

6889
Memorandum M-1367

Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: 6889 AIR DEFENSE BI-WEEKLY, JANUARY 4, 1952

1.0 GENERAL

(C. R. Wieser)

The first two types SCR-584 radars for Rockport and Scituate will be in operation in February and April, a delay beyond the schedules previously established.

A meeting was held at Lincoln to discuss the program which the Air Force Cambridge Research Center and the MIT Instrumentation Laboratory should follow to coordinate their work with the Cape Cod system. Plans for the development of the automatic ground-to-air link and autopilot control of a B-26 and an F-94 were agreed upon and will be issued in a memo next week.

2.0 EQUIPMENT ENGINEERING

(H. J. Kirshner)

This bi-weekly period was spent on vacation.

(A. V. Shortell)

Most of the time during the past bi-weekly period has been spent in studying various types of digital-analog decoders preparatory to constructing two decoders for use in displaying input data from the Scituate and Rockport radars. Use of a binary-weighted resistance ladder network with equal value current sources seems to be the best scheme from a design point of view.

Some attention has also been given to the circuitry needed to convert the decoder outputs to a PPI (plan position indicator display) on a 5-inch scope. This equipment will probably be quite similar to that used in the Bedford PPI display.

Work on the display equipment has been suspended temporarily due to a lack of definite information concerning the characteristics of the terminal equipment to be used with the data links.

2.0 EQUIPMENT ENGINEERING (Continued)

(A. V. Shortell) (Continued)

At present I am working on a method for recording two signals on each channel of a dual channel tape recorder by frequency multiplexing. Present plans call for recording one signal directly and the other as a carrier-suppressed single sideband signal derived from a balanced modulator and filter network. Information bandwidth requirements are estimated to be about 4kc and the -3db response of the Ampex two channel recorder, at a tape speed of 7.5 inches per second, is expected to be 300 - 12000 cps. A carrier frequency of 11 kc will be used and the filter will pass the lower sideband. Thus there will be sufficient bandwidth between channels to prevent interference. Due to bandwidth limitations the filter design will be the most critical part of this equipment, so most of the time will be devoted to work on filters.

The photoelectric time source panel to be used in the real-time clock is operating satisfactorily after removal of the gear train. This eliminates the jitter mentioned in a previous bi-weekly but necessitates manual starting of the motor.

3.0 BEDFORD EXPERIMENT

(D. R. Israel)

The majority of this period was spent on vacation.

(W. S. Attridge, Jr.)

Flight Tests

On December 27, 1951 a flight test was held using a C-47 as the target aircraft and a B-25 as the interceptor aircraft. The interception program with wind compensation was used. Four interceptions were attempted with final separations being 200 yards, 50 yards, 200 yards, and two miles with aircraft flying parallel. A fifth run was made using the program with NLS-2, (Non-Linear-Smoothing-2) but the computer stopped.

On December 28, 1951 an interception flight test was held using a C-47 as the target and a B-17 as the interceptor. Attempts were made to note the effect of varying the interceptor WWI AS (Whirlwind Input Air Speed) while keeping the IAS (Indicated Air Speed) constant. The following results were obtained:

3.0 BEDFORD EXPERIMENT (Continued)

(W. S. Attridge, Jr.) (Continued)

Flight Tests (Cont'd)

IAS=180, WWI AS=180. B-17 passed ahead of C-47 at 500 yds.

IAS=180, WWI AS=195. Zero separation. Headings increased near end.

IAS=180, WWI AS=165. B-17 turned inside and passed the C-47 500 yds. on the left. Headings increased with the final heading being 184°.

IAS=180, WWI AS=210. Zero separation. Headings increased at end with final heading being 148°.

This test gave the unexpected results that all were of the over-lead variety; i. e., the interceptor came in on the target's nose. We would expect this with WWI AS $<$ IAS. With WWI AS $>$ IAS we would expect the interception to end in a tail chase.

On January 2, 1952 we ran a flight test to determine what caused the unexpected results of December 28. The B-17 was the target and the B-25 the interceptor. After one run with results similar to those above, we decided to run a calibration test. The azimuth commutator was discovered to be off by 10°. The situation was corrected by the crew at Bedford. Three more runs were then made and expected results were obtained.

As a result of this experience we plan to make a calibration run at the beginning of every flight test.

(P. R. Bagley)

Programs for Stationary Clutter Rejection and Verification (T-716) and High-Speed Data Display (T-746), described in the previous bi-weekly, are being debugged.

Radar Data Counting (T-826) has been written to count and print for each scan the number of occurrences of each of the following types of data: 1) azimuths, 2) total number of ranges, 3) ranges corresponding to stationary clutter, 4) ranges greater than 1 but not stationary clutter, 5) zero ranges. The program counts and stores this information for 20 scans and then carries out the printing process.

3.0 BEDFORD EXPERIMENT (Continued)

(C. H. Gaudette)

The NLS-2b Parameter Analysis Program has been revised to extend the boundary conditions in an attempt to improve the results listed in the previous bi-weekly (M-1361, December 21, 1951). Photographs of the velocity errors have been taken with the NLS-2b Display Program using the parameters mentioned above. Parameter Analysis Programs have been written for NLS-2 and Linear Smoothing with 1 mile and 1/2 mile quantization.

The procedure required for 6889 computer operation has been outlined in a flow diagram for use in the indoctrimation program. Copies are available from Mrs. Susskind.

(F. Heart)

The movie mentioned in the last bi-weekly was observed; it appeared much better than all previous attempts. The ground clutter was still not as clearly visable as desired, but the two aircraft appeared very distinctly. Further attempts will be made as soon as possible. Probably the next attempt will utilize a method suggested by C. R. Wieser: take single frames once every 15 seconds, with the target and interceptor displayed at higher intensity than the clutter, and then photographically reproduce each frame about 64 times in a row before going to the next frame--this reproduction achieves the necessary time ratios.

Most of the last bi-weekly period was spent on vacation.

(S. Knapp)

There is an error in the initiation section of PWTFT-6 (Printing-While-Tracking From Tape) (Selective Smoothing). The program works except when initiation is performed on scan number zero. The error has not been determined as yet.

DPO now tracks and punches satisfactorily. However, errors still remain which cause the punching to start before initiation.

A program was written for John Dodd which computes the value of the power series:

3.0 BEDFORD EXPERIMENT (Continued)

(S. Knapp) (Continued)

$$x+\frac{1}{2^2}x^2+\frac{1}{3^2}x^3+ \ldots +\frac{1}{n^2}x^n+ \ldots$$

for values of x between -1 to +1. This program is operating satisfactorily.

A General Smoothing Display program has been written. This program simulates a straight line, constant velocity flight and computes the errors in smoothing and prediction of velocity and position, displaying these errors on the D-scope and F-scope respectively. The smoothing method may be chosen from LS,(Linear Smoothing) NLS-2, NLS-2b, and NLS-6. The program has not yet been tested.

(C. Zraket and P. Cioffi)

The two interception test programs discussed previously have been combined into a single program employing a comparison check between the two methods. An interception problem is printed out only when the two methods do not agree according to the comparison check.

C. Zraket spent most of the past bi-weekly period on vacation.

4.0 MULDAR DATA SCREENING

(W. S. Attridge, Jr.)

I have been trying to think of as many ways as possible of using returns from more than one radar concerning one track. It may be convenient to use the drum field switching as a time base if the field switching occurs at some regular interval of about ten seconds. Assuming this, every time that field switching occurs all smoothing and predicting could be done.

If no time is assigned to each piece of data we can use this data in one of the following ways:

1. Average "best fits" from each radar. It is impossible to select the real "best fit" as we now do in the Bedford experiment unless we have some uniform time arrangement, but this is rejected by the premise of no time assignment.

4.0 MULDAR DATA SCREENING (Continued)

(W. S. Attridge, Jr)(Continued)

2. Average the "average best fits" from each radar. ("Average best fits" means an average of all the data received by one radar which has some reasonable probability of being the tracked target. This would include all the data found inside the search area.)

3. Average the "weighted average best fits" from each radar. ("Weighted average best fits" means weighting each "average best fit" according to the number of pieces of data which were used to find this average.)

4. Use the returns from the nearest radar only. (This removes the advantages of over-lapping coverage.)

5. Smooth for each radar individually and then average the position and velocity data from each such smoothing. Obviously some of these methods are better than others in obtaining the desired result, but at the same time are more difficult to use.

If time is assigned to each piece of data, there are several more methods of handling the data:

1. Effectively do a combination of position and velocity tracking. On each return, see if this return is inside some large area placed about the previously smoothed position; if so, predict the position for the present time from the previous data. (Note that this area is placed about some previous position, not some predicted position. This area might be a function of the time since the last return for this track. It may be necessary to predict a new position if no pertinent data was received since the last field switching time.) Find D_x and D_y, and examine further to see if it is within some smaller search area. If so, smooth the velocity and the present position. This method necessitates smoothing once for each pertinent return.

2. There may be a possibility of combining the pertinent data, considering the time for each return as well as the position. Then the one all-inclusive piece of data could be used with the smoothing and tracking programs at each field switching time.

3. A third method is to add to each return the product of the velocity of the track and the time from the occurence of this return to the occurence of the field switch-

4.0 MULDAR DATA SCREENING (Continued)

(W. S. Attridge, Jr.) (Continued)

ing:

$$x = x_R + \dot{x} (t_S - t_R)$$

Then a "best fit" or average of these could be used in the tracking program.

(N. S. Potter)

The report on the availability of storage positions on a buffer-drum was completed, with the following results. The probability of storing a piece of information on a buffer-drum, given varying quantities of previously stored material, was used as a measure of its reliability. Two systems were considered, subject to the hypothesis that information is received during time intervals whose lengths are distributed with equi-probability over a range of 450µs to 550µs. It was found that the probability, with a system of 256 registers, exceeds 0.9 over 75% of its range to saturation. If, however, at most 128 registers are employed, the same reliability is available only up to half the saturation. An appreciable increase is obtained by characterizing the absence of information awaiting storage by the transfer of stored information from a section of the buffer-drum approaching the read-in element to that portion which has just passed it. This reduction in the effective density increases the range of good reliability to at least 65% of the saturation value. A number of properties of the probability function employed, having bearing upon the optimization of the reliability, are discussed in the report.

Work has been initiated upon various aspects of data fitting for a muldar system.

5.0 MULDAR TRACKING AND CONTROL

(J. Arnow)

During a meeting with members of Division 2 of Project Lincoln, it was announced that the transmission system for sending slowed down video has been altered, and consequently schedules for the arrival of the first two data links were changed from January and February to February and April. Consequently the immediate objectives of obtaining working track-

5.0 MULDAR TRACKING AND CONTROL (Continued)

(J. Arnow) (Continued)

ing programs immediately has been altered.

For the next two months, simulated data for about three specified courses with various parameter variations will be obtained. Various tracking and smoothing schemes will be tried with these simulated courses and compared as to their effectiveness in order to obtain a quantitative idea as to the method that will be later employed when the radars are in actual operation.

In February, after the installation of the first radar, some tests will be made to determine the quality of the data.

(M. Frazier)

The slowed-down video data analysis program has been written, together with a parameter providing artificial data, and these will be run as soon as converted. Some time has been spent and will be spent with Mathiasen on getting the present set of three-radar programs up to a working status.

Other methods of using the data from two radars than that used at present will be studied for both smoothing and correlation, and tried out when the combination of two-radar single-aircraft tracking program and Simulated Muldar Data II is working.

(A. Mathiasen)

Synthetic Muldar Data II (SYMULDATA II) has been run on the computer and shows one trouble. For the radar antennas displaced initially from North, the airplane tracks from the two radars were inconsistent. The error has not yet been found. For antenna displacement initially zero, the program successfully computes data for both straight and curved paths.

A radar tracking program for the Rockport radar has been written.

6.0 ASSOCIATED STUDIES

(P. R. Bagley)

Programming has begun for a simplified automatic initiation program which attempts to initiate upon and track all returns not stored in the stationary clutter table.

6.0 ASSOCIATED STUDIES (Continued)

(P. R. Bagley) (Continued)

Sections of the program are being written in relative form in a manner similar to subroutines, so that sections once run and checked may be reused in future programs to save time and reduce the probability of making programming errors.

(A. Katz)

After modifying EAC-1,(Ensemble Averaged Linear Correlation-1) we have been able to obtain useful intermediate results from it. This program calculates and prints the linear auto-and cross-correlation coefficients at several points in the non-stationary time serves corresponding to the angular variation of a target flying a straight-line constant-velocity course. Not only will these coefficients enable us to derive predicting filters, but they also provide an experimental verification of certain properties of ensemble-averaged correlation functions.

Several predictors will be synthesized during the coming period and an evaluation of their effectiveness will be made.

(G. Cooper)

I have been assisting A. Katz in running EAC-1 on the computer and evaluating the results.

Work has also been continuing on the preparation of the thesis proposal.

7.0 COMPUTER OPERATIONS

(J. Arnow)

Radar and Relay Link	0.5 hours
Data Screening	1.75 hours
Tracking and Smoothing	7.75 hours
Aircraft Control	2.0 hours
Miscellaneous	2.0 hours
Sub Total	14.0 hours
Flight Tests and Visitor Preparation	11.75 hours
Total	25.75 hours

Bob Kyle is now working full time for the group and will be responsible for obtaining tapes and operating or assisting in the operation of the computer as required. He will also prepare the day by day schedule of operation.

The math group has also prepared a so-called Bank B conversion program which should be used in the majority of programs in the future that require less than about seven hundred registers. Since tape conversion will probably not be handled by the math group in the future, and since modifications can be made extremely easily in standard form, this form of input (using a standard tape) will be used in the future and a 5-5-6 tape made in only a few instances and then only when the program is completely satisfactory in its operation. This process will probably produce a large decrease in the time required for tape preparation.

8.0 PUBLICATIONS

(M. R. Susskind)

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

LABORATORY REPORTS

1. "Description of Basic Track-While-Scan and Interception Program," Israel, D. R., M-1343, December 3, 1951, 51 pp. CONFIDENTIAL

TECHNICAL REPORTS

1. "Survey of Sites for Cape Cod Air Defense System," Project Lincoln, Fox, G. W., Brown, L. W., Whelan, C. R., Janvrin, W., October 11, 1951, Lib. No. 1629. CONFIDENTIAL

2. "Muldar System. Clutter Elimination by the Use of Narrow Band Video plus Frame to Frame Storage and Filtering at the Central Point," Harrington, J. V., September 28, 1951, M24-1, Lib. No. 1630. CONFIDENTIAL

3. "Note on Loading Magnetic Drum with Slowed-down Video using Circulating Register on Drum as Buffer Storage," Harrington, J. V., September 28, 1951, M24-2, Lib. No. 1631. CONFIDENTIAL

4. "Video Mapping Technique to Remove Ground Clutter for Muldar System," Bivans, E. W., September 28, 1951, M24-3, Lib. No. 1632. CONFIDENTIAL

5. "Note on Bandwidth Requirements for Radar Data Transmission," Harrington, J. V., M24-4, Lib. No. 1633. (September 28,1951) CONFIDENTIAL

6. Memorandum to Harrington, J. V., Bivans, E. W., from G. E. Valley, cf M24-1-4, October 5, 1951, M24-5, Lib. No. 1634. CONFIDENTIAL