervals although this is not regarded as a check of the radar system, per se.

Communications

4.79 Communications are checked during each periodic flight check. Likewise, communications were checked as either satisfactory or unsatisfactory during the RQCFE.

Standby Equipment and Power

4.80 Standby equipment, spot-checked during periodic flight checks and standby power, is checked once a year. The data forms for the RQCFE were filled out to show which channel was being used and thus indicated how the standby equipment was operating.

Comments and Observations

4.81 One of the conditions of the RQCFE was that the radar observer need not communicate with the aircraft pilot to ascertain information. Such requests were considered as being, perhaps, an infringement upon normal control operations. During reasonably slack hours, however, controllers found that they could obtain information from the pilot without interfering with the control operation.

4.82 Many of the checks called for during periodic flight checking are, in fact, being checked during normal day-to-day operation with user aircraft, although such checking is not formalized. The RQCFE was found to have formalized many of these checks. For example, every Monday at Norfolk, a user flight is tracked to check radar coverage and the possible changes in coverage from week to week. In discussion with some of the controllers from Norfolk, the comment was made that after recording a number of runs, they obtained a more detailed knowledge of the radar's limitations than they previously had and that they felt the technique would also be useful in the training of new radar controllers to give them a better knowledge of the radar's performance.

4.83 The RQCFE showed that deleterious effects of weather exist and may significantly degrade radar performance. Likewise, holes in coverage exist which degrade the capability for controlling aircraft. Neither of these two significant factors can be adequately checked by the present periodic flight inspection.

V. TECHNICAL AND ECONOMIC FEASIBILITY

TECHNICAL FEASIBILITY

General

5.1 Based upon the results of the short term RQCFE, flight checking of long and short range primary radar systems using the normal flow of user aircraft traffic appears to be technically[1] feasible.

5.2 This manner of flight checking is based upon the hypothesis that the parameters which characterize the performance of radar systems are constantly changing variables, and that significant variations can occur from day to day and at even higher frequencies. This hypothesis has been verified both by tracking of user aircraft (Figs. 4.6, 4.7, 4.8, 4.9, 4.10, 4.15, and 4.16), and tracking of a controlled Gulfstream aircraft which was simulating user tracks. It was found that radar coverage of the Gulfstream varied widely when measurements were separated by one month in time (paragraphs 4.6 through 4.8). The fact that checks utilizing the user technique are as consistent as those obtainable with a DC-3 aircraft, during normal periodic flight checking, is borne out by the reference checks which showed that the differences between DC-3 and Gulfstream coverage were correlated when both aircraft were tracked at approximately the same time, in the same location, and under identical equipment configurations (paragraphs 4.3 through 4.5).

5.3 The rapidly changing nature of radar performance creates the need for frequent monitoring. The many variables characterizing radar performance, in particular those relating to coverage, and the complex manner in which they interrelate create the need for statistical analyses. All checks with user aircraft, discussed in the following paragraphs, are therefore conceived as dynamic performance monitoring.

Coverage

5.4 The RQCFE showed that it is possible to determine radar vertical coverage on a statistical basis. The emergence of some regularity

[1] Economic considerations depend, in large measure, upon the manner in which the flight check procedure might be implemented. Specifically, the significant variables are the time allotted to tracking of aircraft and the extent of anaylsis.

to the coverage patterns depends upon the number of samples obtained. For the ASR-2/4, it was seen that 160 samples (DC-6 aircraft) provided a regular and meaningful vertical coverage pattern.

5.6 Vertical coverage patterns can also be obtained at various azimuths or routes to ascertain selected coverage around the radar site.

5.7 It is also possible to obtain intermediate and high altitude route structure coverage.

5.8 Fix coverage at minimum instrument altitude cannot, in general, be assured for any given date by tracking user aircraft. Coverage over fixes, however, can be obtained with user aircraft at the range of altitudes of normal traffic load by observing coverage over the fixes as it appears on the radar scope without regard to the pilot's ability to mark his position over these fixes. This of course includes the minimum instrument altitude if aircraft are utilizing it.

5.9 Similarly route coverage at minimum instrument altitude cannot, in general, be assured for any given date. However, route coverage with user traffic can be checked over a range of altitudes including the minimum instrument altitude at such times as they are being utilized. Emphasis will be automatically placed on altitudes of greatest traffic.

5.10 It is possible to check accuracy of the video and fixed maps by checking the location of known fixed targets against these maps. Such checking can be and is presently performed on a continuous basis, although such checking is not now formalized.

5.11 MTI performance within the MTI gate setting can be checked by using the normal flow of air traffic.

5.12 Surveillance approach checking, in the manner described in the Flight Check Manual, requires cooperation on the part of the pilot and, therefore, cannot be assured at any given time with user aircraft. However, the fact that the controllers at Norfolk presently direct such approaches a few times each month to maintain and improve their skills is evidence of the feasibility of checking surveillance approaches with user aircraft.

5.13 The strobe line feature can be checked with user traffic upon transmission of a voice communication.

5.14 The checking of fixed targets cannot be assured, in general, with user aircraft unless communications with the user aircraft are permitted for this purpose. (This check is done only during periodic flight inspection, if requested by air traffic control.)

5.15 Communications can be checked continuously by monitoring conversations between pilot and controller.

5.16 Controller proficiency can be checked by monitoring the control operation at selected intervals, although such a check is not regarded as a check of the radar system, per se.

5.17 Standby equipment and power can be checked under the normal operating conditions with user traffic. Such checks are best performed during slack periods.

Additional Items

5.18 The RQCFE showed that deleterious effects of weather exist and may significantly degrade radar performance. Likewise, holes in coverage exist which degrade the capability for controlling aircraft. Neither of these two significant factors can be checked adequately during present periodic flight inspection, since both of those are a function of aircraft types and propagation variables.

5.19 Present periodic flight inspections do not provide a measure of the dynamic performance of radar systems. This is evidenced by the extreme fluctuations in performance during the period between present periodic flight checks.

5.20 A great deal of monitoring of dynamic performance is presently being performed by controllers and maintenance personnel. Many of these procedures regarding information similar to that obtained during flight inspection are not formalized or statistically analyzed with time. The RQCFE indicated that it is possible to formalize such monitoring and then obtain significant statistical analyses of dynamic radar performance.

5.21 It is indicated above that some of the checks presently being performed during periodic flight inspection cannot be assured on any given date with user aircraft; for example, checking of route coverage at minimum instrument altitude. However, the day-to-day monitoring called for in quality control checking with user aircraft inherently has a great deal of flexibility, since aircraft can be chosen to test radar performance. For example, suppose it is desired to check the coverage on a certain route. In such a case, the next aircraft which flies this route may be used as a check aircraft. If conditions for this next flight are not amenable to tracking (possibly because there are no previous statistical data on that particular aircraft), one has a 120-day interval to wait for appropriate conditions and still will be able to obtain the information obtained during present periodic flight inspection. This increased flexibility, in general, allows day-to-day checking of questionable conditions when they exist.

ECONOMIC FEASIBILITY

General

5.22 Although technical feasibility has been established, economic feasibility is intimately related to possible implementation and steady state operation at the radar sites. The following is a discussion of the economic implications of using echo returns from normal air traffic as a means of flight checking radar performance.

5.23 Since it is, at best, extremely difficult to assess the value of flight checking of radar facilities on an absolute basis, it is necessary to establish a standard, or reference, against which the capability of flight checking with user aircraft can be measured. Therefore, present periodic flight inspection is used in this section as the reference against which quality control checking may be compared.

5.24 One may then consider quality control checks which, in comparison to present periodic flight inspection, obtain:

(i) Approximately the same information plus day-to-day performance data at less cost.

(ii) More information at the same cost.

(iii) More information at a greater cost.

Emphasis in the following discussion will be placed upon the first two items mentioned above.

5.25 Within the framework outlined in the preceding paragraph, implementation of a quality control check with user aircraft can be viewed from two interdependent aspects:

(i) What can be done in the immediate future?

(ii) What is required for a long term implementation program?

Emphasis in this section is placed on the first of these two considerations although recommendations for a long term program are also discussed.

ECONOMIC CONSIDERATIONS

Case I - Approximately the Same Information Plus Day-to-Day Performance Data at Less Cost

5.26 Consider first the case of obtaining approximately the same information as present periodic flight inspections at less cost. Periodic flight checking calls for a vertical coverage pattern up to 10,000 feet at one azimuth at 120-day intervals. Assuming, on the basis of the vertical coverage pattern (to an altitude of 14,000 feet) obtained during the RQCFE, that approximately 150 samples are required to establish a meaningful vertical coverage pattern (to 10,000 feet), and a tracking time per sample of 30 minutes, then 75 hours of tracking time are required. On the average, this corresponds to 38 minutes per day over the 120-day period.

5.27 To check an additional route (corresponding to periodic route checking) would require an additional 30 minutes.

5.28 To check fix coverage might require two more tracks on selected low altitude traffic, or an additional 60 minutes.

5.29 The number of surveillance approaches required depends upon the number of runways. Assuming an average of six runways, an additional 3 hours is required for this check.

5.30 All other checklist items are integral parts of the tracks indicated above. Further, quality control checking is extended over the 120-day interval which provides a measure of dynamic performance and allows flexibility in choice of check times. The total number of hours required, therefore, is approximately 79.5, plus an estimated additional 30 hours for sites with air traffic control beacon interrogator (ATCBI) installed. At an assumed average salary of $8,000.00 per year, roughly equivalent to GS-11, the cost per 120-day interval is then $318.00 to $438.00 for the quality control flight check.

5.31 Assuming an hourly cost of flight inspection of $290.00 plus an additional $40.00 for the ATCBI, and an average of 5 hours per check, a flight check will cost approximately $1450.00 to $1490.00. This is about three to four times (four, if the ATCBI is not installed) the cost of the quality control flight check and does not provide the day-to-day performance information.

Case II - More Information at the Same Cost

5.32 Consider now the availability of $1450.00 to $1490.00 per 120 days for the purpose of obtaining quality control checks with user aircraft. At the assumed salary of $8,000.00 per year, approximately 362 to 372 hours are available for the quality control check. This corresponds to 548 to 724 tracks in the 120-day interval, or about three to four times that required to obtain the same information during a periodic flight inspection. These additional samples may be used to obtain vertical coverage patterns at different azimuths or routes. This allows over 150 samples for each of three or four routes (four, if ATCBI is not installed) to be obtained, leaving 98 to 124 samples to be used for fix and route coverage checking and surveillance approaches. The figures for both cases discussed above are summarized in Table 5.1.

5.33 General. In this cost analysis, it is assumed that the additional workload will require additional manpower. It may, however, be possible to collect these data during lower traffic activity intervals without the additional manpower. Therefore, this economic analysis is conservative.

TABLE 5.1

COST COMPARISON
QUALITY CONTROL AND PERIODIC FLIGHT CHECK

	No. of Samples	Time Required (hrs.)	Cost (hr.)	Cost	Facility
Case I - Same Information at Less Cost					
Quality Control Check - 120-Day Interval	159[1]	79.5[2]	$ 4.00[3]	$ 318.00	ASR or ARSR
		30.	4.00	120.00	ATCBI (additional cost)
Periodic Flight Check	-	5.[4]	290.00[5]	1450.00	ASR or ARSR
		5.	8.00[7]	40.00	ATCBI (additional cost)
Case II - More Information at the Same Cost					
Quality Control Check - 120-Day Interval	724[6]	362.	4.00	1450.00	ASR or ARSR
	548	372.	4.00	1490.00	ATCBI (additional cost)
Periodic Flight Check	-	5.	290.00	1450.00	ASR or ARSR
		5.	8.00	40.00	ATCBI (additional cost)

1 Taking 150 samples required for vertical coverage:
1 sample required for additional route coverage,
2 samples required for fix coverage,
6 samples required for surveillance approaches.

2 Assuming an average time of 30 minutes per track.

3 Assuming $8,000.00 per year, roughly equivalent to GS-11.

4 Average ASR and ARSR.

5 Estimate based on User Charge Study of $250.00 for aircraft and pilots, plus $40.00 for controller and technician.

6 Will allow vertical coverage patterns to be obtained at four different routes or azimuths.

7 Cost for additional controller and technician for ATCBI check.

CONCLUSIONS

Based upon the results of the short term RQCFE, herein described and analyzed, flight checking of surveillance radar systems using the normal flow of user aircraft traffic appears to be both technically and economically feasible.

It is concluded that:

1. The variables which affect radar performance, in particular those relating to coverage, vary from day to day, creating the need for dynamic performance monitoring.

2. Present periodic flight checks are not capable of providing a significant measure of the dynamic performance of radar systems.

3. It is possible to monitor the dynamic performance of radar systems by tracking user aircraft and analyzing the results on a statistical basis.

4. Although the user aircraft flight inspection technique does not perform all the tests as require by the flight inspection manual in the manner outlined, the information obtained by the user technique closely approximates that obtained by the present periodic flight inspection. In addition the user technique provides the additional data on the overall performance of the radar facility on a day to day basis including the effects of environment and atmosphere. The ability to determine whether or not system performance continues to be at or above a predetermined acceptable level is the base to which each technique can be weighed to determine its relative merits. Accordingly the capability to perform additional daily checks makes the user aircraft flight inspection approach a better inspection technique, not withstanding the fact that all tests are not performed in the manner set forth in the flight inspection manual.

5. Essentially the same information as obtained during present periodic flight inspection plus the day to day dynamic performance data can be obtained for about one-third (one-forth, if ATCBI not installed) the cost of present flight inspection.

6. The capability of present flight inspection for air route surveillance radar systems appears to be severely limited. Preliminary analysis indicates that the loss of the flight inspection aircraft target for the vertical coverage check is a result of shielding rather than limitations of radar equipment performance.

7. Although the DC-6 aircraft was suitable for performing the RQCFE on the FPS-8 radar system, selection of an aircraft with a smaller cross sectional area may be required if this technique is to be applied to the higher powered ARSR-1A and ARSR-2 radar systems.

8. Deleterious weather effects exist and may significantly degrade radar performance. Quality control radar checks may be used to determine the magnitude of the effects when they occur.

9. A great deal of monitoring of dynamic performance is presently being performed by controllers and maintenance personnel. Many of these procedures regarding information similar to that obtained during flight checking are not formalized or statistically analyzed with time. The RQCFE showed that it is possible to formalize such monitoring to obtain significant statistical analyses of dynamic radar performance.

10. Quality control checking of radar performance with user aircraft provides a great deal of flexibility in the overall ability to check for conditions of degraded performance when they actually occur.

11. Although the ATCBI facility was not a part of this experiment, it appears feasible to apply the same techniques for flight inspection of these equipments.

RECOMMENDATIONS

Having established the technical feasibility of the concept of radar quality control by making use of target returns from user aircraft, this concept appears to be highly practical and economically feasible. The latter consideration is based upon a rudimentary economic comparison between quality control flight checks and present periodic flight inspections.

It is recommended that:

1. Immediate plans be made to perform the necessary experimentation to determine the optimum method for collecting and analyzing data by manual means for both the primary and secondary radar facilities. Once this determination has been made, a pilot implementation should be put into effect so that the merits of the technique and its actual cost can be evaluated.

2. The pilot implementation be used also to demonstrate the feasibility of using radar quality control techniques to check the performance of ATCBI facilities.

3. Techniques for the enhancement of quality control checking of radar facilities be investigated. These techniques include the use of standardized target strengths by integration of pulses over selected

aircraft sectors, automatic readout of video, and automatic analysis of the results of quality control flight checks.

4. An investigation be conducted to determine the requirements for flight inspection aircraft equipment to quantitatively establish the performance of radar facilities for siting and commissioning so that echo fluctuations due to aircraft aspect variations and loss of target return, due to shielding, are no longer factors in establishing the initial performance of radar facilities.

5. Since the concept of the necessity for monitoring the dynamic perforance of radar facilities appears to carry over to other ATC navigation aids (navaids) --present periodic flight inspection of these navaids may be too infrequent compared with the natural variability of their performance to serve as dynamic performance checks--this problem should be investigated more carefully. The possibility of joint quality control checking of various navaids should also be considered. The recent recommendation for flight checking of VOR facilities, based upon radar returns from user aircraft, falls into this category.

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APPENDIX I

IMPLEMENTATION PLAN

FOR

RADAR QUALITY CONTROL FEASIBILITY EXPERIMENT

Objective

The objective of this effort is to determine, by a relatively short experiment, the feasibility of using user aircraft for the purpose of continuously monitoring the performance of primary radar systems. The experiment shall be so designed as to permit a comparison to be made between the user aircraft method of monitoring and the present periodic flight inspections from both a technical and an economic standpoint. Final recommendations shall be based on all the advantages and disadvantages of each technique. If the user aircraft technique proves more advantageous, then, in addition to considering the results for possible field implementation, the experience gained will also furnish a foundation for subsequent work in this general area at NAFEC.

Requirement

The basic requirement for examining the use of user aircraft for radar performance monitoring has been established by the Systems Performance Branch, RD-309, as a result of research work performed for the Aviation Research and Development Service in this general area. Existing Aviation Research and Development Service plans call for the assignment of an experimentation project at NAFEC during the fourth quarter of FY-62, to examine in detail both qualitative and quantitative methods of performing radar quality control performance checks using user aircraft. The project will determine the optimum method for collecting and analyzing the data by manual, semi-automatic and/or automatic means.

In response to an Air Traffic Service request, this accelerated plan has been prepared for performing a limited experiment at an operating facility. Due to the requirement for facility control and the instrumentation needed for the quantitative monitoring technique, this plan has been limited to an experiment using the qualitative technique with manual methods for data collection. The conditions under which such an experiment appear practical are detailed below. Timing is based on the immediate approval of this plan by the Directors of Aviation Research and Development Service, Flight Standards Service, Air Traffic Service, and Aviation Facilities Service.

Description of Effort

The Washington, D. C., center and terminal facilities were examined and discussions were held with appropriate Agency personnel. A determination was made by the Eastern Region that it was not practical to perform the experiment in Washington. In lieu thereof it was suggested that the experiment be performed at the combined center and terminal facility at Norfolk, Virginia. An examination of Norfolk by representatives of the Aviation Research and Development Service, Air Traffic Service, and Aviation Facilities Service, indicates the experiment can be performed there under the following conditions:

1. One ASR-2 and one FPS-8 indicator display with communications on both center and terminal frequencies will be required 16 hours a day, 7 days a week, between March 26 and May 2, 1962. This will require patching in the proper communication frequencies at the ASR-2 position, for the joint use of the ASR-2 and FPS-8 radar observer, and the relocation of the maintenance spare FPS-8 indicator from the equipment room to a position in the center next to the available ASR-2 display. During the period from March 15 through March 23 the radar displays will be required without communications for approximately 8 hours a day.

2. Two radar observers will be required 16 hours a day, 7 days a week, during the period from April 2 through May 2, 1962. The personnel involved should be assigned by March 26 and made available during that week for approximately two hours each for a data collection procedure shakedown. To assist in designing the experiment, past data on center and terminal traffic will be required from the ATC at Norfolk during the period of March 15 through March 23.

3. Normal maintenance will be required during the period of the experiment to keep the indicator displays used for data collection in proper working condition. In addition, a copy of the daily maintenance log (FAA Form 406C) and completed daily data sheets (FAA Form 418) will be required. A maintenance technician will be required for recording flight inspection data on April 2 and 3 and May 1 and 2.

4. One DC-3 flight inspection aircraft and one standard Gulfstream with crews will be required to run a flight inspection and simulate user flights on the ASR-2 and FPS-8 on April 2 and 3. The same flights will be repeated on May 1 and 2. It is estimated that a total of approximately 26 hours of flying time will be required for each type of aircraft.

5. Engineering personnel will be required to design the experiment, work up forms and procedures, analyze data, and prepare a report.

6. The assigned liaison group will continue to function throughout the experiment and provide assistance in their specialized fields as may be required.

It has been tentatively decided by the liaison group assigned to this effort, subject to the final approval of the Directors, that Aviation Facilities Service should be responsible for items 1 and 3, Air Traffic Service for item 2, Flight Standards Service and Aviation Research and Development Service for item 4 (DC-3 flight inspection aircraft and crew by Flight Standards Service and Gulfstream and crew by Aviation Research and Development Service), and Aviation Research and Development Service for item 5 (Program Manager from System Management Division, one engineer from Experimentation Division, and two engineers on contract).

Timing

Design, procedures and forms will be completed by March 23. The necessary equipment installation will be completed by March 26. During the week of March 26 to March 30 the radar observers assigned to this project will be briefed and perform dry runs with user aircraft requiring approximately two hours each. Any refinement of forms or procedures required will be completed by March 30. A standard DC-3 periodic radar flight inspection and a reference Gulfstream simulated user aircraft check will be completed on both the ASR-2 and the FPS-8 April 2 and 3. Data will be collected 16 hours a day, 7 days a week by the radar observers on selected user aircraft during the period from April 3 to May 1. Flights identical to those performed April 2 and 3 will be performed May 1 and 2. The data collection period will end May 2. Analysis of data and preparation of a report will be completed May 28.

Estimated Funds

1. Radar observers: 16 hours a day for 30 days - $4,464 (ATS overtime)

2. Flight inspection aircraft and crew: 26 hours of flying time - $5,018 (FS)

3. Installation: move FPS-8 radar display and patch in required communication frequencies - $260 (AFS)

4. Engineering support: six man months by contractor - $15,000 (ARDS)

The above estimates do not include amounts for aircraft, equipment or personnel assigned to the project full time or part time for which additional funds are not required.

Authentication

Recommended:

Kenneth E. Coonley
Program Manager, Aviation Research and Development Service

Concurred:

S. J. Connors
Flight Standards Service Liaison

James M. Ritchey
Air Traffic Service Liaison

Lawrence L. Miller
Aviation Facilities Service Liaison

Approved:

for
Director, Aviation Research and Development Service

G. E. Moore
Director, Flight Standards Service

D. D. Thomas
Director, Air Traffic Service

Donald S. King
Director, Aviation Facilities Service

APPENDIX II

GENERAL AND DETAILED PROCEDURES

DATA SHEETS AND FORMS

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

PROCEDURES FOR
DC-3 FLIGHT INSPECTION/GULFSTREAM USER SIMULATION RUNS

The DC-3 flight inspection aircraft will run a complete periodic flight inspection on the FPS-8 and the ASR-2/4 radar facilities at Norfolk on April 2 and 3, and May 1 and 2. During the vertical coverage checks, the flight inspection DC-3 aircraft will make a series of inbound and outbound runs on a 235° radial from 1,000- to 10,000-foot altitudes. As the DC-3 climbs to the 10,000-foot altitude for the final run, the Gulfstream should be positioned on V1-194 to join the DC-3 in making the outbound run to maximum range, reverse course and return inbound to minimum radar range, thus providing comparative radar data. This check shall be done for both facilities. In addition, the Gulfstream rescheduled on the airways listed below on a normal user basis to fly to maximum radar range at specified altitudes and return. Data for the Gulfstream runs shall be recorded in accordance with the "Detailed Procedures" for the Radar Quality Control Feasibility Experiment.

ASR-2/4 Radar Check

1. Gulfstream on V1 North at 10,000-foot altitude and return.

2. Gulfstream on V194, V156 North and West at 7000-foot altitude and return.

3. Gulfstream on V194 South at 3000-foot altitude and return.

4. Gulfstream on V260 South and West at 4000-foot altitude and return.

5. Gulfstream on V1-194 South at 10,000-foot altitude for comparison run with flight inspection DC-3 on 235° radial.

AN/FPS-8 Radar Check

1. Gulfstream on V1 North at 10,000-foot altitude and return.

2. Gulfstream on V194, V286 North and West at 10,000-foot altitude and return.

3. Gulfstream on J79V North and South at 25,000-foot altitude and return.

4. Gulfstream on V1503 North and South at 15,000-foot altitude and return.

5. Gulfstream on V1-194 South at 10,000-foot altitude for comparison run with flight inspection DC-3 on 235° radial.

PROCEDURES - FLIGHT CHECK EXPERIMENT

I. Choice of Aircraft - Schedule

The most significant determination of this experiment is to be the basic altitude radar (FPS-8 and ASR-2 Modified) coverage using the DC-6 as a target. Therefore, a DC-6 flight which can be lost as far as radar coverage is concerned is of greatest priority. A listing of preferred aircraft and routes in order of priority for the three altitude structures is shown below.

	Basic	Intermediate	High
Aircraft	DC-6 V170	DC-6 L 188, DC-7	720 DC-8
Routes	V1, V139, V194, V286, V266, V229, V260	1503, 1685, 1546 1677, 1505	J79V

It is emphasized that although the list above establishes general guidelines for the choice of aircraft and routes, controllers should exercise judgment in their choice, based upon their knowledge of what data has already been taken and the objectives of the over-all experiment. Also, if convenient, the T-33 can be considered an appropriate military aircraft.

II. Data Sheets

Two forms should be completed for each track for each radar. One form contains a flight strip and indications of scope alignment, maximum coverage, holes, equipment characteristics, weather and any additional remarks which describe the conditions under which the tracking was performed. The second form shows a polar plot of the Norfolk area and either the basic, intermediate or high altitude route structure. The latter form is to be used to show the actual aircraft track with a solid line indicating radar returns and a slash across the line indicating misses. A number next to the slash can serve to show the number of consecutive scans missed.

III. Transmittal of Completed Data Sheets

After a complete track, the two data forms may be stapled together and put in an addressed envelope. The envelope will be sent to Washington once a day.

IV. Questions

Should a question of procedure arise, a discussion with other controllers will probably suffice to clear it up. However, a change of procedure should be checked with either of the people below by direct communication if they are at Norfolk or by calling them collect.

Mr. Kenneth Coonley FAA - ARDS Washington, D. C. WOrth 7-3809	Mr. Howard Eisner or Mr. William Rogers Operations Research Inc. Silver Spring, Maryland JUniper 8-6180

DETAILED PROCEDURES-FLIGHT CHECK EXPERIMENT

B. 1 General Information

All aircraft to be tracked for the flight check experiment:

(a) should have a radar target strength such that they can be expected to be lost as far as radar coverage is concerned.

(b) should have a flight strip filed for them, and

(c) should be chosen in accordance with the choice of aircraft schedule described in "General Procedures-Flight Check Experiment."

B. 2 Check of the Modified ASR-2

Two data sheets should be completed for each track with the modified ASR-2 radar. A continuous track of the range and bearing is to be shown on the polar coordinate form (Figure B. 1). The track is to be recorded as a solid line in the direction of flight as long as the target return is sufficient to be used for control of the aircraft. If the target return is not sufficient to be used for control, a short line across the solid track should be indicated. A number next to this short line will indicate the number of scans for which the target was "lost." All other pertinent information, which can be conveniently recorded on this polar plot, should be provided such as the existence (location and shape) of ground clutter returns, precipitation, ducting, altitude information, etc.

In addition, a data form (Figure B. 2) should be completed for each track with the modified ASR-2 radar. This form has the following indications:

(a) Date

(b) Equipment Characteristics

1. Channel-check either channel A or B
2. STC-check either STC on or off
3. FTC-check either FTC on or off
4. Polarization-check either LP or CP
5. MTI Gate-indicate the setting of the MTI Gate in nautical miles

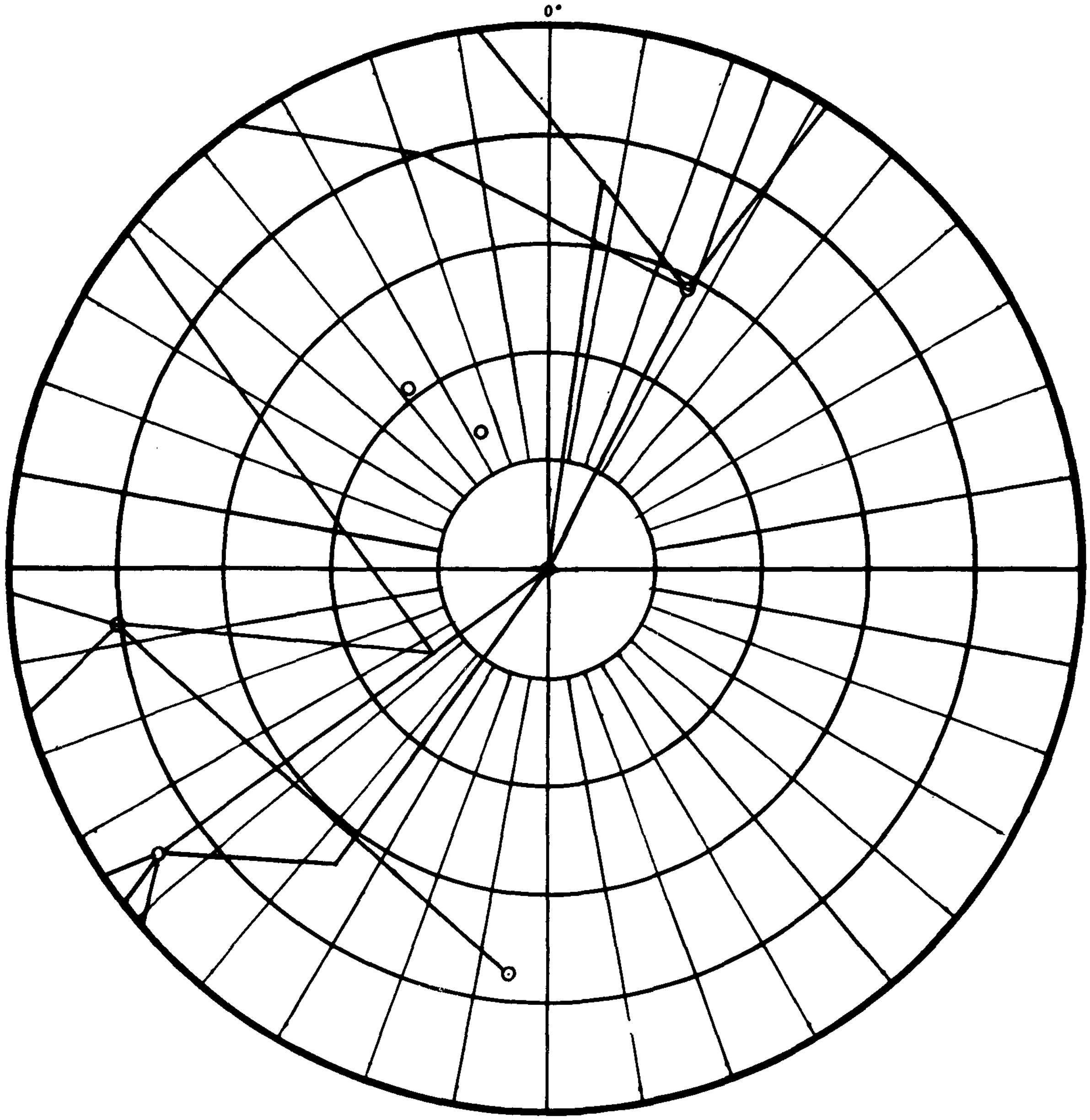


FIG. B.1 ASR-2/4 RADAR TRACKING FORM FOR NORFOLK AREA

INSTALLATION NORFOLK REGION 1 RADAR ASR 8 MAD

Date____________________

Equipment Characteristics

Channel A☐ B☐

STC On☐ Off☐

FTC On☐ Off☐

Polarization LP☐ CP☐

MTI

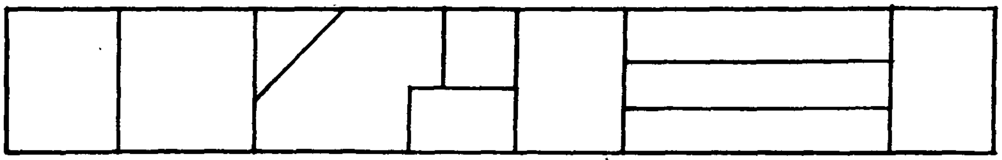
MTI Gate____________nm

Cancellation

Single ☐ Double ☐ Vel.Shape_____db

PRF Stagger On ☐ Off ☐

Approach Visual ☐ ILS ☐ PAR ☐



	Sat.	Unsat.
Scope Range and Azimuth Accuracy		
Fixed Map Accuracy		
Strobe Line		
Communications		

MAXIMUM COVERAGE

Maximum Range		nm
Altitude		feet
Azimuth		degrees

____nm beyond______ON________

HOLES IN COVERAGE

Range					nm
Altitude					feet
Azimuth					degrees
No. of Scans					

REMARKS

Antenna Speed__________RPM

Noise Figure____________db

Relative Tuning Error______KC

Power Output____KW or____db

Receiver Sensitivity

Normal________________db

MTI________________db

Operator(s)________________

Technician(s)________________

WEATHER CONDITIONS

FIG. B.2 ASR-2/4 RADAR DATA FORM

6. Cancellation-check either single or double cancellation with an indication of the velocity shaping level.

7. PRF Stagger-check either on or off (at bottom of form).

8. Antenna Speed-indicate number of RPM.

9. Noise Figure-indicate db level.

10. Relative Tuning Error-indicate tuning error in KC.

11. Power Output-indicate radar power output in KW or db.

12. Receiver Sensitivity-indicate normal and MTI receiver sensitivities in db.

NOTE: Normal settings of the equipment are known and need not be recorded. If, however, there is a deviation from normal operation, equipment characteristics in such cases should be recorded. For example, normally, STC is on and FTC is off. Hence these do not have to be recorded unless, for some reason, these settings change.

(c) <u>Flight Strip</u>

The flight strip should be completed in accordance with ATS regulations. Particularly relevant information which will be taken from the flight strip for purposes of this experiment are:

1. Aircraft type.

2. Fixes and estimated time over fixes.

3. Altitude of aircraft.

4. Routes of flight.

(d) <u>Scope Range and Azimuth Accuracy</u>

The scope range and azimuth accuracy should be checked against fixed targets with known azimuth and ranges. The accuracy is satisfactory if the indicated azimuths and ranges of the fixed targets are indicated within a tolerance represented by a circular area about the known position at the fixed target, the radius of which is 3% of the fixed target to radar site distance, or 500 feet, whichever is greater.

(e) Video and Fixed Map Accuracy

The ASR-2 fixed map (on the thirty mile range) accuracy and FPS-8 video map (all operating ranges) accuracy should be checked against fixed targets with known positions with respect to the map in two quadrants. The accuracy is satisfactory if the indicated map checkpoints are within a tolerance represented by a circular area about the correct map position as established by the fixed targets, the radius of which is 3% of the correct map checkpoint to radar site distance, of 500 feet, whichever is greater.

(f) Strobe Line

The strobe line feature should be checked upon a short voice transmission. The azimuthal error of the strobe line indication with respect to the aircraft will not exceed $\pm 10^{\circ}$ at any point within the surveillance radar coverage pattern.

(g) Communications

Communications should be clear and readable for all monitored communications between pilot and controller. Poor communications on any frequency should be noted as unsatisfactory.

(h) Maximum Coverage

For the track considered, the maximum range, and altitude and azimuth at that range should be recorded. A target is said to be at the maximum range if the controller could no longer use the target return on subsequent scans for control. If the target is on a route, this may be indicated; for example, 5 nautical miles beyond CCV on VI.

(i) Holes in Coverage

Holes which appear in the coverage should be indicated by the mean range to the hole, its altitude, azimuth, and the number of scans over which the target was "lost." This data actually appears on the polar coordinate plot and need not be transferred to this data sheet unless it is convenient to do so.

(j) Remarks

Any additional comments which are relevant to the track which was recorded should be indicated here.

(k) Weather Conditions

Weather conditions which appear to have an effect on the performance of the radar should be indicated here, such as thunderstorm activity, ducting, etc.

(m) Additional Indications

1. If radar contact is lost prematurely (as in the case of holes), if possible an indication of the reason for such a loss should be recorded. The controller should indicate whether or not the reason cited is conjecture or has been factually determined. For example, radar contact may be attributed to aircraft flight at the radar MTI blind speed, flight in and out of the upper lobe structure, etc.

2. If operational PPI approaches are made during the course of the experiment, an attempt should be made to track the targets and record the radar characteristics during these approaches.

3. Noticeable trends or degradation in equipment characteristics and radar target returns, from hour to hour or day to day, should also be recorded.

B. 3 Check of the FPS-8

Two data sheets should be completed for each track with the FPS-8 radar. A continuous track of the radar and bearing is to be shown on one of the polar coordinate forms (Figures B. 3 through B. 5), depending upon whether the aircraft is at basic, intermediate or high altitude. The details of recording on these polar coordinate forms are identical to those described in paragraph B. 2 for the modified ASR-2.

In addition, a data form (Figure B. 6) should be completed for each track with the FPS-8 radar. This form has the following indications:

(a) Date.

(b) Equipment Characteristics-see paragraph B. 2(b).

(c) Flight Strip-see paragraph B. 2(c)

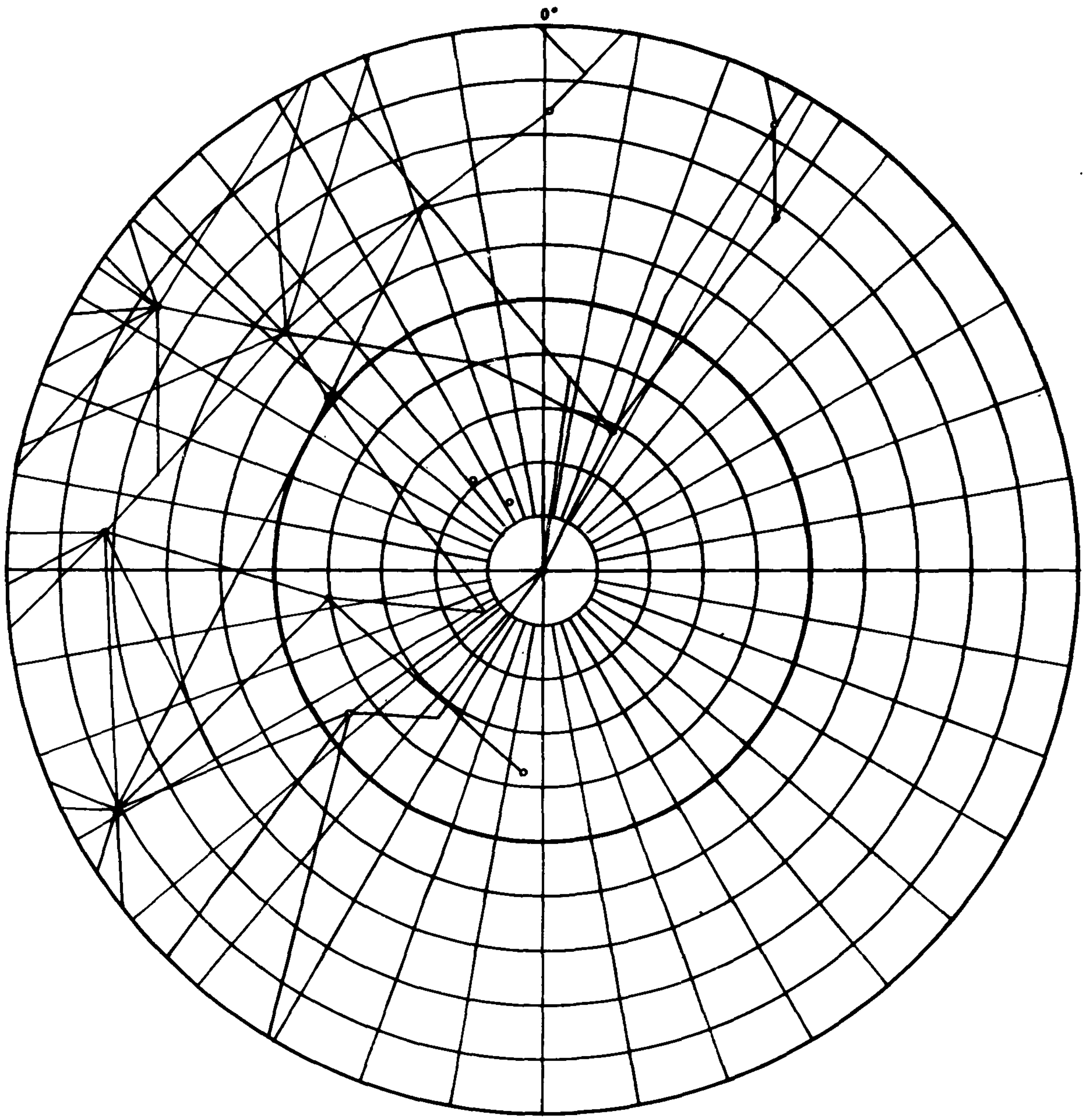


FIG. B. 3 FPS-8 RADAR BASIC ALTITUDE TRACKING FORM FOR NORFOLK AREA

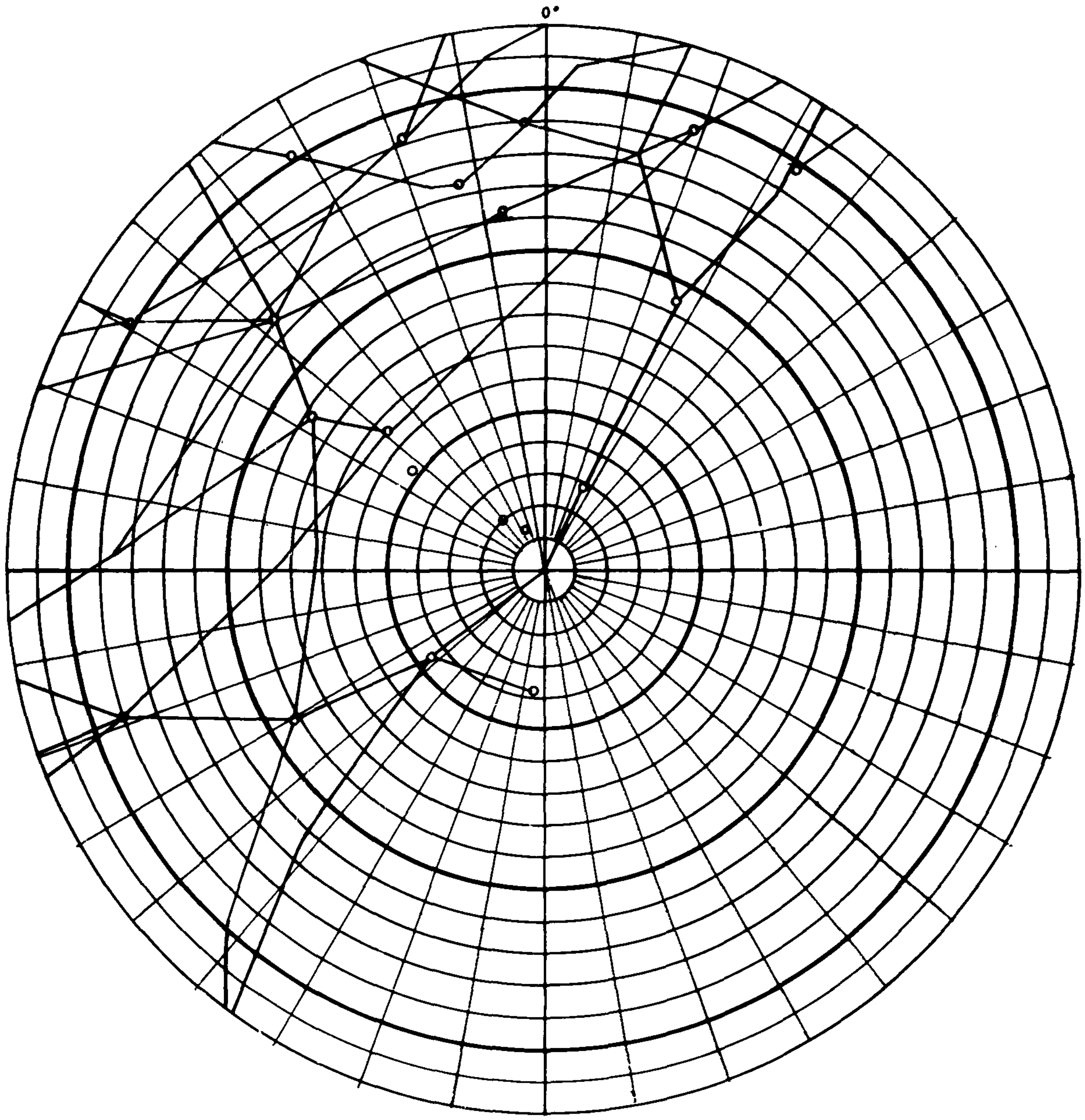


FIG. B. 4 FPS-8 RADAR INTERMEDIATE ALTITUDE TRACKING FORM FOR NORFOLK AREA

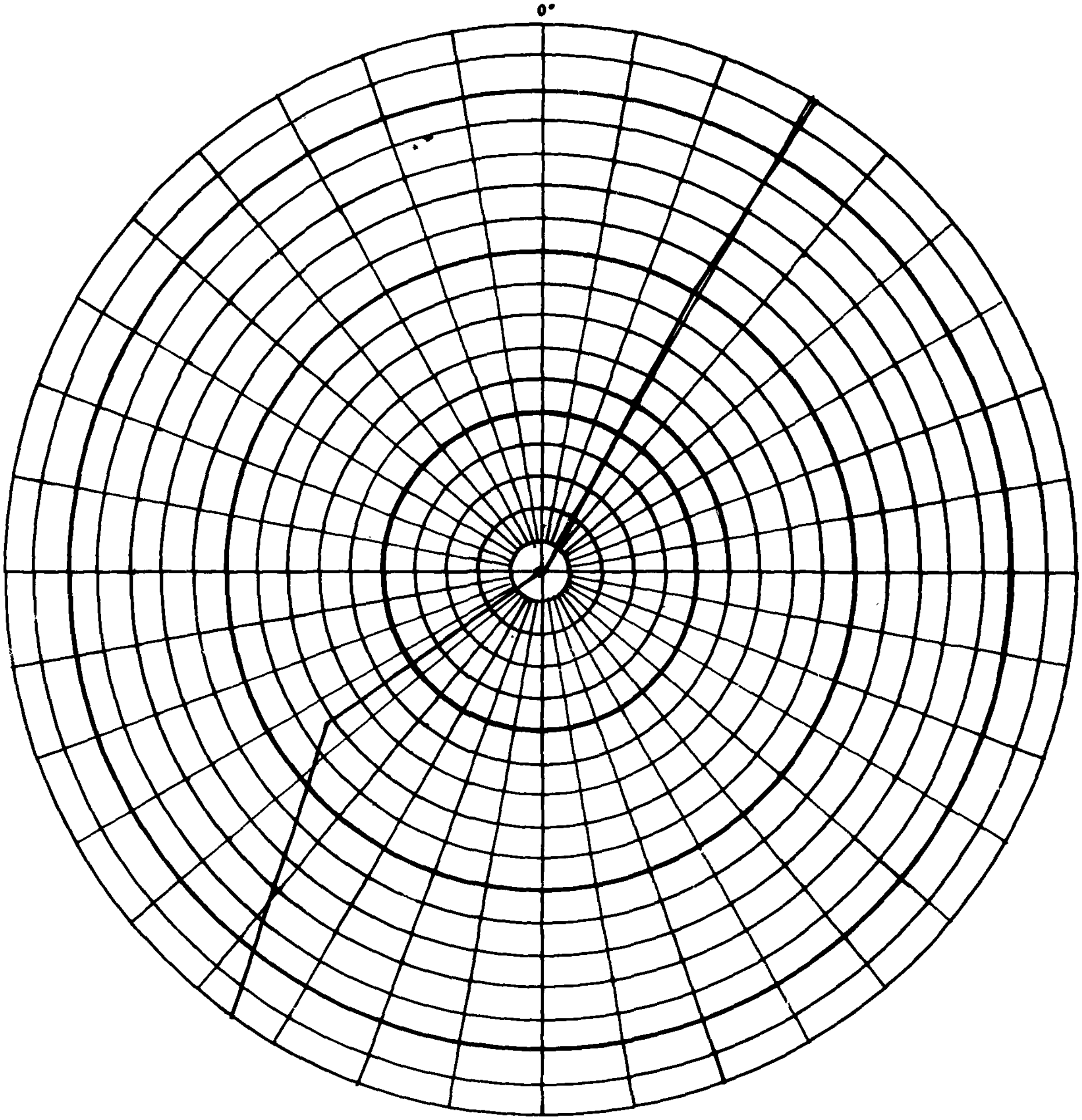


FIG. B. 5 FPS-8 RADAR HIGH ALTITUDE TRACKING FORM FOR NORFOLK AREA

INSTALLATION NORFOLK REGION 1 RADAR FPS-8

Date ____________________

Equipment Characteristics

STC On ☐ Off ☐

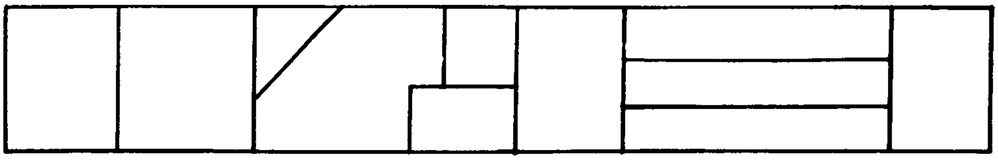
FTC On ☐ Off ☐

Polarization LP ☐ CP ☐

MTI Gate __________ N.Mi.

Approach

Visual ☐ ILS ☐ PAR ☐



	Sat.	Unsat.
Scope Range and Azimuth Accuracy		
Fixed and Video Map Accuracy		
Communications		

MAXIMUM COVERAGE

Maximum Range		n.mi.
Altitude		feet
Azimuth		degrees

______ NM BEYOND ____ ON _____

HOLES IN COVERAGE

Range						n.mi.
Altitude						feet
Azimuth						degrees
No. of Scans						

REMARKS

Antenna Speed ______ RPM

Power Output ______ db

Receiver Sensitivity:

Normal __________ db

MTI __________ db

Beam Elevation ______________ degrees

Operator(s) ________________

Technician(s) ________________

WEATHER CONDITIONS

FIG. B. 6 FPS-8 RADAR DATA FORM

(d) Scope Range and Azimuth Accuracy-see paragraph B. 2(d)

(e) Fixed and Video Map Accuracy-see paragraph B. 2(e)

(f) Communications-see paragraph B. 2(g)

(g) Maximum Coverage-see paragraph B. 2(h)

(h) Holes in Coverage-see paragraph B. 2(i)

(i) Remarks-see paragraph B. 2(j)

(j) Weather Conditions-see paragraph B. 2(k)

(k) Additional Indications-see paragraph B. 2(m), excluding item 2.

APPENDIX III

FPS-8 AND ASR-2/4 DATA COMPILED

FOR DC-6 AIRCRAFT

TABLE I

DATA COMPILED FOR ASR-2/4 FOR DC-6 AIRCRAFT

Date (April)	Time (Zebra)[1]	Maximum Range (NM)	Altitude (ft.)	Route	Inbound or Outbound	Comments	Holes
4	2040	28	8,000	V194	O	--------	27(3)[3]
4	1946	37	10,000	V1-194	O	--------	lost between 3-4 NM
4	1900	28	8,000	V260	I	--------	----------
4	----	36	9,000	V1N	O	w_x[2]	32(2)
4	----	32	9,000	V194	O	--------	lost between 20-23 NM
5	1550	41	7,000	V194	O	w_x	1.5(2), 37(8)
5	1859	42	7,000	V1N	I	w_x, ducting blocked track	----------
5	1952	49	10,000	V1-194	O	--------	----------
5	2130	26	5,000	V194	O	--------	----------
5	0310	28	6,000	V194	O	--------	5(8)
6	1411	44	6,000	V1N	I	missed 25 sweeps-MTI	45(2), 40(2), 34(2)
6	1539	22	7,000	V194	O	--------	----------
6	2200	26	2,000	PH[4]	O	--------	----------
6	2020	25	2,000	PH	O	--------	----------
6	2020	30	3,200	PH	O	--------	----------
6	0323	42	8,000	V260	I	--------	----------
6	0100	31	6,000	V194	O	--------	----------
6	0102	36	7,000	V194	O	--------	30(2)
6	0012	34	5,000	V1-194	I	--------	32(3)
7	1547	30	7,000	V194	O	--------	28(2)

[1] Time Zebra = Eastern Standard Time + 5 hours.

[2] w_x = Weather Prominent on Scope.

[3] n(m) = missed target for m scans at an average range of n NM.

[4] PH = Patrick Henry area.

TABLE I (Continued)

DATA COMPILED FOR ASR-2/4 FOR DC-6 AIRCRAFT

Date (April)	Time (Zebra)	Maximum Range (NM)	Altitude (ft.)	Route	Inbound or Outbound	Comments	Holes
7	1703	38	6,000	V260	I	--------	15(1), 33(2), 35(3)
7	1812	32	5,000	V1-194	O	--------	24(4), 26(1), 32(2)
7	1913	35	5,000	V139	I	--------	34(2), 32(1), 31(1)
7	0005	45	5,000	V1-194	I	--------	Target Intermittent
7	2228	36	5,000	PH	O	--------	24(1), 26(1), 32(1), 34(1,
8	1956	20	2,500	PH	O	--------	----------
8	1755	34	5,000	V260	I	--------	----------
8	1540	24	6,000	V1N	O	w_x	double target returns
8	2211	28	2,750	PH	O	--------	----------
8	0115	45	8,000	V286	O	--------	32(2), 34(2)
8	0008	50	8,000	V1-194	I	--------	35(2)
8	0305	49	11,000	V286	O	--------	----------
8	0331	38	3,000	PH	I	--------	Intermittent from 29-38 NM
8	0409	37	5,000	V139	O	--------	33(1), 35(2)
9	0321	18	6,000	V194	O	w_x- ducting beyond 18 mi.	12(1),14(1)
9	1300	34	5,000	PH	O	--------	30(2), 32(1), 33(3)
9	1625	34	8,000	PH	O	--------	22(2), 26(2), 30(6)
9	1908	40	9,000	V286	O	--------	32(6)
9	1930	25	4,000	V1N	I	--------	22(1), 24(2)
9	----	41	10,000	V1N	O	--------	30(1), 39(1)
9	0120	34	7,000	V194	O	w_x	Intermittent past 26 NM
10	1730	27	5,000	V194	O	--------	24(1), 26(1)
10	1821	34	7,300	V1N	I	w_x	Intermittent target from 28-34 NM

TABLE I (Continued)

DATA COMPILED FOR ASR-2/4 FOR DC-6 AIRCRAFT

Date (April)	Time (Zebra)	Maximum Range (NM)	Altitude (ft.)	Route	Inbound or Outbound	Comments	Holes
10	1534	28	5,000	V194	O	--------	----------
10	1948	45	10,000	V1-194	O	--------	32(1), 4(1), 43(3)
10	2104	34	5,000	V1N	O	w_x	18(1), 32(1)
10	0035	42	7,000	V286	O	w_x	many holes
10	0308	22	5,000	V194	O	--------	----------
10	0349	37	9,000	V1N	O	w_x	missed 23-27 NM
11	1540	30	3,500	PH	I	--------	28(2)
11	1540	22	1,500	PH	I	--------	----------
11	1540	29	3,200	PH	I	--------	28(2)
11	1250	30	8,000	V1-194	O	--------	25(4)
11	1537	30	5,000	V194	O	--------	28(3)
11	1630	28	5,000	V1N	O	--------	22(1), 23(1), 25(1), 27(1)
11	0058	27	7,000	V194	O	--------	----------
11	2142	24	5,000	V194	O	---------	------------
11	2049	22	2,500	PH	I	believed lost due to tangential aspect	12(7)
12	1552	50	9,000	V266	O	---------	------------
12	1749	45	7,000	V156	O	---------	------------
12	1810	30	4,000	V1-194	O	---------	------------
12	2212	28	5,000	PH	O	---------	------------
12	2212	21	1,000	PH	O	---------	------------
12	2212	22	1,500	PH	O	---------	------------
12	1850	47	10,000	V139	O	---------	------------
12	2012	43	6,000	V1-194	O	---------	40(2)
12	2030	42	5,000	PH	O	---------	32(2), 36(3), 40(3)
13	----	30	3,000	V1N	O	---------	27(3)
13	1914	47	8,500	V286	O	---------	36(2), 42(2)
13	2104	27	7,000	V194	O	---------	27(3)
13	2304	28	3,000	V266	O	---------	------------

TABLE I (Continued)

DATA COMPILED FOR ASR-2/4 FOR DC-6 AIRCRAFT

Date (April)	Time (Zebra)	Maximum Range (NM)	Altitude (ft.)	Route	Inbound or Outbound	Comments	Holes
13	2301	47	6,000	V1N	I	----------	35(5)
13	0028	33	5,000	V1-194	I	----------	------------
14	2254	33	5,000	V1N	I	----------	------------
14	0349	33	9,000	V1N	O	w_x	------------
14	0307	30	7,000	V194	O	----------	------------
14	1608	43	8,000	V260	I	----------	------------
14	2007	45	10,000	V194S	O	----------	38(3)
15	1604	50	11,000	V286	O	----------	34(3), 26(2)
15	1650	49	12,500	V1-194	O	----------	------------
15	1745	42	10,000	V1-194	O	----------	36(3)
15	1840	39	11,000	V139	O	----------	33(3), 36(2)
15	2006	38	12,000	V1-194	O	----------	------------
15	2037	39	7,000	PH	O	----------	32(2), 35(2), 36(2)
15	2127	37	11,000	V1N	O	----------	------------
15	1550	32	5,000	V194	O	----------	------------
15	2009	30	4,000	PH	O	----------	24(3)
15	0100	30	5,000	V194	O	----------	------------
15	0036	29	7,000	V194	O	----------	------------
15	0355	29	5,000	V139	O	----------	26(2)
16	1534	30	5,000	V194	O	----------	------------
16	----	28	5,000	V1N	O	----------	------------
16	1705	28	10,000	V194S	O	----------	------------
16	1945	30	5,000	V1-194	O	----------	------------
16	1915	28	6,000	V1N	O	----------	------------
16	2151	47	11,000	V286	O	----------	------------
16	2212	39	7,000	PH	O	----------	------------
16	2223	50	10,000	PH	O	----------	------------
16	0057	45	9,000	V286	O	----------	------------
17	1943	42	12,000	V1-194	O	----------	Lost from 5-6 NM
17	1522	40	10,500	V1-194	O	----------	------------

TABLE I (Continued)

DATA COMPILED FOR ASR-2/4 FOR DC-6 AIRCRAFT

Date (April)	Time (Zebra)	Maximum Range (NM)	Altitude (ft.)	Route	Inbound or Outbound	Comments	Holes
17	0350	30	9,000	V1N	O	w_x - heavy ground return and clutter	3(3)
17	2156	32	5,000	V194	O	-----------	-------------
17	2038	32	5,000	V194	O	-----------	-------------
17	1800	42	11,000	V260	I	-----------	-------------
18	0103	28	7,000	V194	O	-----------	-------------
18	0311	27	5,000	V194	O	-----------	-------------
18	2125	23	5,000	V1N	O	Lost due to normal clutter	-------------
19	1825	20	5,000	V1N	O	w_x - Lost in rain and clutter using LP	-------------
19	2015	40	5,000	PH	O	-----------	34(6), 37(2), 38(5), 39(2)
19	1908	42	5,000	V286	O	w_x - heavy cloud over ORF	-------------
19	2138	49	7,000	V286	O	-----------	36(7), 47(4), 47(2)
19	0107	42	7,000	V286	O	-----------	32(3), 35(2), 36(8)
19	0324	38	5,000	V286	O	-----------	32(2), 34(3), 36(8)
20	0400	22	9,000	V1N	O	If gain low	------------
20	1914	42	11,000	V1N	O	-----------	36(3), 38(2), 40(3)
20	1926	33	8,000	V266	O	-----------	32(5)
20	2005	23	1,500	PH	O	-----------	21(10)
20	2033	35	5,000	PH	O	-----------	32(2), 34(2)
20	2033	28	3,000	PH	O	-----------	-------------
20	1555	44	11,000	V286	O	-----------	36(2), 38(2)
20	1827	26	2,500	PH	O	-----------	-------------
20	1321	33	6,000	V260	I	-----------	-------------
20	----	29	3,000	V194	O	w_x	27(3)

TABLE I (Continued)

DATA COMPILED FOR ASR-2/4 FOR DC-6 AIRCRAFT

Date (April)	Time (Zebra)	Maximum Range (NM)	Altitude (ft.)	Route	Inbound or Outbound	Comments	Holes
20	2223	35	4,000	PH	O	w_x	35(2)
20	2206	28	3,000	PH	O	w_x	----------
20	0107	32	3,000	V194	O	----------	30(4)
20	2333	36	5,000	V194	O	----------	----------
20	0325	46	3,000	V286	O	----------	----------
21	1858	44	10,000	V1N	I	----------	39(2), 42(2), 43(3)
21	0102	28	5,000	V194	O	----------	----------
22	1538	27	6,000	V194	O	----------	25(1)
22	1527	38	10,000	V1N	I	----------	33(1), 35(1)
22	1943	33	10,000	V1-194	O	----------	29(1), 31(1)
22	0100	30	9,000	V194	I	----------	----------
23	2003	31	12,000	V1-194	O	----------	28(1), 29(1)
23	1826	29	11,000	V1N	O	----------	26(1), 27(1)
23	2138	22	5,000	V1N	O	Ducting 22 mi.	----------
24	1549	34	9,000	V194	O	----------	32(2)
24	2140	18	5,000	V1N	O	If gain too low	17(2)
24	2225	33	5,500	PH	O	----------	23(2), 25(1)
24	0054	38	7,000	V194	O	----------	22(3), 30(1) 34(3)
24	0000	27	5,000	V194	O	----------	15(2)
24	0322	34	6,000	V194	O	----------	20(3)
25	0048	29	5,000	PH	O	----------	27(3)
25	1549	33	9,000	V194	O	----------	----------
25	1625	22	5,000	V1N	O	hole 9 mi. MTI blind speed - stagger off	9(7), 11(2)
26	1600	45	9,000	V286	O	----------	41(2)
26	1738	48	14,000	V260	O	----------	37(2), 39(1), 41(1), 43(1)
26	2004	44	10,000	V1-194	O	----------	----------
26	0404	38	7,000	V1N	O	----------	----------
27	2228	37	7,000	PH	O	----------	33(6), 35(4)
27	2216	28	5,000	PH	O	----------	24(1)

TABLE I (Continued)

DATA COMPILED FOR ASR-2/4 FOR DC-6 AIRCRAFT

Date (April)	Time (Zebra)	Maximum Range (NM)	Altitude (ft.)	Route	Inbound or Outbound	Comments	Holes
27	2148	45	9,000	V286	O	----------	33(4), 38(5), 40(2), 43(7)
27	1538	38	7,000	V194	O	----------	31(4), 35(5), 36(3)
27	0057	35	5,000	V194	O	----------	33(3)
28	1857	50	10,000	V1N	I	----------	44(2), 47(2), 49(1)
28	0115	43	7,000	V286	O	----------	38(16), 42(1)
28	0318	38	7,000	V194	O	----------	32(2), 35(4), 36(5)
28	0413	41	9,000	V1N	O	----------	33(3), 38(5)
29	1317	34	7,000	V194	O	----------	32(2)
29	0130	32	5,000	PH	O	----------	------------
29	0110	29	5,000	V1N	O	----------	------------
29	0100	30	5,000	V194	O	----------	29(1)
29	0051	39	9,000	V156	O	----------	39(2)
30	0120	38	7,000	V1N	O	----------	34(1), 36(3)
30	0136	32	5,000	V194	O	----------	28(1), 29(2), 30(4)
30	0059	46	9,000	V286	O	----------	34(3), 39(4), 43(3)
30	1312	33	7,000	V194	O	----------	27(1), 29(5)
30	1237	28	5,000	V194	O	----------	lost 20-24 NM

TABLE II

DATA COMPILED FOR FPS-8 FOR DC-6 AIRCRAFT

Date (April)	Time (Zebra)[1]	Maximum Range (NM)	Altitude (ft.)	Route	Inbound Or Outbound	Comments	Holes
4	0040	88	9,000	V286	O	w_x[2]	60(5)[3]
4	1415	112	16,000	1503N	I	----------	-------------
4	1946	108	10,000	V18	O	w_x	93(5)
4	2040	85	8,000	V286	O	----------	70(4)
5	2230	78	9,000	V157	O	----------	------------
5	0027	80	11,000	V18	I	----------	------------
5	0329	90	6,000S[4]	V157	O	w_x	------------
5	1951	56	10,000	V1	O	Radar Out 56 mi.	15(1), 18(2), 30(4), 34(1)
6	1619	100	17,000	1503N	O	----------	------------
6	1718	108	18,000	1503S	---	----------	80(2), 90(2), 95(4)
6	0324	82	8,000	V286	I	----------	------------
6	0122	100	5,000S	V286	O	----------	------------
6	0118	90	6,000S	V286	O	----------	------------
7	1913	88	5,000S	V1N	I	----------	78(3)
7	0146	136	17,000	1503N	O	w_x	103(3)
7	0058	85	6,000	V286	O	w_x at 85 mi.	28(2),46(1)
8	1823	108	16,000	1503S	O	----------	Intermittent past 90 NM
8	1930	90	13,000	V1N	O	w_x - heavy ducting	81(1), 84(1), 89(3)

[1] Time Zebra = Eastern Standard Time + 5 hours.

[2] w_x = Weather Prominent on Scope.

[3] n(m) = missed target for m scans at an average range of n NM.

[4] S = loss of target may have been due to shielding by radio horizon.

TABEL II (Continued)

DATA COMPILED FOR FPS-8 FOR DC-6 AIRCRAFT

Date (April)	Time (Zebra)[1]	Maximum Range (NM)	Altitude (ft.)	Route	Inbound or Outbound	Comments	Holes
8	0119	96	8,000	V286	O	---------	85(1), 88(1)
8	0323	93	5,000S	V286	O	---------	73(1), 75(1) 81(1), 86(1)
9	1300	90	5,000S	PH[5]	O	---------	75(2)
9	1640	82	18,000	V1053S	O	---------	------------
9	2142	112	11,000	V1N	O	---------	------------
9	0130	84	14,000	V1-194	O	---------	45(1)
10	0325	72	5,000	V286	O	---------	63(1), 67(1), 69(1)
10	0054	70	7,000	V286	O	w_x	------------
11	1412	102	10,000	V1N	I	w_x - precipitation at 60 NM	------------
11	1851	82	6,000	V286	I	---------	------------
11	2300	90	6,000	V1N	I	---------	82(2)
12	1849	112	11,000	V139	O	---------	100(3)
12	2010	86	6,000	V1-194	O	---------	75(5)
12	1550	88	9,000	V286	O	---------	------------
12	1812	70	4,000	V194S	O	---------	------------
12	2032	78	5,000	V286	O	---------	73(4)
12	2212	90	7,000	V286	O	---------	------------
13	0605	90	9,000	V286	O	---------	71(2)
13	0048	85	9,000	V1-194	I	---------	------------
14	1601	120	14,000	V1N	I	---------	------------
14	1601	110	14,000	V1-194	O	---------	------------
15	1609	90	11,000	V286	O	---------	------------
15	1710	93	12,500	V266	O	---------	------------
15	1745	85	10,000	V229	O	---------	------------
15	2004	95	14,000	V1-194	O	---------	------------
15	0102	109	17,000	1503S	I	---------	------------
15	0102	124	17,000	1503N	O	---------	100(4)
15	2125	115	15,000	1503S	I	w_x	------------
15	2125	98	15,000	1503N	O	w_x	------------
16	1552	87	7,000	V286	O	---------	------------

[5] PH = Patrick Henry Area

TABLE II (Continued)

DATA COMPILED FOR FPS-8 FOR DC-6 AIRCRAFT

Date (April)	Time (Zebra)	Maximum Range (NM)	Altitude (ft.)	Route	Inbound or Outbound	Comments	Holes
16	1922	95	10,000	V194S	O	---------	-----------
16	2000	98	10,000	V1-194	O	---------	-----------
16	2203	89	9,000	V286	O	---------	-----------
16	2216	78	10,000	V286	O	---------	-----------
17	2102	82	9,000	V286	O	w_x	-----------
17	1539	98	16,000	1503S	O	Ground return strong	-----------
17	1721	90	14,000	V1-194	O	---------	-----------
17	1721	76	14,000	V1N	I	---------	-----------
17	1958	93	12,000	V1-194	O	---------	-----------
18	2221	97	6,000S	V286	O	---------	-----------
18	2309	84	10,000	V139	I	w_x	39(1), 44(1), 47(1)
18	2045	93	9,000	V139	O	w_x	58(1), 62(1), 64(1)
18	2210	107	19,000	V1503N	O	w_x	39(1), 43(1), 48(1), 53(1)
18	0130	45	7,000	V286	O	w_x ducting at 45 mi.	-----------
19	2138	85	7,000	V286	O	---------	80(2)
19	0125	85	7,000	V286	O	---------	74(2)
20	1321	85	6,000	V286	I	w_x	-----------
20	2124	75	4,000S	V286	O	---------	-----------
20	2215	80	5,000	V286	O	---------	-----------
20	0133	80	5,000	V286	O	---------	-----------
20	0330	90	8,000	V286	O	---------	-----------
20	0401	97	9,000	V1N	O	---------	-----------
21	1554	95	9,000	V286	O	---------	-----------
21	0114	85	6,000	V286	O	---------	-----------
22	1606	123	18,000	V1503N	I	---------	98(2), 102(4), 106(4), 112(3)
22	1606	109	18,000	V1503S	O	---------	80(1), 97(3) 104(2), 106(3)

TABLE II (Continued)

DATA COMPILED FOR FPS-8 FOR DC-6 AIRCRAFT

Date (April)	Time (Zebra)	Maximum Range (NM)	Altitude (ft.)	Route	Inbound or Outbound	Comments	Holes
22	0100	85	9,000	V286	O	----------	74(1), 77(1), 80(1), 82(1)
23	1945	85	12,000	V1S	O	----------	-------------
23	0255	105	18,000	1503N	I	----------	25(1), 49(1), 91(1)
23	0255	122	18,000	1503S	O	----------	89(1), 100(3), 110(2)
24	1540	85	9,000	V286	O	-----------	-------------
24	2130	87	7,000	V1N	O	w_x	lost from 75-85 NM
24	2217	92	8,000	V286	O	w_x	25(2), 45(2)
24	0305	88	6,000	V286	O	----------	48(2), 67(3)
26	2008	83	16,000	V1-194	O	----------	-------------
26	1735	85	14,000	V156	O	----------	-------------
26	1550	82	9,000	V286	O	w_x	-------------
27	1832	110	13,000	V1-194	I	w_x - heavy ducting	many holes
27	2135	62	9,000	V286	O	w_x - heavy ducting	18(2), 24(2), 27(2)
28	1859	108	18,000	V1503N	I	----------	16(6), 38(4), 96(2)
28	1859	94	18,000	V1503S	O	----------	missed 15-28 NM
28	1544	87	7,000	V286	O	----------	weak 75-81 NM
29	2048	85	11,000	V156	O	----------	78(2)
29	1337	80	7,000	V286	O	----------	27(8), 73(2)
29	1249	86	7,000	V286	O	----------	11(2), 84(2)
29	2017	70	10,000	V1-194	O	w_x - thunderstorm radar poor	missed 12-21 NM 23(3), 58(3), 63(2), 68(1)
30	1245	89	5,000	V286	O	----------	70(1), 79(2)
30	1257	90	7,000	V286	O	----------	-------------
30	1330	90	7,000	V286	O	----------	-------------
30	2129	85	14,000	V1N	I	----------	38(3)
30	2129	89	14,000	V1-194	O	----------	80(4)
30	0059	67	9,000	V286	O	----------	-------------
30	0120	78	7,000	V1N	O	----------	14(3)

APPENDIX IV

PERIODIC FLIGHT CHECK DATA WITH DC-3

April 2 and 3, and May 1 and 2, 1962

COPY

FEDERAL AVIATION AGENCY

Chief, SMDO-12, Richmond, Virginia April 11, 1962

Chief, SMS-53, Norfolk, Virginia

Routine Periodic Flight Check Report, Norfolk, Virginia ASR-2

A routine periodic flight check was conducted April 2, 1962 on the Norfolk, Virginia ASR-2 radar system. Participants in the flight check were Messrs. Bankston and Converse of the Aircraft Management Branch; Mr. Brinkley of Norfolk ATC; Mr. Morris of Norfolk SMS-53.

The ASR-2 radar system was determined by performance checks to be operating normally. The antenna tilt was +3.0 degrees.

I. Flight Checks

A. Vertical Coverage

Vertical coverage was flown, using C/P and Channel "B" for all runs, with the following exceptions. An outbound run at 10,000 ft. was made, using Channel "B" L/P, from a point 40 miles from the antenna to a point 49 miles from the antenna. An inbound run at 10,000 ft. was made, using Channel "A" C/P, from a point 41 miles from the antenna to the antenna. This was done to spot check the stand-by channel and L/P operation.

B. Fix and Route Coverage:

The following fixes were checked for map accuracy and coverage and found to be satisfactory.

FIX	RANGE	COMMISSIONING	PERIODIC
Hampton Roads Int.	9.4 mi.	800'	800'
Patrick Henry Airport	20.4 mi.	1000'	1000'

The following route was checked and found to be satisfactory.

Patrick Henry 1000' climbing to 2000' direct Yorktown: Patrick Henry 1000' - 44444 - 24443 - 34444 - 4320 - 1500' - 43232 - 41120 - 2000' - 34424 - 41403 - 44044 - 43040 - 30241 - Yorktown 27 mi. (See attached FAA Forms 496.37).

C. PPI Approaches:

Approaches were flown to runways 1, 4, 13, 19, 22, and 31 using MTI, C/P and stagger ON. Accuracy was found satisfactory and good coverage throughout the approaches. (See attached 496.38 Forms).

II. Conclusions

The Norfolk ASR-2 periodic flight check was within tolerance as compared to the commissioning check.

s/s R. S. Smith

Attachments

SL Morris/mb

PERIODIC RADAR FLIGHT CHECK REPORT

STATION Norfolk, Va. DATE 4/2/62	TYPE OF CHECK Periodic
RADAR CONTROLLER Brinkley	AIRCRAFT TYPE. C18S ☐ DC3 ☒ NO. 26
RADAR MAINT. TECH. Morris	PILOTS Bankston-Converse
FACILITY TYPE ASR-2	CHANNEL A ☐ B ☒
ANTENNA TILT +3.0 (mech)	ANTENNA SPEED 13 RPM

PPI APPROACHES

R/W NO.	DEVIATION OBSERVED	R/W REFLECTORS YES	R/W REFLECTORS NO
4	C/L	X	
19	75 ft. left	x	
1	100 ft. left	x	
22	C/L		x
13	100 ft. left		x
31	C/L		x

TEMPERATURE /1000 FT.

FEET MSL	TEMP °C	FEET MSL	TEMP °C
1000	+6	8000	-10
2000	+4	9000	-13
3000	+2	10000	-14
4000	+0		
5000	-2		
6000	-4 1/2		
7000	-7		

EQUIPMENT PERFORMANCE

	SATIS.	UNSATIS.
SCOPE RANGE ACCURACY	x	
SCOPE ALIGNMENT ACCURACY	x	
IFF (IF INSTALLED) N/A		

Describe any adjustments required during flight check:

	SATIS.	UNSATIS.
FIX ACCURACY	x	
FIXED TARGET IDENT.	x	
STROBE LINE ACCURACY N/E		
STC OFF ☐ ON ☒		
FTC OFF ☒ ON ☐		

THIS FACILITY ☒ Does ☐ Does not MEET OPERATIONAL CRITERIA

s/Donald S. Brinkley
SIGNATURE OF RADAR CONTROLLER

EQUIPMENT DATA

PEAKED SYSTEM ☐ YES ☒ NO	DF INSTALLED (STROBE LINE) ☒ YES ☐ NO
POWER OUTPUT 400 watts ave.	BLIND SPEED 110 KNOTS
NORMAL RECEIVER SENS. 101.8 db	POLARIZATION TYPE ☒ Circular (Required) ☐ Linear
MTI RCVR. SENS. 100.8 db	
RECOVERY TIME 10 micro sec.	Describe any adjustments required during flight check:
STANDBY POWER CHECK ☐ SATIS. ☐ UNSATIS. N/A	

THIS FACILITY ☒ Does ☐ Does not MEET MAINTENANCE CRITERIA

s/S. L. Morris
SIGNATURE OF RADAR MAINT. TECH.

MOST STRINGENT (OPERATION) FIX (ON ALTERNATE CHANNEL)

NAME CH A checked Sat. on 10,000 ft.
DISTANCE inbound run. NAUT. MILES
MINIMUM ALTITUDE FEET MSL
SATIS. ☒ UNSATIS. ☐
REMARKS:

COVERAGE	SATIS.	UNSATIS.
HORIZONTAL N/C		
VERTICAL	x	
FIX	x	
ROUTE	x	
PPI APPROACH	x	

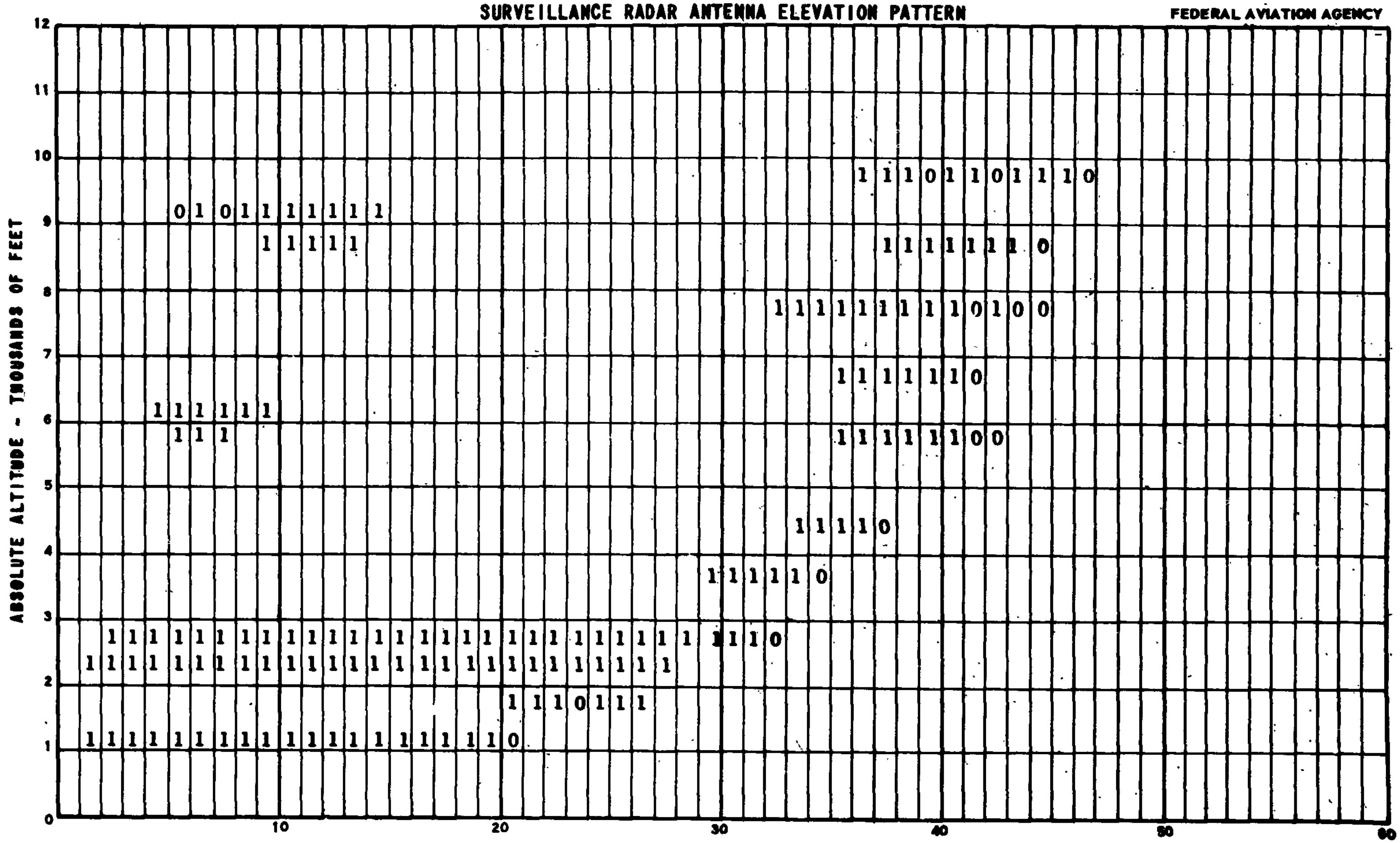
THIS FACILITY ☒ Does ☐ Does not MEET FLIGHT INSPECTION CRITERIA

SIGNATURE OF FLIGHT INSPECTOR

FAA Form NY-272 (4/59)

SURVEILLANCE RADAR ANTENNA ELEVATION PATTERN

FEDERAL AVIATION AGENCY

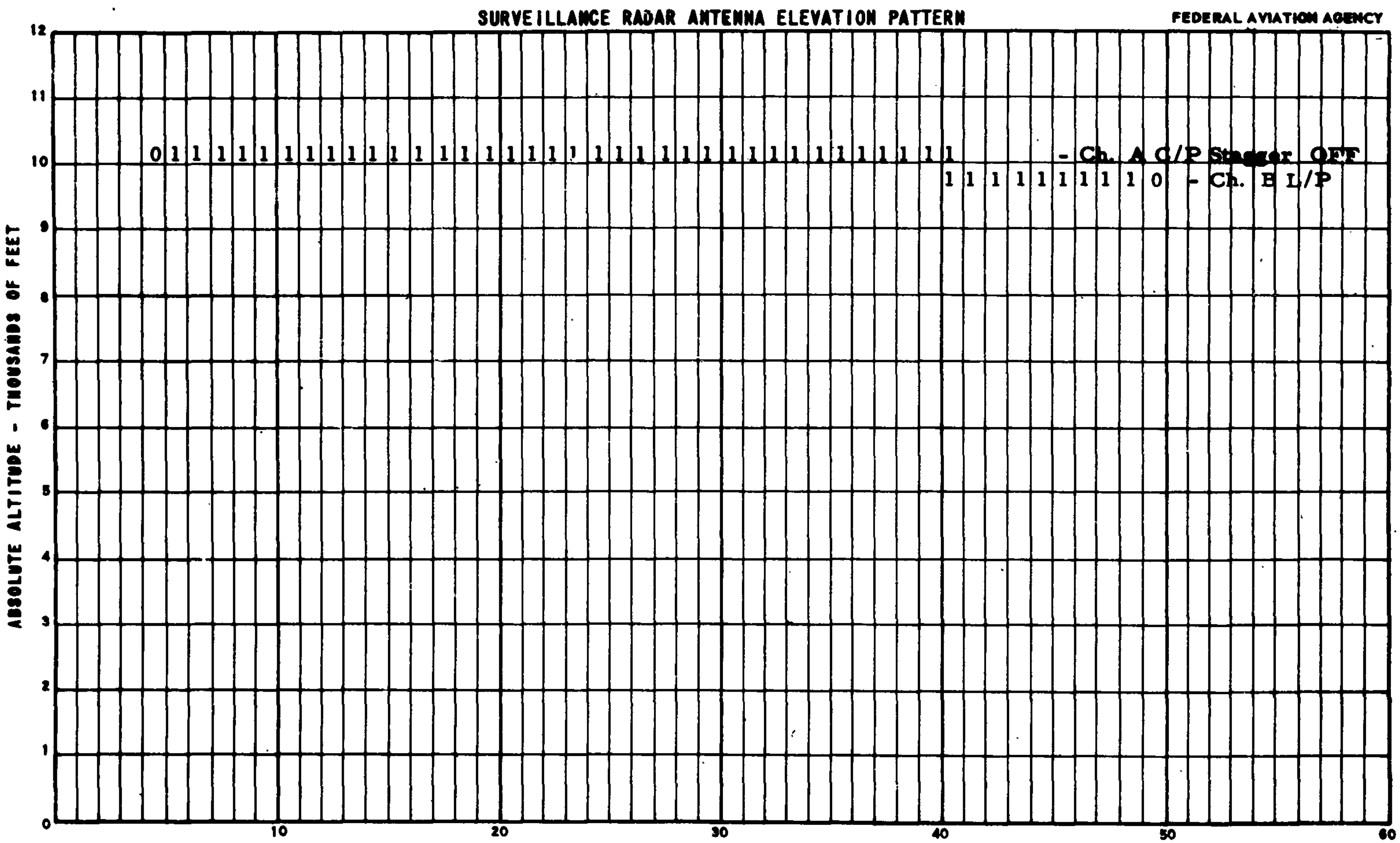


CH. B C/P MTI GATE 17 Mi.

INSTALLATION ARS-2	AIRCRAFT (Type and No.) DC-3 N=26	SCALE OF SIGNALS	EXAMPLE: HEAD-ON VALUE	PILOT(S) Bankston - Converse
REGION NO. EA	BEAM ELEVATION +3.0°	0 - NOT USUABLE	1 1	
DATE 4/2/62	SYSTEM PERFORMANCE NOR 101.8 MTI 100.8	1 - USUABLE		TECHNICIAN Morris / OPERATOR Brinkley
WEATHER VFR	AFC: ON OFF / STC: ON OFF		TAIL-ON VALUE	
HEADINGS FLOWN 235° - 055°	FTC: ON OFF / MTI: ON OFF			

GPO 904835

Form FAA-406.31 (9-60)



MTI GATE 17 Mi.

INSTALLATION ARS-2	AIRCRAFT (Type and No.) DC-3 N-26	SCALE OF SIGNALS	EXAMPLE:	PILOT(s)
REGION NO. EA	BEAM ELEVATION +3.0°	0 - NOT USUABLE	HEAD-ON VALUE 1	Bankston - Converse
DATE 4/2/62	SYSTEM PERFORMANCE NOR 101.8 MTI 100.8	1 - USUABLE	TAIL-ON VALUE 1	TECHNICIAN Morris
WEATHER VFR	AFC: ON ~~OFF~~ STC: ON ~~OFF~~			OPERATOR Brinkley
HEADINGS FLOWN 235° - 055°	FTC: ~~ON~~ OFF MTI: ON ~~OFF~~			

GPO 904292

Form FAA-496.31 (9-56)

FEDERAL AVIATION AGENCY

SURVEILLANCE RADAR APPROACH CONTROL COVERAGE

INSTALLATION	REGION	DATE
Norfolk, Va. ASR-2	EA	4/2/62

AIRCRAFT (Type and No.)	WEATHER	SCALE OF SIGNALS
DC-3 N-26	VFR	1 = USABLE 0 = UNUSABLE 0 - No. return 1 - Unusable 2 - Useable 3 - Good 4 - Very Good

BEAM ELEV.	RECEIVER SENSITIVITY	POWER OUTPUT		
+3.0°	NOR 101.8 NTI 100.8	400 watts	IAGC: ~~ON~~ OFF STC: ON ~~OFF~~ AFC: ON ~~OFF~~	FTC: ~~ON~~ OFF MTI: ON ~~OFF~~ RADAR CHANNEL: B

PILOT(S)	OPERATOR(S)	TECHNICIAN(S)
Bankston - Converse	Brinkley	Morris

1 NAME OF "FIX"	2 MINIMUM INSTRUMENT ALT. (MSL) AND RANGE (FROM ASR ANTENNA)	3 OPERATIONAL REQUIREMENT INCLUDING SAFETY FACTOR OF 300 FT.	4 MINIMUM COVERAGE OF PEAKED SYSTEM
Hampton Roads Int.	MOCA 800' 9.4 mi.		FIELD ELEV. ______ FT.

800 FT. MSL..OUTBOUND ALT.

3 mi. N. Hampt. Rds. - 44444 - 44444 - Hampt. Rds. - satisfactory.

800 FT. MSL..INBOUND ALT. COLUMN 4 REQUIREMENTS MET ☐ YES ☐ NO

4 mi - 096° Hdq. INBND - 44444 - 44444 - 44444 - Hampt. Rds. - satisfactory

1 NAME OF "FIX"	2 MINIMUM INSTRUMENT ALT. (MSL) AND RANGE (FROM ASR ANTENNA)	3 OPERATIONAL REQUIREMENT INCLUDING SAFETY FACTOR OF 300 FT.	4 MINIMUM COVERAGE OF PEAKED SYSTEM
Patrick Henry Airport	NOCA 1000' 20.4 mi.		FIELD ELEV. ______ FT.

1000 FT. MSL..OUTBOUND ALT.

15 mi. NW ORF - 5 mi. Pat. Henry - 1500' - 44444 - 44433- 44444-Descd. 1000'-
44444 - 443 - Patrick Henry - satisfactory

______ FT. MSL..INBOUND ALT. COLUMN 4 REQUIREMENTS MET ☐ YES ☐ NO

Form FAA-496.37 (3-61)

FEDERAL AVIATION AGENCY

SURVEILLANCE RADAR (P.P.I.) APPROACH PERFORMANCE

INSTALLATION	REGION	DATE
Norfolk, Va. ASR-2 C/P	EA	4/2/62

AIRCRAFT (Type and No.)	WEATHER	SCALE OF SIGNALS
DC-3 N-26	VFR	I USABLE O UNUSABLE

BEAM ELEVATION	RECEIVER SENSITIVITY	POWER OUTPUT		
+3.0°	NOR 101.8 MTI 100.8 Db	400 watts Db	IAGC: ~~ON~~ OFF STC: ON ~~OFF~~ AFC: ON ~~OFF~~	FTC: ~~ON~~ OFF MTI: ON ~~OFF~~ RADAR CHANNEL: B

PILOT(S)	OPERATOR(S)	TECHNICIAN(S)
Bankston - Converse	Brinkley	Morris
FLIGHT PROCEDURES SPECIALIST		

RUNWAY 4 FORM FAA-511.5 ISSUED ☐ YES ☐ NO DATE 4/2/62

3 1/2 mi. - 11111 - 2 1/2 mi - 111 - 2 mi - 11111 - 1111 - 2 mi - 11111 - 1 - Boundry

FLIGHT INSPECTION MANUAL STANDARDS MET ☒ YES ☐ NO

RUNWAY 19 FORM FAA-511.5 ISSUED ☐ YES ☐ NO DATE 4/2/62

4 mi - 11111 - 1111 - 3 mi - 11111 - 11111 - 2 mi - 11111 - 111 - 1 mi - 11111 - 11 - Boundry

FLIGHT INSPECTION MANUAL STANDARDS MET ☒ YES ☐ NO

RUNWAY 1 FORM FAA-511.5 ISSUED ☐ YES ☐ NO DATE 4/2/62

5 mi - 11111 - 11111 - 3 1/2 mi - 111 - 3 mi - 11111 - 111 - 2 mi - 11111 - 1111 - 1 mi - 11111 - 1111 - Boundry

FLIGHT INSPECTION MANUAL STANDARDS MET ☒ YES ☐ NO

RUNWAY 22 FORM FAA-511.5 ISSUED ☐ YES ☐ NO DATE 4/2/62

5 mi - 11111 - 1 - 4 mi - 11111 - 3 mi - 11111 - 111 - 2 mi - 11111 - 111 - 1 mi - 11111 - 11 - Boundry

FLIGHT INSPECTION MANUAL STANDARDS MET ☒ YES ☐ NO

GPO 894778 Form FAA-496.30 (3-61)

FEDERAL AVIATION AGENCY

SURVEILLANCE RADAR (P.P.I.) APPROACH PERFORMANCE

INSTALLATION		REGION	DATE
Norfolk, Va. ASR-2 C/P		EA	4/2/62

AIRCRAFT (Type and No.)	WEATHER	SCALE OF SIGNALS
DC-3 N-26	VFR	I USABLE O UNUSABLE

BEAM ELEVATION	RECEIVER SENSITIVITY	POWER OUTPUT		
+3.0°	NOR 101.8 MTI 100.8 Db	400 watts Db	AGC: XXX OFF STC: ON XXX AFC: ON XXX	FTC: XXX OFF MTI: ON XXXX RADAR CHANNEL: B

PILOT(S)	OPERATOR(S)	TECHNICIAN(S)
Bankston - Converse	Brinkley	Morris
FLIGHT PROCEDURES SPECIALIST		

RUNWAY 13 FORM FAA-511.5 ISSUED ☐ YES ☐ NO DATE 4/2/62

4 mi - 11111 - 11 - 3 mi - 11111 - 2 mi - 11111 - 111 - 1 mi - 11111 - 1111 - Boundry

FLIGHT INSPECTION MANUAL STANDARDS MET ☒ YES ☐ NO

RUNWAY 31 FORM FAA-511.5 ISSUED ☐ YES ☐ NO DATE 4/2/62

4 mi - 11111 - 11111 - 111 - 2 mi - 11111 - 111 - 1 mi - 11111 - 1 - Boundry

FLIGHT INSPECTION MANUAL STANDARDS MET ☒ YES ☐ NO

RUNWAY ______ FORM FAA-511.5 ISSUED ☐ YES ☐ NO DATE ______

FLIGHT INSPECTION MANUAL STANDARDS MET ☐ YES ☐ NO

RUNWAY ______ FORM FAA-511.5 ISSUED ☐ YES ☐ NO DATE ______

FLIGHT INSPECTION MANUAL STANDARDS MET ☐ YES ☐ NO

GPO 894776 Form FAA-406.30 (3-61)

COPY

FEDERAL AVIATION AGENCY

Chief, SMDO-12, Richmond, Virginia April 11, 1962

Chief, SMS-53, Norfolk, Virginia

Norfolk, Virginia ARSR/FPS-8 Periodic Flight Check Report

A periodic flight check of the Norfolk ARSR/FPS-8 was conducted April 3, 1962. A DC-3, N-26 was used for the entire check.

Participating in the flight check were Messrs. Bankston and Covert of Aircraft Management Branch; Mr. Merritt of Norfolk ATC; Messrs. Morris and Brown of Norfolk SMS-53.

I. Flight Check:

A. Vertical Coverage:

Vertical coverage was flown, using C/P for all runs, with the exception of a 10,000 feet outbound run from a point 90 miles from the antenna to a point 110 miles from the antenna. This portion was flown on L/P for a spot check. All runs were on a magnetic heading of 235 degrees from the station and 055 degrees to the station. The antenna tilt was +3.0 degrees mechanical. True inner fringe data was difficult to obtain due to clutter caused by dusting. (See attached Form FAA 496-31).

B. Fix and Route Coverages:

The following fixes were checked for map accuracy and coverage, using primary radar and found to be satisfactory.

FIX	RANGE	COMMISSIONING	PERIODIC
Sharps Int.	54 mi.	4000'	2000'
Tappahannock LFR	71 mi.	6000'	5000'
Richmond VOR	65 mi.	5000'	5000'
Windsor Int.	23 mi.	2100'	2100'
Surrey Int.	31 mi.	1500'	1500'

Chief, SMDO-12 April 11, 1962

The following was checked while enroute to fix checks and found to be satisfactory.

V-19h, V-286 North-bound: 20 mi. N. ORF 2000' - 44444 - 44444 - 30 mi. - 44444 - 44444 - 44444 - 44444 - 44444 - 40 mi. - 44444 - 44444 - 45 mi. - 44444 - 44444 - 4 - 50 mi. - 4444 - Sharps Int. 1/2 mi. S. - 44444 - 44 - climb 3000' communication difficulty - 44444 - 44441 - climb 4000' - 43444 - 60 mi. - level 4000' - 44444 - 44444 - 65 mi. - 44422 - 02300 - climb 5000' - 44 - 70 mi. - 44 - Tapp. OK - 44444. (See attached FAA Forms 496.37).

C. Radar Beacons

Beacon was checked throughout the vertical coverage and fix checks. Beacon exceeded primary radar coverage in all cases with strength four returns.

II. Conclusions

The Norfolk ARSR/FPS-8 and Radar Beacon (SECRA) periodic flight check was within tolerance as compared with the commissioning flight check.

/s/ R. S. Smith

Attachments

SL Morris/mb

PERIODIC RADAR FLIGHT CHECK REPORT

STATION Norfolk, Va. DATE 4/3/62 TYPE OF CHECK Periodic

RADAR CONTROLLER Merritt

RADAR MAINT. TECH. Morris-Brown

FACILITY TYPE ARSR/FPS-8

ANTENNA TILT +3.0 degrees (mech)

AIRCRAFT TYPE C135 ☐ DC3 ☒ NO. 26

PILOTS Covert-Bankston

CHANNEL A ☒ B ☐

ANTENNA SPEED 6 RPM

PPI APPROACHES

R/W NO.	DEVIATION OBSERVED	R/W REFLECTORS YES	R/W REFLECTORS NO

TEMPERATURE /1000 FT.

FEET MSL	TEMP °C	FEET MSL	TEMP °C
1000	+7	8000	-9
2000	+3	9000	-10
3000	+2	10000	-11
4000	0		
5000	-2		
6000	-4		
7000	-7		

EQUIPMENT PERFORMANCE

	SATIS.	UNSATIS.
SCOPE RANGE ACCURACY	x	
SCOPE ALIGNMENT ACCURACY	x	
IFF (IF INSTALLED)	x	

Describe any adjustments required during flight check:

	SATIS.	UNSATIS.
FIX ACCURACY	x	
FIXED TARGET IDENT.	x	
STROBE LINE ACCURACY N/A		
STC OFF ☐ ON ☒		
FTC OFF ☒ ON ☐		

THIS FACILITY ☒ Does ☐ Does not MEET OPERATIONAL CRITERIA

SIGNATURE OF RADAR CONTROLLER

EQUIPMENT DATA

PEAKED SYSTEM ☐ YES ☒ NO

POWER OUTPUT .9 Meg Watts

NORMAL RECEIVER SENS. 106 db

MTI RCVR. SENS. 105 db

RECOVERY TIME N/A

STANDBY POWER CHECK ☐ SATIS. ☐ UNSATIS. N/A

DF INSTALLED (STROBE LINE) ☐ YES ☒ NO

BLIND SPEED 78 KNOTS

POLARIZATION TYPE ☒ Circular (Required) ☐ Linear

Describe any adjustments required during flight check:

THIS FACILITY ☒ Does ☐ Does not MEET MAINTENANCE CRITERIA

s/ S L Morris

SIGNATURE OF RADAR MAINT. TECH.

MOST STRINGENT (OPERATION) FIX (ON ALTERNATE CHANNEL)

NAME N/A

DISTANCE NAUT. MILES

MINIMUM ALTITUDE FEET MSL

SATIS. ☐ UNSATIS. ☐

REMARKS:

COVERAGE	SATIS.	UNSATIS.
HORIZONTAL N/C		
VERTICAL	x	
FIX	x	
ROUTE	x	
PPI APPROACH N/A		

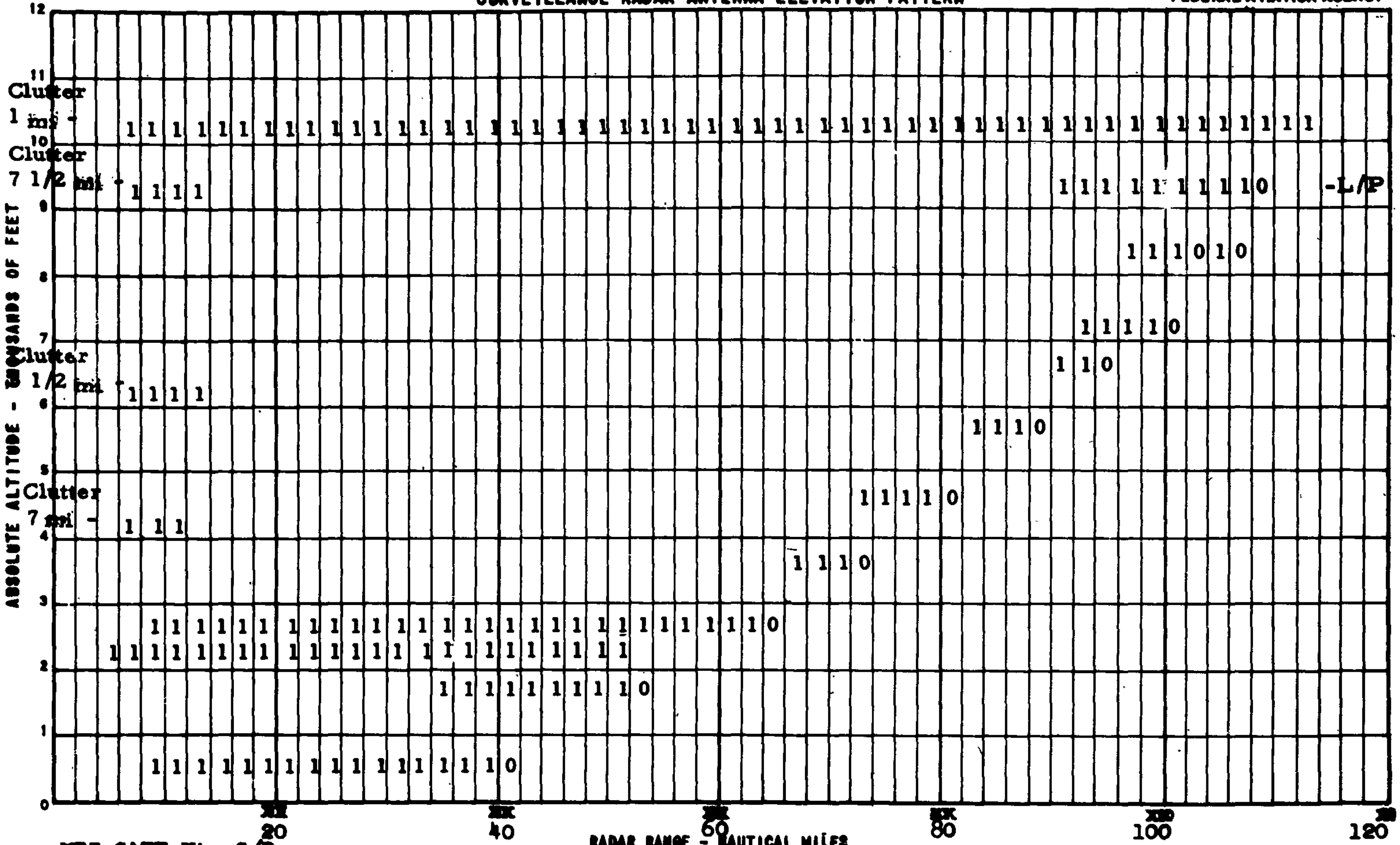
THIS FACILITY ☒ Does ☐ Does not MEET FLIGHT INSPECTION CRITERIA

SIGNATURE OF FLIGHT INSPECTOR

FAA Form NY-272 (4/59)

SURVEILLANCE RADAR ANTENNA ELEVATION PATTERN

FEDERAL AVIATION AGENCY



MTI GATE Ml. C/P

INSTALLATION ARSR/FPS-8	AIRCRAFT (Type and No.) DC-3 N-26	SCALE OF SIGNALS	EXAMPLE:
REGION NO. EA	BEAM ELEVATION +3.0°	0 - NOT USUABLE	HEAD-ON VALUE 1
DATE 4/3/62	SYSTEM PERFORMANCE NOR 106 MTI 108	1 - USUABLE	TAIL-ON VALUE 1
WEATHER IFR	AFC: ON	STC: ON	
HEADINGS FLOWN 235° - 055°	FTC: OFF	MTI: ON	

PILOT(S) Covert-Bankston

TECHNICIAN Morris Brown

OPERATOR Merritt

GPO 884288

Form FAA-496.31 (9-56)

FEDERAL AVIATION AGENCY

SURVEILLANCE RADAR APPROACH CONTROL COVERAGE

INSTALLATION	REGION	DATE
Norfolk, Va. ARSR/FPS-8	EA	4/3/62

AIRCRAFT (Type and No.)	WEATHER	SCALE OF SIGNALS
DC-3 N-26	VFR	1 = USABLE 0 = UNUSABLE 0-No return 1-Unuseable 2-Useable 3-Good 4-Very good

BEAM ELEV.	RECEIVER SENSITIVITY	POWER OUTPUT	IAGC: XXX OFF STC: ON XXX AFC: ON XXX	FTC: ON OFF MTI: ON XXX RADAR CHANNEL: Single
+3. 0°	NOR. 106 db MTI 105 db	. 9 Meg. Watts		

PILOT(s)	OPERATOR(s)	TECHNICIAN(s)
Covert-Bankston	Merritt	Morris-Brown

1 NAME OF "FIX"	2 MINIMUM INSTRUMENT ALT. (MSL) AND RANGE (FROM ASR ANTENNA)	3 OPERATIONAL REQUIREMENT INCLUDING SAFETY FACTOR	4 MINIMUM COVERAGE OF PEAKED SYSTEM FIELD ELEV. ____ FT.
Windsor Int.		2100'	

2100 FT. MSL..OUTBOUND ALT. Hdq. 260° 15 mi. ORF - 44334 - 432 - TRN. RT 265° - 33 - TRN. RT. 275° - 444 - 1/2 mi. South Int. as indicated on radar. Recheck of fix good.

____ FT. MSL..INBOUND ALT. COLUMN 4 REQUIREMENTS MET ☒ YES ☐ NO

1 NAME OF "FIX"	2 MINIMUM INSTRUMENT ALT. (MSL) AND RANGE (FROM ASR ANTENNA)	3 OPERATIONAL REQUIREMENT INCLUDING SAFETY FACTOR	4 MINIMUM COVERAGE OF PEAKED SYSTEM FIELD ELEV. ____ FT.
Surrey		1500'	

1500 FT. MSL..OUTBOUND ALT. Hdq. 360° 22 mi. ORF - 33244 - 44 - TRN. LFT. 300° - 444 - 33333 - 33 - TRN. RT. 305° - 24444 - 44 - Surrey

____ FT. MSL..INBOUND ALT. COLUMN 4 REQUIREMENTS MET ☒ YES ☐ NO

Form FAA-496.37 (3-61)

FEDERAL AVIATION AGENCY

SURVEILLANCE RADAR APPROACH CONTROL COVERAGE

INSTALLATION	REGION	DATE
Sharps Int. 4000'		

AIRCRAFT (Type and No	WEATHER	SCALE OF SIGNALS
4000' North bound 45 mi. ORF - 44444 - 44444 - 4 - 50 mi. - 4444 - Sharps 1/2 mi. south as indicated on radar - 4444		1 = USABLE 0 = UNUSABLE

BEAM ELEV.	RECEIVER SENSITIVITY	POWER OUTPUT	IAGC: ON OFF STC: ON OFF AFC: ON OFF	FTC: ON OFF MTI: ON OFF RADAR CHANNEL: ______

PILOT(s)	OPERATOR(s)	TECHNICIAN(s)

1 NAME OF "FIX"	2 MINIMUM INSTRUMENT ALT. (MSL) AND RANGE (FROM ASR ANTENNA)	3 OPERATIONAL REQUIREMENT INCLUDING SAFETY FACTOR	4 MINIMUM COVERAGE OF PEAKED SYSTEM FIELD ELEV. ______ FT.
Tappahannock LFR		6000'	

5000 FT. MSL..OUTBOUND ALT. North bound 65 mi. ORF - 4000' - 44422 - 02300 - climb. 5000' - 44 - 70 mi. - 44 - Tapp. - 44444 -

______ FT. MSL..INBOUND ALT. COLUMN 4 REQUIREMENTS MET ☒ YES ☐ NO

1 NAME OF "FIX"	2 MINIMUM INSTRUMENT ALT. (MSL) AND RANGE (FROM ASR ANTENNA)	3 OPERATIONAL REQUIREMENT INCLUDING SAFETY FACTOR	4 MINIMUM COVERAGE OF PEAKED SYSTEM FIELD ELEV. ______ FT.
Richmond VOR		5000'	

5000 FT. MSL..OUTBOUND ALT. Hdq. 320° to RIC - 60 mi. ORF - 44334 - 44444 - 44444 - over RIC VOR OK - 44444 -

______ FT. MSL..INBOUND ALT. COLUMN 4 REQUIREMENTS MET ☐ YES ☐ NO

Form FAA-[illegible] (3-61)

COPY

Chief, SMDO-12, Richmond, Virginia DATE: May 3, 1962

Chief, SMS-53, Norfolk, Virginia

Special Flight Check Report, Norfolk, Virginia ASR-2/4

A special flight check was conducted May 1, 1962 on the Norfolk, Virginia ASR-2/4 radar system. The purpose of this check was to complete the data needed by RD-309 for the Radar Quality Control Feasibility Experiment that was conducted at this station April 2 through May 2, 1962.

Participants in the flight check were Messrs. Whitehurst and Gowin of the Aircraft Management Branch; Messrs. West, Jennings and Brinkley of Norfolk ATC and Mr. Morris of Norfolk SMS-53.

The ASR-2/4 radar system was determined by performance checks to be operating normally.

I. Flight Checks:

A. Vertical Coverage

Vertical coverage was flown, using C/P and Channel "B". One, two, three and ten thousand feet altitudes were flown all the way, while only the inner and outer fringes were flown on the other altitudes. (See attached 496.31 Form).

B. Fix Coverage

The following fixes were checked for coverage and found staisfactory at those altitudes flown.

Channel "A"

FIX	RANGE	ALTITUDE
Williamsburg INT	38 Mi.	8000'
Eclipse FM	19.3 Mi.	1500'

Chief, SMDO-12, Richmond, Virginia May 3, 1962

Channel"B"

Chesapeake Light Ship INT	23. 8 Mi.	2000'
Windsor INT	21 Mi.	1500'
Surry INT	30 Mi.	4500'
Felker Airport	24 Mi.	4500'
Yorktown FM (MHW)	27 Mi.	4500'

(See attached 496. 37 Forms).

II. Conclusions

The data obtained on this Special Flight Check Compared favorably with the commissioning check.

There was heavy ducting present in the north quadrant although a temperature inversion was not indicated.

/s/ R. S. Smith

Attachments

SLMorris/mb

FEDERAL AVIATION AGENCY

SURVEILLANCE RADAR APPROACH CONTROL COVERAGE

INSTALLATION	REGION	DATE
Norfolk, Va. ASR-2/4 C/P	EA	5/1/62

AIRCRAFT (Type and No.)	WEATHER	SCALE OF SIGNALS
DC-3 N-69	VFR	I = USABLE 0 = UNUSABLE ~~4-Very Good~~ ~~3-Good~~ ~~2-Useable~~ ~~1-Unuseable~~ ~~0-No Return~~

BEAM ELEV.	RECEIVER SENSITIVITY	POWER OUTPUT	IAGC / STC / AFC	FTC / MTI / RADAR CHANNEL
+ 3. 0 degrees	NOR - 101. 8 db MTI - 99. 8 db	400 watts	IAGC: ~~ON~~ OFF STC: ON ~~OFF~~ AFC: ON ~~OFF~~	FTC: ~~ON~~ MTI: ON ~~OFF~~ RADAR CHANNEL: A

PILOT(s)	OPERATOR(s)	TECHNICIAN(s)
Whitehurst, Gowin	West, Brinkley, Jennings	Morris

1 NAME OF "FIX"	2 MINIMUM INSTRUMENT ALT. (MSL) AND RANGE (FROM ASR ANTENNA)	3 OPERATIONAL REQUIREMENT INCLUDING SAFETY FACTOR OF 300 FT.	4 MINIMUM COVERAGE OF PEAKED SYSTEM
Williamsburg INT	Min. useable Alt. 8000' 38 N. M.		FIELD ELEV. ______ FT.

______ FT. MSL..OUTBOUND ALT.

8000 FT. MSL..INBOUND ALT. COLUMN 4 REQUIREMENTS MET ☐ YES ☐ NO

Hdq. 322° 8000' over fix 38 mi ORF - 24433 - 34334 - 33443 - 34444 - 44434 - 33 mi ORF

1 NAME OF "FIX"	2 MINIMUM INSTRUMENT ALT. (MSL) AND RANGE (FROM ASR ANTENNA)	3 OPERATIONAL REQUIREMENT INCLUDING SAFETY FACTOR OF 300 FT.	4 MINIMUM COVERAGE OF PEAKED SYSTEM
Eclipse FM	MOCA 1500' 19. 3 N. M.		FIELD ELEV. ______ FT.

1500 FT. MSL..OUTBOUND ALT. Hdq. 283° 1500' 21 Mi ORF - 44444 - 34444 - 44444 - 44444 - Over Fix - 4 - 19 Mi. ORF

1500 FT. MSL..INBOUND ALT. COLUMN 4 REQUIREMENTS MET ☐ YES ☐ NO

Form FAA-406.37 (3-51)

FEDERAL AVIATION AGENCY

SURVEILLANCE RADAR APPROACH CONTROL COVERAGE

INSTALLATION	REGION	DATE
Norfolk, Va. ASR-2/4 C/P	EA	5/1/62

AIRCRAFT (Type and No.)	WEATHER	SCALE OF SIGNALS
DC-3 N-69	VFR	I = USABLE 0 = UNUSABLE ~~4-Very Good 3-Good 2-Useable 1-Unuseable~~

BEAM ELEV.	RECEIVER SENSITIVITY	POWER OUTPUT	IAGC: XX OFF STC: ON XXX AFC: ON XXX	FTC: XX ~~0-No return~~ MTI: ON XXX RADAR CHANNEL: B
+ 3. 0 degrees	NOR 101. 8 db MTI 99. 8 db	400 watts		

PILOT(s)	OPERATOR(s)	TECHNICIAN(s)
Whitehurst, Gowin	West, Brinkley, Jennings	Morris

1 NAME OF "FIX"	2 MINIMUM INSTRUMENT ALT. (MSL) AND RANGE (FROM ASR ANTENNA)	3 OPERATIONAL REQUIREMENT INCLUDING SAFETY FACTOR OF 300 FT.	4 MINIMUM COVERAGE OF PEAKED SYSTEM FIELD ELEV. ________ FT.
Chesapeake Light Ship INT.	Min. Useable Alt. 2000' 23.8 N. M.		

2000 FT. MSL..OUTBOUND ALT. Hdq. 270° 2000' 1 Mi. - NW of INT - 34423 - 342 - 20 Mi. ORF 44 - 43444 - 44444 - 44444 - 44444 - 44444 - 44444 - 44 - 10 Mi. ORF

________ FT. MSL..INBOUND ALT. COLUMN 4 REQUIREMENTS MET ☐ YES ☐ NO

1 NAME OF "FIX"	2 MINIMUM INSTRUMENT ALT. (MSL) AND RANGE (FROM ASR ANTENNA)	3 OPERATIONAL REQUIREMENT INCLUDING SAFETY FACTOR OF 300 FT.	4 MINIMUM COVERAGE OF PEAKED SYSTEM FIELD ELEV. ________ FT.
Windsor INT	1500' 21 N. M.		

1500 FT. MSL..OUTBOUND ALT. Hdq. 260° 1500' 5 Mi East Fix - 44444 - 44444 - 44444 - 44444 - 04044 - Windsor - 1442

________ FT. MSL..INBOUND ALT. COLUMN 4 REQUIREMENTS MET ☐ YES ☐ NO

Form FAA-406.37 (3-61)

1 NAME OF "FIX"	2 MINIMUM INSTRUMENT ALT. (MSL) AND RANGE (FROM ASR ANTENNA)	3 OPERATIONAL REQUIREMENT INCLUDING SAFETY FACTOR OF 300 FT.	4 MINIMUM COVERAGE OF PEAKED SYSTEM FIELD ELEV.________FT.
Surry INT	Min. Useable Alt. 4500' 30 N. M.		

________ FT. MSL..OUTBOUND ALT.

4500 ________ FT. MSL..INBOUND ALT. COLUMN 4 REQUIREMENTS MET ☐ YES ☐ NO

Hdq. 120° 4500' over Surry INT - 30 Mi. ORF - 22232 - 22224 - 42444 - 44444 - 25 Mi ORF

1 NAME OF "FIX"	2 MINIMUM INSTRUMENT ALT. (MSL) AND RANGE (FROM ASR ANTENNA)	3 OPERATIONAL REQUIREMENT INCLUDING SAFETY FACTOR OF 300 FT.	4 MINIMUM COVERAGE OF PEAKED SYSTEM FIELD ELEV.________FT.
Felker Airport	Min. Useable Alt. 4500' 24 N. M.		

4500 ________ FT. MSL..OUTBOUND ALT. Hdq. 330° 4500' Over Fix - 25 Mi ORF - 44423 - 22324 - 44222 - 34421 - 30 Mi ORF

________ FT. MSL..INBOUND ALT. COLUMN 4 REQUIREMENTS MET ☐ YES ☐ NO

1 NAME OF "FIX"	2 MINIMUM INSTRUMENT ALT. (MSL) AND RANGE (FROM ASR ANTENNA)	3 OPERATIONAL REQUIREMENT INCLUDING SAFETY FACTOR OF 300 FT.	4 MINIMUM COVERAGE OF PEAKED SYSTEM FIELD ELEV.________FT.
Yorktwon FM (MHW)	MOCA 2500' 27 N. M.		

________ FT. MSL..OUTBOUND ALT.

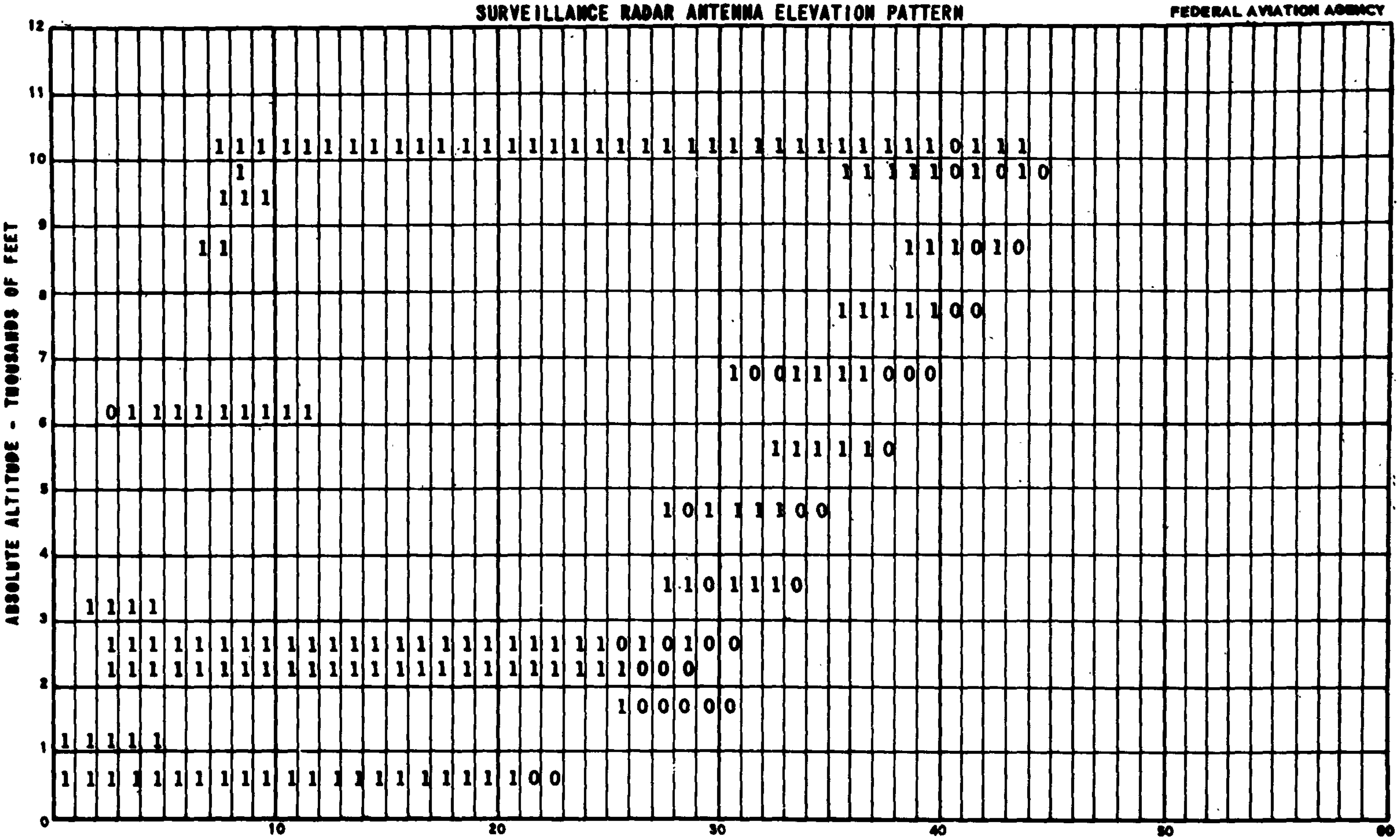
4500 ________ FT. MSL..INBOUND ALT. COLUMN 4 REQUIREMENTS MET ☐ YES ☐ NO

Hdq. 200° 4500' Over Fix 29 Mi ORF - 44333 - 33333 - 34433 - 23344 - 25 Mi ORF

GPO 904281 Form FAA-496.37 (3-58)

FEDERAL AVIATION AGENCY

SURVEILLANCE RADAR ANTENNA ELEVATION PATTERN



MTI Gate 17 Mi. Ant. C/P

INSTALLATION Norfolk, Va. ASR 2/4	AIRCRAFT (Type and No.) DC-3 N-40	SCALE OF SIGNALS	EXAMPLE:	PILOT(S) Whitehurst, Gowin
REGION NO. EA	BEAM ELEVATION +3.0 Degrees	0 - NOT USUABLE	HEAD-ON VALUE	
DATE 5/1/68	SYSTEM PERFORMANCE DB.	1 - USUABLE	TAIL-ON VALUE	TECHNICIAN Morris
WEATHER VFR	AFC: ON OFF STC: ON OFF			OPERATOR Jennings, West
HEADINGS FLOWN 235° - 055°	FTC: ON OFF MTI: ON OFF			

GPO 904898 Form FAA-406.31 (9-56)

COPY

Chief, SMDO-12, Richmond, Virginia DATE: May 4, 1962

Chief, SMS-53, Norfolk, Virginia

Special Flight Check Report, Norfolk, Virginia ARSR/FPS-8

A special flight check was conducted May 2, 1962 on the Norfolk, Virginia ARSR/FPS-8 radar system. The purpose of this check was to complete data needed by RD-309 for the Radar Quality Control Feasibility Experiment that was conducted at this station April 2 through May 2, 1962.

Participants in the flight checks were Messrs. Bankston and Gowin of the Aircraft Management Branch; Messrs. West, O'Berry and Merritt of Norfolk ATC and Mr. Morris of Norfolk SMS-53.

The ARSR/FPS-8 radar system was determined by performance checks to be operating normally.

I. Flight Check:

A. Vertical Coverage

Vertical coverage was flown, using C/P for the entire check. Three and ten thousand feet altitudes were flown all the way, while the other altitudes were only fringed. One and two thousand were not flown due to weather and traffic. (See attached 496.31 Form).

II. Conclusion:

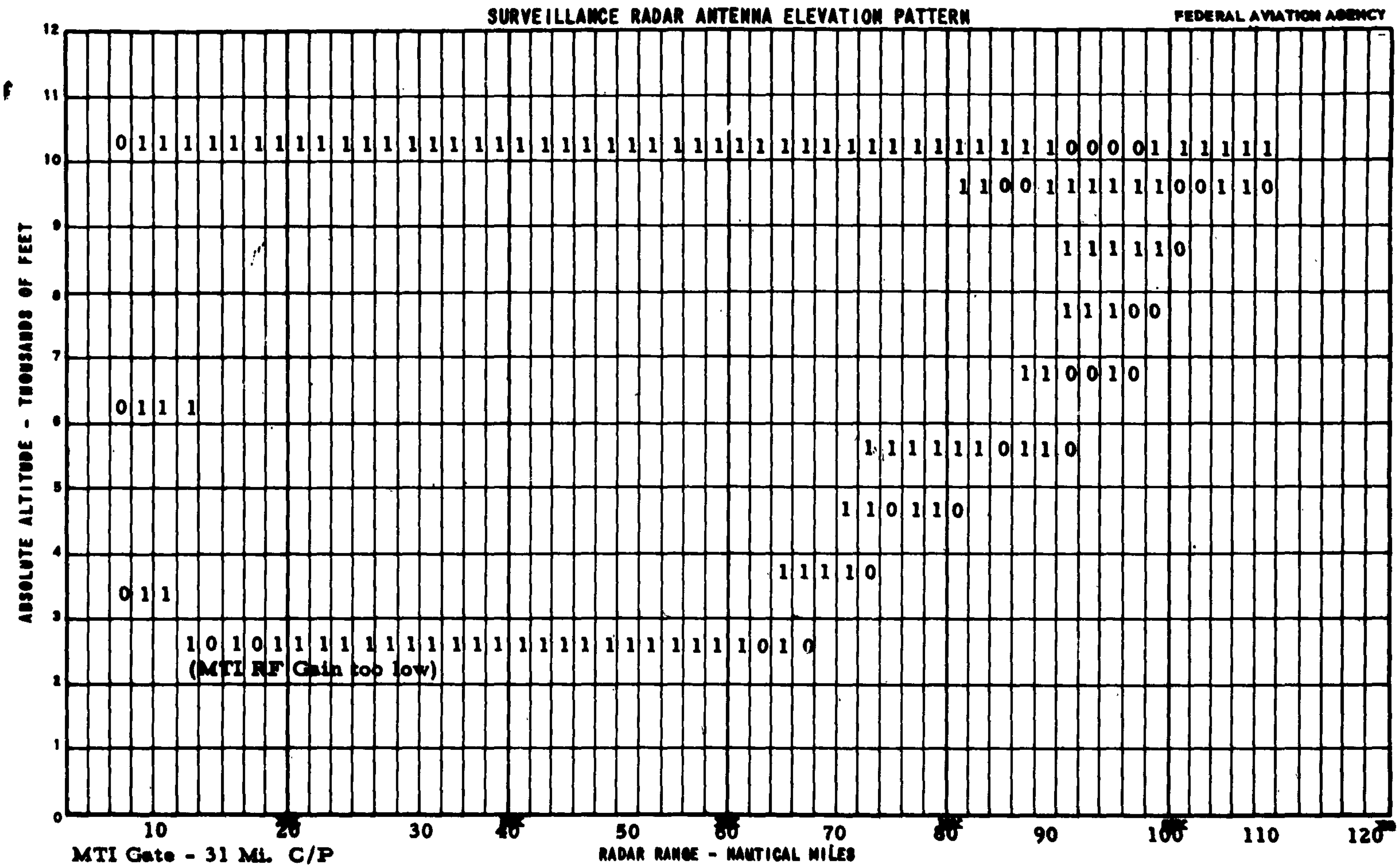
The vertical coverage data compared favorably with the commissioning check.

Weather conditions throughout the checks were 300 to 500 feet ceiling with fog.

/s/ R. S. Smith

Attachment

SLMorris/mb



MTI Gate - 31 Mi. C/P

INSTALLATION Norfolk, Va.
REGION NO. EA
DATE 5/2/62
WEATHER VFR
HEADINGS FLOWN 235° - 055°
AIRCRAFT (Type and No.) DC-3 N-69
BEAM ELEVATION + 3.0
SYSTEM PERFORMANCE 107 MTI DB.
APC: ON
STC: ON
FRC: OFF
MTI: ON

SCALE OF SIGNALS
0 - NOT USUABLE
1 - USUABLE

EXAMPLE:
HEAD-ON VALUE
TAIL-ON VALUE

PILOT(S) Bankston-Gowin
TECHNICIAN Morris
Merritt

GPO 904288
Form FAA-496.31 (9-61)