

APPROVED FOR PUBLIC RELEASE. CASE 06-1104.

Memorandum M-1906

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 Digital Computer Laboratory  
 Massachusetts Institute of Technology  
 Cambridge, Massachusetts

SUBJECT: AIR DEFENSE BIWEEKLY REPORT, April 10, 1953

CAPE COD

1.0 GENERAL

(C.R. Wieser)

A system has been established to give advance notice concerning visitors who will see a test or a demonstration. In general a rather extensive list is notified when special arrangements are made for a formal demonstration, but only those more directly concerned with tests are notified when visitors are to watch a routine test. It is hoped that these notices will aid laboratory members in their planning. R.J. Horn should be notified of all visits which involve either a demonstration or watching a routine test.

2.0 EQUIPMENT ENGINEERING

(H.J. Kirshner)

Measurements of transmission loss of S.D.V. telephone circuits are continuing. With 50% of the lines measured, it has been found that the maximum excursions from circuit specifications have been  $\pm 2$ db.

A fourteen channel pre-amplifier has been constructed for use with one of the Ampex recorders to be delivered July 1. A second pre-amplifier of the same type will be constructed for the second Ampex recorder.

Discussions with R.G. Enticknap of Group 21 were held relative to control-center and direction-finding equipment. Samples of control center equipment which may be useful to us have been ordered. Direction finding equipment, remoted from the D/F station at North Truro, will be operable here during the first or second week in May provided that telephone cable facilities can be obtained at that time.

(B. Morriss, G. Young)

A revised set of drawings covering all input-output equipment to be available for September Cape Cod work has been under preparation for some time. These drawings have been essentially finished except for the magnetic tape units. The work of the past two weeks has been divided almost equally among the following three tasks:

1. Revising drawings of the present In-Out Element to show changes necessary for new equipment and to bring old drawings up-to-date, and preparing drawings covering new equipment.

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SECURITY INFORMATION

CLASSIFICATION CHANGED TO:  
 Auth: DD 254  
 By: R.R. Everett  
 Date: 2-1-60

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2.0 EQUIPMENT ENGINEERING (CONTINUED)

(B. Morriss, G. Young)

2. Discussing the operation of the new equipment with programmers and the individuals involved in the design and installation of the new equipment.
3. Investigating and discussing ways of converting SDV for an expanded system for WWII.

The following period will be spent in preparing the drawings for drafting, discussing them with the In-Out section, and seeing that descriptive material is written.

(J.H. Newitt)

The installation phase of the Cape Cod September program is now planned and scheduled in considerable detail. The presently scheduled installation work is in reasonable agreement with our original rough scheduling.

A few items have fallen slightly behind schedule in fabrication. This has been due to two things: 1) last minute engineering changes, and 2) improper estimates of the magnitude of the shop work in our original allowance.

Due to the nature of the work, these delays cannot be attributed to a lack of diligence; they were just unavoidable. The delays, however, are not serious since by special measures the overall loss is not more than two weeks and the items involved do not constitute a major bottleneck.

The data on the control room has been released and the magnitude of this work is a trifle larger than we expected. Wiring schedules from the Remote Station Distribution Box to the computer panels and the remote stations have been devised in semi-final form. Wireways to the control room are virtually complete and the room itself is practically ready for equipment installation. The scope consoles and 16" scopes are well underway. We expect five consoles to be available for installation by April 20 and five 16" scopes will be available by the end of April. The scope frames for the remote stations are designed and the first 10 will be made in our shop and will be ready for use by April 20. The various panels for these frames are now in frozen form and are being detailed in drafting. The sheet metal work on those panels will start in the shop within the next few days so that when the panel assembly drawings are available (end of April) there will be no delay in producing the final assemblies. We can expect to have some of the panel assemblies early in May and the others will follow within the month.

In summary, it appears very likely that the major part of the installation work should be completed by June 1. It is very possible that part of the system could be operated toward the latter part of May if special arrangements are made. Every effort is being made

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2.0 EQUIPMENT ENGINEERING (CONTINUED)

(J.H. Newitt) (Continued)

to parallel operations and eliminate steps wherever possible in order to shorten the program,

(G.F. Sandy)

Signal Wiring. The Remote Station Distribution Box has been installed back of AX row in the computer room. The first shipment of the 20 conductor cables for connecting to the Remote Station Distribution Box has been received and is now being fabricated for installation of the cable between the Remote Station Distribution Box and the proper computer panels in AX row. It is planned to run these 122 cables between AX row and the box during installation next Monday morning. The actual connections will be made during next week, insofar as possible. These 122 cables used up approximately 3,000 feet of the cable. We still have enough cable to make about 30 runs towards the New Control Room. It is planned to cut these cables next week and install them next Friday based on the final layout of the room as given to me by Dave Israel. The vendor has promised to deliver the balance of the 16,000 feet of the 20 conductor cables by Monday, April 20, at which time it is planned to cut this cable for installation from the Remote Station Distribution Box to the remaining remote stations.

Power Distribution and Control. The wireways for the New Control Room have been completely fabricated and construction has proceeded for about a week. These wireways should be completed in another two weeks. Power wiring of racks in the computer for the New In-Out is practically complete. Rack J1 in Room 156 has not been wired for power yet, but it is contemplated that the wiring for this rack will proceed next week. This is the rack which supplies all power for a New Control Room. All of the panels that go in this rack have been received.

(N.N. Alperin, A.V. Shortell, Jr.)

The phototube mount for the "Pathfinder" radar mappers has been completed and a model has been constructed. Sheet metal work on these mounts should start next week. This mount allows the operator to look at the display from above the phototube and should have less parallax than the present mapper.

Norman Alperin is constructing an H.V. power supply and distribution system for the mappers.

3.0 BEDFORD EXPERIMENT

(D.R. Israel)

A large part of the time of this biweekly period has been spent in preparation of material for the Quarterly Report covering the period December 1 to March 1.

On Monday, April 6, William Lemnios, Walter Wells, Charles Zraket, and I visited the Electronic Research Laboratory at Columbia University. Professors Ragazzini and O'Neil at this Laboratory have developed analog equipment for use in the control of interceptors. A large part of the day was spent discussing interceptor guidance techniques, particularly with respect to the problems introduced in the climb-to-altitude of the interceptor. The trip was extremely interesting. Brief notes have been made of the discussions; a short memo describing the trip will be prepared if time permits.

(M. Brand)

Command Tracking. The results of the simplifications to the Command Tracking Program mentioned in the last biweekly were quite successful. However, it was felt that by merely using a constant number of degrees as the criterion for whether or not headings should be transmitted to an aircraft, there could possibly be trouble in the final few moments of an interception. Because of this it was decided to re-incorporate the "twice the time to interception" criterion into the program. This, however, is the last vestige of resemblance between the original command tracking program and a new one for which Francis Garth and I constructed a flow diagram. This new program contains almost all the features of the original but is logically much more simple. Garth has written a program for this new system which is much smaller than the first. Work is progressing with this new program to see if it yields the same results with our four test parameter tapes as the first program. If this is so, and we feel it will be, we think we will have a command tracking program which will work efficiently with all interception programs.

(A.W. Curby)

The switch interrogation section for the new Four Pair Program has been written. It makes use of the two display boxes and allows one to cease tracking a target or interceptor; or have the interceptor return to the base, stand by at the base, or take-off from the base.

Conferences with S. Knapp, L. Murray, and F. Heart on the Four Pair Program were attended.

(F. Garth)

Further investigation since the last biweekly substantiated the hypothesis that a  $10^\circ$  change in heading be the criterion for giving a new heading to an interceptor. By this method an accurate course could be followed until the last minutes of an interception when it became apparent that some heading changes less than  $10^\circ$

3.0 BEDFORD EXPERIMENT (CONTINUED)

(F. Garth) (Continued)

should be given. Milton Brand and I have further simplified command tracking but reintroduced the "time to interception" feature. By simply making the new heading the sum of the old interceptor heading and that portion of the required change in heading the interceptor can accomplish during one scan, we found results again to be hopeful. Several more simulated tracks must be investigated before positive conclusions can be reached.

The Single-Pair Combined Interception Rewrite Committee, of which I am a member, has been continuing its work. See Charles Gaudette's biweekly report for particulars.

I have got down the first draft of the overall interception flow diagram for the September effort.

(F. Heart)

Efforts are being made, with Knapp, Curby, and Murray, to complete a four-on-four interception program using the Truro CPS-6B. All logical decisions and about half of the program writing have been completed.

The program for displaying geography in conjunction with the Combined Two Aircraft Intercept Program has been completed and successfully operated. It will be given a more complete test, however, prior to trying to use it in lieu of the present combined interception program. This new program, T-2510, produces a geography display similar to the display produced by the scope calibration program.

(W.Z. Lemnios)

Work has continued on the Combined Two Aircraft Interception Program being written with C. Gaudette and F. Garth for the Truro radar. Among the refinements which the new program will contain are a better final-phase program, the ability to track the interceptor during the final-phase turn, and a special display which will allow the interceptor's path to be observed better during final phase.

The equations for a three-dimensional interception when there is no "foldback" have been obtained and an attempt is being made to work out a flow diagram for their solution.

On Monday, April 6, a trip was made to the Electronic Research Laboratory at Columbia University with D. Israel, C. Zraket, and W. Wells. A conference was held with Dr. Bagazzini and Dr. O'Neil with regard to interception techniques.

(C.A. Zraket)

An automatic interception using the Instrumentation Lab's F-94 with the VHF automatic ground-to-air data link was attempted

3.0 BEDFORD EXPERIMENT (CONTINUED)

(C.A. Zraket)

on April 3. The test showed that the receiving equipment for the data link in the F-94 was not operative. A head-on final-turn interception, using a Navy F-3D as target, was then held in place of the above test. Results were satisfactory and are discussed under FLIGHT TESTS. The F-94 has been returned for overhaul, thereby nullifying any future tests with this aircraft.

4.0 DATA SCREENING

(R.L. Walquist)

A list of the indicator lights and intervention switches for TWS (track-while-scan) in the 1953 Cape Cod System has been completed. The action which each switch is to perform has been tentatively decided upon so that flow diagrams could be drawn up for those programs which utilize switch information.

Indicator lights are being used for the following:

- 1) a manual intervention register,
- 2) program-trouble indicators,
- 3) input radar data trouble indicators,
- 4) computer alarm indicators,
- 5) indication of illegal switch settings by the track initiators and track monitors.

The design of an audible alarm panel has been discussed with E. Rich and J. O'Brien. Such audible alarm panels will be used in conjunction with the indicator lights mentioned above in order to bring a trouble situation to the attention of an operator.

Responsibility for programming of TWS for the 1953 Cape Cod System has been delegated as follows:

- |                                 |               |
|---------------------------------|---------------|
| 1. Master Control Program       | - W. Attridge |
| 2. Radar Data Analysis          | - W. Wolf     |
| 3. Correlation                  | - J. Ishihara |
| 4. Track Initiation             | - " "         |
| 5. Tracking & Trouble Detection | - W. Attridge |
| 6. Track Trouble Interpretation | - J. Levenson |
| 7. Displays                     | - H. Peterson |
| 8. Switch Interpretation        | - J. Levenson |
|                                 | H. Peterson   |

Conferences have been held to discuss initial flow diagrams and written descriptions for each of the above sections. All of the major logical decisions for each section have been decided upon. More detailed flow diagrams are now being prepared by the persons responsible in order to be able to mesh satisfactorily the various sections.

4.0 DATA SCREENING (CONTINUED)

(W.S. Attridge, Jr.)

I have contributed a few ideas about scope console set-ups and the TWS panel arrangements.

I have made rough flow diagrams and descriptions of the master control and tracking sections of the 1953 Cape Cod Program. All block transfers of both data and subprograms will be controlled by the master control section. Also, all timing counters will be controlled by the master control section; counters of hours and minutes will be available for use in any other subprograms.

(H. Frachtman)

The data counting and mapping program for N. Truro CPS-6B is ready to be checked out.

Some time has been spent with W. Wolf collecting data in order to evaluate the video mapper.

Together with W. Wolf and H. Peterson, plans were made for some September programs.

(D. Goldenberg)

A program is being written which will compute the distances between the two positions of a target reported by one long and one short-range radar. The computations will be performed for various combinations of distances between the radar sites, slant ranges to the target from the two radars, heights of the target, and azimuths of the target.

(J. Ishihara)

Preliminary flow diagrams for the correlation section of the 1953 Cape Cod TWS were drawn up and discussed with members of the TWS group.

Final diagrams and descriptions are now being written.

(J. Levenson)

During this biweekly period, more computer time was spent on the Track Monitor Program and its behavior still remains inexplicable. New procedures of investigation have been established, and we can expect better results.

Plans are being made for the September Cape Cod System. I have drawn up flow diagrams and descriptions for the monitoring section of the TWS program, and these are now being revised in final, detailed form preparatory to programming. I have also

4.0 DATA SCREENING (CONTINUED)

(J. Levenson) (Continued)

worked with Peterson on the interpretation of switches and indicators for use by the TWS program. The work done on these two sections will probably appear later in an inter-office memo.

(H. Peterson)

The Track Monitoring Program was on the computer once more. J. Levenson and I have found a few omissions on the tape but no real errors in our logic as yet. However, the program still has not run successfully. I believe our difficulty now is rather that of correctly getting the program into the computer.

I have also been working on the displays and switch interpretation of the TWS section of the Cape Cod System. This work is planned to be put out in a memo so that further information will be available to those interested.

(N.S. Potter)

Work is proceeding on the report on information storage on the magnetic drum, using the probability of obtaining an empty storage position during a fixed scanning interval as a measure of the reliability. The re-examination of the earlier report is finished, and some alteration in approach and extension of previously obtained results seems to be called for.

(H.H. Seward)

The programming of the track sorting section for the Cape Cod System will be started next week. The program will sort tracks into rectangular strips four miles wide, each strip extending over the entire range of the system. Horizontal or vertical strips may be selected automatically or manually according to the arrangement of track positions.

(W. Wolf)

Data was collected from the CPS-6B at N. Truro. It was found that, as might be expected, the scan time varies daily over a small range around twelve seconds (about  $12 \pm 1/2$  seconds).

The returns were categorized as to quadrants. As an example, on a day characterized by light rain throughout New England there were approximately 5,000 returns distributed as follows:

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4.0 DATA SCREENING (CONTINUED)

(W. Wolf) (Continued)

	Quadrants			
	N-E	E-S	S-W	W-N
Before filtering	500	750	1250	2500
Filter data (radar mapper used)	130	70	120	80

The 400 returns of filtered data were passed after about 25% of the mapping scope was blocked out.

Flow diagrams were written for the data collection and display sections of the TWS program for the 1953 Cape Cod System. These flow diagrams were criticized in confernece with other members of the Data Screening Group.

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5.0 TRACKING AND CONTROL

(J. Arnow)

The major portion of the last bi-weekly period was devoted to writing for the quarterly progress report.

An attempt is being made to obtain data on the accuracy that can be obtained when tracking an aircraft separately from two radars in order to obtain an estimate of how accurately the tracking is actually carried out. This data is for use by Boeing in attempting to evaluate whether Bomarc can be used with the WW2 system.

(S. Best)

A large number of combinations of linear velocity-heading smoothing parameters have been tried for one particular simulated flight path. One of the most suitable combinations was found to be:

$$\alpha_m = .06$$

$$\alpha_m = .30$$

$$\alpha_p = .39$$

$$\alpha_p = .07$$

These values are not very critical. It is somewhat surprising that  $\alpha_m$  is much less than  $\alpha_p$ . Other flight paths will be tried. It is planned to write a program which will print out positions and velocities each scan in order to compare this smoothing method with other methods.

The program to check the radar data from Rockport and Scituate failed to work again. It is very difficult to use the computer's own operating speed to subdivide the clock intervals as this program attempts to do.

(M. Frazier)

A satisfactory criterion for the detection of trouble spots in tracking associated with misses and non-linear-smoothing in the presence of noise returns has been developed. The resulting program amounts to a new form of non-linear smoothing based on some ideas of W. Wells.

(W. Lone)

Attempts to obtain recorded data of crossing tracks to aid in more extensive investigations of programs designed to eliminate

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5.0 TRACKING AND CONTROL (CONTINUED)

(W. Lone) (Continued)

the problem were continued with little success. Weather and equipment shutdowns were the major obstacles.

A few changes appear necessary in the track crossing program written with S. Best. The search areas at present are too small.

A conversion program has been written and awaits testing. Since the proposed September system will lead to extensive programming on the part of Group 61, with possible tape preparation on the part of the programmer, it was felt that a program which converts a standard tape prepared without the present encumbrances and punches out on 5-56 tape would be desirable.

(A. Mathiasen)

All the data wanted from the non-linear smoothing routine comparison program has been obtained. This data is being looked at by B. Stahl.

Data on how well we can track is being prepared at the request of Boeing. This data is being taken from simulated tracks and, weather permitting, from live tracks. A height-correction parameter has been prepared for the single radar tracking program which uses live or simulated data to see what improvement is given by such correction.

(H. D. Neumann)

Several more University of Michigan reports on Bomarc were studied. For the time being, this terminates my work on the solution of the equations.

(B. R. Stahl)

Work is continuing on several previously-mentioned programs, attempts being made to get them to operate properly. Of these, the tracking program for two radars and the multiple-radar timer show the most sign of encouragement.

Most of my attention during this period, however, has been directed toward compiling results from A. Mathiasen's program for comparison of non-linear smoothing routines.

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6.0 AIR DEFENSE CENTER OPERATIONS

(D. R. Israel)

The following work was carried out in connection with the 1953 Cape Cod System.

1. A revised and final version of the layout of the operations center has been prepared and is available as drawing SC-54407-1. This drawing is unclassified. The same layout, but with classified names, is available as a CONFIDENTIAL drawing SC-54531. The former of these drawings will be issued with M-1966, FLOOR PLAN FOR CAPE COD OPERATIONS ROOM. Drawing SC-54407-1, which was prepared to scale, shows the exact location of the equipment in the center. Rick Onanian will outline the positions of the equipment in chalk on the floor of the operations center early next week. Discussions have been held with Hal Mercer and John Newitt regarding the erection of certain temporary partitions within the operations room.
2. A large effort has been made in the past two weeks to prepare information for use by Dodd, Newitt and O'Brien in connection with the ordering and preparation for wiring of the equipment in the operations room. Together with Geraghty, Zraket, and Onanian, the following two items have been prepared:
  - a) scale drawings of the composition of panels and frames
  - b) detailed sheets listing the makeup of various panels and frames.

Preliminary copies of this have been distributed to those who needed the information immediately. The material will be incorporated into memorandum form within the next week.

3. Herb Benington has prepared a proposal for the allocation of display lines and a related proposal for the categories of information to be made available at each of the scope consoles. This proposal has been reviewed and it is presently being put into memo form for distribution. Five of the major types of displays have been assigned to people for detailed consideration. These are as follows:

Track Situation Displays -- Herb Benington  
Digital Information Display -- Orin Conant  
Radio Communication Display -- Lee Murray  
Identification Display -- Milton Brand and Peter Cioffi  
Summary Display -- Frank Heart

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6.0 AIR DEFENSE CENTER OPERATIONS (CONTINUED)

(D. R. Israel) (Continued)

4. Additional meetings have been held with members of Group 61 to discuss program frame work and design. Coordination with Walquist's section has been made and several decisions regarding items of joint interest have been settled. These include program sequence, availability of clock time, assignment of intervention registers, panel numbering, etc. Responsibility for the activities of the Combat Data Director has been undertaken by Walquist's section. For initial tests, those functions of the Combat Data Director which concerned the supervision of height-finding activity have been given to a height supervisor. Responsibility for the Height Supervisor will rest with this section.
5. Over the past month it has become quite apparent that there are a number of problems and pieces of equipment which are not directly associated with computer input and output. Among these are radio equipment, room lighting, tote boards, teletypes, etc. These items were discussed last week with Howard Kirshner, who will assume responsibility for them.
6. Several meetings with members of this section have been held during the past two weeks to discuss problems in connection with weapons direction. In particular, the discussions have been concerned with the need for storing aircraft characteristics in the computer and the use of these characteristics in the interception equations. Garth, Lemnios, and Murray are giving further consideration to this problem.
7. Major Paterson (formerly Captain) will return to the laboratory next week in connection with the motion picture activity. During the past two weeks, Bob Rathbone and I have given detailed consideration to a scenario for the initial film attempt in connection with computer programming. A scenario now exists as Memorandum M-1970. This material will be discussed with Major Paterson, and work on the film should begin late next week.

(H. Benington)

I am completing a fourth inter-office memo on the preliminary investigations of display for September Cape Cod. This memo, superseding all others, will give a complete list of display categories, their si-addresses, and scope destinations. Tables will be included of individual scope displays and switches. Finally, a survey will be made of the equipment demands of such a system. Obviously such a scheme is highly tentative, but planning and programming according to its details will be necessary before more insight is gained.

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6.0 AIR DEFENSE CENTER OPERATIONS (CONTINUED)

(H. Benington) (Continued)

I have started work on a program that will prepare and display the points, vectors, identities, track numbers (and, when they exist, the assignment status and bearing attack angles) for all tracks in the system.

(M. Brand)

In conjunction with Ann Curby, I have prepared a memo which describes the storage which the Identification program will use in the September system. Our plans call for two major blocks of storage, the Temporary Identification Data Storage (TIDS) and the Identification Data Storage (IDS). TIDS will contain two blocks of four registers which are filled subsequent to each switch read-in and interpretation. IDS contains eight blocks of forty-eight registers which contain in the category type of storage all the Flight Plan, Diversion, Cross-tell and GOC processed data. Of the 48 registers in each block of IDS, the first twenty-four will be reserved for Flight Plan and Diversion data. The next sixteen will contain Cross-tell data and the last eight will contain GOC data.

After having spent several days worrying about a time interpretation program we learned from R. L. Walquist that the master control program will provide for all programs to use three permanent ES registers which will contain respectively the correct hours, the correct minute, and the correct sixteenth of a second. This permits us to insert the time "past" the hour at which a flight will be activated (i.e., when it reaches a check point within our domain) rather than the number of minutes remaining before activation.

We have decided to use our proposed September system storage system for our "phase 2" simulated program. This will provide us with a method for checking out A. Curby's difficult processing and extrapolation program in virtually its final form. The master control program will be changed now to provide the same sort of time interpretation as the September Master Control Program will contain. We have also decided to use the drum so that the programs can more nearly simulate the September system. We hope to have the complete program finished within this bi-weekly period.

I have spent quite a bit of time considering the Flight Test Umpire function. I have prepared a proposal containing a suggested input switch digit plan and switch panel arrangement and a flow diagram showing a suggested form of operating the FTU function.

I have continued to spend time with D. R. Israel, C. Zraket, C. Gaudette and F. Heart in overall discussions concerning the September system.

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6.0 AIR DEFENSE CENTER OPERATIONS (CONTINUED)

(J. J. Cahill, Jr.)

Practically all of this period was spent working with Geraghty on the Eight-Aircraft AA Guidance and Height-Finder Program for Truro data. It is felt that work will be completed in a day or two.

No flight test activity in AAA or H-F took place during this period because of the weather.

(P. O. Cioffi)

A report of my recent visit to Building B, where I discussed the Cape Cod communications system for September with R. N. Davis and R. G. Enticknap, was made to D. R. Israel. It was concluded at this meeting that it would be of utmost importance to both groups 21 and 61 that members from each be brought together to decide on a satisfactory system of communications that would serve the needs of both groups for the coming months of increased activities for these groups in the field of operational air defense.

The program to simulate the identification feature of the 1953 System referred to in the last report was completed this period; however, any testing of this program will be delayed in order to incorporate certain changes which have been suggested.

(O. T. Conant)

During the past bi-weekly period several conferences with D. R. Israel and other members of the group, concerning organization and programming for the 1953 System, have resulted in my undertaking a digital information display program, in addition to the previously mentioned geography and calibration display, and, in conjunction with F. Garth, the general outline of programming and timing of the intercept function.

A meeting with H. Weiss and J. Lickliger of Group 31 was also attended along with F. Webster, C. Zraket, F. Heart and H. Kirshner. Display presentation and group organization were discussed and several items of specialized display equipment observed. Dr. Lickliger expressed interest in observing some of our work with displays.

A summary of the present (April 6th) status of external telephone lines for the 1953 systems was prepared in cooperation with D. Israel and J. Arnow, and the physical location of telephone keyboxes was noted on copies of floor plan SC 64407-1 for the use of Arnow and the telephone company.

Memorandum M-1962: Standard Designations for Cape Cod Equipment and Operating Personnel has been written and should be published soon.

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6.0 AIR DEFENSE CENTER OPERATIONS (CONTINUED)

(A. W. Curby)

A trip was made to Truro on Friday, March 27, at which time both the Quick Fix Station and the GCI station were visited. Information was obtained from Miss Anne Smalley of the Quick Fix Group about a Vidicom system being set up for the transmission of track data over phone lines from the plotting board at Truro to a scope in the Lexington laboratory. If used between GCI stations and ADCC, this system would give the ADCC complete visual information on the situation over its area of responsibility with a maximum time lag of 30 seconds.

A memo was obtained from Captain Walker of the Truro GCI station which describes in detail the Multiple Corridor Identification System now in use and includes a map of the corridors. Copies have been made and are available.

A data processing program for the ID section of the September system has been written and will be tested shortly, along with the Flight Plan Extrapolation program and P. Cioffi's correlation program, by means of the master control program being written by M. I. Brand. It is hoped that these programs are in essentially the form in which they will be used in September.

(C. Gaudette)

Most of the time during this period was spent rewriting the Combined Interception Program. This program should be written by the end of the next period.

An Interception Calculation Subprogram has been added to the Subroutine Library. Lee Murray is now writing a program to check this subroutine.

(M. Geraghty)

Progress has been made on the Eight Aircraft AA and Height-Finder Guidance Program with J. Cahill. It should be finished in time for the Truro data.

Lists and drawings, as complete as possible at this time, of the panel and frame components in the September System have been completed and distributed.

(F. Heart)

On March 30 a visit was made by Zraket, Webster, Kirshner, Conant, and Heart to Group 31 of Lincoln. Discussions were held with H. Weiss and J. Licklider. A short inter-office memo commenting on this visit was written and may be obtained from D. Israel or me.

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6.0 AIR DEFENSE CENTER OPERATIONS (CONTINUED)

(F. Heart) (Continued)

The revisions to Room 222, Barta, described in M-1935, were completed by Kirshner's group. The equipment has since been checked and used. It is still necessary, however, to check the Jones plug connections in test control prior to using the G.O.C. or display input boxes.

I have continued to participate in conferences directed toward Cape Cod planning.

(S.C. Knapp)

The Eight Aircraft Tracking Program was revised to use the ab order, which is to be available very soon. The program is now completed.

Meetings to discuss the programming for the Sector Commander, Sub-Sector Commander, Weapons Director, and Senior Director functions have been attended. Some time has been spent in considering the problem of weapon assignment for the Cape Cod System.

(L.J. Murray)

Work has continued on the Four-Pair Intercept Program. S. Knapp has utilized the ab order to some advantage in the correlation section. F. Heart and I are doing likewise in the interception and display phase.

At present I am writing a check program for the proposed Interception Subroutine. When this subroutine has been checked and we feel that it is satisfactory, it will be issued as an M-note.

I have also been assigned to determine what information the Radio Communicator(s) for the 1953 Cape Cod System should receive in order to perform his duties most efficiently. During the coming biweekly period we plan to have several meetings to answer this and other such questions.

(F.A. Webster)

A drawing entitled "Easterly Approaches to Boston" (D-54424) has been made from sectional aeronautical charts for use in analysis of simulated enemy raids from the east. Specific raid situations will be drawn on sepias. Additional aeronautical charts of various relevant areas are being ordered from the Air Force Chart Service.

A rough memo has been written for Division 5 (Special System) dealing with earlier investigations on GOC operations. This information is to be used in connection with the possible use of sonic detectors.

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6.0 AIR DEFENSE CENTER OPERATIONS (CONTINUED)

(F.A. Webster) (Continued)

During a visit to Group 31 (Licklider and Weiss) the use of "conducting glass" was demonstrated. With their arrangement, an individual can make anotations -- numbers, symbols, notes, etc. -- directly over his display scope, and they will appear (and persist for a short time) over the corresponding position on a selected remote scope. Some use of this method might expedite the transfer of certain data in the 1953 Cape Cod System.

(C.A. Zraket)

Equipment and programming studies for the 1953 Cape Cod System are continuing with members of the group. Switch and panel layouts, displays, data storage, and weapons direction were discussed during the past period. The present final-turn interception equations and program have been issued in inter-office memo form in order that C. Gaudette may write a standard subprogram.

A visit was made to Prof. J.R. Ragazzini at Electronic Research Labs., Columbia University, on April 6 with D.R. Israel, C.H. Gaudette, and W.Z. Lemnios to discuss weapons direction problems. In addition, analogue equipment which that group is building for the purpose of increasing the present capacity of GCI controllers was demonstrated to us. The results of the visit have been written up in inter-office form.

Two memos, "Non-Track-While-Scan Data Storage Allocation" and "Tentative Digit Utilization for UHF Automatic Ground-to-Air Data Link" are being written as time permits. They will be issued as soon as possible.

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7.0 ASSOCIATED STUDIES

(E.J. Craig)

A preliminary draft of the proposal for a doctoral thesis on Iteration Procedures has been completed and given to Prof. W.K. Linvill (supervisor) for criticism.

An iteration procedure for finding the characteristic equation of  $AA_t$  has been evolved, and follows as a consequence of the iterative solution of  $\underline{Ax} = \underline{y}$ .

Work progresses with the problem of finding the characteristic equation of  $\underline{A}$  itself when  $\underline{A}$  is non-singular.

(B.G. Farley)

Most of my time was spent learning the ins and outs of computer organization and practice as exemplified by MTC, particularly studying and redrawing diagrams of the control and timing.

(W.I. Wells)

Some preliminary work on the specification of a class of non-linear filter has been completed. At present I am doing a numerical example which is expected to give a rigorous exposition of the optimum non-linear filter which is needed to filter the aircraft tracks normally encountered. It is known from preliminary investigations that this filter will be closely analogous to the "non-linear" technique now in use.

8.0 COMPUTER OPERATIONS

(M. Brand)

The following is a summary of scheduled computer time used by Group 61 during the last biweekly period.

MEW Tracking and Control	
Flight Tests	1 hrs 50 min
Magnetic Tape	5 hrs 15 min
Data Screening	5 hrs 50 min
Radar Analysis	3 hrs 50 min
Multiple Radar Tracking and Control	19 hrs 35 min
Air Defense Center Operations	2 hrs 50 min
Indoctrination Programs	30 min
Miscellaneous	1 hrs 55 min
Equipment Characteristics	1 hrs 0 min
Calibration	10 min
Demonstration	2 hrs 10 min
Total Time Used = A	44 hrs 55 min

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8.0 COMPUTER OPERATIONS (CONTINUED)

(M. Brand) (Continued)

Time Lost to Computer (parities, etc.)	11 hrs 45 min
Time Given to Magnetic Drum	10 hrs 5 min
Time Given to Group 6345	20 min
Time Given to Magnetic Tape	<u>55 min</u>
 Total Time Lost = B	 23 hrs 5 min
 Total Assigned Time (A+B)	 68 hrs 0 min
 Percentage Assigned Time Used	 66.1%
Percentage Available Time Used	100.0%

(C.A. Zraket)

Demonstrations:

1. A canned demonstration was shown on March 31 to a group of pilots from the 6520th Wing at Bedford. Ampex 238 (P-2466-1).
2. A group from Research Development Board and a group with Capt. Bergeson were shown a canned demonstration on April 10; a) Automatic Interception using automatic ground-to-air data link. Ampex 238. (P-2466-1); b) Multiple Aircraft Tracking and Initiation, Ampex 245. (T-2109-16).

9.0 FLIGHT TESTS

(F. Heart, M. Brand)

The following statistics apply to the last biweekly period:

1) Computer hours scheduled for flight tests	18
2) Computer hours used for flight tests	2
3) Computer hours returned due to flight test cancellations	11
4) Total Aircraft Hours Flown	8
5) Aircraft hours flown by 6520th Wing at Bedford	6
6) Aircraft hours flown by Navy (Quonset-based Squadron)	1
7) Aircraft hours flown by A.I.T. Instrumentation Laboratory	1

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9.0 FLIGHT TESTS (CONTINUED)

(F. Heart) (Continued)

A flight test summary for March, 1953, was issued as M-1956. Unusually poor flying weather caused almost a complete halt in flight test activities during the month of March.

In the next few months, as the number of aircraft per test increases, a greater integration of Air Force personnel into flight test "planning" and "running" is being accomplished. During tests of the four-on-four intercept program, in particular the experience of Capt. Sullivan's group is being drawn upon as to aircraft operating procedures and actual test operation.

(P.F. Dolan)

April 1, 1000-1200 Coverage Test, Arnow

B-29 #969 from 6520th flying as directed. Tracked well on Martha's Vineyard; Foxboro and Scituate, fair tracking.

April 3, 1300-1400 Final Turn, Zrakat

Target: F-3D at 8.5, IAS 250 knots, holding 15 miles east of Rockport, vectored 345°  
Fighter: F-94 (MIT) 9.0, IAS 300 knots, holding over Concord. Fighter passed 2500 yds. to right of target. Auto-intercepts were scheduled for this test, but due to data link trouble in aircraft test was held without data link.

1400-1500 Two Aircraft Tracking, Lone

C-82 #749 at 5.0, IAS 180, 7 miles north of Scituate, B-25 #423 at 5.0, IAS 200, 7 miles south of Scituate, both flying as directed. Excessive clutter made tracking difficult.

April 9, 1000-1200 Coverage, Lone

B-17 #9281 at 7.5, IAS 190 flying as directed. Good tracking on Foxboro and Chatham, poor on Londonderry. At no time did Scituate see aircraft. Martha's Vineyard ceased operating just after test started.

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DATE	TIME	SCHEDULED TEST		TEST ACTUALLY RUN		REASONS FOR CHANGES OR COMMENTS
		A/C	Description	A/C	Description	
3/31	1000-1200	2	Final Phase Intercept	-	Cancelled	Weather
	1400-1600	4	Two-Pair Intercepts	-	Cancelled	Weather
4/1	1000-1100	2	Final Phase Intercepts	-	Held Coverage test* from 1000-1200	Computer Inoperative
	1100-1200	1	AAA Test	-	Cancelled	Computer Inoperative
4/2	1000-1200	1	Small Radar Coverage	-	Cancelled	Weather
4/3	1300-1400	2	Automatic Intercepts	2	Held Intercepts without Data Link	Aircraft Data Link inoperative
	1400-1500	2	Two Aircraft Tracking	2	As Scheduled	
4/7	1000-1100	2	Final Turn Intercept	-	Cancelled	Weather
	1100-1200	1	AAA & Height Finder	-	Cancelled	Weather
4/8	1000-1200	2	Two Aircraft Tracking	-	Cancelled	Weather
4/9	1000-1200	1	Small Radar Coverage	1	As Scheduled	

\* Added to schedule during week of test

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9.0 FLIGHT TESTS (CONTINUED)  
(Art Hill)

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10.0 PUBLICATIONS

(M.R. Susskind)

The following material has been received in the Library, Whittemore Building, and is available to Laboratory personnel:

LABORATORY REPORTS

1. "Radar Jamming as Applied to Buffer Drum Considerations," D. McCann, M-1924, March 24, 1953. CONFIDENTIAL
2. "Testing Cores for WWII," J. McCusker, M-1943, March 30, 1953. CONFIDENTIAL
3. "Air Defense Biweekly Report, March 27, 1953," M-1944. CONFIDENTIAL
4. "Summary of IBM-MIT Collaboration," March 1 to March 31 inclusive, A.P. Kromer, M-1955, April 3, 1953. CONFIDENTIAL
5. "Flight Test Activity Report for March, 1953," F.Heart, P.Dolan, Art Hill, M-1956, April 6, 1953. CONFIDENTIAL
6. "Floor Plan For Cape Cod Operations Room," D.R. Israel, M-1966, April 9, 1953. CONFIDENTIAL
7. "Proposal for a High-Speed Random-Access Buffer Storage of Small Capacity," M. Epstein, E-528, February 24, 1953. CONFIDENTIAL

TECHNICAL REPORTS

1. "Integrated Fire-Control System for Terrier," (Abstract), RCA Victor Division, January 1953, Lib. No. 1951C.
2. "Quarterly Progress Report, Div. 7," Lincoln Laboratory, M.I.T., November 15, 1952, Lib. No. 2267C.
3. "Quarterly Progress Report, Div. 2," Lincoln Laboratory, M.I.T., January 15, 1953, Lib. No. 2304C.
4. "Evaluation of Analog and Digital Computers for Flight Simulation," National Bureau of Standards, January 28, 1953, Lib. No. 2326C.
5. "Bibliography and Index of Project Hermes Reports 1945-1952," Guided Missiles Dept., General Electric, Schenectady, N.Y., January, 1953, Lib. No. 2325R.

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10.0 PUBLICATIONS (CONTINUED)

(M.R. Susskind)

6. "Integrated Fire-Control System for Terrier," RCA Victor Division, August 9 to November 9, 1952, (Abstract), Lib. No. 312/S.
7. "Index of Missiles Division Reports, Research Memoranda, and Papers," Project Rand, Missiles Division, March 3, 1953, Lib. No. 313/S.
8. "The Integrated Electronic and Control System," Project MX-1179, Monthly Progress Newsletter No. 28, Research and Development Laboratories, Hughes, January 1, 1953, Lib. No. 314/S.
9. "Quarterly Progress Report, Div. 4," Lincoln Laboratory, M.I.T., February 15, 1953, Lib. No. 315/S.
10. "Theory of Interceptor Fire-Control Systems, Part I," Floyd, G.F., Tillotson, J.H., February, 1953, Hughes Research and Development Laboratories, Lib. No. 316/S.
11. "Electronic Display Equipment," Evans Signal Corps Laboratory, Belmar, N.J., January 5, 1953, Lib. No. 2323C.

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WHIRLWIND II

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(N. H. Taylor)

The following paragraphs represent short summaries of current activity in Group 62:

1) MTC Computer

The system is being subjected to a vigorous program of marginal checking, and the circuits for the magnetic coincident-current memory are being added. All work is in preparation for insertion of the coincident-current memory; it is hoped that this will occur before the end of the month.

2) Coincident-Current Memory

The first plane of the MTC memory has been inserted, and preliminary tests are now being made. Results are very encouraging, and the indications are that we may expect the 1,000-bit memory to work as well as, or better than, the 256-bit memory which we have been testing for many months. Quantitative results on margins of operation will be available during the next bi-weekly period.

3) Basic Circuits

The high-speed basic circuits which will be used in the control part of the machine are going along relatively well, with MIT engineers assigned to most of these. In order to provide the slow-speed basic circuits (100-kilocycle type) which will be used in the magnetic drums and in-out terminal equipment, we will probably allocate most of this responsibility to the IBM corporation, as it has had a broad background of experience in this type of basic circuitry and will have more manpower available than will we for these assignments.

4) Arithmetic Element

Two decisions have been firmly made as a result of numerous conferences during the last bi-weekly period:

- a) A scheme of multiplication has been decided upon, and
- b) A 32-bit split arithmetic element has been approved by all interested parties. IBM will now undertake a program of vigorous breadboard testing in order to get detailed quantitative circuit margins before proceeding with the final design.

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WHIRLWIND II (CONTINUED)5) Control

Active liaison between IBM and MIT has resulted in a proposed control system patterned somewhat after the MTC type. Discussions with the WWI engineers have indicated some differences of opinion on the importance of including a check register in the framework of the WWII system. We hope to resolve this difference of opinion within the next bi-weekly period. The presently-conceived checking system in Whirlwind assumes the ability to stop the machine on any time pulse as a result of check register failure. If this is a necessary requirement, it will not be possible to use the MTC type of control system very effectively.

6) In-Out Activity

It has temporarily been decided that a time-shared type of input equipment is inferior to the non-time-shared separate register at each phone line. We are now embarking on a discussion of the input buffer system and the relative merits of using a magnetic drum in the internal memory of the machine as a means of accepting the data from the individual phone line registers. It is becoming quite apparent that some of the decisions associated with the in-out activity may have to be rather arbitrary in order to allow us to build sufficient equipment in time to meet the proposed schedule for the WWII prototype system.

7) Magnetic Circuits

One of the proposals for separate registers in the input system of WWII incorporates the slow type of shifting register as a part of the SDV-to-r, $\theta$  converting system, and evaluation of this scheme is now under way.

8) IBM Participation

IBM will very shortly be working under a prime contract as a result of negotiations between AFCRC, IBM, and MIT. It is hoped that the freedom and additional funds resultant from this arrangement will help to expedite some of the early problems associated with obtaining components for the prototype machine. Conferences between two of the tube companies, GE and RCA, indicate that we may expect a healthy cooperation in procuring premium tubes, and negotiations, in a preliminary form, are under way to achieve this end. Liaison between the two organizations is improving week by week, and it is hoped that IBM will find it possible to take a more active part in the time schedules which have been proposed as a means of providing the necessary checking system to keep these two organizations working

WHIRLWIND II (CONTINUED)

toward the same goals. There seems to be no difference of opinion as to what has to be done or how some of it should be done, but the method of controlling the activity is under debate.

(G. R. Briggs)

Input System. During the past two IBM-MIT meetings, the following decisions were reached with respect to the input system:

1) The SDV counting, north mark detection, spurious signal protection and radar mapping will all be done in a non-time-shared manner. The counting will be done with improved MITE equipment, using cores and low-speed vacuum-tube circuitry wherever possible to save cathodes.

2) Radar mapping will be done using rotating-yoke scopes operating directly from the SDV data with simple flux-brake circuits. These circuits are in a fairly advanced stage of development by Division 2. This will give an x-y display without the necessity for supplying x-y digital deflection information.

As mentioned previously, these decisions will necessitate the construction of a special x-y converter to deflect the output display scopes, if it is found desirable to furnish masked data to these scopes in the event of computer failure. Since for the rest of the system x-y is unnecessary or even undesirable, it was felt best to develop a special-purpose piece of equipment for this purpose.

(W. Clark)

The Input-Output meetings and Control meetings of the last two weeks have required a great deal of time in attendance.

With C. Grandy, a detailed analysis of an adequate correlation program for the Transition System was undertaken as part of the evaluation of the proposed order code and index register apparatus. Our results show that the addition of one index register will increase the capacity of the correlation program by about 23%; the addition of two index registers, by about 43%; the addition of three index registers, by about 55%. The provision of a return path from the B registers to the Accumulators results in a further increase in capacity of about 10%, and the inclusion of a "D register" for temporary storage in the arithmetic element increases the capacity by a further 7%. A summary of these results was presented at the April tenth meeting of the Control groups.

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WHIRLWIND II (CONTINUED)

(C. Grandy)

Programming with the proposed order code for WWII has continued during this period. The interception (mid-course) program mentioned in the last bi-weekly was revised to make better use of the index registers. A correlation program was written and used as the basis of a comprehensive analysis of the value of index registers, sub-operations involving internal transfers in the arithmetic element, and an additional register, called the D register, in the arithmetic element to be used by sub-operations. This analysis was done in conjunction with W. Clark, and the results are reported in his bi-weekly report.

This program consists of the following: conversion of  $r, \theta$  radar returns to  $x, y$  and translation to generalized  $x, y$  for the sector; generation of box number for the "box method" of correlation; association of radar returns with tracks in four boxes surrounding a return, ultimately doing a "best fit" correlation after a preceding square area check and search circle check. The association process was stopped at the first successful best fit correlation. Both the square area and the search circle were considered to vary from track to track as a function of range, misses, etc. The program assumed that the track monitoring program had set the search circle = 0 for tracks sufficiently close together to be in tracking trouble.

The program did not include a section to sort tracks into the boxes and make up the A-table for the boxes; however, W. Clark wrote a separate program for doing this, and a similar analysis of his program is underway.

During the next period an attempt will be made to write and analyze programs for the remaining track-while-scan functions, starting with a track monitoring program, then an initiation program, and ultimately a smoothing and prediction program. Work that was started on the interception equations and BOMARC guidance equations will be continued at a later date.

Some time was spent in attendance at Input-Output and Control group meetings. The analysis of display categories of track information mentioned in previous bi-weeklies was discussed at one meeting of a part of the Input-Output group.

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WHIRLWIND II (CONTINUED)

(J. Hayase)

The past bi-weekly period has been spent coding the sixteen aircraft tracking programs mentioned in the last bi-weekly report. Coding techniques using the index registers are being studied in the process of coding.

Error diagnosis programs are being written for non-real-time problems as a term project for MIT course 6.537, and the possibility of writing an error diagnosis program for simulated real-time problems is being explored.

(J. Jacobs, R. Callahan, R. Jeffrey, R. Mayer)

WWII Arithmetic Element and Control. The past two weeks were spent working with people from IBM and Whirlwind concerned with decisions about the arithmetic element and control element of WWII. Questions considered were:

- 1) Should the split arithmetic element be kept? (Answer: yes).
- 2) Should sub-operations such as  $BR \rightarrow AC$  and  $|AC| \rightarrow AC$ , to be inserted at the programmer's option during program timing before such regular operations as add, be included?
- 3) Should transfers between registers take place via a bus, as in WWI, or by separate paths between registers?
- 4) What should be the logic and circuitry of central control?

We spent April 6, 7 and 8 at Poughkeepsie working with Ross, Sarahan and Steinberg of IBM on questions 2, 3 and 4. We will spend April 13-15 continuing this, especially completing the design of one version of the control element and discussing checking (check register, marginal checking, etc.) Decisions on these questions are expected on April 17 or thereabouts.

(D. McCann)

M-1919 from J. O'Brien, H. Ziemann and myself, describing operation of the display for the 444 ADC system has been issued. Study of the requirements for the output terminal equipment from a weapons standpoint continues with assistance from G. Rawling. At present the AN/GSG-2 AA Defense System is being analyzed to determine ways to tie the computer in-out register to links to the AA Operations Center.

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WHIRLWIND II (CONTINUED)

(G. Rawling)

1. In the past period, coding of Cape Cod routines in WWII code was begun. Many novel techniques (such as use of Special Add Memory) must be dropped and rewritten to incorporate WWII benefits.

2. A study of the frequency of occurrence of the Square Root and Radius Vector Subroutines in Cape Cod programs was made. Using air traffic density distributions suggested by TM-20 Revised ("A Proposal for Air Defense System Evolution: Transition Phase"), with Corridor Identification System of Commercial Flights, the times of the Cape Cod Programs in terms of WWI are:

square root, approximately 159 milliseconds/frame

radius vector, approximately 66 milliseconds/frame

3. A survey of literature available in the Project Meteor Library concerning the ground computers in the Nike, Terrier, and proposed Talos missile systems was begun and will continue through other phases of these weapons in the Interim and Transition Air Defense System.

4. Weapon Evaluation and Employment Flow Diagrams previously reported are under revision and modification as new information appears.