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6673  
Memorandum M-2102

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Electronic Computer Division  
Servomechanisms Laboratory  
Massachusetts Institute of Technology  
Cambridge, Massachusetts

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SUBJECT: BI-WEEKLY REPORT, PROJECT 6673, June 22, 1951

1. GENERAL

(C. R. Wieser)

The month-old mystery of curved collision courses has been solved with the discovery of about 10° orientation error in the relay link at Bedford (see Section 3).

The rough correction of this error produced a much better collision course during a demonstration for a group of people visiting Project Charles. In order to get a good check on orientation, a calibration flight-test will be held next week.

Indoctrination lectures for new people are well under way. Any suggestions for improving the program are welcome.

2. ENGINEERING

(C. R. Wieser)

The procurement of 16-inch tubes for the new display scopes has been held up by the supplier's reluctance to furnish tubes with clear-glass faces. The tubes are readily available with grey filter-glass faces, but the effect of the filter-glass on a P-7 phosphor is not certain. Further, filter-glass is certainly not ideal for the photographic tubes with a P-11 phosphor.

More detailed inquiries are being made, and it is hoped that tube procurement can be settled in the next bi-weekly period.

A satisfactory orientation of the scope tube in a mock-up console has been made. The cabinet design can now be completed.

(H. J. Kirshner)

The operational communications system described in previous bi-weekly reports has been installed and used during the flight test of June 20, 1951. Having heard no unfavorable comments from operating personnel, it is assumed that performance is satisfactory.

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2. ENGINEERING (continued)

(H. J. Kirshner) (continued)

One addition to the system will be an amplifier to boost the received signal level on the Barta-Bedford private phone line.

The demultiplex equipment has been re-calibrated for use with new multiplex equipment at Bedford.

The construction of an amplifier permitting the display of the digital radar data on a five inch scope will be undertaken during the next bi-weekly period.

Investigation of modification of the present channel "O" phase shifting networks and amplifiers will also be undertaken during the next fortnight.

(R. Best)

In the 16-inch scope, horizontal amplifier, one 715 tube has been replaced due to an intermittent open plate lead.

A marginal checking circuit has been built into the vertical amplifier, and appears to operate satisfactorily. This circuit will be built into future amplifiers.

3. ANALYSIS FOR BEDFORD EXPERIMENTS

(D. R. Israel)

The major part of the activity of the past bi-weekly period has been devoted to

- a) an investigation of the causes of errors in previous flight tests, and
- b) the preparation for and execution of a visitor demonstration.

For several weeks we have been puzzled by an apparent difficulty which has been revealed in our recent interception tests. This has been particularly noticeable in several right-angle interceptions which were attempted; the difficulty manifests itself as a sudden decrease of heading angle as the target and interceptor draw close to each other. In these tests the final separation of the two aircraft has usually been over 1000 yards, considerably poorer than earlier tests.

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3. ANALYSIS FOR BEDFORD EXPERIMENTS (continued)

(D. R. Israel) (continued)

Data of a previously-recorded flight test with the apparent error was printed out by the computer during the bi-weekly period; this data was analysed and plotted up for closer inspection. There was no immediately evident source of error, but after considerable analysis and discussion among other members of the group some suspicion did arise as to whether the interceptor was exactly following our instructions. Bob Wieser checked with the pilots and it was ascertained that the pilots were following our instructions exactly. Careful study and rechecks of our programs were sufficient satisfactorily to assure us that the programs were not at fault. Accordingly, as a further test four interceptions were essayed on June 20th. Between the actual interception tests, which were to be of the right-angle variety, the target aircraft was requested to criss-cross over Sanford, Maine. These interceptions were run while using a new program which punched a paper tape during the flight test. Immediately after the interceptions, the paper tape was reprocessed by the computer and a good deal of data printed out. From this data it was apparent that the azimuth calibration of the radar set was incorrect. This fact was checked and confirmed with the people at Bedford.

A standard demonstration (vector display, a live interception, FWTWS, and synthetic combat) was given on Friday, June 24th, to a group of military personnel visiting Project Charles. A live interception (right-angle) held during the demonstration was the first flight test after the azimuth error had been corrected. Much to our delight, the results of the interception was a final separation of about 300 yards.

Plans have been drawn up in conjunction with Dave Kemper for special and additional indoctrination for new members of 6673. Part of this indoctrination will consist of a study of the chief 6673 tracking program; a written description of this program is nearly complete and will be used for this training purpose. A second part of the indoctrination program will be a group problem relating to a simple form of the assignment of interceptors to bombers.

An M series note entitled 6673 Record Handling Procedures (M-2101) has been written and will be issued shortly. This note describes in some detail some procedures to be used for keeping fairly complete records of our programs, data taken, and the results of 6673 computer operation.

Work is being forwarded on preparation of part of the Quarterly Report.

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3. ANALYSIS FOR BEDFORD EXPERIMENTS (continued)

(J. Arnow)

Some work has been done on least squares fitting to data on tracked aircraft using a variable number of points and different degree polynomials.

A polar coordinate chart, D-45301, has been prepared by the drafting room. The calibration of the chart corresponds to quantizing of the MEW, i.e., 256 units in azimuth and up to 100 units in range.

(W. S. Attridge, Jr.)

The punched tape program has been checked out. With it and F. Heart's program for tape analysis we have tracked an interception and then typed out from the punched tape pertinent information for both aircraft. It has proved to be a great time saver.

I have written a program that optimizes a polynomial approximating the function

$$f(x) = x^{\frac{1}{2}}$$

over the range  $\frac{1}{4} \leq x < 1$ . The program has been run successfully and the constants have been determined to an accuracy of  $2^{-15}$ . The maximum error over the given range of  $x$  is 0.0027. Using this polynomial, a program has been written for

$$f(y) = y^{\frac{1}{2}}$$

over the range  $0 < y < 1$  with the maximum error being no greater than that of the polynomial. This program has a duration of  $21\frac{1}{2}$  orders (maximum of 23, minimum of 20) and a storage requirement of 27 registers.

(F. Heart)

The Data Analysis program for studying the results of one and two aircraft tracking programs has now been completely checked out. This program accepts data from punched paper tape in the form of  $R, \theta, \beta$  information. (For the two aircraft case, this tape is prepared by Attridge's interception program T 259-5.)

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3. ANALYSIS FOR BEDFORD EXPERIMENTS (continued)

(F. Heart) (continued)

The analysis program then smooths, predicts, and prints out data consisting of the following information for each aircraft (except, that for a target, there is no  $\phi$  given):

$R, \theta, \phi$  given;  $X, Y, \dot{X}, \dot{Y}, V, \phi$  calc.; Scan number

Part of the time was spent on the smoothing problem, and several discussions of an informal nature occurred. A program has been written which will study the possibility of varying the smoothing parameters  $\alpha, a$  in the following manner:

$$\begin{aligned} \dot{\bar{X}}_n &= \dot{\bar{X}}_{n-1} + \alpha e & \alpha_n &= A\alpha_{n-1} + B e \\ \bar{X}_n &= \bar{X}_{n-1} + \dot{\bar{X}}_n + a e & a_n &= C a_{n-1} + D e \end{aligned} \quad e = X_{\text{meas.}} - X_{\text{pred.}}$$

This program has not been tested as yet. It is, in any case, only a first attempt at this analysis. Criteria for evaluating the best values for A, B, C, D will be the same criteria as previously used in the linear case: Minimum Summed Error Magnitude In Velocity.

(D. A. Kemper)

A program has been written and corrected which displays vectors for two aircraft and the distance between them in nautical miles as decimal digits on the face of the scope, but the corrected form has not yet been tried. This program uses the extra 48 ES registers.

(J. Rossbach)

J. Arnow's Data Punch-Out Program was modified so that the data will be punched out instead of printed. A new program was written which will track and print using the data on this punched tape.

The Circle and Fixed Points Display Program was modified to display a point with coordinates in 2 flip-flop registers when flip-flop 0 is set to 1/2. This program operated satisfactorily, and and some other improvements were added. In the near future, it will be modified to display a circle on one scope and a spiral on the other.

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3. ANALYSIS FOR BEDFORD EXPERIMENTS (continued)

(J. Rossbach) (continued)

PWTWS -- Data Mean was run again, without any modifications, and failed to operate. It has now been revised, except for some difficulty with the printing program which has not yet been straightened out.

4. THEORETICAL ANALYSIS

4.1 General Studies

(R. L. Walquist)

Work has continued on the Cape Cod Muldar System. A first proposal has been written describing a solution to the problem which involves a minimum amount of modification of WWI and two relatively simple drum storage systems. This proposal has been issued as E-2023.

(D. A. Kemper)

M-2097, the Trig. Check and Square-root Check, has been issued.

The Indoctrination Program has been going quite well and now is only two days behind schedule. There are 6 Whirlwind applications people attending, two listeners from Building 32, one listener from Prof. Morse's group, and one secretary. They have been meeting from 1 to 3 p.m. every day. To date the following people have addressed the group: John Salzer, Dave Israel, Jack Arnow, Ron Mayer, Charlie Adams, and myself. We expect to have Jack Gilmore and Phyllis Fox next week to cover their conversion program. Notes are being taken on each lecture and written up as a guide to the preparation of future indoctrination programs.

Plans are being made for the 6673 Indoctrination program proper, which will get under way Wednesday, June 27. Four people are expected in this group.

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4.1 General Studies (continued)

(P. R. Bagley)

Studies have been carried out in connection with the proposed Muldar system. Consideration has been given to various methods of handling four or five binary digits representing altitude angle. It is probable that altitude angle will not be transmitted with each azimuth and range report, and further that it will be an asynchronous transmission with respect to the azimuth and range report. Hence provisions are necessary for storing the angle and associating it with the corresponding azimuth and range report.

A flow diagram is being prepared for an automatic acceptance or initiation program. The program is intended for handling the reports from a single radar set. The first version of the program will require the following conditions for the initiation of a target:

a) Three successive reports of the same target in three successive scans, or three reports occurring in the first, third, and fourth scans of four successive scans.

b) An apparent radial velocity component inward greater than 120 mph (the minimum observable in three successive scans), and less than 600 mph.

Most of the afternoons of the past bi-weekly period have been spent in indoctrination, attending classes held by D. Kemper, and in reading laboratory publications.

4.2 Data Smoothing and Aircraft Control

(J. M. Salzer, C. Gaudette)

The velocity smoothing using the inverted Simpson's  $\frac{3}{8}$  -- rule modified for stability has been operated successfully. It was compared with the presently used program under the condition of a suddenly applied velocity, with the following conclusions: (1) the transient response of the new program is better, and (2) the smoothing effect of the new program is inferior under quantization. These two observations appear paradoxical, but are very easily interpreted by frequency analysis; indeed, the experiment has pointed the way to a better understanding of the relation between frequency characteristics and time response.

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4.2 Data Smoothing and Aircraft Control (continued)

(J. M. Salzer, C. Gaudette) (continued)

In accordance with the above observations 5 new smoothed-velocity programs were synthesized in the frequency domain, and their time behavior will be observed as soon as computer time becomes available. A program has been written for comparing new programs, having a complexity of up to 7th degree numerator and 6th degree denominator in their transfer functions, with the presently used program under constant velocity with quantization.

In conjunction with this a program that displays the loci of the numerator and denominator of the transfer function and the transfer function itself has been written. The numerator is of the third degree and the denominator of the fourth degree. The various sets of coefficients are introduced by a separate parameter tape, and the program is intended for the design of simpler smoothed-velocity programs.

4.3 Correlation Studies

(F. Van Wyk)

I am continuing work on the problem of correlation of information concerning targets being tracked by Muldar. In the process I have reached the conclusion that a pre sort on an area basis can probably be more efficiently handled by means of a super imposed rectangular grid rather than the octant of a circle. I am now involved in the ramifications thereof.

5. COMPUTER OPERATION

(J. Arnow)

The past bi-weekly period has been rather satisfactory as far as efficiency in computer operation. There has been a minimum of delay in running programs. It is suggested that requests for computer time be submitted as early as possible.

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6. RECORD OF COMPUTER UTILIZATION

(J. Arnow)

6-12-51

- 1500 - 1530 T 259, Two Aircraft Interception - Punched Tape Output. Changed one order as needed by MIV. Trouble not eliminated and irregularities in punching developed.
- 1530 - 1555 T 295-2, Two Aircraft Interception - Calc.  $V_i$ . There was difficulty in tracking after the aircraft got closer together. The trouble encountered with the angle display was possibly an indication that the aircraft data was mixed.
- 1555 - 1630 T 196-2, Two Aircraft Interception. Satisfactory operation. Got data comparing given heading and calculated heading for  $V_i = 200$  knots and  $V_i = 210$  knots on Magneorder tape 46A.
- 1630 - 1637 T 300, Square Root Polynomial. Program gets arithmetic alarm at the end of range  $1/4 \leq x \leq 1$ . Parameters need changing.
- 1637 - 1650 T 269, Data Punch Out. Printing appeared fallacious. Requires further investigation.
- 1650 - 1700 T 275, PWTWS - Data Mean. Programming error.

6-13-51

- 1500 - 1600 T 194-6 and T 147-3, Two Aircraft Interceptions by Angle, and by Time. Taken from 46a in previous test flights.
- 1600 - 1615 T 183-5, One Coordinate Prediction Test Program. Program did not run as it did on the previous occasion. Considerable difficulty encountered in reading in.
- 1615 - 1645 T 278, One Coordinate Velocity Smoothing Program. Operation Satisfactory.
- 1645 - 1700 T 253-6, Printing from Tape. Operation Satisfactory.

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6. RECORD OF COMPUTER UTILIZATION (continued)

(J. Arnow) (continued)

6-15-51

- 1330 - 1350 T 286, Range Gate and Target Identification. Tape difficulties encountered.
- 1350 - 1415 T 185, Synthetic Interception. Satisfactory Operation.
- 1415 - 1430 T 259, Two Aircraft Interception and Punch. Program difficulties.
- 1430 - 1500 T 300-3, Square Root Polynomial. Good results were obtained for optimizing the polynomial with a maximum error of 0.27% in the square root.
- 1500 - 1530 T 278-1, One Coordinate Vel. Smoothing Program. Storage Punch out, no results.
- 1530 - 1615 T 183-5, One Coordinate Prediction Testing Program. Program Satisfactory.
- 1615 - 1625 T 261-1, One Coordinate Prediction Comparison Program. Arithmetic check alarm. Punched out Storage.
- 1630 - 1715 T 185-2, Synthetic Interception. Program operated satisfactorily; pictures with Land Camera were unsuccessful.

6-19-51

- 1545 - 1615 T 286-1 and T 286-0, Range Gate and Target Identification. sp, op record taken. Storage read out did not appear to operate as planned.
- 1615 - 1645 T 259-5, Two Aircraft Interception - Punched Tape. Initial attempts at conversion unsuccessful due to PETR. Time used in adjusting PETR.
- 1645 - 1700 T 253-6, Printing from tape. Program successful.

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6. RECORD OF COMPUTER UTILIZATION (continued)

(J. Arnow) (continued)

6-20-51

0845 - 1315 T 259-5, T 259-6, T 253-7, Flight Tests.  
Flight test made and data taken on same. Results  
successful. Punched two data tapes. Data printed  
from tape.

6-21-51

0900 - 1100 Preparation was made for an expected group of  
1600 - 1700 visitors.

6-22-51

0845 - 1130 The time was used for demonstration of a  
number of active programs. A very successful flight  
test was also held.

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6. RECORD OF COMPUTER UTILIZATION (continued)

(J. Arnow) (continued)

6-20-51

0845 - 1315 T 259-5, T 259-6, T 253-7, Flight Tests.  
Flight test made and data taken on same. Results  
successful. Punched two data tapes. Data printed  
from tape.

6-21-51

0900 - 1100 Preparation was made for an expected group of  
1600 - 1700 visitors.

6-22-51

0845 - 1130 The time was used for demonstration of a  
number of active programs. A very successful flight  
test was also held.