Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

SUBJECT: 6889 AIR DEFENSE BI-WEEKLY, FEBRUARY 15, 1952

1.0 GENERAL

(C. R. Wieser)

A simple experiment has been designed to compute range, azimuth, and elevation orders for a SCR-584 Antiaircraft tracking radar. The object is to utilize track-while-scan data to put the 584 on target. The necessary program is very similar to ordering a height finder, except that elevation angle is included. Elevation data will have to be obtained from altitude instructions. Arnow will be responsible for preparation of the program.

Group 22 has received an MPS-4 height finder (in addition to the two TPS-10 height finders mentioned in the last bi-weekly). It will be convenient to install the first height finder at Rockport where power and phone service are already available.

Group 22 has been working on the telephone requirements for voice and data handling at the Barta Building. The specifications for and request for the Barta installation are contained in a memorandum from C. R. Whelan to J. A. Vitale, February 13, 1952, entitled "Switchboard Installation at the Barta Building." The specifications have been checked with Group 61 and agreed upon. The request calls for installation of the switchboard by March 17, 1952.

A meeting was held with Whalen and Martin of Group 22 to discuss construction of phone-line terminal equipment for the Cape Cod System. It was agreed that Division 6 will be responsible for constructing the range and azimuth counters for the slowed-down video systems. This supercedes the previous agreement (M-1346, Section IV) that Division 2 would furnish counters. The change was made in order to keep terminal equipment construction, maintenance, and checking as uniform as possible. Also, the use of Whirlwind wide-bandwidth plug-in flip-flops makes possible marginal checking procedures in which the computer is programmed to simulate demodulated phone line signals.

2.0 EQUIPMENT ENGINEERING

(H. J. Kirshner)

Terminal equipment for the Rockport radar has been delivered by Division 2 and is undergoing test by Group 24 personnel. Cabling for this equipment for connection to Whirlwind will be undertaken during the next two WW installation days. It is hoped that 8 ft. racks will be delivered prior to the completion of the cabling so that the terminal equipment may be (relatively) **permanently** installed before it is placed in operation with Whirlwind.

Thought was given to various means for displaying slowed-down video data on a PPI. A scheme was devised which would provide a PPI display utilizing all of the incoming data. It has been learned that Group 24 is now engaged in developing a PPI for SDV, so rather than duplicate effort, our plans for building a PPI have been dropped. It appears that the PPI under development by Group 24 will not be suitable for use as an equipment checking device as is the PPI now used with the MEW. For that reason, decoders providing a "B" scan, are to be constructed. These decoders were to be constructed during the last bi-weekly period but were delayed in order to integrate them into the proposed PPI. Now that this need no longer exists, they will be constructed to present a direct display on our 16" 'scopes. Two decoders, built by Group 24, are presently in use as an interim measure. The decoders provide an approximately 7" x 7" "B" scan on the 16" scope. The decoders which are to be constructed will also be incorporated in a clutter rejection system.

All requests for flight tests are now being logged on Form DL-362. It is requested that if a flight test be desired, it be scheduled for either a Tuesday or Thursday morning and that requests be made on the Friday of the week preceding the week of the requested test. The procedure is desired in an attempt to obtain maximum aircraft utilization.

(R. L. Best)

The flip-flop designed by Group 24, is still undergoing test. Their crystal gate scheme for counting is beautiful; the only possible objection would be the large number of crystals necessary.

2.0 EQUIPMENT ENGINEERING (Continued)

(F. Heart) (Continued)

I am now spending part time working on In-Out Block Diagrams. During the past bi-weekly period I have been reading memos, studying block diagrams, and generally becoming familiar with the work to date.

(B. Morriss)

In determining the general modes of operation of the external units many of the details of operation were glossed over. Present effort is divided between preparing drawings showing the details of operation of the different types of external units and the development of modes of operation for those units needed by the Air Defense Group. Drawings of each group of external units will be prepared in the near future by F. Heart, P. Stephen, or myself.

One of the panels of the digital display system being constructed by Teleregister Corporation for Project Lincoln was examined. The panel consisted of approximately eight columns and four rows of indicators arranged so that each row would contain information on one aircraft. The indicators were plug-in units which rotated a numbered cylinder one position for each pulse received, the numbers were quite clear and the panel had a neat appearance. The disadvantages were the counting of pulses rather than searching for the correct position and the slow operation of the system. (Approximately one second for a single posting of data). If large quantities of data are to be displayed on "tote" boards by the computer such a system would be rather complex. The computer would have to remember the positions of each indicator and send out signals only when changes occur, and several separate controls which do not tie up IOC would have to be provided. It may be easier to provide higher-speed indicators and switching equipment, and other methods of displaying information certainly should be investigated.

(A. V. Shortell, Jr.)

Approximately half of the past bi-weekly period has been spent designing filters which would use standard values of inductance. These coils are high-Q toroids available from U. T. C. The procedure of designing filters around stock values of inductance is rather tedious but a 4-7kc bandpass and a

2.0 EQUIPMENT ENGINEERING (Continued)

(A. V. Shortell, Jr.) (Continued)

3kc lowpass filter have been designed. These coils have just been received and it is expected that they will give much better results than the low-Q coils previously used.

The remainder of the bi-weekly period was spent revising the block diagram of the multiplexing system, designing a 7kc phase shift oscillator and designing a balanced modulator using four matched 1N56 germanium crystal diodes.

By the first of the next bi-weekly period I hope to have a breadboard setup which can be used to record two signals on a single channel, one directly, the other as a single sideband on a 7kc carrier.

3.0 BEDFORD EXPERIMENTS

(D. R. Israel)

Recent flight tests have been extremely successful. In these tests the interceptor is initially on the ground at Grenier AFB (sourthern New Hampshire). Communication with Grenier is implemented by means of a phone call to Bedford Operations and an inside "drop" line to Grenier Operations. The interceptor is given a "scramble" order when the target--usually a B17 approaching the coast of Main--is sighted and tracking is initiated. The interceptor is given proper headings and is directed to the altitude at which the target has been instructed to fly. Due correction is made for winds. In the most recent tests non-linear smoothing (NLS-2) was used and the target made evasive 90° turns; successful interceptions resulted in all cases. In the next test the pilot of the target aircraft will be requested to take any evasive maneuvers which he desires.

Several added features will shortly be added to the basic interception program. One modification (by F. Heart) will display velocity vectors for the target and interceptor and will display the separation distance and bearing angle between interceptor and target in numerical form at the center of the F scope; a modification by Zraket and Cioffi will display, once per scan before initiation upon a target, the last 50 pieces of data received in the NE quadrant. (This display will aid in the manual initiation of the target). Another modification by Zraket and Cioffi will permit the computer to automatically initiate tracking of the interceptor departing from Grenier, provided that the computer is

3.0 BEDFORD EXPERIMENTS (Continued)

(D. R. Israel) (Continued)

notified of the takeoff time of that aircraft.

The next step in the improvement of the interception program will be to make use of the MPS-4 height finding radar which has recently been received by Lincoln Group 22. If the MPS-4 were situated at Rockport where phone lines have already been installed, the height-finder could be used to determine the height of an incoming target aircraft. The computer would calculate the proper azimuth and range to direct the MPS-4 and these values could be relayed by voice to Rockport. The height information would be relayed by voice back to WWI where it would be inserted into the computer by means of the flip-flop reset switches.

A series of weekly seminars on smoothing methods have been established. These seminars, open to all members of the Air Defense Group, will temporarily be held on Mondays at 3:00 p.m. in Room 250. The first two seminars discussed the smoothing studies previously undertaken as part of the Bedford Experiments.

As a means of giving new staff members a comprehensive and closely supervised programming experience, two programming problems have been drawn up. The first of these problems is fairly simple and illustrative of a non-real time problem; the second problem is of the real-time variety and involves tracking an aircraft. One or the other of these problems has been assigned to each of the new staff members.

(C. Zraket)

Flight Tests

A Flight Test was held on the morning of February 12, using a B-17 as the target and a B-25 as the interceptor. This was a three dimensional interception using a wind correction in the velocity calculations. The target traveled a course due west from a starting point 40 miles east of Sanford. The interceptor scrambled from Grenier as soon as the target was initiated on, climbing to 9000' at an IAS of 225 knots. The final separation was 100 yards.

A single aircraft run was made at a constant altitude, speed, and heading for purposes of Wind Study.

3.0 BEDFORD EXPERIMENTS (Continued)

(C. Zraket) (Continued)

Flight Tests (Continued)

Two Interception runs, similar to the one described above, were held on the morning of February 14. NLS-2 smoothing was used. On the first run, the target made a 90° left turn on reaching Sanford, thereafter traveling due south. The final separation was 500 yards. On the second run, the target made a 90° left turn on reaching Sanford, and sometime later a 90° right turn. The final separation was 200 yards. Both interceptions terminated in tail chases.

(P. R. Bagley)

The Stationary Clutter Rejection Program (T-716) has been run several times. Trouble was encountered with certain Magnecorder tapes whose azimuths apparently occurred out of numerical sequence. With recent tapes the program operates correctly. Some samples of printed stationary clutter tables and photos of scope displays of clutter and filtered data have been made. The program was found to do a more effective job of identifying the clutter for a criterion of 3 occurrences of a particular return in 10 successive scans, rather than 3 out of 5, as previously used. Further work remains to be done in selecting an optimum criterion.

The process of rejecting stationary clutter returns, when using a clutter table arranged in azimuth sequence, requires a section of program 12 registers long (provided that the return is available as a single word, in which θ, measured clockwise, occupies digits 1-8 and R occupies digits 9-15).

The High-Speed Data Display (T-746) still manages in some obscure fashion to scramble the display data. Several test routines have been written to assist checking the operation of the magnetic reading and recording sections of the program.

(C. Gaudette)

The NLS-2 Smoothing Program has been modified to make the break point a linear function of the range when the range is greater than 45 miles. (See bi-weekly, February 1, 1952, Section 3.0, D. Israel). This type of smoothing has been called NLS-2c. Sue Knapp's PWTFT (Printing While Tracking From Tape) Program has been modified to use NLS-2c. Results obtained using this program indicate that this method will eliminate the undesirable jump in velocity when a jump in position due to quantization is obtained. C. Zraket has modified the interception program to use NLS-2c.

3.0 BEDFORD EXPERIMENTS (Continued)

(F. Heart)

The modification of the Interception Display Program, now numbered T-971, has been debugged. This program, now operating, displays the Heading Angle, Bearing Angles, and Velocity Vectors in addition to the various displays originally included in T-835-6. Unfortunately, this MOD does not fit together with a MOD written by Zraket and Gaudette, but changes will be made to allow simultaneous operation.

Some time was spent attending group meetings on the subjects of Smoothing and Interception.

The wind question was considered further, and some data on straight line, constant velocity flight was taken during the flight test of 2/12/52. This data will be "tracked" and analyzed during the next bi-weekly period. This has been tried before, but in the previous attempt the radar set was out of calibration.

(S. Knapp)

R, θ PWTFT is working and records of Simradata Tapes 53 and 55 have been taken. The program was originally written to use NLS-2, but NLS-2b and LS have now been incorporated into the program. More data will be taken with this program and with the x, y PWTFT. The data so far seems to indicate that r, θ smoothing works best on radial courses and x, y smoothing on tangential courses. NLS-2c (using a variable break point) has given some good results.

Interceptor Assignment has been rewritten for Bank B, and is awaiting trial on the computer.

(P. Cioffi and C. Zraket)

Modification 2 of the Interception Test Program has been written and is waiting for tape room preparation before being tried on the computer. It is believed that previous difficulties encountered in the time solutions have been corrected.

The three sections of the Interceptor Ass'g. Program have been rewritten and combined into one program (T-948), utilizing Bank B. Tape room preparation has held up a demonstration of the program.

3.0 BEDFORD EXPERIMENTS (Continued)

(P. Cioffi and C. Zraket) (Continued)

A modification written by C. Gaudette allowing use of NLS-2c has been incorporated into the Interception Display Program. This tape is T-974-0. MOD 1 has been written to correct a program error.

The F scope display of the northeast quadrant in the Interception Display Program (T-835-12) has been checked out. The automatic initiation modification (MOD 11) will be checked out next.

Effective February 15, 1952, Mrs. Susskind will keep a record under Program 974 of all wind and Interceptor velocity parameter tapes made up. The values of wind components and interceptor velocity, as well as the Magnecorder Reel No. with which they were used, will be listed under each parameter number. These parameter tapes will be available in the tape room in the box, "T-974 Parameters."

4.0 DATA SCREENING

(W. S. Attridge, Jr.)

The Simulated Tridar Data program has been run on the computer once and some program errors have been detected. Much time has been lost on this work because of tape preparation delay.

I have thought of a method for automatic cessation of tracking. The two criteria for cessation are (1) speed decreasing below some minimum specified value and (2) loss of radar data on the track. A way of combining the two is to count in one counter every time the smoothed speed gets too low and every time the track is missed by the radar. The counter would be reset every time both the speed is above the minimum value and data on the track is received.

(P. R. Bagley)

The program for setting up clutter rejection tables for the multiple-radar case (T-908) has been coded. It is being rechecked in detail before the tape is made in order to avoid extensive troubleshooting later.

Work has begun with Norman Potter on a program to record on magnetic tape filtered data from multiple radars (T-909). ("Filtered data" is here defined as data from which stationary clutter returns and any zero ranges have been removed.)

4.0 DATA SCREENING (Continued)

(N. Potter)

In reference to the construction of a probabilistic analysis of the tracking problem, the following definitive results have been obtained. Appropriate formulae for the velocity, heading, and position coordinates at any given instant, especially adapted for computer needs, have been developed. The turn sensing procedure, based upon simple arithmetic criteria, may be roughly described by stating that if the dispersion of the ensemble of the most recently acquired position coordinates exceeds that which is implied by probability theory, a turn is indicated. An interesting result, though primarily of theoretical interest, is that the error generated in the estimates by the inaccuracy of the observed data is a transient in the system. Of greater practical significance is the fact that no more than six sets of coordinates need be stored for computational purposes, it being further demonstrated that under no circumstances is greater precision made available by the retention of more than ten such sets.

Only the experimental determination of a parameter closely related to the magnitude of the dispersion of the position ensemble and an analysis of the characteristics of the process during a turn remain undone. The programming problems of the basic formulae and the necessary indexing system are being studied. Preliminary trials of the formulae, computed on a desk calculator and using simulated quantized data from a two radar system, have proven highly successful.

5.0 TRACKING AND CONTROL

(J. Arnow)

A rough idea of the type of telephone service that we will require was drawn up and discussed with the telephone company. The results of the conversation were reasonably satisfactory, all things considered. The equipment is in the process of being ordered by Group 22.

The Rockport radar should be in operation with the computer within a week, and tests may then be run to give us an idea about the data and the coverage to be expected. A few cursory glances at the B-scan during the past week indicate that returns on the few observable aircraft in the vicinity leave much to be desired.

(M. Frazier)

Polysmooth has been written and will be debugged as rapidly as possible. In its present form, it uses three methods of data combination according to the logic of TRASACT, namely smoothing for both radars and performing all other red tape operations once every fifteen seconds, and one new type of logic,

5.0 TRACKING AND CONTROL (Continued)

(M. Frazier) (Continued)

suggested by Arnow; namely having each radar track the aircraft separately, and smoothing for each radar at the end of its search sector, but having a common velocity for both radars. It is anticipated that further study will be devoted to this latter approach, as it is felt to be inherently simpler and more capable of extension to more aircraft and/or more radars.

The three radar display program has been rewritten for use with real data.

Slowed Down Video Data Analysis II is not yet entirely debugged, but will probably be ready for operation in the next week.

(A. Mathiasen)

Tests of the single aircraft tracking programs for one and two radars using simulated (r, θ, t) have proved inconclusive. Checking of the programs indicate that this is due not to faulty logic in the main programs but to errors in handling simulated data which does not, for instance, provide a continuous time source.

Several flight paths remain to be computed by the synthetic muldar data program. Some paths have been plotted on double polar coordinate paper and are very satisfactory. A list of data tapes showing the parameters used will be drawn up on completion of the present series and will be available to all who have an interest in the two radar problem.

Work is being started on a modification of the basic tracking program used in the Bedford experiment to provide height, range, and azimuth information for a tracking radar.

6.0 AIR DEFENSE CENTER OPERATION

(D. R. Israel)

Contact has been made with Colonel Merle Drury, Air Force Liaison Officer with the Commonwealth of Massachusetts for the Ground Observer Corps. The discussion with Colonel Drury is summarized in an inter-office memorandum of February 5. Colonel Drury was extremely cooperative and is very eager to aid and assist us in every way possible. Arrangements are now being made to hold further discussions with officers from the Eastern Air Defense Force at Stewart Field, N. Y.

6.0 AIR DEFENSE CENTER OPERATIONS (Continued)

(D. R. Israel) (Continued)

Topographic charts of the sites of the proposed Cape Cod radars have been ordered. Airways maps of the Cape Cod area and surrounding land and ocean areas have been secured. One map has been mounted and various colored pins are used to indicate the positions of the proposed radar sites and the G.O.C. posts in Massachusetts.

A visit has been made to the Boston Air Route Traffic Control Center where the operation of the Aircraft Movement Identification Section (AMIS) was observed. This visit is described in an inter-office memorandum of February 6. Present indications are that if we attempted to identify aircraft at the same points at which they are presently identified--this, it should be noted, would require long-range coverage of the ocean approaches--we could get satisfactory data merely by "tapping" into two phone circuits linking the AMIS controllers with the GCI stations. If we are restricted to the short range of the 584's and must attempt to do identification at short distances off the New England coast, our problem will be much more difficult and one or two of our people might have to be stationed at the Traffic Control Center. A further study of the problem will be made during a second trip to the Center next week.

Information is being gathered concerning the available "tote board" equipment made by Teleregister Corporation. Other possible sources of similar display equipment are being investigated.

(F. A. Webster)

Investigation of auxiliary (non-radar) data, and its relation to radar data, has been continued. Analysis is being made of information handled by the various communication channels, with particular reference to such factors as: urgency, reliability, completeness and liability to misrepresentation, delay or possible complete cut-off.

7.0 ASSOCIATED STUDIES

(R. L. Walquist)

Several programs have been written for checking the magnetic tape unit and for using it as an intermediate storage device. The checking programs have demonstrated the highly reliable

7.0 ASSOCIATED STUDIES (Continued)

(R. L. Walquist) (Continued)

operation of the tape equipment when the associated electronics (amplifiers, gates, flip-flops, gas tubes, etc.) are working properly. The major sources of unreliable operation appear not to be caused by the tape unit itself. This would indicate that dust might not be as detrimental as previously supposed. On February 10, over 1 1/2 million 16-digit registers of information were read from a new, unspliced magnetic tape without error; this was accomplished without using a redundant read for the 2 information channels. Such operation opens up the possibility of recording 4 useful binary digits per line of tape instead of the present 2.

Subprograms have been written which will record and read blocks of information on magnetic tape. For recording, AC holds the address of the register containing N, (the number of registers to be recorded). The recording subprogram will then record the contents of the N registers immediately following the address in AC. The number N is also recorded for the benefit of the reading program. For reading, AC again holds the address of the register which is to contain N. The reading subprogram will then read the block of information on tape into the N registers immediately following the address in AC; the block length N is stored at the address held in AC upon entering the program.

At present, only subprograms for block reading in reverse have been written. If and when the need arises, a subprogram for block reading in the forward direction will also be written.

(G. Cooper and A. Katz)

During the past bi-weekly period, ESP-1 was run successfully thus providing us with an experimental evaluation of three two-element statistical predictors. The results were quite encouraging -- in seventy-five percent of 210 test samples, the magnitude of the error in prediction (using quantized angular input data) was equal to or less than one degree. The maximum error was less than 2.5 degrees. Our predictors were not designed to handle the discontinuity in the angular data ($\theta = \pm 1/2$ revolution) and hence do not operate satisfactorily near this region.

In the near future ESP-1 will be used to test various three-and four-element predictors. Further thought will be given to the problem of handling the discontinuity.

7.0 ASSOCIATED STUDIES (Continued)

(P. R. Bagley)

Programs are being planned for testing the block recording and reading subroutines, written by R. Walquist for use with the magnetic tape equipment.

(J. Ishihara)

Work has been initiated on coding a "three stage" data correlation program for the Muldar system. (R. L. Walquist proposal mentioned in the January 18, 1952 bi-weekly).

Part of this period was also spent with R. L. Walquist revising the programs of "Solution: Indoctrination Problems".

(B. Lone)

Work has been continued on the print out of double length numbers. It appears that a necessary requirement for ten decimal digit accuracy is that the factor of conversion from integer to fraction be contained in three registers.

I have begun consideration of the problem of tracking a single aircraft with returns from two radars, choosing the returns from the first radar which reports in a fifteen second interval as the criteria for smoothing.

8.0 COMPUTER OPERATION

(C. Gaudette)

Relay Link Characteristics	0.75 hours
Data Screening	2.25 hours
Tracking and Smoothing	12.92 hours
Aircraft Control	9.75 hours
Miscellaneous	3.00 hours
Total Useable	28.67 hours
Time Lost	4.00 hours
Time Returned	0.33 hours
Total	33.00 hours
Assigned Time	33.00 hours
Unaccounted Time	0.00 hours

9.0 PUBLICATIONS

(M. R. Susskind)

The following material has been received in the Library, Room 217, and is available to Laboratory personnel:

1. "Project Lincoln Accessions List," Project Lincoln Document Room, January 1952 through December 1952, Lib. No. 1693. (New lists are available each week.) RESTRICTED

TECHNICAL REPORTS

1. "C.I.C. (Combat Information Center) Shore Based Fighter Control, Air Warning and Radar Notes," Office of the Chief of Naval Operations, Navy Dept. OPNAV 30/37, March-October 1944 and December, 1944. (Copies are available in Room 216.) CONFIDENTIAL

2. "C.I.C.," Office of the Chief of Naval Operations, Navy Dept., OPNAV 30/37, January-December 1945, (Copies are available in Room 216.) CONFIDENTIAL

3. "C.I.C.," Office of the Chief of Naval Operations, Navy Dept., OPNAV 30/37, January-May 1946. (Copies are available in Room 216.) CONFIDENTIAL

4. "Noise in Tracking Radars, Part II, Distribution Functions and Further Power Spectra," Hastings, A.E., Meade, J.E., Gerwin, H.L., Naval Research Laboratory, Radio Division III, Washington, D.C. January 16, 1952, Lib. No. 1694. CONFIDENTIAL

5. "Shock Interference Control Systems for Supersonic Missiles," Summary Report, Schweiger, M.I., Davis, T., Project Meteor, United Aircraft Corporation, Research Department in cooperation with MIT, October, 1951, Lib. No. 1695. CONFIDENTIAL

LABORATORY REPORT

1. "Discussion with Warren White on Non-Linear Filters," Cooper, G., January 30, 1952, M-1387, pp. 1-5. CONFIDENTIAL

2. "Sample Problems for Applicants for Employment," Israel, D.R., February 11, 1952, M-1396, pp. 1-9. UNCLASSIFIED