Memorandum 6L-212
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Division 6 - Lincoln Laboratory
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SUBJECT: TEST PROGRAM FOR 1954 CAPE COD SYSTEM

To: Jay W. Forrester, Carl F. J. Overhage

From: Howard W. Boehmer, C. Robert Wieser

Date: 28 July 1955

I. STATUS OF THE TEST PROGRAM

In the letter from the SAGE Test Committee to J. W. Forrester, C. F. J. Overhage, H. W. Boehmer, C. R. Wieser, S. H. Dodd, Subject: Coordination Direction of 1954 Cape Cod System, 29 June 1955, the suggestion was made that planning, maintenance, operation and evaluation in the 1954 Cape Cod System be "coordinated or directed by a single centralized source." The Committee felt that lack of this centralized source has caused the over-all program to suffer.

During the past three weeks we have been reviewing the test program to determine whether this recommendation is sound and whether it would in fact bring about a solution to the problem.

We have found that the sources of trouble in the test program are:

1. The STC had not presented a completely formulated statement of test objectives.

2. The SAGE Test Committee had not presented a 1954 Cape Cod System test program with realistic schedules properly phased with the development program. The publication of 6M-5001 and supplements is a comprehensive listing with priorities assigned, of all the work items suggested by all the people represented in the SAGE Test Committee. While a list of this sort is needed to formulate a test program, the list itself should not be mistaken for a test program. The memorandum does not make clear whether it was intended to be a proposed test program or merely a first step in obtaining one.

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3. The planning which has been done to date has not taken into account the costs (in computer time, aircraft, manpower availability, etc.). The relative priority of this program with respect to the others being pursued by the Laboratory (SAGE equipment development, SAGE master program production, etc.) has not been established.

4. Some of the equipment and parts of the program are under development or need repairs.

5. The SAGE Test Committee confuses its planning and advisory function with the executive functions which properly belong within the executing groups (i.e., the STC cannot establish priorities on equipment use within the Laboratory nor can it schedule the execution as stated on Page 3 of 6M-3476). The methods and procedures necessary to the coordination for the execution of the program had not been worked out and manned.

II. RECOMMENDED SOLUTION

It is our feeling that the suggested solution to the problem (i.e., the establishment of a completely separate SAGE test group) will not eliminate the difficulties which motivated the memorandum of 29 June 1955 and further, the elimination of those difficulties can best be done within the present group structure. The test program now proposed is aimed primarily at obtaining information for development and should be run by the people responsible for development. System evaluation designed to establish the over-all effectiveness of a SAGE type system should be accomplished as soon as possible. However, these studies should not interfere with the development necessary to insure the best possible performance in the first subsectors.

1. Objectives

The principal objective of the test program is to support the development of SAGE equipment and programs by performing tests to determine areas of weakness, to isolate their causes, and to indicate how they can be corrected.

The objectives of the test program are bounded by the availability of aircraft, computer time, and radar site time. Since the number of people now on the program are less than the equipment can support, it is limited by manpower. We recommend that the manpower be increased to insure that we get the maximum use from the equipment.

To this end we have defined a recommended test program for the 1954 Cape Cod System. The tests cover the period up to 1 April 1956 which is the beginning of the shakedown period for the SAGE master program on XD-1. The tests have been limited to conform with aircraft and ground equipment availability. The additional manpower needed has been estimated as 21 staff members for all phases, including equipment development.

2. Completion of the Cape Cod System

The need for further development after equipment is first put into experimental operation must be recognized and adequate manpower must be provided to make the equipment operational in a very short time. We have estimated that 10 additional staff members are needed to insure that the field equipment performance is adequate for early system tests and still allow for the engineering necessary to bring the equipment up to standards adequate for SAGE. The FGD field engineering is expected to have progressed sufficiently to enable the test program to start 15 August 1955. Specifications for operational performances are needed, and will be derived from measurements by 15 August 1955.

The computer program for the Cape Cod System has been found to have errors in two parts, the automatic initiation subprogram and the detection of aircraft formation splits for track monitors. These portions of the program have been investigated during July, and corrections are scheduled to be completed by 1 August.

3. Effective Testing

An effective test effort must meet the objectives sited above and must consist of a planned set of tests which have been examined to see that they fit the SAGE time schedules and the resources available (aircraft availability, computer availability, and manpower in the test sections of Groups 22, 38 and 61). A recommended program (included in this memo) has been worked out but not yet concurred upon by the Bell Telephone Laboratories.

The SAGE Test Committee should continue to carry out the planning function of integrating proposed work items into a single test program. The program should be re-examined monthly by the Committee to note progress and introduce any changes indicated by the results obtained. However, it is recommended that the Committee confine its activities to planning and concurrence and that the responsibility for execution of tests rest fully with the operating groups. This means that the Committee cannot consider

any test program as final until the operating groups have agreed that execution of the program is feasible with available resources.

The SAGE Test Committee should have a full-time secretary to gather suggested test work items, to prepare an agenda for each meeting, and to prepare and distribute minutes.

The Test and Analysis Sections of Groups 22 and 61 do not at present have adequate manning to keep up with the test program now being recommended. Adequate staffing requires addition of an estimated 5 staff for Group 22 and 6 for Group 61.

In addition, better administrative procedures are needed to raise the efficiency of executing tests. The SAGE Test Office should be reoriented to perform its proper function of serving the executors (rather than the planners) of the tests. Renamed the Test Coordination Office, it should convert the test plans approved by the SAGE Test Committee into scheduled tests, keep itself informed of the status of all system elements, make all arrangements for scheduling each test, collect significant data from all observers, keep central files of test results (both successes and failures) and summarize these on a monthly basis for Groups 22, 38, and 61 and for the SAGE Test Committee. The Test Coordination Office requires staffing from Groups 22, 61, and 64 and Bell Telephone Laboratories men already engaged in these activities, and it needs one operational staff member to devote full time to managing the Test Coordination Office.

The acceptance of this (or any other) test program requires a decision about its value relative to other Lincoln work. The program recommended is, we believe, valuable enough to justify the manpower it needs. Some of the manpower is needed for Cape Cod equipment development, and this same equipment will be a part of the Experimental SAGE Subsector.

Implementation of the recommended program requires the following additional staff:

Group 22	Analysis and Evaluation Section	5
Group 61	Test and Analysis Section (including Test Coordination Office)	7
	Total additional staff for Testing & Analysis	12

To develop the Cape Cod field equipment to the point where it is adequate for testing and for introduction into the Experimental SAGE Subsector the following additional staff are needed:

Field Equipment and System Development Radar Problems	4
Data Transmission Problems	6
Total	10

Immediate improvements are needed, and all these people should be transferred from other jobs as discussed in more detail below.

III. RECOMMENDED PROCEDURES AND AREAS OF RESPONSIBILITY

1. Functions

To test a working system the size of the Cape Cod System or the Experimental SAGE Subsector, the plan for execution must be divided into its component functions, and responsibility for each must be understood and accepted by each responsible agency. Each agency must have the resources to fultill its responsibilities.

The test program has lacked a clear-cut breakdown of the job, particularly for the execution of the tests. Also, since the responsible agencies did not have an accurate knowledge of what was expected of them, they did not have a good estimate of the manpower they needed.

A recommended assignment of responsibilities for component functions in carrying out the test program is listed below in Table I.

TABLE I

FUNCTIONS	RESPONSIBLE ORGANIZATION
Long-Range Planning	
1. Formulation of objectives (for not less than 6 months)	STC
2. Proposals for work items to meet these objectives	Groups 61, 22, 38, 311, and BTL Test & Evaluation Staff Members
3. Initial selection of work items	STC
4. Conversion of work items into test specs	Groups 61, 22, 38, 311, and BTL Test & Evaluation Staff Members
5. Schedule all work items for not less than 6-month periods, check against available resources (computer time, site time, personnel, etc.)	TCO and Group Leaders responsible for equipment, people, programs necessary for the execution
6. Negotiation of acceptable test program	STC and Group Leaders responsible for equipment, people and programs necessary to the execution
7. Approval of the test program and its required resources	Lincoln Steering Committee

TABLE I

FUNCTIONS	RESPONSIBLE ORGANIZATION
Short-Range Planning	
8. Conversion of test specs to mission specs	TCO and staff who produced the test specifications
9. Weekly scheduling of missions	TCO
10. Arranging for each mission, a/c, equipment, personnel, programs, Flight Test Director Notification	TCO
11. Integration of aircraft requirements with other Lincoln requirements	Lincoln Lab Flight Test Coordinator
12. Modification of schedules as dictated by troubles (weather, a/c, equipment, programs, etc.)	TCO and Lincoln Lab Flight Test Coordinator
Execution	
13. Conduct of mission	FTD (Flight Test Director)
14. Observation, gathering test data	FTD, staff members who designated tests, also STC for system tests
15. Gathering equipment performance data	Maintenance Coordinator (Group 64)
16. Compiling data, issuing mission report	TCO

TABLE I

FUNCTIONS	RESPONSIBLE ORGANIZATIONS
17. Posting schedules, summary of test results monthly, summary of failures monthly	TCO
Feedback	
18. Evaluation of results and failures (review program, look for modifications needed in over-all test program)	STC and Group Leaders responsible for the execution
Test Results	
19. Analyze and evaluate test results, recommend action to be taken, issue reports	BTL, Groups 22, 38, 61 staff members
Action from Testing	
20. Revise SAGE master program in accordance with test results	Group 61
21. Revise equipment in SAGE in accordance with test results	Groups 64, 62, 22, 24
22. Revise programs and equipment in the Cape Cod System because of test results	STC, Groups 64, 22, 61

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2. Formulation of Objectives

The objectives of the SAGE test program had not been clearly defined. Each member of the Committee, we found, had a different picture of what the objectives were. It appears that the objective was to perform all tests that were requested by the committee members in 6M-5001. The major criticism of this comprehensive program was that a definite time schedule for its accomplishment was not spelled out, even though relative priorities of different parts of it were indicated. Without this clarification the impression could be obtained that the whole of the program was intended to be completed by the time ESS became operational even though a large part of the test program was intended to be of a long-term nature running concurrently with ESS. The SAGE Test Committee was hampered in its formulation of objectives by the lack of enough information about the execution capability of the combined group effort. In order to formulate a 1954 Cape Cod test program of a definite duration, commensurate with our capabilities, we are recommending the following objectives for the first 9 months of the test program.

Objectives

The objective of the 1954 Cape Cod Test Program is to support the SAGE System by investigating and evaluating the weaknesses of a SAGE type System so that the initial computer programs, equipment, and operational doctrine for the first subsector are as effective as possible in the fulfillment of their air defense mission.

Areas of weaknesses in the Cape Cod System have already been detected during system operation in 1953 and 1954. It is evident that the primary weaknesses have been:

1) Deficiencies of the radar data received at the computer (poor orientation, inaccuracy of data, and inadequate rejection non-aircraft returns);

2) Deficiencies in the air surveillance function (initiation, automatic tracking, track trouble detection, and monitoring);

3) Questionable performance of the intercept direction team under saturation conditions (aircraft limitations with F-89C interceptors have previously prevented adequate evaluation).

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The problem areas listed above were primarily responsible for the unsatisfactory interceptions encountered during past operation (omitting aircraft failures and weather difficulties). Other weaknesses may exist, but they could easily be masked by data and tracking deficiencies. The complete system should be operated to determine system performance and to search for other possible weaknesses after the data and tracking have been improved.

The testing and evaluation will result in:

1) Correction of errors of execution (or unsatisfactory adjustment of parameters) in the 1954 Cape Cod System; i.e., if the equipment, program, or doctrines are found not to be operating as designed, the trouble will be diagnosed and corrected;

2) Obtaining information needed for further research and development; i.e., if the design criteria of the 1954 System are found inadequate, the effect will be measured and the trouble diagnosed. Correction will be made in the SAGE master program and Experimental Subsector equipment. Whether or not these basic changes in design or concept are introduced into the 1954 System will be decided individually in each case by Boehmer and Wieser after consulting the SAGE Test Committee;

3) The Bell Telephone Laboratories will use this information to fulfill, in part, their responsibility (under the ADES contract) for assisting the Air Force to evaluate SAGE performance as an air defense system.

It should be noted that this statement of objectives emphasizes the support of the SAGE equipment and program development, and concentrates on finding and diagnosing the system weakness which limitsover-all performance.

3. Proposal for Work Items

Items which become a part of the test program are prepared by members of the contributing groups. For the most part, the results of each test item would be of value to the group which proposed it, and it would contribute to an improvement in equipment, program, or operator training procedures with which the particular group is concerned. In the main,

these are tests which the participating groups would have desired even if the SAGE Test Committee did not exist. To date this process has resulted in 6M-5001, which is a comprehensive list of all work items which the contributing groups felt were of value to the SAGE program.

4. Initial Selection of the Work Items

The SAGE Test Committee reviews the work items and assigns priorities to these items on the basis of the combined committee opinion. Since the work items proposed are in general items which the participating groups would have proposed for themselves even if there were no SAGE Test Committee, the major function of the committee is to:

1) Eliminate redundancies.

2) Act as a meeting ground between groups whose tests require the participation of the other groups represented in the Committee and which the concurrence on the joint use of equipment, programs, and operating personnel can be made.

3) Help to establish priorities among the work items.

The lack of a clearly defined set of objectives, and incomplete information on execution capability has made it difficult for the SAGE Test Committee to select a set of work items which define a test program with a specified end date. The SAGE Test Committee has depended upon the SAGE test office, which is inadequately manned, for data on the cost of executing tests. One of the difficulties with the present statement of the STC responsibilities is that it has been given executive responsibility (i.e., it assigns sections to execute work items, and it integrates schedules, and the SAGE test office reports to it). There should be a clear distinction made between its advisory and concurrence functions and the executing responsibilities of the contributing groups.

It is our opinion that if this committee works within the framework of clear objectives, and if it is supplied accurate estimates of execution capability, that it can make a good selection of work items.

5. Conversion of Work Items into Test Specs

The conversion of work items into test specifications is done by the participating groups after the STC has arranged the items according to priority. The test specifications include what the test is to accomplish, how the test is to be executed, and the cost of the item in terms of aircraft, computer, site, programming requirements. This cost data is used

in the preparation of long-range schedules.

6. Scheduling Work Items For Not Less Than Six-Month Periods Checking Against Available Resources

To date, a 1954 Cape Cod test program has not existed in the form of a time schedule geared to our expansion capability. One of the major reasons for this is that we have not set up an organization to gather all the necessary information, prepare schedules, and the participating groups in estimating costs, and bring the difficulties it uncovers to the attention of the group leaders responsible for the execution. The SAGE Test Office was supposed to perform a function like this, but it was to report difficulties to the SAGE Test Committee. This is unsound, because this function is part of the execution and the SAGE Test Committee is not responsible for execution. What is more important, it cannot be responsible for executing because each of the members has separate responsibility and spends only a fraction of his time on STC work. Because of the need for establishing the 1954 Cape Cod test program, a definite schedule geared to the execution capability, a schedule of events for the next nine months has been established. To insure that subsequent sections of the test program or modifications (to previously scheduled sections) are scheduled, we are proposing to establish a Test Coordination Office (TCO), which, in addition to other duties, supports the execution of the test program by:

1) Gathering together all data on proposed tests and data on execution capabilities;

2) Integrating these tests in a time schedule;

3) Bringing the problem area to the attention of the responsible group leaders for action;

4) After the resolution of the problems, preparing detailed schedules which will be presented to the SAGE Test Committee for negotiation and acceptance by them (acceptance by a group may mean that it will have to shift its manpower around, place more emphasis on equipment development, etc.).

In the absence of this office, staff members of Groups 22 and 61 have drawn up a test program for the 1954 Cape Cod System through 1 April 1956. (The recommended program is Section IV of this memorandum.)

7. Negotiation of an Acceptable Test Program

The test program for not less than a six-month period with its costs should be approved by the STC and all of the groups involved in the execution, with each group taking into account its own resources and internal priorities.

8. Approval of the Test Program and its Required Resources

The test program which is negotiated as above will be presented to the interested members of the Lincoln Steering Committee.

9. Short-Range Planning

The short-range planning (adjustment of long-term schedules for weather, aircraft availability, etc.) has suffered because the SAGE Test Office was not adequately manned. This function has been performed by members of the executing groups. In the future, it is expected that the functions of conversion of test specifications into mission specifications, weekly schedule of missions, arrangements for missions, and modification of missions will be performed by an adequately-manned Test Coordination Office as explained in the next 4 sections.

10. Conversion of the Test Specifications into Mission Specifications

Mission specifications include aircraft requirements, equipment requirements, manning requirements, data recording requirements, flight plans, and computer program requirements. (These are not tied to a specific mission date and hour.) In the past this function has been performed by the Flight Test Director because there has not been an adequately staffed SAGE Test Office. Now we propose that this function be performed by the Test Coordination Office, which reports to the responsible group leaders.

11. Weekly Scheduling of Missions

Weekly scheduling of missions is the process of putting scheduled dates and hours on the resource requirements in the mission specifications. This work requires an accurate knowledge of availability and condition of the computer program, the equipment, and personnel required in the test execution.

12. Arrangement for Each Mission

For each of the system components called for on the weekly schedule, arrangements have to be made with the group supplying the component (or service). For the aircraft

requirements, the Test Coordination Office will prepare a schedule and negotiate it with the Lincoln Flight Test Coordinator's Office. For the equipment and personnel, it will contact Groups 22, 61, 64, and 311.

13. Modification of Schedules as Indicated by Trouble

In the process of executing the tests, troubles which arise because of weather, aircraft and equipment availability, or program trouble may require changes in schedules. It will be the responsibility of the TCO to schedule substitute missions which can be conducted if the aircraft or radar data become unavailable on short notice.

14. The Conduct of the Missions

The mission will be conducted by a Flight Test Director. This part of the job is done adequately now, and there is no need to change it, except to relieve the Flight Test Director of the task of arranging for the missions. (The TCO will make arrangements to set up the missions.) The Flight Test Director will coordinate test aircraft movements with the air-route traffic control center and the local GCI stations. He will offer any assistance possible in the event of an aircraft emergency.

15. Observation, Gathering Test Data

The staff member who designed the test will be responsible for gathering test data and forwarding significant data to the Test Coordination Office together with a statement of where all the raw data will be filed. The Flight Test Director will forward to the Test Coordination Office all data and comments on operational deficiencies found during the mission (operator manning, aircraft delays, program troubles, flight-plan violations, mission planning inadequacies, etc.). These will be filed by the Test Coordination Office and reviewed at least monthly to improve procedures for the arrangement and conduct of missions. The STC will observe all over-all system tests to gain a first-hand knowledge of system limitations.

16. Gathering Equipment Performance Data

The Maintenance Coordinator sees that equipment troubles are localized and corrected as rapidly as possible and that adequate equipment records are kept for analysis of system operation. A copy of the data gathered during each mission will be forwarded to the Test Coordination Office.

Monthly summaries of progress and of mission troubles classified according to cause will be prepared monthly for the

STC and the participating group leaders.

17. Compiling Data, Mission Report

The Test Coordination Office will compile all the data it receives for each mission, summarize the data, and prepare a report on each mission. The report will indicate the degree of success of the mission and state the causes of failure, whether total or partial.

18. Evaluation of Results and Failures

The SAGE Test Committee and the group leaders responsible for execution will review at least once per month the long- and short-range plans of the test program, and if necessary propose and initiate modifications to it.

19. Test Program Monitoring

The test results will be analyzed and evaluated by the groups responsible for the tests. Actions which might result in modification to the SAGE master program and SAGE equipment will be recommended to the groups responsible for these modifications, and reports on each test item will be issued by the individual groups.

IV. RECOMMENDED TEST PROGRAM

Previously there has been no complete test program with 1) a clearly stated objective; 2) a scheduled end date for accomplishing a stated series of tests; and 3) a statement of the resources needed to accomplish the program. A recommended test program is outlined here. We have judged the test effort to be valuable enough to justify adding enough manpower so that the progress of the program is limited by the availability of radar data and aircraft for live tests and the availability of the direction center for tests which need only synthetic data.

The series of tests selected is based on past observation of Cape Cod System performance, and its specific weaknesses. System tests (with live interceptions) will be conducted periodically to check for a required change in emphasis of the remaining tests. The SAGE Test Committee will observe these tests and recommend changes in the remainder of the test program. Changes will be made (provided that they fit within our capacity to execute them).

The test program proposed here provides:

1. Data on system operation for checking and rechecking the selection of critical components for detailed tests and for evaluating qualitatively over-all system performance.

2. Data obtained under non-saturation conditions for evaluation and improvement of critical components in the system. For the most part the data will be obtained from accuracy tests of the components which perform the air surveillance function.

3. Data obtained under saturation conditions to evaluate the two stations most sensitive to saturation in the Cape Cod System, the track monitor station and the intercept direction station.

The recommended test program is outlined below. The cost of each test series in aircraft time, direction center time, WWI and MTC computer time, and manpower is summarized in Table 2. The test items are summarized briefly as follows.

1. System Operation Test (SOT)

A series of system operations tests has been scheduled for the 1954 CCS. These tests will, in general, require data from all radars, will require all consoles in the direction center to be manned, and will require live aircraft interceptions to be performed. The object of the systems operation test is to allow the SAGE Test Committee and test planning personnel to monitor the system

performance under realistic, complete, operating conditions (as contrasted with the conditions of function testing).

It is expected that both quantitative and qualitative data will be obtained during the systems operation tests. This data, in turn, will be used as 1) an indication of the proper emphasis that should go into remainder of the test program and 2) as data for evaluation of over-all system performance.

2. Interception Tests (IS), Reference 6M-5014, 6M-5028

The interception tests are broken down into seven different series. Some of these are with synthetic data only, and some are with live interceptors. The principal objective of the various tests is to obtain a measure of the accuracy with which an interceptor can be guided to an interception point by the 1954 CCS. These tests will investigate both the collision course interceptions and off-set point final-turn interceptions. An attempt will be made to determine the advantages or disadvantages of the final-turn type maneuver over the collision course attack and to arrive at optimum parameters for both types of attack.

After some familiarity with conducting these interceptions has been attained, we will begin tests to determine the maximum number of interceptors that can be handled simultaneously by a given intercept director. These tests will be made both with data link and with voice control.

The results of these tests are needed to confirm the proposed SAGE interception doctrine and saturation capacities. Deficiencies, if found, must be diagnosed so that the SAGE procedures, master program, and equipment can be improved.

3. Tracking Accuracy Tests (TA), Reference to Memorandum 6M-5011, 6M-5012, 6M-5013, 6M-5030

A series of six tracking accuracy tests have been outlined so as to give measurements on the ability of the 1954 CCS to track. Essentially, this test is aimed at determining the accuracy with which the computer is able to follow a given single aircraft. In general, the flights will be made in areas that are relatively free from non-aircraft

returns, and hence, will give an indication of the tracking accuracy in the absence of the need for monitors. A test will be made in the tracking of interceptors to evaluate the improvement in tracking afforded by the command tracking technique as compared with normal tracking. The data obtained from the tracking accuracy tests is expected to be of use, not only in evaluating system performance, but in indicating the areas where improvement in correlation and smoothing techniques is required in the SAGE master program.

4. Trouble Detection and Monitoring Tests (TDM), Reference to Memorandum 6M-5006

The initial series of track monitoring tests is aimed at obtaining a measurement of the improvement in tracking brought about through monitor action. Three modes of operation will be used. First, we will track without any human intervention. Second, we will do normal tracking with the 1954 CCS. Third, we shall do normal tracking with continuous monitoring. These tests are essentially measurements of performance on single aircraft tracks and will indicate the value of the monitor and of the format of information being presented to the monitor.

A second series of tests is being designed to test monitor action under more complicated conditions. These include crossing aircraft tracks, multiple radars, and saturation tests. These tests will tell us how large a load a monitor can carry and how his performance varies with load.

This information is needed to check the trouble detection logic, which is basically the same for SAGE, and to check the assumptions on monitor capacity used in designing the AN/FSQ-7. If the logic or capacity are inadequate, they must be corrected for SAGE, or system capacity will be reduced.

5. Initiation Tests (IN), Reference to Memorandum 6M-5008, 6M-5009, 6M-3274

The major objective of the initiation test is to measure the performance (delay in initiating true tracks and prevention of false tracks) of the manual and automatic modes of initiation in the 1954 CCS. A concurrent analysis will be directed toward

establishing standards for judging initiation performance, projected improved initiation methods, and specifying the criteria for use of these methods in SAGE.

As a part of the study of initiation techniques, the results of these tests will be correlated with other results derived by theoretical methods. It is expected that, not only will the present initiation scheme be tested, but if time permits, tests will be made to compare the present logic with that derived from theoretical considerations.

Automatic initiation in the 1953 system worked poorly (excessive false tracks). Theoretical studies have pointed the way to improved program logic, which has been introduced but not tested in the 1954 system. The present logic needs to be carefully evaluated to justify its use in the SAGE system, where adequate automatic initiation performance is mandatory.

6. Data Studies (DS) References Memoranda 6M-5015, 6M-5016, 6M-5017

A study of radar data inputs of the computer will be made to establish sufficient mathematical models to describe these inputs. From the computer point of view, there are only two kinds of radar data: aircraft returns and non-aircraft returns. Consequently, two mathematical models are required. The first will describe the returns which come from aircraft. The primary work in this area is being done by Group 22 (Item 12 below) but specific applications to the study of system performance are being done by Group 61. The characteristics of importance are the accuracy of the return, the occurrence of multiple prints, and the statistics of the hit and miss sequence (blip scan). For non-aircraft returns we are interested in the spacial density of the returns after mapping and in the correlation of the radar pattern from scan to scan.

There are two specific needs for this type of data. The first and most obvious need arises from the need for designing improved correlation and smoothing techniques. In order to do this, on any other than a trial and error method, an accurate description of the data inputs is required. Second, the best way of obtaining large quantities of data on system performance without having to actually run the system is by methods of simulation. However, in order to put real faith in simulation results, one must be certain that the data inputs have been properly described.

Also, a method of generating realistic synthetic data is needed to aid in the checkout and test of SAGE master programs and as an operator training aid.

7. Radar Mapping Tests (RM) Reference Memorandum 6M-5020.

Radar mapping tests are designed to obtain a measure of the effect upon the Cape Cod System performance of the radar mapping (both gap fillers and heavy radars). Measurements will be taken to obtain percentage of area lost due to mapping, percentage of non-aircraft returns rejected due to mapping, and the percentage of total returns rejected due to mapping. These tests will be conducted first with SDV type data and later

with the fine-grain data system.

Along with the test observations, experiments and studies will be made to determine optimum methods for mapping. This study should result in a set of rules applicable in the SAGE System, compatible with human mapper capabilities, which afford a minimum of non-aircraft returns entering the computer, with a minimum loss of aircraft returns.

8. Manned Interceptor Simulation Program (MISP) Reference Memorandum 6M-5001, Section 2.81

The MISP is a general purpose test program for the Memory Test Computer. It simulates one interceptor-bomber pair with realistic blip-scan ratio characteristics, realistic data accuracy characteristics, and realistic non-aircraft returns (obtained from the Data Studies, Item 6 above). This program will be used to gather statistical data rapidly which describes the dependence of interceptor kill probability on system parameters (radar data accuracy, scan rate, noise, constants selected in the tracking equations, interception tactics, interceptor performance, etc.).

The program will be used to investigate some of the special requirements imposed by supersonic aircraft, such as the slow-down experienced during a tight maneuver. The results obtained from MISP will be compared with and used to augment the results of the live-test program on the 1954 Cape Cod System.

The MISP is the only means now at our disposal for studying performance of the SAGE System with the weapons which will be operational in the 1957-1958 time period (F-102A and F-102B).

9. Utility Program (UP) Reference Memorandum 6M-5019

After having data from all the various tests, it is necessary that they be further processed by computer programs. A list of some of the programs needed is:

1. Tape read-in subroutine.
2. Operations summary print-out.
3. Track log print-out.
4. Detailed single track history print-out.

5. Track position photographic program.
6. Magnetic tape reproduction program.
7. Active track summary.
8. Synthetic data photo program.

These programs are important because they increase the efficiency of execution of other tests.

10. Search and Height Radar System Performance - Coverage (CM)

These tests are designed to measure the coverage of the various types of search and height finder radars in the Cape Cod System. The objective is to measure the effective coverage of the combination of the radar and its associated encoding equipment. The coverage performance is specified in terms of a minimum blip-scan ratio for a given type of target within given boundaries of range and elevation. A sufficient number of tests are made on each type of aircraft so that fairly close limits can be specified on the expected average radar performance at different altitudes for each type of aircraft.

These coverage measurements are fundamental not only to the evaluation of a radar system but also serve to establish the tolerances on the data inputs with which the computer data processing system must work.

The immediate usefulness to the SAGE System of this series of tests of this study is:

1) to determine the effective coverage and check the choice of radar spacings now planned in the SAGE System by determining the effective coverage available;

2) to check the choice of overlapped sites;

3) to derive rules and constants for coverage masking for the SAGE master program;

4) to furnish part of the data needed to verify the input data capacity figure used in the AN/FSQ-7 design;

5) to aid in establishing the specifications for SAGE radars.

11. Search and Height Radar System Performance - Accuracy (AM)

The tests in this category will concentrate on measurements of the accuracy and precision of the radar data (including Mark X) and the orientation of the radar network. After orientation of the radar network is accomplished by the established method, flight tests are carried out and the positional data as determined by the radar and encoding system are compared with a reference position as determined by Raydist equipment. Of particular interest will be the determination of the stability of the orientation of the radars.

A study of the accuracy and precision of the height data from an FPS-6 height finder radar will be made together with a study of the accuracy and precision of the orientation and positional (range and azimuth) data.

These tests will establish the accuracy, precision, and stability of the radar data which the SAGE system will be expected to process.

The usefulness of the results of these tests to the SAGE System will be

1) selection of tracking parameters for the SAGE master program.

2) to determine the adequacy of orientation methods.

These tests use the same aircraft flights as are used in the tracking accuracy tests described above.

3) used in establishing the specifications for SAGE radars.

12. Systemization of Performance Measurements - Mathematical and Physical Models (SPS)

These studies attempt to provide information in order to better systematize our measurements of the various factors which affect system performance. The blip-scan ratio determinations for different aircraft types at the different radars must be combined with the computer data requirements to yield effective overall-system coverage for adequate automatic initiation, tracking, etc. Statistical studies of track data are needed to provide an adequate description, both for the purpose of better understanding radar performance and also to allow a more systematic optimization of signal detection equipment and the logic of computer initiation and tracking programs.

These studies also serve as a basis for describing correct data input models for the simulation studies that are the basis of both direction center training and computer program development.

These studies lead to

1) a better understanding of the data which comes out of radars and data transmission equipment in SAGE;

2) optimization of the mode of radar operation (beam combinations, MTI, STC, antenna tilt, etc.)

13. Evaluation of Radar Data Quality (DQS)

These studies are based on monitoring of the data output of the radar (and data transmission equipment) system both towards the end of obtaining knowledge of its characteristics and developing methods for its control. Radar data in an air defense radar system consists of signals corresponding to actual aircraft and those that are unrelated to aircraft. An assessment of the rate of unwanted signals; i.e., those due to equipment generated noise, ground, sea, precipitation clutter, is essential to an evaluation of system effectiveness for at least two reasons-- the obscuring of targets in regions filled with clutter and the overloading of the computer with an excessive data rate. The average degradation resulting from these factors and their variability will be evaluated in the '54 Cape Cod System.

The results of these studies are needed to determine how much radar overlap is beneficial when noise as well as wanted signals are taken into account. In addition, an evaluation of radar performance is necessary in the preparation of SAGE radar performance specifications. This study extends the results to the search and height finding coverage tests to provide an evaluation of the effective coverage remaining under clutter conditions.

14. Study and Evaluation of Clutter Control Techniques (CCS)

The techniques available in the Cape Cod System for rejection of clutter will be evaluated, principally MTI for ground clutter and circular polarization for precipitation clutter. This investigation necessarily includes measurement of the cancellation achieved and of the sub-clutter visibility attained. In addition, observed intensities of clutter will be analyzed to determine if S.T.C. (Sensitivity Time Control) of some form offers any promise. The analysis of these factors will be extended to their effects in a multi-radar system with radar overlap.

The results of these studies will point out the optimum utilization of the presently available devices or techniques and the need for consideration of retrofit modifications in SAGE radars.

15. Supporting Theoretical and Experimental Investigations

The system analysis and evaluation outlined above will require supporting studies of more fundamental or detailed nature. The accuracy measurements on FCD seriously tax the measuring technique used for its evaluation. The basic limitations of the Raydist technique must be checked both as to the experimental procedures and as to the mathematical solutions of the equations in hyperboloidal coordinates and the computer programs used. More general studies are needed to evaluate the system limitations on radar scan rate and the parameters affecting multiple print occurrence. The stability of the false print rate should be investigated and its optimum level determined as a function of other parameters of the system. Additional statistical studies are needed for an adequate representation of track data characteristics such as further considerations of the effects of lobing and scintillation on signal runs.

RESOURCE REQUIREMENTS

The several activities outlined above have been scheduled both with regard to the manpower requirements and to the equipment requirements. In describing these schedules the following abbreviations are used:

SOT - System Operation Test

IS - Interception Tests (this consists of seven series of tests - IS1 through IS7. IS3 through IS6 require live aircraft).

TA - Tracking Accuracy Tests

ABN - Accuracy B-29 Non-Maneuvering

ABM - Accuracy B-29 Maneuvering

AIN - Accuracy Interceptor Non-Maneuvering

AIM - Accuracy Interceptor Maneuvering

AJN - Accuracy B-47 Non-Maneuvering

AJM - Accuracy B-47 Maneuvering

TDM - Trouble Detection and Monitoring Tests

IN - Initiation Tests

DS - Data Studies

RM - Radar Mapping Tests

MISP - Manned Interceptor Simulation Program

UP - Utility Programs

CM - Coverage Measurements (Search and Height Radar System Performance - Coverage)

AM - Accuracy Measurements (Search and Height Radar System Performance - Accuracy)

SPS - System Performance Studies (Systemization of Performance Measurements - Mathematical and Physical Models)

DQS - Data Quality Studies (Evaluation of Radar Quality)

CCT - Clutter Control Techniques (Study and Evaluation of)

SI - Supporting Investigations (Supporting Theoretical and Experimental Investigation)

Table II lists for each test or study:

1. The number of aircraft flight hours that have been scheduled. These are broken down into four categories: B-29, B-47, F-2H, and F-86 or F-94 type aircraft.

2. Whirlwind I computer hours - these are listed in two categories: those which involve the direction center and those which involve only the computer itself, that is, non-real time computations.

3. Memory Test Computer operation hours.

4. IBM 407 accounting machine hours.

5. South Truro radar operation hours - the hours in the chart indicate those required for each specific test. They do not, however, reflect the total length of time that the radar set must be operated. In order to allow for warm-up time for the radar set, equipment checkout and calibration, etc., it is assumed that South Truro will operate a minimum of four days a week from 7 A.M. until 4 P.M. and on Saturday from 7 A.M. until 12 noon.

6. Manpower Requirements

   A. Group 22 Staff

   B. Group 61 Test Staff

   C. Group 61 Programming Staff

   D. Group 61 Non-Staff

   E. BTL Staff aiding Group 61

   F. Group 38 Staff

The manpower assigned to each of these projects actually constitute only a part of the total being used on the 1954 CC Test Program. The remaining people are classified as overhead for the whole test program and very often only part time is spent on the test program. The overhead functions include supervisory personnel, test direction and coordination personnel, computer operators, secretaries, etc.

TABLE II

TEST	A/C FLIGHT HRS.				WWI HRS.		MTC	IBM 407	S.T.	GR.22 STAFF	GR. 61 MANPOWER REQD.			GR.38	BTL STAFF AIDING GR. 61
	B29	B47	F2H	F86 F94	D.C.	NON D.C.	HRS	HRS	HRS	REQD.	TEST STAFF	PROG.	NON STAFF	STAFF	
SOT	168	0	0	336	84	42	0	0	84	0	1	0	1/2	0	0
IS	0	0	312	384	232	200	0	0	232	0	2	1	1 1/2	1	0
TA	264	264	120	0	324	150	0	0	324	0	1	0	1/2	0	1
TDM	0	0	0	0	172	86	0	0	0	0	3	0	3/4	1	0
IN	216	0	0	0	108	108	0	0	108	0	2	0	3/4	0	0
DS	0	0	0	0	0	108	108	0	0	0	1	1	0	0	1
RM	0	0	0	0	85	35	0	0	85	0	0	0	0	1	0
MISP	0	0	0	0	0	0	900	0	0	0	2	2	1	0	0
UP	0	0	0	0	0	360	0	0	0	0	0	2	1	0	0
CM*	220	120	0	120	0	0	90	60	380	2	0	0	0	0	0
AM*	160	0	80	0	240	60	0	0	240	4	0	0	0	0	0
SPS*	40	0	0	80	0	0	180	0	60	2 1/2	0	0	0	0	0
DQS*	0	0	0	0	0	0	90	0	0	2	0	0	0	0	0
CCT*	0	20	0	80	0	0	0	0	0	2	0	0	0	0	0
SI*	80	0	0	120	0	20	0	0	60	1 1/2	0	0	0	0	0
TOT.	980	404	432	1020	1005	1169	1368	60	833	14	12	6	6	3	2

Those test items marked with an (*) are tests that can be run concurrently with other tests already scheduled. Hence, it is expected that Whirlwind Direction Center hours and South Truro operation hours will not be in addition to those scheduled for other tests. Similarly the aircraft flight hours for the accuracy measurements need not be added since this test will use the same aircraft as the Tracking Accuracy Tests.

Table III (7 pages) is a detailed schedule showing the time at which each test will be run. The schedule begins 1 August 1955 and extends until 1 April 1956. Although some tests are scheduled for the period 1 August through 15 August, these are for the purpose of orientation only, and 15 August is the starting date for this test program. Radar data will be required at the Direction Center four days per week (plus some Saturday mornings for training purposes). Monday of each week is set aside for radar installation and the last Monday in each month is set aside for computer installation. Consequently, the schedule contains only those tests on Monday which do not require live radar data. There is some time reserved in the schedule which does not correspond to any of the tests already discussed. These are considered as overhead and are not chargeable directly to the test program. These time allotments are taken up by:

1. Equipment Checkout (ECO)
2. Simulated Training Missions (ST)
3. Live Training Missions (LT)
4. ISl is Interception Series 1 which has been set aside to perform the dual role of providing a training mission as well as providing some general data on system performance for the test program.

The numbers at the bottom of the chart opposite the abbreviations for each test indicate the day on which each test is to be conducted.

The recommended test program fits within the limits of existing resources, except presently assigned manpower. The scheduled aircraft hours were derived by tripling the actual aircraft flight hours needed. The factor of three is based on past experience with cancellations caused by weather, aircraft troubles, equipment malfunction, etc., and is conservative. The requirement for Fine-Grain-Data from South Truro is based on having data available 35 hours per week, which requires scheduling the radar and data transmission equipment for 41 hours per week when warm-up and, checkout, and adjustment are added. This is about the maximum which can be obtained concurrent with field development work on the site equipment. The demands for time on the direction center and Whirlwind I are up to the maximum now available. The Memory Test Computer time does not exceed what is now available.

The manpower requirements exceed the staff manning now assigned as shown below:

	Group 22 Test & Analysis Section	Group 38	Group 61 Test & Analysis Section
Required manpower	14	3	18
Presently assigned	9	3	12
Additional Required	5	0	6

Group 38 manning is now adequate.

The six additional people required in Group 61 can be assigned from the additional staff recently hired and now being trained in computer programming. (The present Group 61 recruiting requirements have allowed for additional manning on the test program, so this does not change the requirements.)

There are a total of 13 staff members in the test and evaluation section of Group 22.

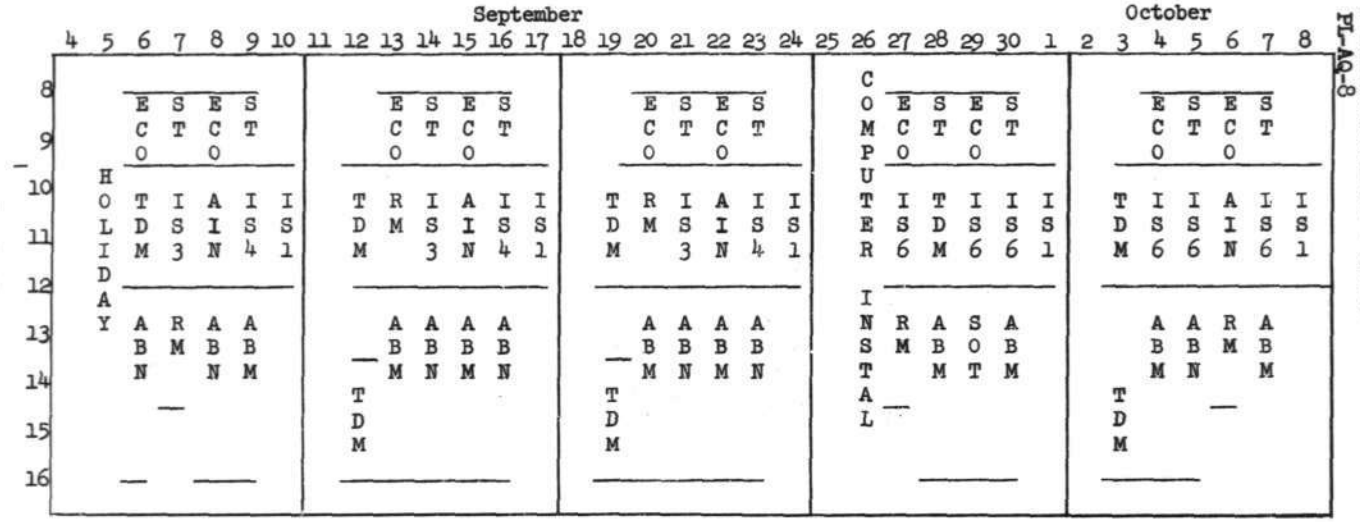
Four of the staff members have joined the Laboratory very recently and are still neither cleared nor completely oriented to the program. At the present time and in the foreseeable future, of the remaining staff, only an equivalent of 5 full-time staff members are available to the test program. The remaining 4 equivalent full-time staff are needed to fulfill continuing important other Group 22 responsibilities which logically should be assigned to members of the test and evaluation section.

It is estimated that 14 full-time and appropriately trained staff members are required for the Group 22 test and evaluation program. This staff must be provided from the 5 equivalent experienced full-time members of the section, the 4 new people now in the section, and by the addition of 5 new people to this program from outside sources. These new people should be experienced engineers or physicists and at least two of them should be familiar with radar problems.

TABLE IIIa

	July 31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	August 17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Sept. 1	2	3
		COMPUTER																																		
			EECC																																	
SOT																																			
ABN																																			
ABM																																			
AIN																																			
AIM																																			
AJN																																			
AJM																																			
IN																																			
IS3																																			
IS4																																			
IS5																																			
IS6																																			
TDM																																			
RM																																			

TABLE IIIb



	7	8			9	10			11	12					10				13			
ABN																						
ABM			3		4	5			6	7				8		9			10		11	
AIN		7				8				9										10		
AIM																						
AJN																						
AJM																						
IN																						
IS3		4			5				6													
IS4			4			5				6												
IS5																						
IS6													1		2	3			4	5		6
TDM	9				10/11				12/13					14					15/16			
RM		8				9				10			11							12		

CONFIDENTIAL

TABLE IIIc

October

	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
SOT								11															
ABM				12						13				14						15			
AIN																							
AIM																							
AJM																							
IN																							
IS3																							
IS4																							
IS5																							
IS6																							
TDM																							
RM																							

November

	1	2	3	4	5	6	7	8	9	10	11	12
SOT												
ABM												
AIN												
AIM												
AJM												
IN												
IS3												
IS4												
IS5												
IS6												
TDM												
RM												

TABLE IIId

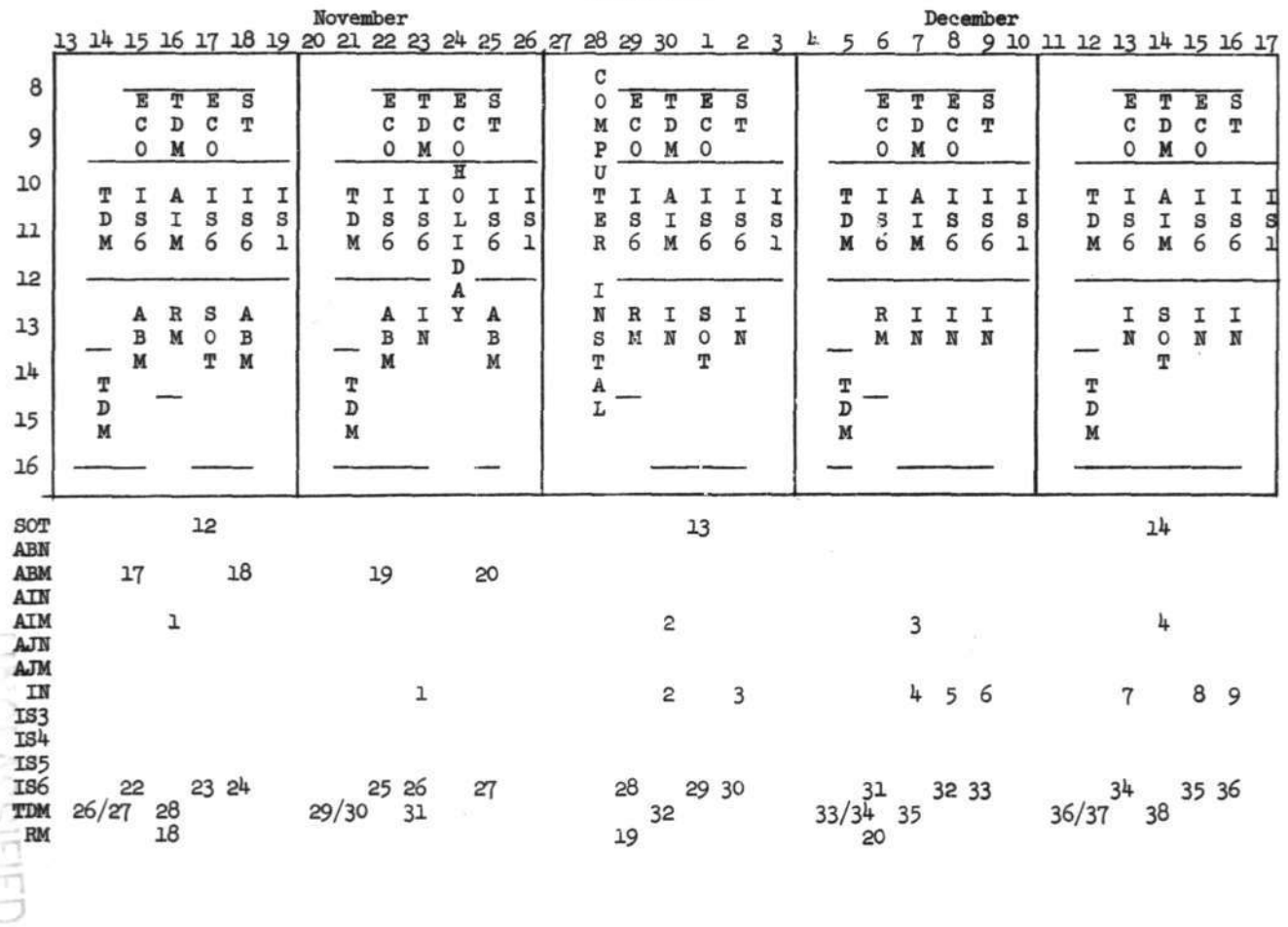


TABLE IIIe

Date	8–10	10–12	12–16	SOT	ABN	ABM	AIN	AIM	AJN	AJM	IN	IS3	IS4	IS5	IS6	TDM	RM
December 18																	
19	COMPUTER	COMPUTER	INSTALL														
20	ECO	IS6	RM												37		21
21	TDM	AIM	IN					5			10					39	
22	ECO	IS6	IN								11				38		
23	ST	IS6	IN								12				39		
24		IS1															
25																	
26		HOLIDAY	HOLIDAY														
27	ECO	IS6	IN								13				40		
28	TDM	AIM	SOT	15				6								40	
29	ECO	IS6	IN								14				41		
30	ST	IS6	IN								15				42		
31		IS1															
January 1																	
2		HOLIDAY	HOLIDAY														
3	ECO	RM	IN								16						22
4	TDM	AIM	IN					7			17					41	
5	ECO	IS5	IN								18			1			
6	ST	IS5	IN								19			2			
7		IS1															
8																	
9		TDM	TDM													42/43	
10	ECO	RM	IN								20						23
11	TDM	AIM	SOT	16				8								44	
12	ECO	IS5	IN								21			3			
13	ST	IS5	IN								22			4			
14		IS1															
15																	
16		TDM	TDM													45/46	
17	ECO	RM	IN								23						24
18	TDM	AIM	IN					9			24					47	
19	ECO	IS5	IN								25			5			
20	ST	IS5	IN								26			6			
21		IS1															

TABLE IIIf

	January													February												
	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
8			E	T	E	S			C																
			C	D	C	T			O	E	T	E	S												
9			O	M	O				M	C	D	C	T												
									P	O	M	O													
10	T	R	A	I	I	I	I		U	T	R	I	I	A	I		T	R	I	I	A	I			
	D	M	I	S	S	S	S		E	M	S	S	I	S			D	M	S	S	I	S			
11	M		M	5	5	1			R		5	5	M	1			M		5	5	M	1			
12			I																						
13			N	I	S	A	A		S	A	A	A	A				A	S	A	A	A	A			
		—		N	O	J	J		S	J	J	J	J				J	O	J	J	J	J			
14			T	N	N	N			T	N	M	M	M				—	N	T	M	N	N			
									A								T								
15		T	D						L								D								
		D	M														M								
16		M																							

	16	17	18	19	20	21	22	23	24	25
					E	E	S			
					C	C	T			
					O	O				
					T	R	O	I	I	I
					D	M	L	S	S	S
					M		I	5	5	1
						D	A			
						A	Y	A	A	A
						—	J	J	J	J
							N	M	M	M
						T				
						D				
						M				

	16	17	18	19	20	21	22	23	24	25
SOT		17							10	
ABN			18							
ABM										
AIN										
AIM										
AJN										
AJM										
IN										
IS3										
IS4										
IS5										
IS6										
TDM	48/49	50								
RM										

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SOT																
ABN																
ABM																
AIN																
AIM																
AJN																
AJM																
IN																
IS3																
IS4																
IS5																
IS6																
TDM																
RM																

TABLE IIIg

February / March

Time	Feb 26	27	28	29	Mar 1	2	3
8–10		COMPUTER	ECO	TDM	ECO	ST	
10–12			RM	IS5	IS5	AIM	IS1
12–14		INSTALL	AJN	SOT	AJM	AJN	
14–16							

Time	4	5	6	7	8	9	10
8–10			ECO	TDM	ECO	ST	
10–12		TDM	RM	IS5	IS5	TDM	IS1
12–14		—	AJN	AJM	AJM	AJM	
14–16		TDM					

Time	11	12	13	14	15	16	17
8–10			ECO	TDM	ECO	ST	
10–12		TDM	RM	IS5	IS5	TDM	IS1
12–14		—	AJM	SOT	AJM	AJM	
14–16		TDM					

Time	18	19	20	21	22	23	24
8–10			ECO	TDM	ECO	ST	
10–12		TDM	RM	IS5	IS5	TDM	IS1
12–14		—	AJM	AJM	AJM	AJM	
14–16		TDM					

Time	25	26	27	28	29	30	31
8–10		COMPUTER	ECO	TDM	ECO	ST	
10–12			RM	TDM	TDM	TDM	IS1
12–14		INSTALL	AJM	AJM	SOT	AJM	
14–16							

	Feb 26	27	28	29	Mar 1	2	3
SOT				19			
ABN							
ABM							
AIN							
AIM						14	
AJN			11			12	
AJM					7		
IN							
IS3							
IS4							
IS5				17	18		
IS6							
TDM				60			
RM			30				

	4	5	6	7	8	9	10
SOT							
ABN							
ABM							
AIN							
AIM							
AJN			13				
AJM				8	9	10	
IN							
IS3							
IS4							
IS5				19	20		
IS6							
TDM		61/62		63		64	
RM			31				

	11	12	13	14	15	16	17
SOT				20			
ABN							
ABM							
AIN							
AIM							
AJN							
AJM			11		12	13	
IN							
IS3							
IS4							
IS5				21	22		
IS6							
TDM		65/66		67		68	
RM			32				

	18	19	20	21	22	23	24
SOT							
ABN							
ABM							
AIN							
AIM							
AJN							
AJM			14	15	16	17	
IN							
IS3							
IS4							
IS5				23	24		
IS6							
TDM		69/70		71		72	
RM			33				

	25	26	27	28	29	30	31
SOT					21		
ABN							
ABM							
AIN							
AIM							
AJN							
AJM			18	19		20	
IN							
IS3							
IS4							
IS5							
IS6							
TDM				73/74	75	76	
RM			34				

V. FIELD EQUIPMENT ENGINEERING

One of the major areas of weakness in the Cape Cod System tests to date has been the deficiencies in the radar data received at the computer.

Because of the critical time schedules imposed on the SAGE System development, it has been necessary to perform system tests in parallel with the research and development on SAGE equipment. The radar sites in the Cape Cod System are called on to perform the dual function of

a) providing high quality radar data of the type which a completely developed system is expected to provide and

b) serving as a laboratory where the equipment development continues and where SAGE System techniques concerned with the radar network are established.

The magnitude of this dual program at the Cape Cod Radar Sites has not been fully recognized. Too often the assumption is made that equipment is delivered to the radar sites with all development work completed. In most cases the research program to prove the feasibility of the new device has been completed but the engineering development work involved in integrating the new equipment into the system and the field development to establish compatibility with other equipments, to improve reliability, to establish effective test and marginal checking procedures, and to properly design ancillary equipment have just started. Because of the pressure of performing system tests so necessary to the development of computer programs and direction center equipment, as well as the analysis of the system to prove that the air defense job can be performed adequately, the radar site equipment has been called on to deliver data on a heavy operational schedule before the site equipment development work has proceded to the point where such a schedule can be accomplished on a reliable basis.

The only solution which is acceptable and possible if the time schedules are to be met is to recognize that the dual program at the sites must be carried out and the magnitude of the program must be recognized and supported by the engineering effort which is necessary to accomplish the task. If the engineering effort is forthcoming, if the importance of the field engineering work is recognized so that more engineers can be attracted to it, and if the personal problems of housing and dislocation expense are resolved, the program at the radar sites should be able to accomplish both of the above described missions in parallel.

It is estimated that at least 6 additional experienced engineers are needed in the site development work on data transmission problems if the operational schedule desired by the test program is to be met together with the continued development of equipment and techniques. It must be recognized that these engineers will be called on to work largely in the field and at times during odd hours when the equipment is not being used

on an operational basis by the SAGE test program. It is imperative that liberal dislocation allowances be made to these staff members so that they can maintain normal living conditions while doing this vital job.

It is estimated that a minium of 4 additional experienced radar engineers are needed in the system program. While it is clear that the development of new radars is not and should not be done by the systems group, it is essential that the many systems problems associated with the radar network be undertaken by first class engineers with both radar experience and an interest in systems problems. It has long been a misconception by many members of the Laboratory that the radar people in the systems business can be inferior ability capable only of installation and routine maintenance work only. In reality they should be competent, responsible engineers with broad experience. In order to cope with the radar systems problems they must

a) be familiar in great detail with what the radar development groups are doing,

b) be able to analyze system needs such as azimuth commutators, trigger generators, buffer amplifiers, etc. in order to make recommendations to and obtain the support of the radar development groups,

c) be able to work out system calibration, maintenance, and orientation techniques,

d) be able to assist the system test and analysis section in special radar test set-ups and in preparing documents on SAGE specifications such as radar performance criteria, justification of radomes, justification of circular polarization for SAGE radars, etc.,

e) be able to represent the Laboratory in carrying out Lincoln's responsibilities in discussions with the Air Force and ADES agencies on radar site installation and phasing problems.

These jobs, best performed by engineers thoroughly familiar with radars, must be done in direct group association with the staff responsible for the operating system and the system test and analysis. These responsibilities cannot be carried out by radar research groups as a part-time area of interest on request by the systems group. To be effective in this work a staff member must maintain full-time contact with the Cape Cod System radars, the system test program, and the development work on other site equipments which are associated with the radars.

The Lincoln Laboratory Cape Cod System program has suffered greatly by the trend to remove many of the most experienced radar staff from this area of work when they have gained proficiency in coping with these problems in order that they might devote their time to long-term radar development. The Laboratory has also been embarrassed at times by not having adequate representation in meetings with ADES, Air Material

Areas, and other organizations on the P-site installation and phasing program and other system problems. The Laboratory has an obligation to educate Bell Labs and Western Electric people to the many problems of the SAGE System in order that they can prepare to carry out their responsibilities such as preparing acceptance test procedures, etc. Our inability to assign staff members familiar with these system problems to spend time with ADES personnel has been a source of friction between Lincoln and the organizations on whom we must depend to implement the production system.

It is recommended that the Laboratory take immediate action to transfer personnel to these activities. It is believed that the time schedules facing the SAGE development require that a priority be assigned to these activities and that staff now assigned to other programs be made aware of the importance of this work and loaned to this program.

VI. COMPUTER PROGRAM DEVELOPMENT

The status of the Cape Cod computer program on July 1, 1955 was as follows:

1. The automatic initiation portion of the program was not working as designed, due to coding errors.

2. The portion of the track trouble detection program which detects formation splits was erratic, due to coding errors.

The major difficulty in correcting the program errors was lack of accurate documentation describing the tracking section of the program. During July Group 61 personnel were temporarily shifted to prepare an adequate description of the tracking section of the program and correct the coding errors. This work will be completed by August 1, 1955.

Another impediment to testing has been the synthetic data generation computer program (not an integral part of the 1954 System program), which was not completed on time. Additional effort has been put on this computer program, which is now written and should be fully checked out by August 8, 1955.

Further programming effort for developmental modifications will be quite small since desired changes which result from testing will be fully specified and require only a small amount of coding. Any large-scale changes will not be incorporated in the 1954 Cape Cod computer program unless the SAGE Test Committee, Group 22, and Group 61 mutually agree that these changes justify the diversion of manpower.

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