

Dr. Brown
Welchman

6673
Memorandum M-2084

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CLASSIFICATION CHANGED TO:
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SUBJECT: BI-WEEKLY REPORT, PROJECT 6673, February 2, 1961

1. ANALYSIS

(W. G. Welchman)

Mr. Lyman and Mr. Litchford of Sperry paid us a visit on Monday January 22nd. They have a contract to extend their work on track following and to develop equipment for schedule following. They brought with them Mr. Palmer who is beginning to consider methods of selecting approach flight plans. We heard that the Sperry track following equipment, in which we were very interested when we were working on Air Traffic Control, had done well in operational tests. Instrument approaches had been made down to 200 ft altitude, using the Sperry navigating system. We suggested that, in preparation for a full study of an approach system, they should first consider how to assign feasible schedules on one fixed track, without worrying about the selection of tracks. Experimental approaches on fixed tracks of various types, including flights in gusty weather, would give an evaluation of the tolerances that can be achieved, and this evaluation is needed before one can plan a realistic approach system.

Successful testing of parts of the interception program made it more evident than ever that the main obstacles to progress towards a trial interception are now at Bedford. News from Bedford has not been encouraging and, after preliminary discussions with C. R. Wieser, S. H. Dodd and D. R. Israel, the matter was taken to J. W. Forrester.

Last July it seemed as if the MEW radar, operating at 4 rpm without MTI, would be able to give us adequate data for experimental flights. We were disappointed and apprehensive when MTI was introduced and the scanning rate was reduced to 2 rpm. From that time the Bedford radar has produced little useful data and has failed to pick up the aircraft that are to be used for a trial interception. It is of course important that the analysis group shall have test flight data on these aircraft before carrying out experiments in guidance and interception. We have never been seriously worried about the clutter and saturation that is to be expected without MTI, since it will almost certainly be possible to eliminate the worst clutter at the radar and still retain an

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(W. G. Welchman) (continued)

adequate area of operation for the experiments. Further 4 rpm is much better than 2 rpm. Consequently, from the point of view of analysis, we are strongly in favor of abandoning MTI and finding out whether the standard of performance that we saw last July can be reproduced regularly.

E. Arthurs, O. G. Aberth, O. N. Becker have joined the analysis group of Project 6673 on a part-time basis, and W. S. Attridge on a full time basis. Three more recruits are expected during the next month. Plans for an expansion of the group's activities have been agreed with C. R. Wieser and J. W. Forrester.

A draft for the analysis section of Summary Report 8 has been prepared. This report covers the period from October 25, 1950 to January 25, 1951.

(John M. Salzer)

Some of the methods resulting from my thesis investigation have been applied to the solution of certain difference equations. The stability and instability of these solutions as a function of choice of parameters have already been observed experimentally on the computer; in some cases the stability conditions have also been determined analytically. The investigation of stability in the frequency domain resulted in identical answers, allowing for the unstabilizing effect of roundoffs, which have not yet been considered in the analysis.

It is interesting to note that the range of a parameter for which stability results can usually be determined by algebraic methods (in the frequency transform), but the behavior at the limits of the range of the parameter can be found only by sketching the Nyquist plot of the difference equation. It is hoped that these plots will give information on the degree of stability, not only on its mere existence. If so, the usefulness of the method to servo design will be greatly enhanced.

(D. R. Israel)

A revised version of the single-aircraft tracking program--with certain corrections as indicated by previous tests--was operated early last week with simulated data. The program worked satisfactorily, except for the fact that the aircraft was missed on several alternate sweeps of the antenna shortly after initiation. Investigation of this defect indicated that the

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(D. R. Israel) (continued)

values of a and α , which had been chosen for optimum smoothing of the quantized data, were too small during the period shortly after the initiation of tracking. This situation was ameliorated by using a larger size of search area, however this is not the optimum solution. A much more satisfactory method would entail non-linear smoothing. Some thought has been given to possible methods and the means of testing them.

By using a larger size of search area, satisfactory tracking has been accomplished on data from the Magnecord tapes. A successful operation of the guidance program on data from Magnecord tape has also been carried out. Both of these programs include a means of periodically reading through all of the ES registers.

The programs for the tracking of two aircraft and/or the interception have been completed and tapes have been prepared. The first of these programs will be tested as soon as some usable data (i.e. with two trackable aircraft) is available.

Flow diagrams for the tracking, guidance, and interception programs have been prepared. A description of these programs is now being prepared.

With the completion of the above-mentioned programs, efforts will now be turned toward the completion and testing of the programs for multiple tracking.

A major proportion of the time during the past week has been spent at various meetings concerned with immediate plans for experiments with actual aircraft and future developments in the 6673 project.

(R. L. Walquist)

With the completion of a satisfactory program for the determination of the interceptor's collision course bearing angle, the problem of multiple target tracking is again being considered. A program to deal with this situation was written several months ago, but was set aside in order to consider more important matters. Present effort is directed towards decreasing the number of ES registers necessary for the program, and hence towards allowing more aircraft to be tracked (the present number is eight). Consideration is also being given to the best method of displaying such information as the present number of targets stored in the program and the number of targets which have been lost or are not being received by the radar on each particular antenna sweep.

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(J. A. Arnow)

A program for the guidance of an aircraft towards any specified point has been completed. The tape has been made and operation of the program appears to be correct. Some preliminary investigation has been done in the problem of automatic initiation of tracking and in the use of magnetic drum storage.

(C. H. Gaudette)

A method for tracking an aircraft using least squares in (r, θ) coordinates is under investigation. If r_0 is the range at time $t_0 = 0$, the value of the range, r_t at a time t is given by

$$r_t^2 = r_0^2 - 2r_0 V \cos (180 - \theta_0 + \phi)t + V^2 t^2$$

where

ϕ = course of the aircraft

V = velocity of the aircraft

θ_0 = azimuth at time t_0

The speed and course of the aircraft are assumed to be constant. If a regression curve of the form

$$R = k + at + bt^2$$

is fitted to the squares of the observed ranges, the coefficient b will be a measure of the square of the required aircraft speed.

(H. Saxenian)

Data taken with the program for checking rate of radar data input shows that, for a particular sample run, the rate was about 1400 pieces of data per revolution. This indicates that the radar antenna was revolving about 7% slower than two revolutions per minute. The same run also indicated that the printing time required for five characters and a carriage return was about 30 pieces of data.

Data taken with the program for checking the accuracy of the (r, θ) to (x, y) conversion routine indicates that the routine is accurate to the closest 1/1000th, using the 4th degree sine approximation polynomial which is accurate to 1/10,000.

Test storage programs have been written to check the number of azimuth indications, range indications, and zero range indications on any given run. Such information will give a rough indication of the calculating times available in time shared tracking programs.

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(H. Saxenian) (continued)

The four new members of project 6673, already familiar with coding procedures, are becoming familiarized with the general layout of the computer room, control room, and specific techniques for handling 6673 problems.

They have had one session operating test storage during which Mr. Welchman's program for solving the differential equations for a circle was run. The program solved the equations by the Runge Kutta method, and two linear interpolation methods. The errors in the Runge Kutta method were always in the same direction and gave a circle of steadily diminishing radius. One of the two linear interpolation methods gave a better solution for reasonably small interpolation intervals.

The new men have also been writing programs of their own to run in test storage on February 2nd. O. G. Aberth has a program for displaying the path of motion of a bouncing ball using a variable coefficient of restitution. E. Arthurs has written solutions to a differential equation given in course 6.535 in order to check for possible overflow, and he has made provision for scale factoring in case of overflow by shortening the more straightforward computing process. O. N. Becker has his own program for checking the number of targets and zero ranges in a given 6673 run. This program has been instructive in ways of handling radar data.

(Edward Arthurs)

I have been preparing programs of suitable length for test storage to aid in my orientation. On the evening of February 2nd I will put one of the above programs on the computer.

I have also been reading literature on fire control to see if there is any work done on fire control which would have bearing on project 6673.

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1.1

COMPUTER OPERATIONS

(J. Arnow)

1-25-51

19 40 - 19 50

Tape 83, tracking program for one aircraft, was converted to a 6-5-5 mode.

20 00 - 22 30

Tape 83 was operated in conjunction with reel 2 during this period. Trouble with both ES and the display equipment prevented prolonged operation on a single target. The smoothed velocities after five readings were in agreement with the values obtained previously by following this target using the program to print the (r, θ) and (x, y) coordinates of this target.

1-29-51

17 26 - 18 00

Tape 86, a revision of T 83, and T 87, tracking program plus guidance, were converted to a 6-5-5 mode without difficulty.

1-30-51

12 05 - 12 36

The guidance program was tested using reel 2. The program computed the heading angle necessary to take the tracked aircraft to Bedford Airport.

12 36 - 13 00

The computer was used with test storage only to obtain an approximate solution to a pair of simultaneous differential equations for the purpose of training new members of the group in the operation of the computer.

1-31-51

15 10 - 17 55

An attempt to convert T 89, to a 6-5-5 mode was unsuccessful due to difficulties with ES.

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COMPUTER OPERATIONS

(J. Arnow)

(con't)

2-1-51

15 43 - 19 20 Tape 88, revision of the smoothing display program, tape 89, program for tracking of two aircraft, and tape 93 were converted to 6-5-5 mode. The process was delayed considerably due to an ES difficulty, but upon location of the trouble the conversion program was modified manually and satisfactory operation of the program resulted. Tape 90, program for tracking two aircraft on an interception was also converted, but errors in the standard form nullified the conversion process.

2-2-51

18 14 - 18 20 A corrected version of tape 90 was converted successfully to a 6-5-5 mode.

18 20 - 18 37 The smoothing display program was operated satisfactorily. No data was taken.

18 38 - 20 03 The guidance program was used. After certain initial difficulties with ES were cleared up, operation was satisfactory.

20 04 - 20 10 The program for tracking one aircraft was used during this period.

2-2-51

20 10 - 21 15 The program for tracking two aircraft was operated. A minor programming error allowed only one aircraft to be tracked at a time, but indications were that with this error corrected operation should be satisfactory.

21 30 - 23 45 The computer was operated with test storage only primarily for the purpose of acquainting the new members of the project with the computer.

The program used during this period consisted of a data count of the incoming radar signals and various solutions to a number of differential equations.

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2. ENGINEERING

(C. R. Wieser)

Arrangements have been made to use an Instrumentation Laboratory B-26 aircraft provided that there is no conflict with their work. Scheduling is handled with Frank Wilkins, and a 24-hour advance notice is desirable.

It may be possible to use the Weather Radar Project's B-17 for flight tests during the summer dry season. Also, they will notify us of their own flight schedules. Arrangements will be made through Alan Bemis.

During the past two weeks, only one flight test (C-45 aircraft) was made, and this one was of no use since, as has been our previous experience, the aircraft was not seen consistently enough by the radar to permit positive identification. For the rest of the period, the following causes prevented tests: no aircraft for pilot, 2 days; radar out, 1 day; bad weather 6 days.

The improved operation of WWI and the continuing lack of consistent radar data from flight tests has led to the conclusion that the radar rather than WWI is now holding up trial interceptions. Taylor, Everett, and Wieser visited Bedford to discuss radar operation, and witnessed typical difficulties. It is evident that most of the trouble is in the radar rather than the relay link. Faulty operation of the MTI appears to be a major source of trouble, although the observations were very limited.

A meeting with Rader and Wells of AFCRL was held to discuss improvements in radar data. It was concluded that: (1) we will base our trials on use of the MEW rather than the new radar since the latter has other commitments; (2) tests without MTI will be made in the next few weeks; and (3) unless these tests indicate a substantial improvement, the MEW will be taken out of service for tests and overhaul. It was decided that necessary radar work should be done now so that the equipment will be functioning properly by the time the weather becomes more suitable for flight experiments.

The digital PPI scope has been installed in Room 138 by AFCRL. As soon as the wireways are delivered, the scope will be moved to Room 224. This scope displays radar data (direct or recorded) without the use of WWI.

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2. ENGINEERING (continued)

(D. A. Buck)

Two-way phone conversations with Bedford have been recorded on top of radar test patterns. Satisfactory speech was reproduced and the voice-modulated carrier had no effect on the scope presentation of the test pattern. The completed equipment consists of four chassis: (1) An input audio amplifier with provision for peak clipping, (2) A balanced suppressor-grid modulator with a multiplex channel protection filter and a filter to eliminate high frequencies generated by the speech-clipping process, (3) A carrier generator consisting of a phase-shift oscillator and phase inverter, and (4) A demodulator using a full-wave bridge rectifier preceded by a filter to separate out the carrier and followed by a filter to separate out the audio. The equipment utilizes 13 tubes and four crystals.

Faulty operation of special display was traced to a recently added transfer check alarm cable which prevented the interlock from stopping the clock.

(H. J. Kirahner)

Light-gun II has been completed, and after the removal of some minor difficulties, was used successfully with WWI for target selection. Random output pulses were observed and found to be caused by charging of the line between the light gun and its amplifier, and subsequent discharging at the grid of the blocking oscillator. This condition was remedied by the isolation of the grid from the line.

It is convenient for the operator of the light gun to have an indication of when a target is picked up. At present, this indication is given by watching the lights of a D.C. Register Panel. A device utilizing less equipment to provide the indication could be comprised of a single thyatron operating a light or a chime. An audible device is probably more desirable in a darkened room.

The sector recording timer has been completed. This equipment permits the selection of a particular sector of the antenna scan for recording. Both the position of the sector and its size may be varied. Operation of this device is attendant upon an indexing pulse from Bedford. One relatively simple method of obtaining this pulse would be to have a cam, somewhere in the antenna drive system, operate a micro-switch. This in turn could key an audio oscillator of suitable frequency which would be fed to the phone line. The Barta Building end of the line would be attached to a resonant relay, possibly preceded by stage of amplification, which would provide the necessary index signals.

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2. ENGINEERING (continued)

(H. J. Kirshner) (continued)

Should it be so desired, the sector recording timer may also be used to remove that portion of a scan which contains objectionable clutter. This could be accomplished by having the timer remove all information channels, with the exception of the timing signal, from the demultiplexer during the portion of the scan that fixed target clutter appears.

The Digital PPI Display system provided by AFCRL has been giving some difficulty. A faulty solder joint attributed to some of the trouble. The display did reveal that the demultiplexing equipment was fairly sensitive to the level of its input signal. A judicious juggling of plug in units in channels 4, 5, and 7 by D. A. Buck enabled a wider tolerance in input level. It was also found that the equipment is erratic for about the first twenty minutes of operation. It is suggested that prior to using the equipment, a twenty minute warm up period be allowed.

Investigation is underway to determine whether a 10" cathode ray tube may be used with the Dumont 304-H Display Scopes without making major modifications in the oscilloscope. This would serve to provide a larger viewing screen until the 16" units are ready for operation.

(R. L. Best)

A new pre-amplifier has been designed for the 16-inch display scope, and is now in the shop. It is hoped that it will minimize the effect of fluctuations in the power supply voltage.