APPROVED FOR PUBLIC RELEASE. CASE 06-1104.

CONFIDENTIAL UNCLASSIFIED

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

CLASSIFICATION CHANGED TO:
Auth: DOE
By: A Everett
Date: 2/4/60

SUBJECT: BI-WEEKLY REPORT, PROJECT 6673, April 27, 1951

1. GENERAL

(C. R. Wieser)

A meeting was called by Robert Alexander of AFCRL to determine the responsibilities of the various groups working on the Bedford experiments, and to determine who should be contacted concerning any plans or requests. Results were as follows:

a) AFCRL is responsible for the automatic ground-to-air communication system now under development. They will supply binary instructions, probably on a relay register in the aircraft. They were also requested to assist with the interim voice communication system. The man responsible for this work is Martin Autman.

b) Instrumentation Lab is responsible for taking data from the AFCRL radio link to the autopilot system. The man to contact in regard to equipment is Bill Greene. Arranging for Aircraft for test flights will be handled through Frank Wilkins.

c) Barta Building is responsible for computation of interceptions, arranging flight tests as needed for computer studies, and for furnishing AFCRL with information necessary for connecting their ground-to-air communications system to WWI. Wieser is responsible.

d) Bedford Radar & DRRL will furnish radar data needed for computer studies. Jack Harrington is responsible for this work.

The AFCRL and Instrumentation Lab groups are engaged in activities other than those which immediately concern us, and it is important that the responsible people be informed of our plans and requests.

During this period there were two successful flight tests. The first was a guidance test using a B-26 from Instrumentation.

UNCLASSIFIED CONFIDENTIAL

APPROVED FOR PUBLIC RELEASE. CASE 06-1104.

CONFIDENTIAL UNCLASSIFIED

1. GENERAL (continued)

(C. R. Wieser) (continued)

The second test, April 20 yielded three successful interceptions and is described in M-2092. The interceptor pilot reported passing the target with a minimum separation of 500 to 1000 yards. This experiment is an important demonstration of the usefulness of digital computers, and it is an important step in the job of extending our efforts to larger systems.

Most of the 6673 computer time after the interception experiment has been devoted to data analysis. This will probably take a good deal of time, and efforts to speed-up data analysis are under way.

More flight tests for interception experiments will be held in the future. Our technique of running these tests needs to be improved. In particular, we should brief the pilots more carefully, and improve communications. As noted above, AFCRL has been requested to assist us in improving communications.

2. ENGINEERING

(D. A. Buck)

The addition of one five-inch scope and the forthcoming addition of a sixteen-inch scope to the special display system has made necessary a change in the $\frac{2}{3}$-axis intensification equipment. It was recommended by the operational personnel that each scope have a switch similar to that which is now on the M-scope in test control to switch the intensification from QD to QF to both.

In conjunction with Robert Gould and Richard Best a system was designed whereby each scope contains an intensification flip-flop which is set and cleared by pulses from the display equipment in rack C-1. This new system makes switching easy, facilitates the addition of new scopes, and eliminates one of the sources of prf sensitivity. Four flip-flops for this purpose have been built and tested, and one five-inch scope has been modified.

Stray currents in the outer conductors of the deflection cables has caused hum to appear on the horizontal and vertical deflection lines. A WWI ground is being run into room 224, and when bonded to the various equipments it will clear up this trouble. In addition, a 500-volt line is being run into room 224 for the sixteen-inch scopes.

CONFIDENTIAL UNCLASSIFIED

APPROVED FOR PUBLIC RELEASE. CASE 06-1104.

CONFIDENTIAL UNCLASSIFIED

2. ENGINEERING (continued)

(D. A. Buck) (continued)

Consideration is being given to possible methods for phone line recording in the MILDAR system. In view of the results with the Magnecorder in the present system, it is felt that some scheme of phone-line data recording is essential to the projected system. A 21-channel Raytheon tape recorder is under development but not at present available. The possible use of sound-on-film has been considered.

(H. J. Kirshner)

A log, containing an index to recorded data on Magnecorder reels has been prepared. The log will be kept in the same location in which the reels are now stored.

In order to alleviate some of the communications lag in giving heading instructions to an aircraft, provision is being made for direct "push-to-talk" operation from the Barta Building. This system will utilize the present VHF equipment at Bedford with remote operation from the Barta Building.

Phantom circuits employing present telephone equipment will be used to permit this mode of operation. These circuits have been partially tested and it appears that no interference with normal information channels will be encountered.

(R. L. Best)

A new flip-flop has been designed for use in the 304-H scopes as intensification gate generators. The very conservatively designed circuit uses a 2051 twin triode, and is set and cleared by 0.1 microsecond negative pulses of at least 15 volts amplitude.

The auxiliary circuits for the 16-inch display scope have been completed by the shop, but have not yet been tested. No difficulty is expected.

UNCLASSIFIED CONFIDENTIAL

APPROVED FOR PUBLIC RELEASE. CASE 06-1104.

CONFIDENTIAL UNCLASSIFIED

3. ANALYSIS FOR BEDFORD EXPERIMENTS

(D. R. Israel)

In the past two weeks we have accumulated four good reels of Magnecord Tape as a result of the two successful flight tests. The most recent flight test, during which several interceptions were carried out, was quite successful and satisfactory as regards program operations and aircraft separations at the collision point.

As a result of these two flight tests and one which was held in the previous bi-weekly period a large amount of data has been accumulated. The present method for obtaining this data in a usable form is to use the computer to print out the data during a re-run of the Magnecord Tapes. This is quite unsatisfactory from time considerations and the present printing programs do not provide all the desired data. For these reasons a new approach to the problem has been taken. This will entail printing out a certain amount of data on paper tape during the actual flight tests. The data punched can then be read into the computer at some future time at a higher rate of speed, and all of the desired data printed out. Arnow is looking after the preparation of the necessary programs.

In the interim period before the above mentioned programs can be prepared an attempt will be made to process and use the data already available. We are behind in this work, chiefly because of a lack of personnel for these purposes. The main bulk of the work consists in plotting data.

A renewed effort is being made to develop "smoothing criterion" programs. Frank Heart has been putting a good deal of effort into this, and much valuable help and assistance has been obtained from Gerry Cooper who is interested in this problem from a thesis standpoint. A large amount of printed data has been taken, and studies are now under way to determine the reasons for certain observed peculiarities.

In regards to the smoothing problem, an interesting explanation of Prof. Wiener's work on the design of optimum filters has been found in the back of Wiener's book on "Time Series, etc." The explanation, by Prof. Levinson, deals exclusively with sampled functions.

Some thought has been given to the idea of smoothing magnitude of velocity and heading angle. Initial investigations seem to indicate that our present smoothing method essentially accomplishes the desired smoothing of velocity and heading angle in a very simple manner.

CONFIDENTIAL UNCLASSIFIED

APPROVED FOR PUBLIC RELEASE. CASE 06-1104.

CONFIDENTIAL UNCLASSIFIED

3. ANALYSIS FOR BEDFORD EXPERIMENTS (continued)

(J. Arnow)

In an effort to obtain a more accurate record of the results of flight tests and to obtain more and varied data regarding the idiosyncrasies of the tracking programs in general, modifications of the Guidance and Interception programs are being made by D. Kemper and W. Attridge respectively. These programs will produce on punched paper tape the r and θ co-ordinates of the aircraft being tracked, and also the computed heading angle. F. Heart and J. Rossbach are working on a program to take this r, θ data and print r, θ, x, y positions, x, y velocities, heading angle, and heading instructions as well as a scan number.

At present, the only method for obtaining these quantities are the PWTWS programs, which are used after the flight test. An attempt is made to indicate on the printed record the heading instructions given by listening to the recording of the day's events. The velocity magnitude is found later still by preparing a flexowriter tape containing the two velocity components and reinserting this into the computer.

The program for determining the amount of data being sent from Bedford was run in conjunction with a tape which was recorded after the elimination of the high-speed storage. The only significant result of this data was that the D.R.R. equipment was operating as it should have operated. It appears also that it is possible to record two targets at the same azimuth since every other piece of data is an azimuth. This means that approximately 375 azimuths are sent per revolution or about 120 azimuths are duplicated in the course of one scan. An extra target could conceivably be coded at these azimuths.

(O. Becker, O. Aberth)

We are in the process of coding a program for target display and range gate operation for automatic target acquisition. The program described in the previous bi-weekly, is approximately one-half completed. Some difficulty is being encountered in compressing the number of orders used down to the present storage capacity of the computer. All remaining programming has been assigned so that progress may be made by either of us independently.

(W. S. Attridge)

Two programs of interception with a vector display at the perimeter of the scope have been run successfully on WWI.

UNCLASSIFIED CONFIDENTIAL

APPROVED FOR PUBLIC RELEASE. CASE 06-1104.

CONFIDENTIAL UNCLASSIFIED

3. ANALYSIS FOR BEDFORD EXPERIMENTS (continued)

(W. S. Attridge) (continued)

The synthetic combat program has been run successfully with a few parameters and peculiarities yet to be corrected. We did however get an interesting display which aroused new interest in the possibilities of such programs being used in the future.

I am now writing a program which will punch on tape the ranges and azimuths of two tracked aircraft and the heading given for an interception course. This program is a part of the overall plan of correlation studies.

(F. Heart)

Several modifications of the "Critera for Smoothing Program" were tested. Results were obtained, but their exact significance is not yet completely clear.

Some time was spent in helping prepare a program which will print out R, θ, heading, x, y, $\dot{x}$, $\dot{y}$, v, and scan number, assuming an input from a paper tape with R, θ, and heading prepared by either the one or two aircraft tracking and interception programs.

Further attempts were made to get familiar with the multiple aircraft tracking problem, and with previously used programs.

(D. A. Kemper)

The two-aircraft velocity vector program was tried once for a few minutes and did not seem to track very well. Not enough time was available to see what was the matter.

The PWTWS program for two aircraft works successfully after correcting a number of programming errors and was used in reducing some of the data from the flight tests made during the week of April 16, 1951.

The memorandum describing the Trigonometric and Square-Root Checking Programs has been written and will be issued as E-2022.

UNCLASSIFIED CONFIDENTIAL

APPROVED FOR PUBLIC RELEASE. CASE 06-1104.

CONFIDENTIAL UNCLASSIFIED

3. ANALYSIS FOR BEDFORD EXPERIMENTS (continued)

(J. Rossbach)

I have prepared one of the two display programs described in the last bi-weekly, and as soon as the tape is ready it can be run on the computer. The other program will follow shortly.

Have been working on a program which prints n characters at the beginning of each scan of the antenna for five revolutions, then either prints the number of azimuths or the number of ranges and azimuths received by the computer during each of the 5 scans when it was printing; this is followed by 5 scans where nothing is printed except the number of ranges or number of ranges and azimuths. This program is practically completed.

Have also been working on a program with F. Heart and D. Kemper which will read in data from paper tape and will print out r, θ, smoothed positions, $\dot{x}$, $\dot{y}$, heading angle and $|V_i|$, for one or two aircraft.

4. THEORETICAL ANALYSIS

4.1 General Studies

(W. Linvill)

An E-note 2020 to point out the particular problems associated with Sampled-error-data systems has been prepared. A Master's thesis concerned with experimental verification of the results stated in E-2020 was completed this term in the Student Servo lab. Copies of it will be available after May 15th.

(J. M. Salzer)

Much of the last fortnight was taken up by academic work.
Engineering Note E-2019 has been published. It discusses frequency analysis of convergence conditions of numerical solutions.

(R. L. Walquist)

The major portion of the past bi-weekly period has been spent on thesis work. Some basic study, however, has been done on the problem of correlating incoming information with stored information when one desires to track a large number of targets. Assume that a program is tracking "n" aircraft and that exactly "n" pieces of information are received each antenna revolution. If the targets are stored in a completely random fashion, the program must make approximately $\frac{n^2}{2}$ correlations before all of the incoming information

UNCLASSIFIED CONFIDENTIAL

APPROVED FOR PUBLIC RELEASE. CASE 06-1104.

CONFIDENTIAL UNCLASSIFIED

4.1 General Studies (continued)

(R. Walquist) (continued)

has been utilized. If, however, the targets are stored in K blocks and the address of a particular block is obtained by some such formula as the following:

$$\text{Address} = C_1 + \left[\text{X target}\right] \text{ Mod } p + \alpha\left[\text{Y target}\right] \text{ Mod } q$$

then the number of correlations is reduced to approximately $\frac{n^2}{2K}$. For any scheme such as separating targets into blocks, an evaluation must be made in terms of total number of computer operations and total computer storage required. It is quite possible that the breaking down of information into blocks will increase the total number of computer operations by extensively increasing the number of operations per individual correlation, even though the number of correlations has been reduced. The optimization problem associated with correlation is at present being studied by F. Van Wyk.

(C. Gaudette)

The "One Coordinate Prediction Testing Program" has been operated successfully several times. Analysis of the results obtained has established the reliability of the program. A minor adjustment of the initial conditions is planned.

The "Focus Display Program" has been operated successfully. A few changes must be made to iron out the transitions between sections of the program. Each section of the program has been operat. ig.

(F. VanWyk)

I am viewing the broad field of computer processing and storing of aircraft tracking information with the intention of narrowing down the field to a specific part which I shall then analyze in detail.

(E. Arthurs)

A study was made of linear prediction using 4 terms: present and immediately past inputs and last two outputs.

Judging from the loci in the frequency domain I doubt very much that good prediction can be obtained using the terms mentioned above.

CONFIDENTIAL UNCLASSIFIED

APPROVED FOR PUBLIC RELEASE. CASE 06-1104.

CONFIDENTIAL UNCLASSIFIED

4.2 Correlation Studies

(C. H. Gandette)

The "Least Square Smoothing Program" has been operated successfully. The smoothed velocities oscillate rapidly until a minimum of 20 observations have been received. Then the smoothed velocities gradually approach the true velocity.

Work has started on a program which uses simulated data for linear smoothing. Using a method suggested by Wieser and Linvill, a better estimate of the initial velocity in comparison with the initial velocity used in previous linear smoothing programs is obtained.

UNCLASSIFIED CONFIDENTIAL

APPROVED FOR PUBLIC RELEASE. CASE 06-1104.

CONFIDENTIAL UNCLASSIFIED

6. RECORD OF COMPUTER UTILIZATION

(J. A. Arnow)

4-16-51

1700 - 1900 The PWTWS program was used to take data on flight tests of the previous week.

4-17-51

1400 - 1430 A program to select optimum parameter values for sinusoidal smoothing was tried, but contained programming errors.

1630 - 1700 A program to plot Nyquist diagrams was tried but several errors were found in the programming.

1700 - 1800 A program to help in the determination of the values of a and $\prec$ was run satisfactorily, but time prohibited the taking of much relevant data.

1800 - 1830 A least square smoothing program was used in conjunction with punched paper tape to test this method of smoothing.

1830 - 2000 Data was taken on the amount of data being sent over the phone lines under the new system.

4-18-51

1300 - 1600 One aircraft was guided to a number of points. The test flight had only a moderate amount of success due to equipment difficulties at Bedford.

4-20-51

1300 - 1600 A test flight was held using three aircraft to run three successful interceptions.

1600 - 1700 A program for synthetic combat was run with reasonable results.

1700 - 1900 A PWTWS program for two aircraft contained several programming errors.

UNCLASSIFIED CONFIDENTIAL

APPROVED FOR PUBLIC RELEASE. CASE 06-1104.

CONFIDENTIAL UNCLASSIFIED

6. RECORD OF COMPUTER UTILIZATION (continued)

(J. A. Arnow) (continued)

4-24-51

1345 - 1600 A large amount of data was taken using the program for criteria smoothing.

1600 - 1715 The PWTWS program was used to obtain data from the flight test of 4-18-51.

1715 - 1750 A 2 a/c interception program using a vector display was operated with moderately successful results.

1750 - 1805 The synthetic combat program was used in order to determine better parameter values, but program errors were still in evidence.

1805 - 1845 The locus Display Program was tried, but contained programming errors.

1845 - 1930 A program to obtain optimum parameters for sinusoidal smoothing was unsuccessful due to faulty tape preparation.

1930 - 2015 More data was obtained using the PWTWS program from the flight test of 4-18-51.

4-25-51

1345 - 1400 A program for parameter analysis in sinusoidal smoothing contained a programming error.

1400 - 1500 The synthetic combat program was run with a new set of more satisfactory parameters.

1500 -1615 A demonstration was held using the 2 a/c interception program and the magnecorder reels from the flight test of 4-20-51.

1615 - 1645 A program for printing the velocity magnitude from the two components was unsuccessful due to programming errors.

1645 - 1700 A program for synthetic combat worked with a very pleasant display.

UNCLASSIFIED CONFIDENTIAL

APPROVED FOR PUBLIC RELEASE. CASE 06-1104.

CONFIDENTIAL UNCLASSIFIED

6. RECORD OF COMPUTER UTILIZATION (continued)

(J. A. Arnow) (continued)

1515 - 1845 The velocity printing program worked after manual modifications were made.

1845 - 1930 Range and azimuth data was taken for the flight test of 4-18-51.

1930 - 2100 The PWTWS program was run but contained errors due to programming and tape preparation.

4-26-51

1300 - 1400 Much data using the program for criteria smoothing.

1400 - 1545 Data was taken from the flight test of 4-20-51 using the 2 a/c printing program. The results were insignificant due to the fact that there was little useful data on the magnecorder reel.

4-27-51

1415 - 1530 A one co-ordinate prediction testing program was used with successful results. Several photographs were taken.

1530 - 1600 The program for printing velocity magnitude was run with good results.

1600 - 1700 The criteria smoothing program was run and more data taken.

CONFIDENTIAL UNCLASSIFIED