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Memorandum M-1389

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Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

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SUBJECT: 6889 AIR DEFENSE BI-WEEKLY February 1, 1952

1.0 GENERAL

A Lincoln Seminar, "The Division 6 Program for Cape Cod," was given on January 21.

Dick Whelan reports that two TPS-10 height finders have been made available to Lincoln. Repairs will be necessary before they are put in service.

In order to extend our present experiments toward a complete air defense system, plans must be made for incorporating many additional air-defense functions. Investigations have been started to learn about 1) getting data from a Ground Observer Corps, 2) using flight-plan data for identification of friendly aircraft, and 3) information requirements of Antiaircraft Artillery. See Section 6.

The additional air-defense functions referred to above will be reported in a new section of the bi-weekly called "Air Defense Center Operations." The revised list of the bi-weekly headings is now:

- 1.0 General
- 2.0 Equipment Engineering
- 3.0 Bedford Experiments
- 4.0 Data Screening
- 5.0 Tracking and Control
- 6.0 Air Defense Center Operations
- 7.0 Associated Studies
- 8.0 Computer Operation
- 9.0 Publications

2.0 EQUIPMENT ENGINEERING

(E. S. Rich)

Terminal Equipment Planning

Studies are being made of the amount of equipment which must be built in our shops in order to install the two magnetic drum systems. This includes planning for air-conditioning, power, marginal checking, and racks. These studies are coordinated with

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2.0 EQUIPMENT ENGINEERING (Continued)

(E. S. Rich) (Continued)

Gus O'Brien and Chan Watt who are concentrating on a new design for plug-in units and their mounting. The aim is to obtain a flexible mounting scheme so that groups of these units can be easily assembled to form parts of the drum systems.

(H. J. Kirshner)

Experiments concerning the digital ground/air link have been temporarily suspended. This suspension is due to the removal from operational service (engine trouble) of the B-25 in which the airborne equipment is located. This aircraft will probably be back in commission during the next bi-weekly period.

A flight test attempted on January 31st was unsuccessful due to a failure in the video integrator at Bedford. The F-51 aircraft used in the experiment has been sent to Rome for repairs, but it is hoped that a replacement will be found.

Negotiations for multi-channel magnetic tape equipment have been reinitiated. It is hoped that suitable specifications and estimates will be forthcoming within a week.

Preparations are underway to install terminal equipment for the Rockport radar in 224. The transmitting equipment has been installed at the Rockport site and is currently undergoing test.

A decoder which will be a part of the system to obtain a direct R-θ display of SDV (Slowed-Down Video) will be constructed during the coming bi-weekly period.

(R. Best)

A sample 6SN7 flip-flop has been received from Group 24 and is undergoing test.

(E. E. Morriss)

During the past period most of my time has been spent examining the various possibilities which exist for handling the transfers of information to and from the computer which appear to be needed by the Air Defense Group.

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2.0 EQUIPMENT ENGINEERING (Continued)

(B. E. Morriss) (Continued)

Previous work has been restricted to the system for handling the returns from radar sets. While this system involves a large percentage of the volume of input, the other inputs and outputs involve slower external units and could require a much larger percentage of the total time. To reduce this time, it appears that some form of buffer storage must be provided. The additional fields of the buffer-drum appear to be one solution and work will continue to develop a plan for using this space with some of the proposed forms of external units.

(A. V. Shortell, Jr.)

The past bi-weekly period has been spent designing and testing filters for the multiplexing equipment to be used with a multi-channel recorder.

During this period bandwidth requirements have been changed from 300-4000 cps per channel to 300-3000 cps per channel. Consequently, the plan for the multiplex equipment have been modified and we now plan to multiplex three signals per channel. This change in plans necessitates a redesign of all filters and places very stringent demands on selectivity and attenuation due to the very close channel separations.

Filters tested during this period show some promise but the poor quality coils causes considerable deviation from predicted results. During the next period filter designs will be recalculated and an attempt will be made to procure some high-Q coils to be used in these filters.

3.0 BEDFORD EXPERIMENTS

(D. R. Israel)

The following talks have been arranged for general educational purposes:

- | | | |
|-------------------------|-------------------|----------------|
| a) Smoothing Methods | Wednesday, Feb. 6 | Rm 250 1:30 pm |
| b) Interception Program | Monday, Feb. 11 | Rm 250 9:00 am |
| c) Computer Operation | Tuesday, Feb. 12 | Rm 250 9:00 am |

The talk on Smoothing Methods is the first of a series which will be sponsored jointly by the groups working on the Bedford and the Three Radar experiments.

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3.0 BEDFORD EXPERIMENTS (Continued)

(D. R. Israel) (Continued)

Investigation of the recent results of the smoothing of simulated $r-\theta$ flight paths has pointed out that we can no longer neglect the variation of the quantizing box size with range. The azimuth quantizing unit is just one mile at a 45 mile range, and hence at that range the quantizing area is practically at square box. At longer or shorter ranges, however, the quantizing area deviates from a square and this fact introduces difficulties in non-linear smoothing, particularly NLS-2. Solutions to the problem would seem to be either to make the position of the breakpoints in NLS-2 increase linearly with range above 45 miles or to switch over to smoothing \dot{r} and $r\dot{\theta}$. The latter idea involves serious questions about r and θ acceleration components and also is not too attractive when one considers the multiple-radar problem. Both solutions will be tried at the earliest possible moment.

The discussions with Capt. Smith (see Section 6.0) have indicated that the installation and operation of beacon or IFF equipment in interceptors is extremely useful and almost a necessity. The question of how beacon or IFF replies can be coded with the SDV data links is one which it appears should be carefully investigated before a SDV data link design is frozen. For the present and in the near future we can carry out beacon and IFF experiments in conjunction with the MEW radar. The Bedford data-link will permit the coding of beacon replies on a spare range channel. An antenna and beacon receiver were installed at the Bedford radar site some time ago but were never tested. In conjunction with Wood of Division 2, Lincoln, we will try to run some experiments with the equipment in the near future.

(C. Zraket)

Flight Tests:

A Flight Test scheduled for January 22, 1952 to test the automatic transmission link was cancelled due to trouble in the computer.

A 3-dimensional, 2 a/c interception scheduled for January 31st was cancelled due to trouble with the radar and the display scope.

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3.0 BEDFORD EXPERIMENTS (Continued)

(P. R. Bagley)

A programming error in the clutter rejection programs has been discovered and is being corrected.

Work has been suspended on the automatic initiation program for one radar in favor of a more general program for 1, 2, or 3 radars.

(C. Gaudette)

During the past bi-weekly period work has been concentrated in the preparation of simulated data tapes and analysis of these tapes with Sue Knapp's PWTFT Programs. This work will continue during the next period. It is hoped that this analysis will point out the difficulties in the present non-linear methods and indicate the usefulness of a non-linear r, θ method.

(F. Heart)

1. Efforts have continued, with S. Knapp and C. Gaudette, on the data analysis program. Additional Simulated Data tapes have been prepared, and numerous sets of parameters have been tried in the analysis program (PWTFT). This program of work has reached a stage where useful information about smoothing is being obtained.

2. Plots were made of data taken from MT-120, in hopes of acquiring more information about wind. This particular data was taken with a plane flying at a constant air speed and constant heading. Unfortunately, the radar set was not correctly calibrated on the day of the test and the plotted results are ambiguous. It is still hoped that reliable wind data can be obtained from the plane-computer-radar link, and further attempts will be made.

3. The modification of the "interception display" program, T835-8, (written with S. Knapp) was tried, but due to both tape and program errors, did not work correctly.

4. A small amount of time was spent assisting in the current indoctrination program.

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3.0 BEDFORD EXPERIMENTS (Continued)

(S. Knapp)

Work is continuing on smoothing analysis. PWTFT records have been taken of five simulated data tapes using LS, NLS-2, and NLS-2b with various parameters. This printed data is to be kept in a notebook entitled "Data Tapes and Data Tape Analysis".

A new r, θ PWTFT program has been written. It will smooth r, θ, \dot{r} , and $\dot{\theta}$ directly and will print a scan number, the observed position, the predicted position, (both in polar coordinates), velocity, heading angle, and the errors in r and θ .

A modification to T-835 has been written in conjunction with Frank Heart. This modification provides for more information to be displayed on the scope, and also for the display of velocity vectors.

The Interception Assignment problem, which was programmed in three parts by P. Bagley, C. Zraket, and myself, is now going to be rewritten for Bank B, so that the entire program can be run without need for reading in after each section is completed.

(C. Zraket and P. Cioffi)

The following programs have been modified and will be checked out as soon as tape preparation and computer availability allow.

The Interception Test Program has been modified to correct program errors discussed in the last bi-weekly. The current modification is T-832-1.

The Guidance Program (T-512) has been modified to correct the selection of data, all data more than 16 miles away being rejected before the comparison. This is Mod 6. Mod 5, which provides for automatic transmission of heading angle and insertion of guide points at any time, has been checked out.

The modification to the Interception Display Program (T-835-6) which gives an F scope display, at south, of the north-east quadrant data before target initiation has been modified to

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3.0 BEDFORD EXPERIMENTS (Continued)

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

retain the D scope display and to extend the F scope display to all of the northeast quadrant. This is now Mod 12. The following are the current modifications to T-835-6.

- MOD- 7 Use of NLS-2
- MOD- 8 Display of Velocity Vectors, Bearing Angle, Heading Angle. (Obsolete).
- MOD-9 Inspection of consecutive ranges to see if they are equal. If so, use second piece of data.
- MOD-10 F scope display discussed above. (Obsolete)
- MOD-11 Automatic initiation of interceptor stationed at Grenier.
- MOD-12 Supercedes MOD-10.
- MOD-13 Supercedes MOD-8.

The above mods are written to work with MOD-6.

4.0 DATA SCREENING

(R.L. Walquist)

An outline has been written up for a set of programs which will allow us to test parts of the Cape Cod Muldar Program before the magnetic drum equipment arrives from E.R.A. The proposal is to record on magnetic tape blocks of filtered radar data from 1, 2, or 3 radar sets. The computer would carry out the necessary filtering and recording operations. A second program would then be read into the computer which would process the radar data on the magnetic tape, a block at a time. In this way, the processing program could be completely divorced from real time, allowing us a great deal of flexibility in testing various information processing methods.

(W. S. Attridge, Jr.)

I am completing the Simulated Tridar Data program for printing and punching simulated data from three overlapping radars having non-uniform scan rates. Each piece of data is quantized to 1/2 mile in range and 1/256 revolution in azimuth, and the associated time is quantized to the nearest 1/4 second. The data tapes will be used for testing various types of tracking and smoothing methods.

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4.0 DATA SCREENING (Continued)

(P.R. Bagley)

Sections of a Muldar program suggested by R. Walquist are being planned and coded. T-908 will set up clutter tables simultaneously for N radars. T-909 will record on magnetic tape data from N radars which does not appear in the associated tables of clutter. In order to test these two programs before the multiple radar setup is available, both will have input sections which will enable a single radar to simulate three radars. T-910 will be a subprogram which will read one block of recorded data from magnetic tape and store it in a designated section of ES.

(N. S. Potter)

The problem of statistical analysis of muldar information is still under consideration. Estimates regarding an upper bound to the number of sets of coordinates necessary to fix the oscillation of the velocity and heading angle within desired limits have been obtained. Minimization of the quantity of stored data is also accomplished by employing modified criteria of reliability which are adapted to the needs of computer operation, the unsatisfactory data being rejected.

I have been on vacation during the past week, so that I have not had an opportunity to complete my analysis of the problem.

5.0 TRACKING AND CONTROL

(M. Frazier)

SDV (Slowed-Down Video) Data Analysis II has been written, but not yet checked out. This program performs either or both of two functions: a) data storage and subsequent print-out; and b) data analysis and subsequent print-out.

Polysmooth -- mentioned in the past bi-weekly -- is nearly completed. The program is largely a collection of sub-routines. At present it is equipped to study eight methods of combining the data from two radars, using data tapes from A. Mathiasen's SYMULDATA II.

(A. Mathiasen)

Because of the computation of flight paths using the Synthetic Muldar Data program, testing of other programs was held in abeyance. Analysis of printed data showed that for certain conditions misses by a radar were prevalent. This appears

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5.0 TRACKING AND CONTROL (Continued)

(A. Mathiasen) (Continued)

to be due to inaccuracy in the arctangent subroutine. A test parameter virtually confirmed this, and points the way to elimination of this defect.

A two-aircraft tracking program has been adapted for the Rockport radar.

6.0 AIR DEFENSE CENTER OPERATIONS

(D. R. Israel)

A visit has been made to the Meteorology Department at MIT where a good deal of information was obtained regarding the availability of pertinent weather information. This visit is described in an inter-office memorandum of January 22, 1952.

A visit has been made to the Boston Air Route Traffic Control Center where the handling of flight plan information was discussed with Mr. Thomas Millea, Chief Controller. Arrangements were made with Mr. Millea for a staff member to visit the Center and study the operation of the AMIS (Aircraft Movement Identification Section). Mr. Millea has promised us his fullest cooperation in our work, although it will also be necessary to secure approval from other officials in the C.A.A.

Arrangements have been made to visit Colonel Merle Drury, the Air Force officer assigned the task of assisting Civilian Defense people in the operation of the Ground Observer Corps (GOC) in Massachusetts.

Captain Smith, Lieutenant Rogers, and Chief Warrant Officer Crow visited the project on January 29th. These men are all experienced in GCI operation and discussed present techniques and tactics with several staff members. The discussions were extremely informative.

Contact has been made with Colonel Hahn, Army Liaison Officer at Lincoln, and arrangements are being made for us to secure information regarding the problems of coordination between GCI's and AAOC's (Anti-Aircraft Operations Centers).

(F. A. Webster)

Preliminary investigation has been undertaken on the use of auxilliary (non-radar) information in an air defense system, with particular reference to the potentialities of a ground observer corps (GOC). A tentative table has been drawn up outlining the sources available, the advantages and shortcomings

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6.0 AIR DEFENSE CENTER OPERATIONS (Continued)

(F. A. Webster) (Continued)

of the data they provide and the efficiency and reliability of the linkages through which they operate.

7.0 ASSOCIATED STUDIES

(R. L. Walquist)

Some time has been spent on discussing "logical programming" with the new indoctrination group. Several problems were written for this group to solve in order that they might gain some supervised experience in logical programming. Ishihara, who went through the previous indoctrination period, is writing sample solutions to these problems.

Two solutions to the problem of converting θ to $\sin \theta$ and $\cos \theta$, by using a cosine table which covers only one quadrant, have been written up. This problem was originally given to the indoctrination group of December, 1951. It is intended that one of these solutions be used for the conversion of r- θ data in the Cape Cod Muldar System. The better of the two programs carries out the sine-cosine conversion with a total of 16-17 successive operations and occupies 111 storage registers (this includes 64 registers for table storage).

(P. R. Bagley)

The Interceptor Assignment Demonstration, T-558, is being rewritten for Bank B with S. Knapp and C. Zraket.

(G. Cooper)

More study has been given to the optimum use of non-linear filters for aircraft tracking. A visit was made to Airborne Instruments Laboratory to discuss this problem with Warren White, and a report of this discussion has been written up in M-1387. Essentially, his method involves making an assumption about the form of the probability distribution governing the radar data and using the radar data to evaluate the parameters of the distribution. When the distribution is obtained,

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7.0 ASSOCIATED STUDIES (Continued)

(G. Cooper) (Continued)

it is a relatively simple matter to make a prediction of the next position according to any desired criterion (e.g., best mean-square error or most probable position). The limit-mean smoothing method effectively does just this, using probability distribution assumptions different than White's.

(J. Ishihara)

In progress: (a) Further study of introductory material;
(b) sample computer programs and solutions for "Indoctrination Problems on Logical Computer Programming," by Walquist, Jan. 24, 1952.

(A. Katz)

Work is continuing on the derivation of statistical predictors. In addition to the two-element predictors previously derived, we now have available three- and four-element predictors. The performances of these filters will be evaluated by ESP-1 as soon as that program has been debugged.

(W. Lone)

I have written a program which will print out numbers where two registers are used to store each number. The factor which converts the number to a fraction is likewise stored in two registers. The remainder of the time was spent reading memoranda on double length numbers and various computer operations.

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8.0 COMPUTER OPERATION

(J. Arnow)

Relay Link Characteristics:	0.25
Data Screening	1.75
Tracking and Smoothing	16.5
Aircraft Control	1.25
Miscellaneous	<u>1.75</u>
Total useable	21.5
Lost time	<u>10.5</u>
Total	32.0

In spite of the great amount of computer time lost, operation was held up in many cases due to great delays in tape preparations.

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9.0 PUBLICATIONS

(M.R. Susskind)

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

TECHNICAL REPORTS

1. "Wind Variability," Signal Corps Engineering Laboratories, Evans Signal Laboratory, Meteorological Branch, Belmar, New Jersey, September 5, 1951, Lib. No. 1668.

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2. "Theory and Applications of Games of Strategy," Dresher, M., R-216, the Rand Corporation, Santa Monica, California, December 1, 1951, Lib. No. 1668.

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BOOKS

1. "Baughman's Aviation Dictionary and Reference Guide," Third Edition, Aero Publishers, Inc., Los Angeles, California, 1951.
2. "A Student Guide for Aeronautics," Tower, M.E., Aero Publishers, Inc., Los Angeles, California, 1950.

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