Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: AIR DEFENSE BIWEEKLY, January 30, 1953

CAPE COD

1.0 GENERAL

(J.A. Arnow)

A conference concerning the distribution of the first pre-production models of the F-102 was attended at WADC in Dayton, Ohio. It does not appear likely that an F-102 with the MX-1179 System will be available for use by the Lincoln Laboratory before 1955.

(D.R. Israel)

A group associated with the development of the Army's 414 System visited the laboratory on January 28. The material of TM-20 was discussed with the group as were plans for possible future coordination between the Signal Corps Engineering Laboratories and the Lincoln Laboratory. A demonstration of several flight test programs was made for the group (see Section 8).

(R.L. Walquist)

On Wednesday, January 28, the following people visited the laboratory to discuss with us our use of ground-to-air data links:

Mr. M.C. Spies, Lt. H. Gorman from BuAer;
Mr. J. Riccabono from NRL;
Mr. S. Levine from BuShips;
Mr. H. Bisschop from ARDC;
Lt. Col. H.B. MacWhirter, Major Eldrich from USAF;
Mr. Seigfried Rieiger, Mr. Weiant Wathen-Dunn,
Mr. E.B. Staples from AFCRC.

Discussion centered on our present and proposed use of the data link designed by Staples' group. A "canned" interception which used the automatic transmission of heading instructions to the interceptor over the CRC VHF data link was shown.

2.0 EQUIPMENT ENGINEERING

(H.J. Kirshner)

"North-Mark" circuits have been added to Halibut and Scituate terminal equipment so that an indication of when each antenna passes through north may be read into the computer. This indication will appear as a "1" in digit seven of the flip-flop storage by means of a toggle switch in Room 224.

2.0 EQUIPMENT ENGINEERING (CONTINUED)

(H.J. Kirshner) (Continued)

Modifications to Scituate terminal equipment to provide facility for the incorporation of a photocell masker ("radar mapper") have been completed.

Adjustments have been made to the Bedford terminal equipment which should make the converted data more error-free.

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

Work on the video mapper for the five-inch scope was halted temporarily in favor of work on the video mapper for the 16-inch scope which will be used with the N. Truro data. Most of the planning for the Truro mapper has been completed. A cabinet for the scope and a hood for mounting the phototube are being constructed. The necessary power and video cabling is on order. The circuitry is being designed and will be built up as expeditiously as possible.

(F. Sandy)

The modifications and changes have been written to bring our records up-to-date on the power and power supply control for the buffer drum equipment in Room 156.

Rack L15 has been removed from the MITE (Multiple input terminal equipment) control and is now controlled by the Auxiliary Drum Control. L15 is to be used exclusively with the Auxiliary Drum. The filament power is fed from the Auxiliary Drum Filament bus. The DC power is obtained from the Whirlwind buses, but is switched on and off by the Auxiliary Drum Control.

(B. Morriss, G. Young)

As discussed in the last biweekly report, the installation of equipment for the N. Truro radar data will take place in three phases:

1. The terminal equipment (MITE) for the N. Truro radar data will be connected directly to the computer through the in-out system.

2. A flip-flop buffer storage will be placed between the terminal equipment (MITE) and the computer to allow temporary storage of several radar returns. Similar storage will be provided for radar data from two smaller sets.

3. Connection will be made through the buffer magnetic drum, as previously proposed.

The method of connecting the MITE equipment for the N. Truro radar data directly to the computer has been agreed upon. A note is being written to describe the operation of the MITE equipment in general

2.0 EQUIPMENT ENGINEERING (CONTINUED)

(B. Morriss, G. Young)

and the operation when directly connected to the computer in particular.

An informal note listing and discussing some of the ways that a small buffer storage might be constructed for the second phase of the N. Truro installation was prepared and discussed with interested parties. No decision was reached, but a decision should be forthcoming during the next biweekly period if schedules are to be maintained.

(J.H. Newitt)

The past biweekly period has been spent in detailed scheduling for the September Cape Cod System. Considerable progress has been made. Decision dates have been set up for the controversial sections and scheduling has proceeded based on such dates.

The schedule is within the realms of possibility but is very tight and will require the utmost cooperation from everyone concerned. Group leaders and other supervisors will be furnished with complete copies of the schedule while others will be furnished with sections pertinent to their activities.

The importance of reaching decisions at the time indicated cannot be too strongly stressed. The many steps that must necessarily follow a decision are difficult to compress into less than a 3-month period in most cases. This means that all decisions involving equipment must be made before Feburary 15 (except for minor modifications).

Another item of importance is the initiation of the construction requisition. Planning for shop time and procurement of parts must be done at the earliest possible time that rough details are known. Some procurement items may take several months and a late definition of parts may either result in the need for engineering compromises or a failure to construct when required.

The schedule progress will undergo daily checking. All engineers are urged to make sketches suitable for construction on one-of-a-kind items so that the drafting load will be eased as much as possible. Arrangements have been made with production control and the shop to work with informal documents.

3.0 BEDFORD EXPERIMENT

(M. Brand)

Command Tracking. I have worked in conjunction with C.A. Zraket on the formulation of a new type of tracking to be known as command tracking. This method of tracking is essentially an extension of the previously tested system known as aided tracking. This new system defines what is called an acceptable heading change. Only acceptable heading changes are transmitted to the pilot for execution. The effect

3.0 BEDFORD EXPERIMENT (CONTINUED)

(M.I. Brand) (Continued)

of this type of tracking is to reduce by a large factor the amount of communication between the computer and the aircraft. The smoothing method as in aided tracking resolves itself into computation of x and y velocity as trigonometric functions of known interceptor speed.

(F.M. Garth)

The first of two automatic initiation flight tests was run on Friday, January 23, between 1300 and 1400 hours. Due to program trouble and the fact that the observing aircraft was flying high enough to be initiated upon instead of the intended interceptor, the operation was unsuccessful.

A week later, by the use of direct telephone communication between the computer and Grenier Air Base, the need of an observer in a second aircraft was eliminated. Two take-offs by an F-51 resulted in desired automatic initiation. For the first time, the GOC Control Box was successfully used to put the computer in standby, airborne, and return-to-base modes. This aided considerably in the operation.

W. Lemnios and I are awaiting computer time to run the equipment check-out program we prepared to be used by technicians before a flight test. To go with it we have written a scope calibration parameter. At present we are encountering difficulties with a second parameter which will permit calibration checks of the Rockport, Scituate, and Bedford radars.

(F. Heart)

Work has continued on consideration of the September Cape Cod System; my effort has centered on displays and output information.

With other members of the group, time has been spent on the four-pair interception program and on automatic initiation of ground-based fighter aircraft at Grenier airbase.

With W. Lone and C. Zraket, I spoke to Major Smith of the 6520th Wing about problems of indoctrination for Hanscom Field Air Force personnel who are interested in our flight test operations.

(C.H. Gaudette)

The Combined Interception Program has been modified to provide the correct coded heading instruction to the VHF ground-air automatic data transmission link and to eliminate all but one program counter end carry per scan. In addition the program now stops sending heading instructions via the VHF ground-air link as soon as the separation between the two aircraft is less than one and one-half miles.

3.0 BEDFORD EXPERIMENT (CONTINUED)

(C.H. Gaudette)

Sue Knapp and I have written a program which attempts to eliminate the effect of multiple returns from the MEW by replacing them with an average value of these multiple returns. If a range is the same or differs from either (or both) of the two previous ranges by one mile, it is considered to be a multiple return. The program displays the unfiltered data on the left half of the scope and the filtered data on the right half of the scope.

The Demonstration of Display Techniques Program has been written; it is now in the trouble-shooting phase.

(S.C. Knapp)

The Four-Pair Intercept Program has been run on the computer with fairly encouraging results. The displays looked pretty good, and although there were errors, many of the sections seemed to be working well. Further work was held up, however, because of the increasing difficulty with multiple returns in connection with the sixteen aircraft program. In some cases, a double return on some aircraft would result in the program tracking it twice. This continued to happen even though the program was supposedly designed to take care of this possibility. Although we still don't know exactly what was going wrong, A. Ward, C. Gaudette, and I worked out a method which seemed to eliminate the trouble for the time being. However, it was felt that further study of the problem might bring about a more satisfactory solution. We have written a display program which will show the extent to which multiple returns occur and to which they can be eliminated as the data is received.

(W.Z. Lemnios)

Tapes were obtained for the in-out equipment check-out program which was written with F. Garth. It is hoped that computer time will be available during the week of February 2 which will enable us to test and finish this program. Upon completion of the program a short note will be written describing in detail what the program checks.

Studies were begun for the writing of a program which will solve the interception equations when several interceptions are to be carried out simultaneously.

(C.A. Zraket)

A visit was made on Monday, January 26, to the Naval Air Squadron located at Quonset Point, R.I., and currently attached to Project Lincoln. Group 61 activities and flight test requirements were discussed. At present, two F-3D jet fighters and one P2V twin-engine patrol bomber are available for our use. An inter-office memo addressed to D.R. Israel has been written describing the results of the discussions.

3.0 BEDFORD EXPERIMENT (CONTINUED)

(C.A. Zraket) (Continued)

A flow diagram for a Command Tracking program has been completed with M. Brand. In general, this type of tracking utilizes the known speed and heading of the interceptor in the smoothing equations for the purpose of obtaining the velocity components. M. Brand and I are currently checking the proposed program with C. Gaudette.

C. Gaudette and I have modified the Combined Interception Program to shut off the data link heading angle when the interception is imminent (1.5 mile separation). The use of the data link angle can be brought back again at the discretion of the operator via a switch (FF) setting.

4.0 DATA SCREENING

(R.L. Walquist)

A tentative time schedule has been drawn up for the programming activities of the Data Screening Group through June, 1953. It is hoped that the other groups will do likewise so that any programming bottlenecks can be rectified.

Installation of the N. Truro SDV demodulator equipment in the Barta Bldg. was scheduled for February 1. This installation is being delayed since the necessary telephone lines are not yet installed. It is hoped that the equipment will be in by February 9. As soon as possible following this installation, a radar mapper and data analysis programs will be operated in order to give information on the characteristics of the data to be expected from this set.

Some study has been made with J. Arnow of the track-while-scan function to be performed in the September Cape Cod System. Tentative lists of the equipment needed by the various men in the system have been made.

(W.S. Attridge)

After a fourth cancellation, the maximum effort flight test was rescheduled and run off on January 27. Very good tracks, including several crossing tracks, were recorded. However, the Rockport radar gave an excessive amount of clutter.

During the next biweekly period, processing of the accumulated data will be started with Data Screening Program #1.

A proposal was made to Ben Morriss for a type of buffer storage for use with the Truro radar. It would require about half as much buffer storage as other proposed systems would need. Its drawback is that the computer program would require sensing operations about nine times as often or about every 100 orders. I am of the opinion that resulting programming difficulty would not be too serious.

4.0 DATA SCREENING (CONTINUED)

(W.S. Attridge)

Ishihara and I, in consultation with Walquist, have drawn up a work schedule for the Data Screening Group through July 1.

Dick Jeffries has asked for my opinion concerning the use of two of the proposed three B-boxes to carry out the multiplication operation in WWII. I feel that only a very small amount of extra programming would be necessary in a few instances and in the majority of cases no inconvenience whatever would result.

(D. Goldenberg)

All of this biweekly period was spent on the problem of determining the errors in the positions of a target as reported by two or more radars due to the curvature of the earth. Before attacking the main objective, which is to establish some reference plane and a system of projection of the radar site coordinates onto this plane, three questions were investigated and their answers found.

1. The true shape of the earth is an oblate spheroid. If we assume it to be a sphere, are the errors which are introduced into the calculations of distance on the surface of the earth of sufficient magnitude so as to prevent this assumption from being made? Investigation, based upon the dimensions of the earth and the definition of the nautical mile, proved that the assumption will introduce a maximum negative error of 0.038% near the latitudes of the Cape Cod System. For the Cape Cod System, the errors are sufficiently small to validate the assumption that the earth is a sphere.

2. If the slant range is assumed to be the ground range distance to a target, errors are introduced into the calculated position of the target. Would the effect of the earth's curvature and a projection system increase or decrease these errors? Investigation showed that these effects would be negligible in increasing or decreasing the errors and therefore, it would be necessary to make the correction of slant range to ground range.

3. Assume the earth a sphere and that it has been projected by radial lines onto a plane tangent to the earth at the radar set, and that the slant range, S, and the height above the earth, H, are known. What is the form of the expression for determining the position of the target in the tangent plane, when the radial projection is made? It was found that the distance from the radar to the target can be found with a maximum error at S = 256 miles of 0.05% by the expression: Distance = $\sqrt{S^2 - H^2}$. For smaller values of S, the percentage error is less.

4.0 DATA SCREENING (CONTINUED)

(J. Ishihara)

Preliminary study of using data screening programs with "live" Truro data and coordinating with the proposed ADC operations continues.

Records of the "maximum effort" flight test of 27 January 1953 have been combined into usable form for data analysis.

(J. Levenson)

The past two weeks have been spent designing and programming for a Track Monitor Display. There is difficulty in bringing man and the computer together in a tracking program, since the computer usually cannot detect "trouble situations" far enough in advance to allow the man to decide on a course of action and convey it to the machine. The procedure I have chosen for coordinating man and machine is as follows:

When the computer detects a "trouble situation" it acts on it immediately, but notifies the Track Monitor through a visual display that something unusual has occurred. This enables the monitor to determine whether the action taken by the computer covered the situation correctly, and to correct it if wrong. Thus, if a track has picked up the wrong identity in crossing another track, its number can be changed with the light gun. If the tracking program loses a track, the monitor can locate it, reinitiate on it giving it the old track's status and identity, but giving it a new speed and heading.

The computer will handle tracks in clutter by dead-reckoning them on a scan-to-scan basis, but the monitor may see more clutter in the future course of the track, and inform the computer so it dead-reckons for a fixed number of scans.

The actual programming has not been completed, and the final choice of display and action will be dependent on time requirements of the program.

(N.S. Potter)

In reference to the investigation of quantization levels in altitude for muldar tracking, extensive calculations have shown that aircraft tracks need only be sorted in three fixed levels, in each of which a median altitude is selected and assigned to all appropriate tracks. With a maximum anticipated altitude of the order of ten miles, and nodding beam antennae possessing a maximum inclination of $20^{\circ} \pm 2^{\circ}$, the altitude levels which were selected yield a mean expected error of less than 1/2 mile in range. This procedure circumvents the need for obtaining and processing highly accurate altitude information.

4.0 DATA SCREENING (CONTINUED)

(N.S. Potter) (Continued)

A detailed report containing the preceding results in considerably more general form as well as relevant properties of the mean and absolute errors will be available very shortly.

(H.H. Seward)

A program is now being considered in which small box areas may be selected from the field of radar coverage and enlarged on another scope line for the initiator's view. The returns falling within this box area are then stored and retained for from 3 to 6 scans. These returns are displayed in cycles from the earliest to the latest scan with 1/2 to 3-second intervals between each scan. A light gun would be used to initiate on any of the returns, after which the return is then correlated with all following scans of data up to the present. If initiation is done on the earlier returns in the area, the resulting track may be considered an established track, eliminating the initiated status in track storage and smoothing and prediction.

(W.M. Wolf)

Two programs have been written within the last biweekly period with the following purposes in mind:

1) to calibrate the present camera-scope equipment so that certain photographic criteria may be set up,

2) to display and photograph random points with associated random velocity vectors and words or combinations thereof. These will be useful in determining scope display saturation conditions.

The above mentioned programs were written at the suggestion of W. Clark. They are in the process of "checking out."

Another program has been started concerning the display of returns from a radar set which will receive the range in half-mile increments.

5.0 TRACKING AND CONTROL

(S. F. Best)

A program to test the accuracy of a version of the sin-cos subroutine labeled A-36477 and described in E-2018 has been completed.

Tapes for the following two programs have been prepared:

1) T-2365, a program to simulate crossing tracks assuming quantization in x,y.

2) T-2366, a program to simulate aircraft tracks and determine suitable linear smoothing coefficients for the velocity heading smoothing method.

5.0 TRACKING AND CONTROL (CONTINUED)

(M. Frazier)

The Bedford-Rockport Two-Radar Single-Aircraft Tracking Program was operated during the flight test of January 30. Certain refinements were indicated to increase the utility of the program; notably, display of one quadrant of the MEW (including Rockport), non-linear smoothing, and velocity vector display. It is not anticipated that highly sophisticated treatment of the problem of non-linear smoothing parameter variation for radar data of differing quantization will be necessary.

The calibration and equipment characteristics programs mentioned in the last biweekly have not yet been run. It has been suggested that a scope calibration program capable of handling quadrant display would be useful. It will be written as soon as information is received on precisely what is desired.

(W. Lone, A. Mathiasen)

The work of standardization of certain common programming and operating features of two-radar programs has progressed further than expected and has taken longer than anticipated. This has been due to the uncovering of new problems and the discovery of solutions. It is now planned to consider one, two, or three radars. In connection with this, a short routine has been written which will compute the coordinates of any two or three radars (whose general coordinates are known) with respect to an origin which will permit full scope utilization. Appropriate scale factoring is included. Decisions have been made on the use of scope lines, light gun digits, flip-flops, parameter tapes, start-over point, and certain ES storage registers. The purpose in this connection has not been to restrict the programmer to a dull stereotype but to make operators interchangeable parts in the system, i.e., to enable anyone in the section to run another's program without understanding it in detail and without unwieldly operating instructions.

Also undertaken was a check list of things that generally need to be done in these programs to help prevent omissions. Some subroutines useful in multiple radar problems will be written up. Both the check list and the set of subroutines will, of course, be expandable.

(A. Mathiasen)

A slight but serious error was discovered in the prediction section of the two-radar tracking program (TRASACT-3PAD). That it tracked as well as it did must be considered a minor miracle. One of the smoothing routines included in the program was found to have an error also. The modified program was tested intensively and extensively one night and worked perfectly at the time.

5.0 TRACKING AND CONTROL (CONTINUED)

(H.D. Neumann)

The program for studying the Bomarc guidance equations was completed. Parameter tapes will be prepared and the program will then be tried.

(B. Stahl)

Repeated modification of the one position, best fit, two-radar tracking program has made it so unwieldy and difficult to follow that it has been completely rewritten. The process of rewriting included a few logical refinements which suggested themselves after several nearly fruitless runs on the computer. In addition, of course, some smoothing difficulties have been corrected as well as some previously undiscovered errors. It is believed that this rewritten program will be checked out and working within a fortnight.

Another radar-timing program has been written to find the scan time (in seconds per scan) of any or all of the three radars now supplying information to WWI. The program is designed to print the time in decimal form, as well as octal and can operate with all three radars if desired. The octal form has been added to facilitate manual insertion.

6.0 AIR DEFENSE CENTER OPERATIONS

(D. R. Israel)

Another round of analysis has produced revised definitions of the personnel complement of the September Cape Cod System. Sheets describing the organization of the center and the specific duties of each person have been prepared for informal discussions.

On the basis of the above sheets, a revised allocation of display lines has been made. Investigations and discussions have also been made of the number and types of scopes which each person in the center will need. Present indications are that about twenty 16-inch scopes and twenty 5-inch scopes will be required. The number of 16-inch scopes is somewhat larger than what otherwise might be expected, and is accounted for by the fact that some of these scopes are used for past history displays and many others are used for present situation displays. The 5-inch scopes are generally used for the display of digital information; these scopes effectively substitute for typewriters or other printing devices. Staff members have been asked to contribute sketches showing their concepts of the displays to be made.

Up to the present time all of the material concerning the plans for the September System have been issued in the form of inter-office memos and have been distributed only to a small group of people for their criticism and suggestions. It has now been decided that all material pertaining to the September System will be issued in the form of M-notes. A memo (M-1815) describing the form and use of these memos is in preparation and will be issued during the next biweekly period.

The preliminary estimate of the number and allocation of scopes has permitted a start to be made on the planning of the floor space which will be needed for the center during the September demonstrations. The space requirements and allocation must be made during the next two weeks if the estimated time schedules prepared by Newitt are to be met.

(M. I. Brand, A. B. Ward)

Work continued in conjunction with P. Cioffi on the identification phase of the September Cape Cod System. We received from the Project Lincoln Drafting Department a linen cloth map of our area of interest showing coast-line, principle cities, airports and airplanes. Several people have expressed a desire to obtain copies. Plans are being followed through for the construction of a back-lit housing for this map so that it may be used as a preplot board for flight plans in accordance with the system of flight plan data input now envisioned.

A study of the number of digits necessary for putting flight plan information into the computer was made, and the results (48) were submitted to D. R. Israel. Also submitted to D. R. Israel were suggestions as to what displays should appear on each of the scope lines pertinent to identification.

6.0 AIR DEFENSE CENTER OPERATIONS (CONTINUED)

(M. I. Brand, A. B. Ward) (Continued)

The operation of the proposed identification program was discussed and roughly outlined. A flow diagram will be drawn shortly.

(M. I. Brand)

Work has continued with C. Gaudette and P. Cioffi on the Demonstration of Techniques Program. Several runs were made on the computer but to this date the program has not run one hundred per cent successfully.

(J. J. Cahill, Jr.)

During the past biweekly period, three highly successful AA Guidance flight tests were performed. The batteries used (C & D of 704 Gun Battalion) were both consistently able to acquire and lock onto the target aircraft under direction from Whirlwind. The results will be described in detail in Memorandum M-1804.

The first test of the Scituate TPS-10 Height Finder, wherein directions from Whirlwind were sent by phone to the site and the radar crew attempted to find the altitude of the test aircraft, was very successful. The efficiency and accuracy of the weapons were surprising, since this was the first mission. Additional tests will be performed, but it is felt that the weapon may be considered "checked out." The test and procedure were essentially the same as those previously used with the MPS-4, and described in Memorandum M-1728.

Some time was spent, during this period, in preparation for and assisting at the demonstration to the Project 414 people on January 28.

A modification is being written to T-2187 so that georef and r, θ, ϕ information for AA Guidance can be produced simultaneously during the operation of the interception program.

Work is progressing on final proposals for Height Finder and AA work in the September system.

(P.O. Cioffi)

I have worked with C. Gaudette and M. Brand on the Demonstration of Techniques program simulating techniques to be used in the Cape Cod and future systems. This program has been written but not checked out yet.

Work on the identification function has continued with emphasis on the formulation of a pattern of techniques and method of operation for the form, handling, processing, and display of data in an air defense system. Results of a final nature are delayed because of the recent changes in the various redefinitions of phases of the work.

6.0 AIR DEFENSE CENTER OPERATIONS (CONTINUED)

(O.T. Conant)

The study of communications in the September System Air Defense Center is continuing. At present the Intercept Team is being considered in greatest detail, but the study will include all communications within the Center and with external units of the system. A chart has been drawn up and sent to the drafting room for reproduction which should be of assistance in determining all of the messages which must pass among individuals in the system. It is expected that copies will be made available to persons concerned with the Center. As information requirements are determined the most efficient allocation of phone lines and messengers in the Center will be studied. Simulated tests of the intercept function will be undertaken as soon as present ideas become sufficiently definite.

(M.A. Geraghty)

During the last two weeks, I assisted J. Cahill in three test runs of the AA Guidance program. Some time was given to preparation for the 414 Project demonstration. In addition, I have been familiarizing myself with the contents of all programs dealing with the height-finding and AA guidance functions.

(F. Heart)

Continued efforts have been made to secure aerial photography of Group 61 flight tests. Another attempt is now being made to install a sound movie camera (belonging to Lincoln) in a B-25. This is now being done on a more official basis than the first attempt, and a trial should be possible next week.

In order to obtain more permanent photographic services, the 6520th Test Support Wing has been asked to obtain, from USAF, Washington, a qualified photographer and various photographic equipment. Although this may take several weeks to appear, the use of aerial photography should then be possible on a day-by-day short-notice basis.

(F.A. Webster)

Data transfer between persons in the Air Defense system is being analyzed as a function of tactical phase with particular reference to the "intercept team." For any given interceptor flight the following phases tend to have distinctive communication features (though all categories do not, of course, occur with every interception):

1. Pre-scramble
2. Scramble
3. Take-off and climb
4. Initiation (or re-initiation)
5. Flight splits
6. Mid-course guidance

6.0 AIR DEFENSE CENTER OPERATIONS (CONTINUED)

(F.A. Webster) (Continued)

7. Pre-final phase (last minute preceding)
8. Final phase and attack
9. Post-attack
10. Patrol
11. Other activity
12. Return-to-base

At stages 7 and 9, for example, voice channels (for "intelligence") between the intercept team and interceptor are likely to be heavily loaded: and the loading piles up more than in direct ratio to the number and length of messages. This is because, at present, simultaneous messages require repetition. Efficient staggering of messages might be achieved by the use of automatic, temporary recording in certain channels when conditions of overload occur.

The situation, in general, probably cannot be treated as simply as this, because of priority weightings; and these may be referable to the sender or to the receiver. Thus the sender may have a message which he knows, in general, to be important. At the same time a given position at the center may need a particular piece of information which, while normally of low priority, is of particular importance at the moment for some high-priority decision.

The best way to arrange message transfer can probably only be worked out by setting up a simulated attack and following, in sequence, a simulated set of operations representing a typical interception pattern. Diagrams are being made to represent the types and grouping of data transfer within the system; and tests will be made to analyze the efficiency of possible methods.

(C.A. Zraket)

F. Webster, C. Conant, and I are currently in the process of studying the traffic and information load on the proposed September Cape Cod System, and specifically in regard to the Weapons Assigner and Squadron Operations Officer functions. It is hoped that a series of tests can be conducted in the next few weeks which will simulate the function of these people and give us an estimation of the traffic load on these poeple and their equipment requirements and layout. When possible, existing programs, such as S. Knapp's Four-on-Four Interception Program, will be used in the tests.

7.0 ASSOCIATED STUDIES

(W.I. Wells)

This biweekly period was spent preparing a memo, M-1812, The Philosophy of Statistical Filter Design. This report is meant to serve as an introduction to a more detailed report to be written on the specific procedures used in the statistical design of systems.

(E.J. Craig)

The report on the work of the past four months is about three-quarters completed. (The report is on iteration procedures, and was described in the last biweekly report.)

It occurred to the author that an exhaustive review of all work done in this regard was in order. Consequently a search in all the recent literature has occupied most of this past biweekly period.

Some work of late by Lanczos and Hestenes of the Institute of Numerical Analysis, National Bureau of Standards (L.A.) still warrants closer attention.

It is hoped the report will be finished next week.

8.0 COMPUTER OPERATIONS

(M. Brand)

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

MEW Tracking and Control	
Flight Tests	18 hrs 55 min
Magnetic Tape	10 hrs 55 min
Data Screening	2 hrs 35 min
Multiple Radar Tracking & Control	4 hrs 50 min
Air Defense Center Operations	15 hrs 10 min
Indoctrination Programs	35 min
Conversion	15 min
Calibration	1 hrs 20 min
Equipment Characteristics	55 min
Equipment Check	35 min
Visitors & Demonstration	2 hrs 50 min
Miscellaneous	35 min
Total Time Used	59 hrs 30 min
Time Lost due to computer difficulties	2 hrs 45 min
Transferred to Math Group	1 hrs 15 min
Transferred to In-Out Group	4 hrs 0 min
	8 hrs 0 min

8.0 COMPUTER OPERATIONS (CONTINUED)

(M. Brand) (Continued)

Total Assigned Time	67 hrs 30 min
Percentage Assigned Time Used	88.15%
Percentage Available Time Used	100.00%

(C.A. Zraket)

The following programs were used in the demonstration of January 28:

1) Multiple Tracking and Initiation Program (T 2109-15).
Ampex Tape 245.

2) Single Pair Interception Program (T 2187-9).
T 2187-9 shuts off data link when interception is imminent.
T 2367-0 does not shut off data link.
Ampex Tape 238.

3) Georef Coordinate Print-Out of Target Track (T 2029 & T 2021).
The georef coordinate print-out will now be incorporated into T 2187 which is the latest version of the Interception Program.
Ampex Tape 245.

4) AAA Display (T 2187-9).
Ampex Tape 245.

9.0 FLIGHT TESTS

(F. Heart)

After many aborts, a very successful "maximum effort" flight test was held on January 27. This test involved more than 10 aircraft and used data from the Bedford, Scituate, and Rockport radars. Contact with aircraft was maintained on three radio frequencies. The test was run to obtain recorded data for W. Attridge and J. Ishihara and the results are described by them.

The following visitors observed Group 61 activities during the last biweekly period:

Capt. F.J. Beck	6520th Test Support Wing
Lt. H.J. Crook	" " " "
Lt. R.E. Wardell	" " " "
Lt. D.V. Haven	" " " "
Lt. L.E. Hilstad	" " " "
Lt. J.J. Mangini	" " " "
Lt. J. Tate	" " " "

9.0 FLIGHT TESTS (CONTINUED)

(F. Heart) (Continued)

Capt. K.J. Kahn	6520th Test Support Wing
Capt. R. Miller	" " " "
Mr. W.A. Russell	M.I.T. Instrumentation Lab.
Mr. R. Lucius	M.I.T. Instrumentation Lab.

(A. Hill)

January 20	0900-1030	AAA Test. See Section by J. Cahill
" "	1030-1200	One Aircraft Three Radar Coverage. Arnow As Scheduled - Satisfactory results
" "	1300-1430	AAA Test. See Section by J. Cahill
" "	1430-1600	Three Radar Coverage One Aircraft. Arnow As Scheduled - Satisfactory results
January 23	1300-1430	Two F-80's Take-off Initiations. Garth See Section by F. Garth
January 27	1300-1600	Maximum Effort 14 Aircraft Three Radio Frequencies. Ishihara & Attridge Good coordination & results
January 30	0900-1030	Take-Off Initiation Two F-80's. Garth See Section by F. Garth
" "	1030-1200	Three Radar Coverage One Aircraft. Arnow As Scheduled - Satisfactory results

9.0 FLIGHT TESTS (CONTINUED)

(A. Hill) (Continued)

DATE	TIME	SCHEDULED TEST A/C	SCHEDULED TEST Description	TEST ACTUALLY RUN A/C	TEST ACTUALLY RUN Description	REASONS FOR CHANGES OR COMMENTS
1/20	0900-1030	B-25	AAA Test	B-25	As Scheduled	
	1030-1200	B-25	Three Radar Coverage	B-25	As Scheduled	
	1300-1430	B-25	AAA Test	B-25	As Scheduled	
	1430-1600	B-25	Three Radar Coverage	B-25	As Scheduled	
1/22	0900-1200	14 a/c	Maximum Effort	-	Rescheduled to 1/27 1300-1600	Weather
	1100-1230	F3D AD	Two Aircraft Intercepts	F3D AD	Aircraft airborne, but did not use	Change in demonstration plans
	1300-1430	F-80 F-80	Take-Off Initiation	-	Rescheduled to 1/23	Field conditions at Grenier
	1430-1600	B-25 B-25	Height Finder Test	B-25	Held scheduled test with 1 a/c from 1400-1600	Change in our plans
1/23	0900-1200	B-26 B-26	Automatic Intercepts with Height Finder	B-26 B-26	As Scheduled. No Height Finder	Cloud deck restricted altitude of aircraft.
	1300-1430	F-80 F-80	Take-Off Initiation	F-80 F-80 B-26	As Scheduled using a B-26 observer	
	1430-1600	B-25 B-25	Height Finder	B-26	Held with one a/c	Change in our plans
1/27	0900-1200	B-26 B-25	Automatic Intercepts with Height Finder	-	Cancelled	Testing Programs for demonstration
	1300-1600	14 a/c	Maximum Effort	14 a/c	As Scheduled	
1/28	1400-1600	F-51 B-25	Two Aircraft Intercepts	-	Cancelled	Weather
1/30	0900-1030	F3D F3D	Automatic Initiation	F-80 F-80		
	1030-1200	B-25	Three Radar Coverage	B-25		

* Added to schedule during week of test

WHIRLWIND II

(G.R. Briggs H.K. Rising)

Investigation of the X-Y conversion problem with a view toward using magnetic-core circuits in a non-time-shared scheme appears to hold great promise. Because of the simplification possible using relatively low-speed magnetic-core circuitry, use of individual magnetic-core X-Y converters for each phone line would involve no great increase in the over-all number of components required to do the job and would, in fact, use only 1/3 as many tubes or even less. This fact, together with the fact that failure of a single unit would throw only one phone line out of action rather than possibly the whole system, would lead to a much greater inherent reliability for the over-all system.

Several schemes have been considered for application to the problem. One method would be to calculate sines and cosines sequentially by use of well-known difference equations of trigonometry. In order to do this, multiplications are necessary, but with the relatively low-speed magnetic circuits proposed, a multiplication involving more than a simple shift operation would be too long to carry out. If this method is limited to multiplications done by simple shifting, the calculation can only be done successfully for either 200 or 400 angular increments per revolution. In addition to this restriction, round-off errors may be serious; this question is being considered further by M. Epstein.

Another scheme can be seen upon inspection of the 6-bit binary sine and cosine table. One observes that cosine or sine never changes more than two in the last digit place from one azimuth value to the next. It is proposed that this increment to be added or subtracted from the previous sine or cosine value be supplied either from a magnetic-core counter and control circuit or as additional information from the radar. The former solution requires a rather complex control of about 100 cores per phone line, whereas the latter would require little additional equipment at the computer end of the phone line and would complicate the radar end but slightly. It is proposed that the radar send, in addition to the azimuth change pulse, but before the north marker, making eight possible full-amplitude pulses in all. Two of these pulses would indicate the sign of the sine and cosine increments respectively, and the other four would indicate the magnitude of the increments as 2, 1, or 0 for the respective cosines and sines. These increments could be obtained from a simple drum rotating 1:1 with the radar antenna, probably by six pick-up heads using a variable reluctance pick-up scheme.

The actual X-Y converter itself has been designed, using as the basic circuit element an improved version of the capacitor-coupled stepping register which has been recently developed in several laboratories. One hundred thirty-three such circuits are needed in a single converter. These can be driven from a single pulser tube of 829 type. Each coupling circuit will require two capacitors and a diode, probably of the junction type. This proposed scheme is being written in much greater detail and will shortly appear as a note.

WHIRLWIND II (CONTINUED)

(W.A. Clark)

Several days have been spent at the conferences between IBM and MIT engineers concerning the basic structure of the WWII machine. In brief, it has now been decided that the machine will have two 16-bit arithmetic elements which can be combined for certain operations into a single 32-bit airthmetic element. The prototype will probably have one magnetic core memory of 4096 32-bit words and probably three index registers (B-boxes). The complete structure of the order code is the subject of current study both here and at Poughkeepsie, but the essential features of the required operations and their nomenclature have been agreed upon. In general, the orders resemble those of WWI with additional orders which direct the accumulator to operate in special modes of combination.

While at Poughkeepsie I discussed the report IM-11, "Proposed Output Display," with E. Goldman. The possibility of displaying directly from the auxiliary drum rather than from the output drum was mentioned. The efficiency of this process apparently depends rather strongly on the manner in which data is organized on the drum and on the categories of information which are to be displayed. This categorization of data is being studied by J. Hayase and will be discussed again with Mr. Goldman during the next biweekly period.

(C. Grandy)

During the past biweekly period I have continued studying outside reports concerning air defense (Rand R-227 and Hughes report of March 1, 1952, on the MX 1179 System), particularly those proposals made by IBM in Reports IM-6, 7, and 8. Also, some time was spent keeping abreast of the current thinking on the Cape Cod System and discussing ideas for track monitoring and identification with people in that group.

The detailed description of the proposed operation of the Track Supervision Room and the Identification Room (outlined in TM-20) has not been completed because of indecision concerning the many alternatives of the display system -- i.e., just what displays are desirable for the track monitors and ID officers and various ways of implementing them. For example areas of manual initiation can be designated to the computer by the track supervisor by means of switches that correspond to grid lines on his scope. In addition to the x,y switches, the Track Supervisor would have a set of approximately five switches with which he designates which track monitor receives the display for manual initiation. Thus by setting three switches and pushing one button the Track Supervisor does all that is necessary to set up an area of manual initiation and to have the data displayed on the scope of the track initiator of his choice. This places the burden of work on the computer and a track monitor (or initiator) has no work to do to get his display.

WHIRLWIND II (CONTINUED)

(C. Grandy) (Continued)

Instead of the x,y switches a conductive glass data take-off system, described in detail in Lincoln Division 3 Quarterly Reports of the past year, could be used to signal the computer. This system would require analogue to digital converters, but if these were provided the system would be a good means of communication with the computer and also for communication among humans at a computing center. A third alternative is the use of a generated matrix of dots displayed on an auxiliary scope. If the dots were made to coincide with the intersections of the x,y grid lines in the first example, the light gun could be used to signal the computer. This display of dots would be controlled by a switch and turned off when not in use. Still another way of doing this would make use of a video mapper at the Track Supervisor console, and data passed by the mapper would be marked for display to the manual initiator.

Exploration of such alternatives, trying to visualize the relative merits, and estimating equipment requirements has slowed progress on writing a comprehensive description. Also the coincident detection display system proposed by IBM engineers (IBM Report IM-11) seems deficient in the ability to provide the kind of "forced display" considered (as the area of manual initiation above). It is hoped that conferences with the IBM people during the next biweekly period will clarify these difficulties.

Some exploratory programming of the better-defined sections of an air defense program will be undertaken during the next period using the new WWII order code as of this date.

(J. Hayase)

A crude flow sheet for the Transition Air Defense System showing the flow of information between three computer centers in a sector was drawn up during the early part of the past biweekly period. Current proposals require that all radars in a sector be subdivided into three groups and a single group of radars be tied into a single computer. The computer that receives a particular radar return correlates and smooths the return and cross-tells this track information to the other two computers. It is evident that the efficient operation of the system depends heavily on cross-telling track information between the computers in a sector.

A preliminary study of cross-telling has been started and a partial list of information to be cross-told has been compiled. It became apparent that the track display assignment information included in this list needed further study. An investigation of various displays required in the Air Defense Center has also been started and the study has neared completion.

WHIRLWIND II (CONTINUED)

(J. Hayase)

Based on this study of displays, efforts will be directed during the next biweekly period towards establishing various categories and sub-categories required to generate these displays using the method of coincidence proposed by Goldman and Triest of IBM (Project High Report, IM-11, "Proposed Output Display"). This method of display generates various displays by combining predetermined categories and sub-categories of information to be displayed. The selection of these categories should be kept at a minimum to insure a simple display system.

(J.F. Jacobs, R.C. Jeffrey)

We have been preparing a proposal for the Whirlwind II arithmetic element. If one assumes a 5μsec read-write time, then on all those instructions which require two memory accesses, approximately 7μsec of operation time are available. Also, assuming that the flip-flop resolution time is 1/4μsec and carry propagate time is in the order of .03μsec per digit, and allowing a time safety factor of 2, the following table holds. This table contains the time added to the weighted average single address order time by multiplications which involve the techniques listed in the left-hand column. It should be noted that all instructions except multiply and divide can be overlapped by the memory cycle and hence do not add to the single address order time.

TIME ADDED TO SAOT		NUMBER OF DIGITS			
		16	16-16*	24	32
TECHNIQUE	Separate add and shift (full carry)	1.3	1.9	2.9	4.9
	Combined add and shift (full carry)	.9	1.3	2.3	4.1
	Combined shift & 1 stage carry; separate add	.5	.7	.9	1.7
	Combined add, shift and 1 stage carry	.1	.1	.5	.9

* Split accumulator; shift when both BR end digits are 0.

WHIRLWIND II (CONTINUED)

(G. Rawling)

A study of several references* pertaining to the Comprehensive Display System which may concern the Transition System has been completed. These contained information regarding personnel, equipment, and physical lay-out for interconsole communication, including types and channels of the cross-telling, forced displays by light gun and jov-stick control of an illuminated circular position indicator; television displays and use of a Bidecon camera; designation sysmbols for identification and target data displays, Target Position Indicators (TPI) and associated uses of color; and various tactical and status displays.

Two first-draft chronological flow sheets for the functions of Weapon Assigner and Intercept Monitor at the Air Defense Center during an attack by hostile aircraft have been completed. They are:

a) Interception by Manned Aircraft which includes consideration of initial status (ground, orbiting, or sector transfer), computer inputs, calculations necessary, and outputs; mid-course guidance with AAA battery control, selection of interception tactics, sector control transfer; final phase intercept, status of aircraft after battle; reattack; landing phase control by suchpresent-day systems as Lantrac, Datac, and Ground Controlled Approach;

b) Interception by Bomarc including such topics as base site selection, initial alerts, warmups, and check outs; the launching; the initial ascent; mid-course guidance; self-destruction; dive phase; and result of attack.

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*
1) "Operation of the Comprehensive Display System" (BR) ADM-SIG &RE
2) "The Comprehensive Display System" (BR) ADM-SIG &RE
3) "Final Engineering Report on Comprehensive Display System," Vance,H., LFE-791-F
4) "Operational Evaluation of the Comprehensive Display System" N-NRL-S-3950
5) "The Integrated Antiaircraft Defense System" A-SCEL-M-36
6) "Air Defense Study I" RAND R-227 (1951)

10.0 PUBLICATIONS

(M.R. Susskind)

The following material has been received in the Library, Room W2-301, and is available to Laboratory personnel:

LABORATORY REPORTS

1. AIR DEFENSE BIWEEKLY REPORT, January 16, 1953, M-1805, pp. 1-23.
   CONFIDENTIAL

2. SUMMARY OF IBM - MIT COLLABORATION, December 1, 1952 to December 31, 1952 inclusive, M-1790, January 5, 1953.
   CONFIDENTIAL

3. MINUTES OF JOINT MIT - IBM CONFERENCE, Held at Hartford, Connecticut, January 20, 1953, M-1810, January 26, 1953, pp. 1-12.
   CONFIDENTIAL

4. COORDINATE CONVERSION WITH MEMORY-CORE MATRIX, M-1811, D.J. McCann, January 27, 1953, pp. 1-4.
   CONFIDENTIAL

TECHNICAL REPORTS

1. Quarterly Progress Report, 15 April - 15 July 1952, Guided Missile "Dove" XASM-N-4, Eastman Kodak Company, Navy Ordnance Division, Rochester, N.Y., Lib. No. 828.
   CONFIDENTIAL

2. Monthly Progress Report, Integrated Fire Control System for Terrier, November 1952, RCA Victor Division RCA, Camden New Jersey, Lib. No. 1951C.
   CONFIDENTIAL

3. Monthly Progress Newsletter No. 27, December 1, 1952, The Integrated Electronic and Control System Project MX-1179, Research & Development Laboratories, Hughes Aircraft Company, Lib. No. 295/S.
   SECRET

4. Quarterly Progress Report, Division 3-Communications and Components, 1 October 1952, Lincoln Laboratory, MIT, Lib. No. 294/S.
   SECRET