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Memorandum M-2091

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CLASSIFICATION CHANGED TO:	
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Date:	<i>2/1/66</i>

SUBJECT: BI-WEEKLY REPORT, PROJECT 6673, APRIL 13, 1951

1. GENERAL

(C. R. Wieser)

Four flight tests have been made in an effort to check out our programs for guidance of an aircraft to an arbitrary fixed point. The first two tests were held April 4, and they were partially successful in that the guidance was approximately correct. Frequent miscoding of range values sent over the relay link made operation difficult since the erroneous ranges either upset the smoothing or appeared to the computer as misses. Also, it was noted that the heading instructions changed rapidly and caused over-correction when the interceptor neared the "target" (see Section 3). There was a failure of air-to-ground communications at moderate ranges.

The third test (April 6) was about the same as the first two mentioned above. The range miscoding was still present. Air-to-ground communications were much better, and consistent two-way contact was maintained.

The fourth test (April 13) was much more satisfactory. The range coding errors had been removed, and the guidance program had been modified to use smoothed position of the interceptor as a basis for computing heading instructions. The aircraft (an Instrumentation Laboratory B-26) was guided to Concord, N. H. and Sanford, Me. without difficulty, and the pilot reported passing over these points within about one mile.

During the next period, we will attempt to run a trial interception.

The digital relay link from Bedford is now being operated without the digital storage feature. This eliminates about 1/3 of the tubes in the DRRL, and is expected to result in a substantial improvement in reliability. Without storage, only one range (or one target) per azimuth quantizing sector can be coded and transmitted to us. In any azimuth sector, the target having the smallest value of range will be sent to us with other targets excluded. A variable-range gate, manually controlled, has been installed at the radar. The gate is displayed on the video PPI, and an operator will manipulate

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1. GENERAL (continued)

(C. R. Wieser) (continued)

the gate to exclude echoes of shorter range than any particular target of interest.

2. ENGINEERING

(D. A. Buck)

Recent timing-channel changes at the Bedford end of the data relay link have made necessary frequent readjustment of timing-channel phase at this end. At present, new incoming data requires a different setting from that required by the old recorded data. Correct adjustment is most easily made by looking at the channel 9 output square wave on a 5" scope while intensifying the scope trace by the timing pulses. The timing pulses put a bright spot on the square wave, and adjustment of the phase control is correct when the bright spot is near the center of the negative (lower) part of the square wave.

A study is at present being made into the possibility of improving some of the circuits in the timing channel receiver at this end.

Now that every azimuth is being sent, the background noise in the voice channel is quite objectionable. A new demodulator is being built which incorporates much more filtering before detection so as to eliminate as much of the multiplex signal as possible.

So as to relieve some of the heavy load on the circuit breaker which was installed for one-switch-control, a second breaker has been added in the WWI synchronizer rack. Power to this second breaker is supplied via a relay which is operated by the first breaker. The second breaker, then, may be left on continuously, power being removed from it by tripping the first breaker. The entire system thus remains on one-switch control.

Dimming of the map illumination has not been possible because fluorescent lamps are used. Incandescent "Lumaline" lamps are being substituted so that the intensity can be controlled by a Variac.

Telephone switchboard headsets have been ordered and a master intercommunication plan has been drawn up to resolve some of the communication difficulties experienced in recent tests. Under this system, four headset stations will be available; one at test control and three in room 224. Communication with the aircraft will be "push-to-talk" over the present private phone line, and conversations between technical personnel at the two ends will be via the switchboard on the outside phone line.

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2. ENGINEERING (continued)

(D. A. Buck) (continued)

A fourth Du Mont 304-H scope has been modified for D-F-M-scope use and mounted under the 12" digital P.P.I.

(H. J. Kirshner)

Major effort during the last bi-weekly period was concentrated in operation of equipment for flight test, testing of programs, and demonstrations.

Operation of the VHF receiver, recently obtained from AFCRL, indicates that complete communication reliability may not be expected under present conditions. It is believed that an improvement would be obtained by relocating the VHF antenna atop the Barta Building smoke stack. If the improvement thus obtained proves to be of insufficient magnitude, then it is suggested that simultaneous operation on VHF and some frequency in the 3 to 6 Mc band be attempted.

Informal conversation with personnel of the Meteorology Dept. indicates that VHF communications service for their experiments has proved satisfactory. The antenna for those experiments is atop Building 24.

(R. L. Best)

The deflection amplifiers for the first 16-inch display scope have been completed by the shop. One amplifier has been tested, and after minor modification, operated satisfactorily.

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3. ANALYSIS FOR BEDFORD EXPERIMENTS

(D. R. Israel)

Of the three flight tests conducted during the past bi-weekly period, the test on Friday, April 13, 1951 proved to be the most successful. Over 1-1/2 hours worth of good data was taken; this data will be analyzed and studied as soon as is possible.

The two earlier flight tests were carried out with poor radar data, range coding errors being particularly disturbing. The tests with this data seem to indicate that as the separation between the guided aircraft and the guidance point decreased below 10 miles, the heading angles varied rather strangely. It was thought at that time that the difficulty was chiefly due to:

- a) errors in evaluating the arctangent at small separations where the errors in measurement were comparable to the separations,
- b) the fact that a large lag is introduced into the guidance because of the smoothing program. The effect of such a lag would be to over compensate on heading instructions.

The difficulty in a) can be corrected by better smoothing of the data, while that of b) can be aided by anticipating in the smoothing equations changes which the pilot is asked to make. This latter step has been studied, and a set of rather simple corrections derived. During the process of this work, it was discovered (by J. Arnow) that our guidance program was using actual positions, rather than smoothed positions. The guidance program was corrected to use smoothed positions for the April 13 test, and during this test no violent heading changes were noted. Careful study of the data taken during this and tests to be made in the future will enable us to determine what further steps, if any, must be taken.

In searching for economies to be made in our interception program, it has been discovered that W. Attridge's Interception Program permits a saving of 15-20 registers if the heading instructions are given by tracing out vectors (from the origin) on a scope. Attridge has been experimenting with this, and if the results are satisfactory, the extra registers made available can be used to improve the interception program. These improvements may include display of the interception point and the use of the tracked velocity of the interceptor, rather than an assumed speed as is now done. It should also be possible to modify the interception program to handle the situation where the interceptor is initially on the ground and a delay time on the ground must be included in the calculations.

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3. ANALYSIS FOR BEDFORD EXPERIMENTS (continued)

(D. R. Israel) (continued)

The imminent availability of extra ES registers has led us to direct some effort towards increasing the capacity of the multiple tracking program as well as improving the automatic initiation program.

A short inter-office memo has been written concerning the subject of apparent inconsistencies in the printing of data. Work is now progressing on a memo describing desirable flight paths for the anticipated availability of a number of aircraft for experimental purposes.

One afternoon was spent at AFCL listening to Dr. Nicholson describe the present status and future plans of the Data Utilization Laboratory. Mr. M. Ballard of AFCL has visited the project several times to discuss the smoothing of velocity and position. Visitors and demonstrations have also taken a heavy toll of available time. The demand on computer time for this purpose has been large, and this fact coupled with flight tests have not left sufficient time for experimental work on the computer with new programs.

(R. L. Walquist)

The first half of the past bi-weekly period was spent on vacation. The remainder of this period has been spent on my thesis work.

(J. Arnow)

A program for the determination of the number of ranges per azimuth unit coded by the DRR equipment, before the elimination of the high-speed storage, was run during the past bi-weekly period. The data was taken from magnecorder reel 27, recorded on 2-10-51. The air traffic this date was relatively heavy, and the Monadnock region was not eliminated. The data was tabulated under five headings. These were 0, 1, 2, 3, and 4 or more ranges between azimuths. The data was summed over approximately five antenna sweeps and then tabulated. In all, data was taken over a total of 215 antenna sweeps.

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3. ANALYSIS FOR BEDFORD EXPERIMENTS (continued)

(J. Arnow) (continued)

The totals were as follows:

	0	1	2	3	≥4	Total ranges and azimuths coded
total for 215 scans	917	7548	663	47	76	18,570
average per 5 scans	21.3	175.5	15.4	1.1	1.8	432
average for 1 scan	4.3	35.1	3.1	0.2	0.4	86.4

Theoretically, there should have been no entries under the column for zero ranges between azimuths, and the entries that did occur in this column were probably due to overloading of the high-speed storage in the Monadnock sector.

It must be remembered that the data recorded is also dependent upon the position of the range gate, and the setting for this particular day was such that most of the Monadnock region was present. Consequently, I believe that little would be lost if we were limited to only one range per azimuth unit assuming that the range gate could be moved manually to permit inclusion of pertinent data.

(O. Aberth)

I have continued work with Orlie Becker on Range gate and Target identification programs. Completed tracking portion of program. Entire flow sheet also completed.

(W. S. Attridge, Jr.)

Previous programs which display the angle of an interceptor's flight in binary-decimal form in a flip-flop register can be shortened by quite a few orders if a vector display on the scope is substituted. The vector points in the direction of the interceptor's course.

A new program has been written which will display a vector from the origin, and this program has been run satisfactorily in the computer. New untried modifications have been written which display the outermost end of the vector only.

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3. ANALYSIS FOR BEDFORD EXPERIMENTS (continued)

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

The synthetic combat program mentioned in the previous bi-weekly has been tried on the computer with unsatisfactory results. The program is being rewritten.

(O. N. Becker)

Continued work on program to accept and display targets from a single radar, rejecting spurious information, and limiting the number of targets processed by means of a range gate. Modified and expanded flow diagram, and started work on detailed program in decimal form.

(F. E. Heart)

A program, mentioned in the last bi-weekly, which punches and prints simulated (r, θ) data for one aircraft has been successfully operated and several tapes produced.

A program for applying various criteria to the simple a, α smoothing case in order to obtain the best values for a and α has been tried. Although operative, the program contained several errors, and a modification is now ready for test.

Some time has been spent studying the problem of smoothing in polar coordinates. Although several equations have been derived which I feel hold some promise, the method seems at this point to inherently require more registers than are now available.

Some time has been spent studying the status of the multiple target tracking problem.

A simple modification of one of the PWTWS programs (T 164) was made and tested.

(D. A. Kemper)

Beacon tracking programs have been temporarily set aside pending information as to when the necessary modifications at Bedford will be available.

A subprogram has been written in about 21 registers which paints velocity vectors (without arrowheads) on the D- and F-scopes,

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3. ANALYSIS FOR BEDFORD EXPERIMENTS (continued)

(D. A. Kemper) (continued)

whose tails are at the location of the aircraft and whose length and direction correspond to the velocities of the aircraft being tracked. This program failed to work the first time it was tried due to a programming error. It has been corrected, but not yet run, due mainly to trouble in converting tapes during the last few days. The converted tape is now available and will no doubt be run soon.

A PWIWS program has been written for two aircraft which prints 3 significant figures of the smoothed positions and velocities for the two aircraft. It has not yet been converted.

(J. Rossbach)

I have been working on the problem of programming a beam-rider course (where the interceptor is somewhere along the line joining the target and the origin at each sampling time). However, so far this seems to require more storage than is available. Among the problems encountered is that of attempting to anticipate in the smoothing program the effects of heading changes given to the interceptor.

I have also prepared two short programs, one for displaying a circle and 9 fixed points, and the other for displaying a heading angle without using an arctangent subroutine. This latter program is to be used in a modified guidance program.

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4. THEORETICAL ANALYSIS

4.1 General Studies

(J. M. Salzer)

We had some difficulty taking pictures with the Fairchild camera. In one case we seem to have used the seventh foot of a six-foot roll of film, while next time a number of exposures were very poor. At any rate, we could determine that the "One-Coordinate Prediction Testing Program" operated well, but satisfactory pictures are needed before detailed evaluation is possible. One question that we hope these experiments will give a clue to is the relative significance of errors in respectively phase and amplitude of the program transfer functions.

Did some further work on my thesis and developed a method of program synthesis which permits up to a 50% saving in data storage. This result is not significant in our present work, which employs a very simple difference equation, and therefore, requires very little data. It should be observed that the suggested method of programming follows in a simple manner by frequency analysis, but that it is not suggested by conventional techniques.

(C. Gaudette)

The "Locus Display Program", mentioned in the previous bi-weekly, has been written, and a trial run on the computer to check for errors will be made during the next bi-weekly period.

The modified "One Coordinate Prediction Testing Program" has been successfully operated, and several photographs were taken.

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4.2 Data Smoothing and Aircraft Control

(C. Gaudette)

A program has been written to determine the optimum value of the parameters in sinusoidal smoothing in one coordinate. The best group of four parameters for varying velocities are selected by determining the minimum value of

$$\frac{1}{nV^2} \sum_{i=1}^n (\dot{v}_1 - v)^2$$

V = true velocity in x direction

\dot{v}_1 = ith smoothed velocity in x direction

n = number of observations

4.3 Correlation Studies

(F. VanWyk)

Continuing the investigation into the relative merits of the use of range rates in tracking aircraft. Every avenue of approach thus far traveled indicates that the disadvantages outweigh the advantages.

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6. RECORD OF COMPUTER UTILIZATION

(J. Arnow)

4-2-51

1700 - 1800

An attempt was made to test a 2 a/c Interception Program, but due to ES difficulties no conclusions could be drawn.

4-3-51

1000 - 1130

The Guidance Program and a 2 a/c Interception Program were run in preparation for a flight test to be held on 4-4-51.

4-4-51

1000 - 1600

The Guidance Program was used in an attempt to guide an aircraft to a number of specified points. The results were somewhat inconclusive due to range coding errors in the relay link.

1800 - 1900

A One Coordinate Prediction Testing Program was run with satisfactory operation.

1900 - 2030

Simulated data was prepared on punched paper tape for various flight paths.

2030 - 2100

A program for Criteria Smoothing contained programming errors.

4-6-51

1300 - 1600

A flight test was held using the Guidance Program and 2 a/c Interception Program. The results were questionable due to range coding errors.

4-9-51

1530 - 1600

The PWTWS and Synthetic Interception programs were used for demonstration purposes.

1800 - 1845

A program for analysing the amount of radar data was tried with unsatisfactory results due to a programming error.

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6. RECORD OF COMPUTER UTILIZATION (continued)

(J. Arnow) (continued)

4-10-51

1700 - 1900

A 2 a/c Interception Program by time, and a time interception with a vector display were used. A few programming errors were discovered but operation was forced to cease due to system difficulties.

4-11-51

1400 - 1515

Several photographs were taken using the One Coordinate Prediction Testing Program.

1520 - 1600

Operation of the Least Square Prediction Program was unsuccessful due to marginal operation of the tape reader.

1600 - 1700

The program for determination of the amount of data sent over the phone lines operated with satisfactory results and substantial data was taken.

4-12-51

1430 - 1530

A program for Synthetic Combat was tried but contained a number of programming errors.

1530 - 1600

Another variation of the PWTWS program was run with successful results in spite of two minor programming errors.

4-13-51

1300 - 1600

A flight test using the Guidance Program was very successful.