Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: AIR DEFENSE BIWEEKLY, February 27, 1953

CAPE COD

2.0 EQUIPMENT ENGINEERING

(E.S. Rich)

Magnetic Drum Systems Engineering Research Associates of St. Paul was visited on February 16 and 17 to discuss problems which have arisen during tests here on the Auxiliary Drum System and to review the status of the Buffer Drum System construction. The principal problem with the auxiliary system is temperature sensitivity in the new ferrite-core heads. After several weeks' work it appears that a satisfactory redesign has been obtained. Production quantities have yet to be made and tested. It is estimated that the latter may take about six weeks.

Assembly of the buffer drum system is now in progress. Bay wiring of one bay is complete, and system tests of the circuits in that bay are underway. Wiring in the remaining three bays is well along so work seems to be progressing on schedule. Further difficulty with the head redesign, however, might adversely affect the schedule.

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

The radar mapper for the N. Truro set is nearly assembled and will be tested during the next week. The circuitry has been tested and debugged using a five-inch scope; some minor adjustments will have to be made for use with the 16-inch scope. Depending on availability of data from N. Truro, the filter will be tried out within the next biweekly period.

(H.J. Kirshner)

Ten reels of magnetic recording tape and parts for pre-amplifiers have been ordered for use with the 14-track recorder now on order.

Data and talking lines have now been installed to twelve of the gap-filler sites as well as to the N. Truro site. For a complete listing of Cape Cod telephone facilities see Lincoln Laboratory prints #B-1286 and B-1287.

The Foxboro site is now operational and data from this site was utilized during a flight test on February 27. A thunderstorm which took place prior to this flight test is recorded on Tapes #203 and 204 and should make an interesting exercise for video filters.

2.0 EQUIPMENT ENGINEERING (CONTINUED)

(J.H. Newitt)

Coordination of Cape Cod work is continuing. The bulk of the work is now scheduled. So far there are no significant schedule delays. Procurement of needed parts looks good. A considerable amount of parts has arrived and has been allocated. Delivery promises on critical items are now suitable to meet our needs although diligence is required to make sure these promises are met. Control room installation planning is virtually complete and will get underway soon. There are a number of items that must be resolved and scheduled very soon, however. These are:

1. Auxiliary scopes
2. Expanded scope facilities
3. Control room switch and switch panel specifications
4. Wiring schedules for control room facilities
5. Building alterations and special facilities.

I have completed the design of a metal console for the 16" scopes and a prototype of this is being built in the shop. The metal console is based on the approved plywood model which was built anddemonstrated in Room #222.

Detail plans have been devised for making the changeover of the WWI air conditioning equipment. I now believe this can be done without affecting the computer operation.

(C.W. Watt)

A good deal of time has been spent in streamlining materials handling and print distribution procedures to reduce the shop and production control time needed on the various pieces of the Cape Cod equipment. Substantial improvements were made, it is believed.

(G.A. Young, B.E. Morriss)

The MITE for the N. Truro radar data has been installed and connected for direct read-in into the computer. The system was tested by simple programs using test patterns from Barta, Rm. 224. Although the equipment has not yet been connected at N. Truro, data from Rockport and Scituate is available for use with the N. Truro MITE.

The N. Truro MITE operates as follows:

si 400 (octal) - select the unit
rd - place the range and azimuth in AC, if data is available. If no data is available, an order will be skipped in the program.

2.0 **EQUIPMENT ENGINEERING (CONTINUED)**

(G.A. Young, B.E. Morris) (Continued)

The si command may be followed by as many rd commands as desired.

The memo describing the operation of the N. Truro MITE with a five-register buffer storage will be distributed during the next biweekly period. The sketches of this system listed in the last biweekly have been sent to the drafting room.

Means of incorporating Indicator Lights, Insertion Registers, and Scope Displays into the computer are under consideration. General discussions of how these units may possibly operate will be written up as memos and distributed soon.

3.0 **BEDFORD EXPERIMENT**

(D.R. Israel)

To avoid confusion resulting from modifications to our operating programs, the following responsibilities have been established:

a) Four Pair Interception Program - F. Heart
b) Sixteen Aircraft Tracking Program - S. Knapp
c) Combined Interception Program - C. Gaudette
d) Final-Turn Interception Program - C. Zraket

A change in the layout of Room 222 is being considered; F. Heart is coordinating the various suggestions for the change. The revised layout would be a minor modification of existing arrangements and should permit better operating conditions until May or June when installation of the Cape Cod operating center will begin. No action on the current room arrangement will be undertaken until after March 13, the date of the scheduled demonstration for the Kelly Committee.

(M. Brand)

Command Tracking I have completed the command tracking test program and the simulated data input for it. With the exception of a few minor bugs it has operated successfully. The first simulated tape has served to test a majority of the logical loops in the program. It is planned to work out several more data tapes and finally to include this system in the combined (two aircraft) interception program.

(F.M. Garth)

Clock checking and radar calibration are the only remaining sections of the checkout equipment program that are still non-operational. We have reprogrammed both of these and are now awaiting additional computer time. The checkouts which are working are those for the photoelectric tape reader, the three Flexowriter printers, the 16 scope lines, both light guns, the punch, the camera, and the mechanical tape reader.

3.0 BEDFORD EXPERIMENT (CONTINUED)

(F.M. Garth) (Continued)

Take-off initiation at Grenier Air Base has been a part of the combined operations flight tests tried February 24 and 25. A single interceptor take-off was made during each test. For the first the velocity used by the computer extrapolated the fighter's expected position too far ahead of its actual position for it to be accepted within the search area. During the second day's attempt the timing was better, but evidently an extraneous aircraft, flying in the same direction as the fighter, came into the search area and was accepted before the fighter's entrance. Manual initiation had to be used to start the correct tracking.

(F. Heart)

In an effort to obtain a shorter 556 tape, the main interception program (T 2187-9) was punched out. The new tape is being checked, and if found satisfactory, will replace its longer ancestor.

The program using the auxiliary drum to obtain a geography display in combination with the main interception program was tested. again. Although the program operated when using several short lengths of tape, the combined tape gave ambiguous results. Further tests will be made. Apparently there is a possibility of a tape error.

(S.C. Knapp)

The height section of MACT-16 has been checked out with the exception of some minor errors in scope deflections. A modification has been written which allows initiation on the scope showing all data not being tracked, instead of the one showing all data. A new version of MACT-16 where multiple returns are eliminated as they are received has been written but not tried.

I have started work in conjunction with C. Gaudette and L. Murray on subroutines for the Cape Cod System.

I have been thinking about the problem of changing existing programs to work with the N. Truro data to be available sometime in April. It won't be impossible, but I am still trying to find a quick and easy way of adapting the old programs for this data.

(W.Z. Lemnios)

The checkout program has been almost completed. The only portions of the program which have not yet been checked are those which check the clock and the radar data. The other sections of the program work very well.

Work was continued on the effect of target maneuvers during final-phase interception. An analytical solution was obtained of the angle between final interceptor heading and final target position as a function of several pertinent variables. It appears that the most

3.0 BEDFORD EXPERIMENT (CONTINUED)

(W.Z. Lemnios) (Continued)

important parameters affecting this angle are the target speed and the time during which the interceptor is in its final phase approach. The final distance of separation between target and interceptor also becomes important if it is less than a critical minimum distance.

Some of the calculations for the out-of-the-sun final phase interception have been carried out.

(C.A. Zraket)

Due to the unavailability of the aircraft no interceptions using the automatic ground-to-air data link in the Instrumentation Laboratory's F-94 (#486) were attempted during the past biweekly period. An interception of this type is tentatively scheduled for Tuesday, March 3.

The work previously done on interception and final turn interception methods and programs is being written up on inter-office forms in anticipation of relaying this information to W. Lemnios and F. Garth.in order that it will serve as a starting point for their studies in this field.

A conference on Airborne Intercept Radar was attended on February 17 at the Bureau of Aeronautics, Navy Dep't., Washington, D.C.

4.0 DATA SCREENING

(R.L. Walquist)

The program for counting the number of returns per azimuth for the N. Truro CPS-6B was tested with the computer this past biweekly period. After a few modifications, the program operated satisfactorily. Since the phone line demodulators for the CPS-6B were not available, data was fed to the MITE equipment from either the Rockport or Scituate demodulators in Rm. 224. Successful operation of the program indicated successful operation of the MITE equipment.

The data from N. Truro is being delayed because of the lack of phone lines into the Barta Bldg. Arrangements are being made so that data should be available on March 1. Besides the program mentioned above, a PPI display program and antenna speed checking program (both written by W.M. Wolf) should be ready for use with the N. Truro data by March 1.

A memo is being written on the internal storage and computing time allocations for the September Cape Cod System. The internal storage capacity of 32 TS registers and 2016 ES registers (the second bank of ES is to be available on May 18) is used for track-while-scan data storage, a master interpretive program, and one of many subroutines plus necessary track data transferred in from the auxiliary drum.

4.0 DATA SCREENING (CONTINUED)

(R.L. Walquist) (Continued)

The total scan time available for computations is split equally between the TWS and the non-TWS operations.

A study has just been completed of the number of display lines, intervention switches, and indicator light registers needed in September for the TWS function. To tie in to the computer two initiators, two track monitors, and a track-while-scan supervisor requires:

1. About 26 different display lines,
2. About 100 binary digits of intervention switches,
3. About 3 16-digit indicator light registers,
4. Five light guns.

(W.S. Attridge, Jr.)

I have asked John Hughes to investigate the mechanization of a "logical multiply" order. This order was suggested by D. Israel many months ago, and the need for it was somewhat alleviated by the insertion of the cl order last summer. Israel and I now feel that the order would be very useful for the toggle switch input registers to be used in the 1953 Cape Cod System.

Tentative lists of scope display lines, switches, and indicator lights needed for the TWS section of the 1953 Cape Cod System have been drawn up with Walquist and Levenson.

Satisfactory photographs of radar data from the maximum effort flight test were obtained. Much of our operation using this radar data has been hampered by erratic operation of Magnetic Tape Unit #1.

(H. Frachtman)

I have been going over the details of the Muldar Tracking Program #2 and patching up my single aircraft tracking program.

(D. Goldenberg)

The biweeklies dated January 30 and February 13, 1953, will aid the reader in understanding the following summary of my work to date.

The reference plane coordinates of a target can be approximated by the formulae:

$$X = X_0 + (S^2 - H^2)^{1/2} \sin(\theta - \Delta)$$

$$Y = Y_0 + (S^2 - H^2)^{1/2} \cos(\theta - \Delta)$$

4.0 **DATA SCREENING** (CONTINUED)

(D. Goldenberg (Continued)

where X,Y = the reference plane coordinates of the target

X_0, Y_0 = the reference plane coordinates of the radar located at latitude L_R and longitude λ_R

S = the slant range from the radar to the target

H = the height of the target above the earth

Δ = a fixed angle depending upon the geographical coordinates of the radar and the origin of the reference plane.

Errors

a) The quantities X_0 and Y_0 are subject to errors due to the assumption that the earth is a perfect sphere. The estimated maximum error is less that 0.005 miles.

b) The quantity $(S^2 - H^2)^{1/2}$ may be in error by -0.02 to +0.12 miles for the long range radar and $\pm$0.04 miles for the short range radars.

c) The angle Δ is a function of θ but a constant value has been determined by splitting the maximum and minimum value for Δ as a function of θ. This value is

$$\Delta \cong \frac{\sin L_0 + \sin L_R}{2} \lambda_0 - \lambda_R$$

The maximum error, mainly due to choosing Δ a constant, is 0.037 miles for a maximum range of S = 32 miles on the small radar and a range of about 100 miles for the CPS-6B. For the large radar Δ = 0.

Future Work

a) An effort will be made to find the total error and to split it.
b) Plots will be made of the maximum and minimum errors versus the variables.
c) A method will be sought which will enable the cross-telling of the coordinates of a target in the reference plane for one system to the reference plane of another system.
d) An effort will be made to extend the analysis to an earth which is an oblate spheroid.
e) Assuming a homogeneous distribution of targets within a system, a probability distribution of errors will be determined. From this it will be possible to state the percentage of possible targets which will be reported with errors less than a prescribed value, thereby determining a criterion upon which can be based the decision to make approximations (simple and short) or more exact (complex and lengthy) programming calculations.

4.0 DATA SCREENING (CONTINUED)

(J. Ishihara)

Trouble shooting of Data Screening Program #1 continues. The first runs on the computer were plagued by tape preparation errors and magnetic tape unit troubles. Some progress has now been made towards locating program errors. Effort will be concentrated on making the program operational without major changes in program design.

(J. Levenson, H. Peterson)

The last two weeks have been spent in a joint effort to get the Track Monitor Program into final shape. Computer time was scheduled but due to computer trouble and magnetic tape difficulties, it was not known whether the program will operate.

We have been making studies to rewrite the program for the auxiliary drum. The new program will also contain several refinements.

(N.S. Potter)

The study of the altitude quantization levels designed to produce an expected error of less than 1/2 mils in projected range has been finished. D. Goldenberg and I visited Bill Martin of Group 22 in Lexington and obtained information on radar beam characteristics, in particular, high altitude blip-scan ratios, which is at considerable variance with the statistics previously available. I have not had an opportunity to evaluate this new information, but it would seem to have a marked influence upon the nature of the problem.

(H.H. Seward)

A program for displaying magnetic tape data with past history (4 scans) in recurring cycles with expansion and off-center control was tried on the computer and is being modified. A similar program utilizing the auxiliary drum and Truro data has been written and awaits installation of the Truro in-out equipment. This program stores six scans of past history for sequential display, with time intervals and number of scans displayed variable through flip-flop settings.

(W.M. Wolf)

A PPI display program for the Truro radar data was modified for present equipment and was run on the computer. The program was unsuccessful since it assumed at least one radar return for every three "no returns" or 8,192 radar returns per scan. It was found that the returns from the Rockport radar being used as test data enter the computer at a much slower rate (of the order of 2,000 returns per scan). A PPI display program without the above assumption has been written but was not tried; it will be tried in the near future.

5.0 TRACKING AND CONTROL (CONTINUED)

(W. Lone) (Continued)

the aircraft when another one is crossing its path, is working reasonably well. In a number of cases, when the dead reckoning feature was eliminated, the program latched onto the wrong track after crossing, whereas repeating the tracking over the same section of Ampex Tape with initiation in the same place exhibited proper correlation after crossing.

Some flaws still exist in the program. One is the use of linear smoothing to track the auxiliary aircraft after an initial full correction. The other is the acceptance of a double azimuth return as representing two auxiliary aircraft instead of one and hence tracking of one spurious piece of data. The program is being rewritten to correct these deficiencies and the merits of the system will be investigated further.

(A. Mathiasen)

The major portion of the computation of the merits of the two radar tracking methods has been completed.

An initial test of Foxboro data was not satisfactory because of the large amount of cloud clutter present. However, a further test of W. Lone's pattern parameter was afforded. This now appears satisfactory in all respects. Also satisfactory was a test of some information displays that were added to the single radar tracking program.

(H.D. Neumann)

The Bomarc guidance program was run unsuccessfully on the computer. Failure was due to typing of wrong headings on the parameter tapes. These were therefore converted to 5-5-6.

The program was also modified slightly, and it is hoped to run it now successfully. Part of this period was spent investigating thesis suggestions.

(B.R. Stahl)

Two radar tracking with one position, best fit, is definitely operating successfully; a complete set of data tapes has been processed with it, and the resulting data have been given to A. Mathiasen for analysis. The program will now be modified with smoothing intervals of 13 and 16 seconds with prediction being done every 3 1/4 and 4 seconds respectively.

6.0 AIR DEFENSE CENTER OPERATIONS

(D.R. Israel)

The following work has been carried out in connection with the 1953 Cape Cod System:

1. A study of the display requirements for the non-track-while-scan functions has continued. One of the major items under consideration is that of the numbers and symbols to be displayed for various categories of tracks. It is hoped that a fairly definite proposal will be available within several days.

2. Together with C. Zraket, estimates have been prepared of the numbers of various switches which will be needed by the operating personnel in the center. Before these estimates could be made, it was necessary to define responsibilities of various personnel in connection with the interception function. These responsibilities have been compiled in a tabular form somewhat similar to that given in M-1839; they will probably be issued in memo form in the next week.

3. M-1857, "Tentative Floor Plan for Operations Rooms," has been issued. Attached to this memo is a copy of a proposed room layout; this layout is only tentative and may be changed after discussions with members of Group 21.

4. In conjunction with O. Conant, an investigation has been made of the detailed requirements of an intercommunication system for personnel in the centers. A tentative, but detailed, plan for lines and interconnections has been given to J. Arnow. Conant will continue to study the requirements.

5. A small group, consisting of Brand, Gaudette, Heart, Zraket, and myself, are continuing to study some of the overall programming aspects for the non-track-while-scan functions. Meetings have been held with Attridge, Ishihara, and Walquist, and a tentative allocation of the 2048 electrostatic storage registers has been made. Topics currently under consideration are a) the timing of various sections on programs and the allocation of the time periods during each scan; b) general provisions for display; c) use of light guns and intervention registers; d) simulated data programs.

6.0 AIR DEFENSE CENTER OPERATIONS (CONTINUED)

(D. R. Israel) (Continued)

6. During the visit by officers from Air Defense Command last week, the subject of simulated data programs was discussed. In the opinion of Air Defense Command, the use of simulated data to train and exercise personnel is very important. Our present plans for use of simulated data in the Cape Cod Programs will permit two modes of operations: one in which all the non-track-while-scan functions will operate solely with simulated data, and a second in which simulated data could be superimposed upon track data obtained from live radar data. More thought will be given to simulated data parts of the program following completion of the work mentioned in 5) above.

7. Discussions with Capt. Marks (6520th Wing) and Air Force personnel associated with the Quick-Fix program have indicated that our interceptors should be based at Otis and Bedford during the tests later this year. Following further discussions with members of Groups 21 and 22, it is expected that a firm decision can be made on the use of these two airports, and that recommendations for the best sites for gap-fillers and nodding-beam radars will be made.

8. Capt. Bergeson, Navy Liaison Officer at Lincoln, has expressed his desire to cooperate with us in taking photographic records and measurements of our interceptions. He expects to secure some equipment to facilitate this. Capt. Bergeson has also discussed with us the possibility of Navy participation in the early Cape Cod experiments. This may first take the form of using early-warning data from a picket ship off the coast, and may later take the form of using SDV data from a picket ship, aircraft, or blimp.

9. Plans for the use of radio channels for interceptor and target test aircraft are now awaiting decisions as to whether we will use UHF or VHF facilities. A problem arises since the F-89 aircraft which we expect to use will be equipped with UHF, whereas up to the present we have been using VHF aircraft and ground facilities.

6.0 AIR DEFENSE CENTER OPERATIONS (CONTINUED)

(M. Brand)

Display of Techniques Program The display of techniques program written in conjunction with C.H. Gaudette is completed and operates successfully.

Identification Section - Cape Cod System A proposal for and Identification data input console has been drawn up. This console requires sixty digits for data input. I have spent considerable time attending meetings of a committee composed of D.R. Israel, C.H. Gaudette, C.A. Zraket, F. Heart, and myself. This committee has been considering problems of correlation of the various sections of the Cape Cod System. I have worked on the combination of the several sections of the Identification Program in conjunction with simulated track data to provide a simulated identification program.

The flight plan pre-plot board has been received from the Project Lincoln carpentry shop. Upon arrival of the plexiglass "sandwich" sheets, the Cape Cod area map will be installed.

(J.J. Cahill, Jr.)

The first attempt to run a combined three-dimensional interception and AAA guidance mission was performed on February 24. Operationally, the attempt was a success but was not too useful to the AA people or to the programmers interested chiefly in AA operations. The run began well within the 60-mile zone of interest of the AA system and hence was no test of the ability of WWI AA guidance information (transmitted via the AAOC - AA Operations Center) to place the batteries on target as soon as the target enters within acquisition range. The run began in too close because of unexpected difficulties in getting radar returns from the target at the proper starting point. Further attempts will be made in the next period, and care will be taken to choose starting points where radar returns are more certain.

A demonstration was held on February 17 for several officers of the 15th Group, AAA. The writer introduced the visitors to the basic properties of WWI and described in simplified form the technique of Interception and AA Guidance. A successful single-pair three-dimensional interception was shown and a successful single-battery AA guidance mission was flown. Some officers of the 6520th Squadron (Bedford) were also present. AA officers present were:

Col. S. Foote, C.O. 15th Group
Lt. Col. J. Guy, Exec. O. 15th Group
Lt. Col. F.J. Roddy " "
Lt. Col. P. Fronsom " "
Maj. J. Tringoli
Maj. J. DaRosa
Capt. W.J. Sandercook
Capt. P. Hubbel
2nd. Lt. H. Pugh

6.0 AIR DEFENSE CENTER OPERATIONS (CONTINUED)

(J.J. Cahill, Jr.) (Continued)

2nd Lt. J. Johnson, 15th Group
" " R. Ross " "
" " C. Witham " "
" " R. Miner " "

On February 20, an AA guidance mission was run with the AAOC with three batteries in action. All units acquired the target, with D Battery, 605 Bn. (formerly 704 Bn.) acquiring first at 40 miles range.

In the last biweekly, it was reported that during the AA guidance mission the first battery to acquire the target did so at 60 miles range. The range was actually 48 miles, which is the extreme range and is 60 miles from the center of the Gun Defended Area.

On February 17 a Height-Finder Calibration Test was performed to ascertain the effectiveness of recent repairs to the MPS-4. The set worked very well, finding targets at ranges up to 54 miles.

Both height finders are being used during all interceptions, with one man at Barta guiding both sets by means of a conference circuit.

(P.O. Cioffi)

I have completed the preliminary work for the identification action section - that portion which acts on a selected situation for identification- of the main identification program for the 1953 Cape Cod System. I am holding up the actual programming pending some knowledge of overall Cape Cod System program organization and mode of operation.

(O.T. Conant)

The present allocation of telephone lines in the 1953 Cape Cod System, on the basis of direct lines and switchboard lines, is being translated into equipment requirements. Persons concerned with communications within and among the various functions of the Defense Center will be asked to justify all direct lines now allotted, with the intention of minimizing the amount of equipment. Conference calls will receive special attention, since the equipment under consideration allows for only a very limited number of conference lines.

(A.W. Curby)

The first week of this biweekly period was spent on vacation.

During the past week, work has been done on a program to extrapolate flight plans. When a decision on the method of putting flight plan information into the computer is made, it is hoped that this program can be written in final form.

6.0 AIR DEFENSE CENTER OPERATIONS (CONTINUED)

(A.W. Curby) (Continued)

A detailed description of the work of the CTIC and the FPIC has been drawn up, and a form for the recording of flight plan and identification information has been designed.

(C.H. Gaudette)

S. Knapp. L. Murray, and I have started work on a Subroutine Library for the Cape Cod System. As these subroutines are written, they will be issued as an inter-office memorandum. In this interim state, they will be thoroughly checked by computer programs and will be subject to changes that may be suggested by the members of the group. When the subroutines become fixed, the complete library will be issued as a memorandum.

Several subprograms are now written and will be made available during the next biweekly period. S. Knapp and I have slightly modified the Radius Vector Subroutine previously issued in John Salzer's memorandum, E-2018. I have written a new Arctangent Subroutine, and L. Murray is now working on a new Arcsine Subroutine which will use the table needed in R. Walquist's Sine-Cosine Subroutine.

The Demonstration of Techniques Program now appears to be operating satisfactorily. M. Brand will now take over control of this program.

(M. Geraghty)

During the last two weeks two height-finder runs, two AAOC guidance runs, and one combined 3-D intercept with AAOC guidance have been completed. Further combined operations are to be held to gain experience in coordination of interception and AA activities. In addition, I have written a program which incorporates all operations thus far found practicable and desirable in height finder and AA tests. This includes display of r,θ from the three height finders, r in thousands of yards, θ in tens of mils, and $\emptyset$, elevation angle, in mils from any of the AA sites, and georef print-out and scope display together with altitude and altitude freshness display. It is hoped this program will prove useful as a guide in the Four-Aircraft Height Finding and AA Guidance Program, soon to be written using S. Knapp's Multiple Aircraft Initiation and Tracking Program as model and guide.

(F. Heart)

Some time was spent considering mdofications to the layout of equipment in Room 222, Barta.

The problem of acquiring weather information for the Cape Cod System was studied. A visit was made with Capt. Sullivan to the Bedford Weather Station. An inter-office memo on this subject was written and is available from D. Israel or myself. Specifically

6.0 AIR DEFENSE CENTER OPERATIONS (CONTINUED)

(F. Heart)

recommended was a direct phone connection from Barta to the Bedford Weather Station.

Continued effort was put on acquiring aerial photographic recording of flight tests. Cameras were rented from Gelotte's (Boston) on two occasions, in addition to using a Lincoln camera, mentioned in previous biweeklies. No action has yet occurred regarding the request, by 6520th Wing, for USAF photographic support.

The cost of renting a 16mm camera with associated lenses is about $11.00 per day. The cost of purchasing an equivalent camera (hand-held, 16mm with 6" telescopic lens) varies from $350 to $625.

(L.J. Murray)

During the past biweekly period I have been assisting C. Gaudette and S. Knapp to compile and revise standard subroutines for the Cape Cod programs.

(F.A. Webster)

Work is being continued on the communication lines between persons in the September system. A drawing showing the distribution of probable individual lines has been made. This drawing is now being revised in order to permit a study of the message loads on these lines under conditions of simulated attack.

(C.A. Zraket)

The major part of the past biweekly period has been spent in conferences with members of the group discussing the programming and equipment requirements for the 1953 Cape Cod System. The allocation of Electrostatic (ES) Registers, the major programs required, and the switch inputs needed for the system were under discussion. The time compatibility of the major programs during the radar frame was also analyzed. At the present time, a study is underway of the programming requirements for acceptance of information from the insertion registers whose contents are set up via the console switch settings and buttons.

7.0 ASSOCIATED STUDIES

(E.J. Craig)

A rapidly converging iteration procedure for a set of n non-linear equations has evolved from the n-step procedure discovered for linear equations. In 2n steps, in one example, I obtained the answer within 5%.

7.0 ASSOCIATED STUDIES (CONTINUED)

(E.J. Craig) (Continued)

It remains now for me to demonstrate the usefulness of these methods, as well as to make an error-analysis resulting from round-off errors.

(B.G. Farley)

Thus far, a considerable portion of my time has been spent reading reports and memoranda to acquire a general knowledge of operation and organization of digital computers and the fundamentals of their programming.

Considerable time has also been employed reading to get an idea of the general objectives of Lincoln and the computer project in air defense.

Consideration is now being given to problems concerning utilization of actual radar data by the computer.

In addition work is going forward on a mechanism of pattern recognition and association, which it is hoped will eventually prove amenable to calculation, programming or instrumenation.

A small amount of consulting with other members of the staff on transistor data and problems has been carried on, resulting in a memorandum with D.J. Eckl presenting the specifications on the Bell M-1734 transistor and their genesis.

(W.I. Wells)

This period has been spent studying the characteristics of random noises that occur in different systems. It is desired to find a description of these noises that will be more useful than that given by the "Power Spectrum" approach.

In addition some time was spent investigating a scheme of tracking which will reduce the loss of aircraft during turns. It seems that with the addition of a small complexity to the present smoothing program we can cut this loss by an appreciable factor. A memo is being prepared on the subject.

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	16 hrs 35 min
Magnetic Tape	5 hrs 15 min
Data Screening	7 hrs 30 min
Multiple Radar Tracking and Control	11 hrs 30 min
Air Defense Center Operations	5 hrs 20 min
Indoctrination Programs	1 hr 5 min
Calibration	2 hrs 35 min
Equipment Characteristics	2 hrs 15 min
Visitors and Demonstrations (included in Flight Tests)	
Miscellaneous	1 hr 15 min
Total Time Used	53 hrs 45 min
Time Lost to Computer (Parities, etc.)	4 hrs 45 min
Time Transferred to Magnetic Drum	5 hrs 20 min
Time Not Used (Turned over to Math Group)	2 hrs 30 min
Total Assigned Time	66 hrs 0 min
Percentage Assigned Time Used	81.3%
Percentage Available Time Used	96.0%

(F. Heart, M. Brand)

The following statistics apply to the last biweekly period:

1. Computer hours scheduled for flight tests	22 hrs 0 min
2. Computer hours used for flight tests	16 hrs 35 min
3. Computer hours returned due to flight test cancellation	5 hrs 25 min
4. Total aircraft hours flown	29
5. Aircraft hours flown by 6520th Wing at Bedford	23
6. Aircraft hours flown by Navy (Quonset-based squadron)	4
7. Aircraft hours flown by M.I.T. Instrumentation Laboratory	2

8.0 COMPUTER OPERATIONS (CONTINUED)

(C.A. Zraket)

The following programs were used in the demonstration for the officers from the Air Defense Command (ADC) on February 25, 1953.

1) Combined Interception Program (T-2187-15)
A live interception with the use of the automatic ground-to-air data link was attempted. A program modification nullified use of the data link. Final separation of interceptor and target was 800 yards. The height finder operated normally.

2) Multiple Aircraft Tracking and Initiation (T-2109-15)
Live data from the Bedford MEW was used.

3) Two-Radar Single Aircraft Tracking (T-2087-10)
Live data from the Scituate and Rockport radars was used.

9.0 FLIGHT TESTS

(P. Dolan, A. Hill)

February 17, 1953, 1000-1200, 3 Dimensional Intercepts, Gaudette.

B-25 #893 Fighter over Concord 8,000' IAS 225.
B-25 #857 Target at Plymouth 9,000' IAS 190 Vector 010 Magnetic.
F-3D (Navy) Camera Ship.
Separation: 8000 feet vertical and zero feet lateral.

February 17, 1953, 1400-1600, Height Finder, Cahill.

Two B-25's were used for this test. Results were satisfactory and the targets were picked up as far away as 54 nautical miles from the height finder.

February 18, 1953, 1000-1100, Coverage, Mathiasen.

A B-25 was used for this test, flying between Rockport and Scituate. Results were satisfactory.

February 18, 1953, 1100-1200, Two-on-One Intercepts, Knapp.

Two jets were used as interceptors, F-80 and T-33, with a B-25 as Target.
F-80 jet started from Kennebunk, intercepted first, and passed 1500' to rear of Target.
T-33 started from Concord, intercepted Target, and passed 1/4 mile to rear.

February 20, 1953, 1300-1430, AAA, Cahill.

Used a B-25 #423, holding Portland at 15,000', vectored towards Boston. One run completed successfully.

9.0 FLIGHT TESTS (CONTINUED)

(P..Dolan, A. Hill)

February 20, 1953, 1430-1600, Two Aircraft Tracking, Lone.

B-25 #423 and B-17 #8635 used for tracking with satisfactory results.

February 24, 1953, 1000-1200, Two Aircraft Intercepts, Gaudette.

Used jet T-33 as Fighter (scrambling from Grenier) and Navy F-3D as Target. One run made, T-33 passed at nine o'clock to Target; 3000' separation.

February 24, 1953, 1400-1500, Coverage, Mathiasen.

Used a C-47 on this test, results generally not satisfactory.

February 25, 1953, 1000-1200, Two Aircraft Intercepts, Zraket.

B-26 #898 was used as Fighter (with Data Link), B-17 #8635 used as Target (with camera)
Program trouble on data link, completed intercept using voice radio. Fighter passed about 800 yds. to rear of Target.

February 27, 1953, 1300-1430, Coverage Test

Used B-17 #9281 and tracked same for about thirty minutes with some interference due to storm conditions in area. Computer not used.

DATE	TIME	SCHEDULED TEST A/C	SCHEDULED TEST Description	TEST ACTUALLY RUN A/C	TEST ACTUALLY RUN Description	REASONS FOR CHANGES OR COMMENTS
2/17	1000-1200	3 a/c	Two Aircraft Intercepts with Data Link	3	Held without data link	Aircraft with Data Link not available
	1400-1600	2 a/c	Height Finder	2	As Scheduled	
2/18	1000-1100	1 a/c	Coverage	1	As Scheduled	
	1100-1200	3 a/c	Two-on-One Intercepts	3	Made on good run	Target aircraft returned to base - radio trouble
2/20	1300-1430	2 a/c	Take-Off Initiation	1	Held AAA Test	Grenier weather caused change in plans
	1430-1600	2 a/c	Two Aircraft Tracking	2	As Scheduled	
2/24	1000-1200	2 a/c	Two Aircraft Intercepts	2	As Scheduled	
	1400-1500	1 a/c	Coverage	1	As Scheduled	
2/25	1000-1200	2 a/c	Automatic Intercepts with Take-off Initiation and Height Finder	2	Did not use automatic data link	Did not use data link due to program trouble.
2/26	1400-1600	4 a/c	Height Finder	-	Cancelled	Weather
2/27	1300-1430	1 a/c	AAA Test	1	Held Coverage Test	AAA Battery not available

* Added to schedule during week of test

WHIRLWIND II

(H. Boyd)

High-speed (5965) flip-flop. Two E notes (E-525 and E-526) were written to describe the high-speed (5965) flip-flop. E-525 outlines the procedure used in designing the flip-flop and is entitled "The Normalized Flip-Flop Chart." E-526, entitled "High-Speed (5965) Flip-Flop," is a collection of test data on the flip-flop, and contains such things as PRF response characteristics, marginal checking data, and counting characteristics.

Low input-impedance diode-driving flip-flop. This flip-flop was designed to drive diode gates and logic and is similar to the high-speed (5965) flip-flop recently designed. This flip-flop, exclusive of the triggering circuits, will be used for the flip-flop portion of the high input-impedance diode-driving flip-flop.

The flip-flop was designed to have less than 0.2-μsecond rise and fall times, to have output levels of 0 to +5 and -30 to -35 guaranteed, and to operate at 2 megacycles. A second design was necessary to meet all of the above requirements, and initial tests on this unit give slightly better results than necessary. Reliability tests and marginal checking tests are yet to be made.

If the flip-flop passes its tests, the circuit will be turned over to Basil Remis for adaptation to his high input-impedance diode-driving flip-flop.

(S. Bradspies)

Buffer Amplifier. A Class C buffer amplifier is to be investigated. Its purpose is to amplify the power content of pulses. The expected input pulses will vary in width from 0.08 to 0.12 μseconds and will vary in height from 15 to 30 volts. It is desired that the ringing be kept to a minimum and that the positive overshoot be kept below 2 volts. The voltage gain of the amplifier should be of the order of magnitude of unity.

(W. Clark)

On February 25 and 26 the Laboratory was visited by B. L. Sarahan, W. H. Thomas and G. Stierhoff, all of Project High, and current thought on the command organization of an air defense sector was presented. At a subsequent meeting, attended also by R. P. Mayer, the WWII order code format was discussed. Because of the

WHIRLWIND II (CONTINUED)

added complexity of verbalization when the "right" or "left" arithmetic element must be specified, it has been difficult to compose an order code nomenclature which is reasonably self-consistent and at the same time mnemonically meaningful. Work on this has now progressed to the point of "freezing" the format during the next period.

In answer to certain questions concerning specifications which have appeared in connection with a particular coordinate converter being considered by Briggs, Linvill, and Rising, a memo has been prepared and will be issued shortly. In it, it is pointed out that programmed coordinate conversion in WWII would probably require only 1% of the machine cycle. This seems to be the principal argument against coordinate converters, and it would appear that development work on conversion equipment might more suitably be redirected toward the replacement of PPI equipment so that it would be possible to monitor and map radar data with ordinary x-y scopes. The number of bits for this job is considerably smaller, perhaps 5 or 6. (In this connection, a study program has been written which will degrade the WWI scope deflection decoders to a preset number of digit stages. It is currently awaiting machine time).

(C. Grandy)

During the past bi-weekly period I have undertaken a study of the display categories that could be used in the proposed coincidence display system for WWII. Information sought in this study includes the following: the exact number of coincidence digits required for each category; the utility of each category and sub-category (utility being the ratio of the number of useful displays to the total number of displays); the percent of the total aircraft a selection in each sub-category will display; the percent of noise reduction afforded by each sub-category. Two different groups of categories have been examined and the above information tabulated. A representative result is Speed with a utility of 0.46. Sub-categories Subsonic and Supersonic have utility of 0.60 and 0.97; percents of total aircraft 54% and 46%; and percents of noise reduction of 46% and 54% respectively.

In addition to the above-listed information it is hoped that this study will enable us to make a selection of the best combination of categories for use in a coincidence display system with WWII. Also, certain combinations of sub-categories may be sufficiently useful that they should be made prime categories and displayed by the operation of a single switch. The study indicates that displays made by combining more than three categories need be used only rarely (the utility of combinations of four categories is about 0.20, and the utility of combination of five categories is about 0.04). Furthermore,

WHIRLWIND II (CONTINUED)

the information at hand indicates that a coincidence display system (regardless of which categories are included) of eight to ten categories has an overall utility of 0.25. This means that 75% of the displays such a system affords are not useful in the air defense system.

During the next bi-weekly period I hope to complete the analysis and reach some conclusions concerning the best combination of categories and special sub-category combinations. In addition to this information it seems advisable to examine the coincidence system for ways to save equipment and ways to improve the overall utility of such a system. It seems costly to provide coincidence circuits for the system which gives an output only one-fourth useful.

(J. Hayase)

During the past bi-weekly period efforts have been directed toward acquiring a background to compile a master control program for the transition air defense system that brings in the correlation program, smoothing program, interception programs, etc., for the auxiliary drum into high-speed storage. Flow sheets of various programs for the Cape Cod system are being collected so that the Cape Cod master control program can be extended to the transition air defense system.

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

WWII arithmetic element. The survey of possible arithmetic elements for WWII has been continued. We met with Ross, Crawford and Rocket of IBM and decided, with them, on a group of five arithmetic elements for intensive study and evaluation by both groups. We agreed on a common set of weights for different kinds of equipment, e. g., two pulse mixer diodes = one logical (d-c level) diode. A meeting with the IBM group during which a single arithmetic element will be decided upon has been scheduled for March 9 or thereabouts.

(C. Laspina)

Level Amplifier. Methods for resetting d-c levels in the carry line of an adder are being investigated. One method now being analyzed involves modifying a high-speed flip-flop (E-526) to trigger on d-c levels instead of standard 0.1-μsecond pulses.

WHIRLWIND II (CONTINUED)

(H. Platt)

Gate Tube. Investigation of the gate tube circuits continues. Many interesting facts are being learned, but no conclusions can be drawn now.

(G. Rawling)

The previous period was spent in setting up a chronological flow sheet for the employment of Point Defense Weapons and attempted integration into the Transition Phase of the Air Defense System. Various reports* pertaining to this type of defense were examined.

Weapon systems considered may be of the guided missile type, both ground controlled and of homing types of the future; barrage defense by guns and unguided missiles; and low altitude defense.

Preliminary considerations must include type and amount of equipment for control; relation of the Antiaircraft Operations Center at the Point to the Sector Air Defense Center; feasibility of centralizing control computers, and communication circuits necessary.

At the present time two different schemes are conjectured, but ultimate choice appears dependent on technical development in the fields of weapons and radar.

(D. Shansky)

Memory plane drivers. Investigation into x-y plane memory driver circuitry is continuing with a view toward evaluating different selection techniques, coupling methods, and current control schemes.

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* "Study of a Multi-Weapon Automatic Target Battery Entry Evaluator for Use in a Coordinated Defense System," Burroughs Quarterly Progress Report, November 30, 1951.

"A Multi-Weapon AA Defense System Employing Guided Missiles, Rockets and Guns," Report #35, Signal Corps Engineering Laboratories, 1951.

"Study of a Coordinated AA Defense System," Moore School, University of Pennsylvania, June, 1950.

"Guidance Control and Accuracy of Defensive Guided Missiles," Rand #629.

WHIRLWIND II (CONTINUED)

(J. Woolf)

Delay lines. An investigation of the use of the gate tubes and trigger amplifiers in driving delay lines is under way. The delay interval to be considered will be from 0 to 2 μseconds. Both lumped constant and distributed lines will be considered.

(H. Zieman)

WWII terminal equipment - display 'scope deflection amplifier. The new deflection amplifier, as originally designed, has been found susceptible to ground currents. The susceptibility is a function of both the position control and the gain control.

A balanced input impedance has been substituted and has practically eliminated the dependence of the susceptibility on the position control. With the gain control in minimum gain position, the circuit can now be adjusted to have negligible response to a two-volt common signal, regardless of the setting of the position control.

However, the response to the two-volt ground signal still becomes objectionable as the gain control is varied to the maximum position. Since the gain control operates by controlling the amount of feedback, it is hoped that a more carefully balanced feedback system may reduce the susceptibility to an acceptable level.

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. "Tentative Floor Plan for Operations Rooms," M-1857 (Supplement to M-1815), D.R. Israel, February 17, 1953, pp.1-2.
   CONFIDENTIAL

2. "Air Defense Biweekly Report, February 13, 1953," M-1859, pp. 1-31.
   CONFIDENTIAL

3. "Pulse Delays," M-1865, J. Woolf, February 25, 1953.
   CONFIDENTIAL

4. "March Flight Test Schedule," M-1870, A.P.Hill, P. Dolan, F. Heart, February 26, 1953, pp. 1-2.
   CONFIDENTIAL

5. "Project Lincoln 15 March Quarterly Progress Report," M-1873, J. Ulman, Jr., February 27, 1953, pp. 1-2.
   CONFIDENTIAL

TECHNICAL REPORTS

1. "Electromagnetic Radiation from Rocket Motors," C.D. Hendricks, Jr., A.B.C. Anderson, U.S. Naval Ordnance Test Station, November 25, 1952, Lib. No. 2291C. (Abstract).
   CONFIDENTIAL

2. "The NOTS Integral Flight-Termination Command Receiver Model 2 Mod 8," S.D. Warner, U.S. Naval Ordnance Test Station, October 21, 1953, Lib. No. 2290C. (Abstract).
   CONFIDENTIAL

3. "Integrated Fire-Control System for Terrier," Project Terrier, December 1952, Radio Corporation of America, Lib. No. 1951C. (Abstract).
   CONFIDENTIAL

4. "Radar Interceptor," Monthly Newsletter, Research and Development Laboratories, Hughes Aircraft Company, February 1, 1953, Lib. No. 1763C.
   CONFIDENTIAL

5. "The Aerodynamic Characteristics of Fin-Stabilized Rocket Models With Oversized Heads," Part 4, MACH Number 2.87, U.S. Naval Ordnance Station, October 17, 1952, Lib. No. 2043R.
   RESTRICTED