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Memorandum M-1382

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Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

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SUBJECT: 6889 AIR DEFENSE BI-WEEKLY, January 18, 1952

1.0 GENERAL

(C. R. Wieser)

The memorandum on automatic aircraft guidance referred to in the last bi-weekly has been issued as M-1370.

The ground-to-air data link has been connected to WWI and tested. The first test was unsatisfactory (see Section IV below), and further tests will be made.

Colonel Young, USA, visited the group to discuss our work. He is assigned to the Air Navigation Development Board (ANDB). He informed us that ANDB is going to experiment with the use of a magnetic drum for storing aircraft flight-plan data.

(D. R. Israel)

A good deal of the bi-weekly period was devoted to talking to prospective members of our project. As an aid in screening some of these people and in giving them an idea of the problems which we handle, a set of 11 non-classified questions has been drawn up. Copies of these questions will be available shortly.

A start has been made on investigations relative to the Air Defense Center of the Cape Cod System. Information is being secured and contacts made regarding:

- 1) weather information
- 2) air traffic control data
- 3) ground observer data
- 4) coordination with anti-aircraft units

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2.0 EQUIPMENT ENGINEERING

(H. J. Kirshner)

Work will continue on providing a display system for viewing digital radar information prior to its introduction into the computer. The display equipment will be general purpose in that decoders will be built for both range and azimuth. It had been thought that a sweep circuit might be used for range, but since no definite information is forthcoming as to the final form of the slowed-down video data (SDV), it will probably be best to assume that the data will be available in the form of eight azimuth digits, six range digits and a read pulse. Simplification of the display equipment will be made when a relatively permanent form of SDV data has been decided upon. It is anticipated that this display equipment will be used to attempt a form of stationary clutter rejection.

The digital ground/air link has been checked through from the output of FFSR-1 (Flip-Flop Storage Register-1) to the zero reader in the aircraft. A combination of aircraft troubles and airborne equipment difficulties has prevented a trial interception using the equipment. It is hoped that such a test will be conducted early in the next bi-weekly period.

Major Eichler of AFCRC is attempting to obtain a gun-camera for the F-51 and a motion picture camera for the purpose of photographing our flight tests. Frank Wilkins of the Instrumentation Laboratory has informed me that the Instrumentation Laboratory has a motion picture camera and that pictures (in Kodachrome) have been taken of one of our recent flight tests.

(A. V. Shortell, Jr.)

Most of the past bi-weekly period has been spent designing filters for use in the frequency multiplexing equipment for recording two signals on each channel of a multi-channel recorder. The proposed system requires a 4kc low pass, a 7kc high pass and a 7kc - 11kc band pass filter. Designs for these filters have been worked out and three days have been spent working with Bill Karlsen on experimental models.

Some difficulty has been encountered as the coils available have a fairly low Q. These cause a considerable reduction in the desired bandwidth and in the peak attenuation

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2.0 EQUIPMENT ENGINEERING (Continued)

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

predicted from conventional filter theory. This difficulty necessitates a rather tedious cut and try process of calculating parameters, testing and recalculating till a satisfactory filter is obtained.

(W. S. Attridge, Jr.)

On January 10th Van Wood explained to me the logical operation of the integrator system now in operation at Bedford. From the information he gave me, it seems definitely better to use the second of two successive, identical ranges.

With the present type of storage tube integrator it doesn't appear to be possible to correct for misassociated azimuths (except by computer programming.)

3.0 BEDFORD EXPERIMENT

(C. Zraket)

Flight Tests:

Two flight tests were held on January 8th, one in the morning and one in the afternoon, as preparation for the visitor demonstration the next day. The new 2 a/c Interception program with special display was used. The two runs in the morning and one in the afternoon were of the usual two-dimensional type and resulted in the interceptor passing 200 yards ahead of the target, 100 feet behind it, and 300 yards ahead of it respectively.

The second run in the afternoon had the interceptor (E-26) take off from Grenier Air Base and climb to 8000' when the target (E-17) had been initiated on. A phone link connecting WWI, Bedford, and Grenier allowed us to instruct the interceptor when to take off and proceed to an interception. The target started its run 40 miles due east of Sanford and proceeded due west.

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3.0 BEDFORD EXPERIMENT (Continued)

(C. Zraket) (Continued)

Flight Tests: (Continued)

A successful interception resulted, with the interceptor turning to avoid collision. Photographs taken during these tests are available in the Flight Test Book.

A Flight Test scheduled for January 18th to test the automatic transmission link was cancelled when it was observed that the Zero Reader was off by a constant error of 45-50°.

(P. R. Bagley)

Programs for stationary clutter rejection and verification (T-716), High-speed data display (T-746), and Radar data counting (T-846), mentioned in previous bi-weeklies, are still being tested.

Some photographs have been made of the displays of stationary clutter produced by the clutter rejection program (T-716).

(C. Gaudette)

The parameter analysis programs have provided several sets of parameter values for the various methods of smoothing. Since the selection of these parameters was made under the assumption of straight line paths, a new program introducing the effects of turns is being written. The parameters selected for straight line paths will be tried in the new program, and the set having the minimum error will be chosen as the best parameters for general flight paths.

The new DPO Program (Data Punch Out) appears to be working except for one major fault. Occasionally, a position is selected that is far removed from the predicted position of the target, and thereafter the target is lost. I believe the error is introduced in the calculation of the best fit, that is, finding the minimum

$$[(\Delta x)^2 + (\Delta y)^2] (2^{-11}) .$$

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3.0 BEDFORD EXPERIMENT (Continued)

(C. Gaudette) (Continued)

After $(\Delta x)^2 (2^{-14})$ has been calculated, the result is shifted left three times. If Δx is larger than 45 nautical miles, part of the result will be shifted out of the accumulator. This error has been corrected in the DPO Program by comparing the Δx and Δy with a maximum allowable value before squaring.

(F. Heart)

1. The data analysis program is still proceeding slowly, but somewhat more hopefully. With C. Gaudette and S. Knapp, time has been spent on debugging and using the Simulated Radar Data Program (Simradata) and the program for Printing While Tracking From Tape (PWTFT). Additional Simradata tapes have been produced, and several have been analysed. Effort is being directed at further analysis of NLS-2, and NLS-2b. DPO still is not working, but it is felt that the major mistakes are known.

2. The wind question has been studied further. Data was taken on a flight test, (MT-120), in which the aircraft was given a constant heading, flying through a strong cross wind. It is hoped that plots of this data will indicate the accuracy of the Computer-Plane-Radar link for determining wind data. This data has now been printed up by a single aircraft tracking program and will be plotted during the next bi-weekly period.

A report was received from Mr. H. G. Yamins, of the MIT Signal Corps Liaison Office: 5 September, 1951, Wind Variability, Signal Corps Engineering Laboratories, SIEGEL-RME-4, Project 172A-1. This report is a study of the variability of wind in space and time, and appears quite applicable to our problems. It approaches the question from experimental balloon measurements. However, since most of the measurements were made optically, it is a "fair-weather" study. This report will be studied as soon as possible, and will then be filed in the library.

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3.0 BEDFORD EXPERIMENT (Continued)

(F. Heart) (Continued)

3. Some time was spent in attempting to debug the magnetic tape sections of a program written by P. R. Bagley. Errors were found, but the program still does not work.

4. Further time was spent on the movie question. D. Israel and J. Arnow took over efforts to produce a movie for the Lincoln Lecture of 1/21/52, and in this connection Fairchild pictures were taken at a one/scan rate. Each frame of this film was photographically reproduced about 64 times to produce a movie at a display rate about 4 times faster than real time.

In addition, and somewhat prematurely, a program was written to display all the clutter all the time. This program depends upon the new decoders, and upon the "cl" order (not yet installed). Sometime in the near future this program will be tried, (T-854).

5. A modification of T-835-6 (Interception Display Program) was written, with the cooperation of S. Knapp. This modification (T-835-8) produces a display of velocity vectors for the target and interceptor, a three digit display of the Heading angle, and a three digit display of the Bearing angle; all on the F-Scope. This is one of several modifications to this program, and efforts have been coordinated with C. Zraket and P. Cioffi.

6. The Single Aircraft Print-From-Tape program (T-457-4) was operated to process a data tape prepared by C. Zraket. It operated satisfactorily.

7. Two attempts were made to operate the Two Aircraft Print-From-Tape program (T-335) in order to process a data tape prepared by W. Attridge, Jr. Both trials resulted in failure, despite the fact that this program has operated many times correctly; an attempt to find the trouble is being made.

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3.0 BEDFORD EXPERIMENT (Continued)

(S. Knapp)

Printing While Tracking From Tape-6 (Selective Smoothing) is now operating satisfactorily. A few printed records of simulated tapes have been taken using NLS-2 and NLS-2b. This work will continue with new Simradata tapes now being made. The PWTFT program has been expanded to include linear smoothing and NLS-2b. All the smoothing methods now in the program will be tested with different sets of parameters as computer time permits.

PWTFT-5 (Semi-Average Tracking) has been checked out.

The General Smoothing Display program seems to be operating satisfactorily. This program will also be used to test smoothing methods and parameters by means of photographs taken of the error curves. NLS-2b has been added to this program.

Work is continuing on DPO, but its operation is still not very good. It will track an aircraft for about 15 scans and then lose it. A modification has just been made which, it is hoped, will remedy this situation.

(C. Zraket and P. Cioffi)

The Interception Test Program was run during the past period with unsuccessful results. Although the selection of the various interception problems to be solved and the print program worked successfully, a program error exists in the time solution and in the calculation of the pursuit angle in the angle solution, nullifying any successful comparison between the two. The error in the time solution for small separations may be inherent in the method used, due to difficulties in scale factoring. Debugging was put aside until other work is completed.

The Guidance Program with final approach calculations needs about two full days of work before a tape can be made up and the program tried on the computer.

The straight Guidance program has been modified for use with the automatic transmission link and to make provision to insert new guide points at any time during operation of the program.

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3.0 BEDFORD EXPERIMENT (Continued)

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

A modification of the Interception Display Program (T-835-7) allowing use of NLS-2 was run on the computer using a MagLecorder Reel. Erratic results were obtained -- the heading angle and interception point calculated by the program having relatively large discontinuities. Further analysis of this will be made.

A run of the Guidance Program again showed up the selection of a best piece of data quite a distance away from the actual position of the aircraft, necessitating re-initiation. This trouble has been occurring relatively often recently in all tracking programs employing the 2⁻¹¹ scale factoring of Δx^2 and Δy^2 . A discussion with C. Gaudette was held to investigate and make corrections.

Modifications to the Interception Display Program suggested by D. Israel for the Grenier Experiments are almost ready. After a suggestion by W. Attridge, the following was agreed upon. Before initiation on the target, the program will display on the F 'scope, once per scan at south, all of the data from the previous three or four scans. The data displayed will be located in a rectangle in the northeast quadrant, a maximum of 50 pieces being displayed. Also, semi-automatic initiation on the interceptor stationed at Grenier will be provided.

4.0 MULDAR DATA SCREENING

(J. Arnow)

On January 17, a flight test was held using the automatic ground-to-air-link. Initially heading angles were set in the switches and the turns were timed to determine approximately what rate turn could be expected from the zero reader. The results were vague since the pilot later reported that he was unable to fly the zero reader properly i.e., the needle would always give a full scale deflection.

An attempt was then made to use the zero reader with the data link during an interception. It was immediately obvious that the headings received by the aircraft were in considerable error. This error was of the order of 45-50 degrees

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4.0 MULDAR DATA SCREENING (Continued)

(J. Arnow) (Continued)

and was produced in the aircraft after the receipt of the proper binary headings.

Frazier and I took a look at the TPS-10 used by the meteorology department. It would appear that maintenance on the TPS-10 is quite a problem and this set hadn't been used for about two months prior to our visit. It was turned on, and apparently worked, much to the amazement of everyone in attendance.

Calibration is a prime problem and errors of the order of 2000' are not uncommon. It is conceivable that a flight test can be held using this TPS-10 on some sunny day in the near future.

(M. Frazier)

A program has been written, as mentioned in the last bi-weekly, for analysis of the data from the new radars. This program is now in operation. An ancillary program for merely printing out a set number of pieces of data has also been written. These will be combined into a multipurpose analysis program in the near future. A tape was prepared to check the necessity of scale factoring in the Two-Radar-Single-Aircraft-Tracking (TRASACT) program arc tangent subroutine, and has indicated that scale factoring is unnecessary when a precision of one azimuth unit is all that is required.

A study has been made of some methods of combining the data from two radars. TRASACT has proved too inflexible to use in such a study, and a new program, tentatively called polysmooth, is being written to test these methods with synthetic data.

(A. Mathiasen)

Synthetic Muldar Data (SYMULDATA) now seems to be free of errors. A total of about 27 flight paths corresponding to 3 different conditions of velocity, heading, and antenna orientation, will be prepared for use in TRASACT. At present, troubles in TRASACT appear numerical rather than logical. It will be rerun with Gaudette's values of a and α . The radar tracking program for the Rockport radar (RTPR) has been run

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4.0 MULDAR DATA SCREENING (Continued)

(A. Mathiasen) (Continued)

but was not successful apparently because an incorrect data tape was used. A program to check the read-in sections of various programs using SYMULDATA tape as well as the tape itself has been written.

5.0 MULDAR TRACKING AND CONTROL

(R. L. Walquist)

The various methods of correlating radar data with tracked targets have been reviewed. A method has been found which appears optimum for the Cape Cod Muldar System. This method, in conjunction with a new sine-cosine program, will be coded in the near future for testing with radar data recorded on magnetic tape. Once a successful program has been obtained it should be usable, without modification, when the magnetic drum equipment is installed.

Work has been initiated on the Muldar section of the quarterly report for July 25 - October 25, 1951.

(N. S. Potter)

Work on the development of an optimum reliability muldar data fitting procedure is progressing. In the system under consideration all observed positions are projected with uniform velocity to a common time reference point. The resultant distribution is then employed as a basis for estimates of the reliability of the observations which are regarded as concurrent. The probable error effectively specified upon the assumption of a law of error distribution, is a function of velocity v and the heading angle θ , the minimization of which yields extremal values of v and θ which constitute the optimum estimate. Thus far only linear motion has been studied extensively, though several methods of accomplishing turn detection and data rejection are under consideration. The data rejection aspect of the study is of course mandatory in view of the considerable storage and processing problem.

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6.0 ASSOCIATED STUDIES

(P. R. Bagley)

Programming is continuing on sections of an automatic initiation program.

(A. Katz and G. Cooper)

Using the correlation coefficients calculated by EAC-1, we have derived three two-element linear filters. These filters when provided with the present and the most recent past data, should predict angular variation of a target flying a straight-line constant-velocity course. As might be expected from the non-stationarity of this ensemble of signals, each of these predictors should be characterized by a different transfer function, as indeed they were. Furthermore, each should be most effective over a particular portion of the trajectories of the targets. The composite filter is then time-varying in nature. A program for testing these predictors, ESP-1 (Evaluation of Statistical Predictors), has been written and will be run in the near future.

Lack of a program for solving matrix equations has prevented the derivation of more complicated filters. Since this problem is under consideration by the math group, we have not undertaken this labor.

7.0 COMPUTER OPERATION

(J. Arnow)

Normal Operation	
Relay Link Characteristics	1.25 hours
Data Screening	2.00 hours
Tracking and Smoothing	7.25 hours
Aircraft Control	6.00 hours
Miscellaneous	<u>0.5 hours</u>
Total	17.0 hours
Visitor Preparation	11.0 hours
Visitor Demonstrations	3.0 hours
Indoctrination	0.5 hours
Down Time	<u>1.0 hours</u>
Total	32.5 hours

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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. "Automatic Aircraft Guidance," Boehmer, H. W., Wieser, C. R., M-1370, January 14, 1952, 3 pp. CONFIDENTIAL

TECHNICAL REPORTS

1. "Radar Performance Testing Manual," Headquarters Army Air Forces, Washington, D. C., C-563, AF, February, 1943, Lib. No. 1645. CONFIDENTIAL
2. "Relationships Between Airport Separation, Protection Distance, GCI Radar Range, and Interceptor Performance," Weller, N.T., Douglas Aircraft Co., Inc., Santa Monica Plant, California, SM-13579, August 5, 1949, Lib. No. 1646. CONFIDENTIAL
3. "Interceptor Maneuvers," Klemperer, W. B., Douglas Aircraft Co., Inc., Santa Monica Plant, California, SM-13553, June 1949, Lib. No. 1647. CONFIDENTIAL

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