Electronic Computer Division
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SUBJECT: BI-WEEKLY, PROJECT 6673, NOVEMBER 24, 1950

1. ANALYSIS
(W. G. Welchman)

A meeting was held on Monday, November 13th at which various methods of speeding up supply of radar data to the computer for experimental work were discussed. The idea of modifying filters so that the magnecorder equipment could be run at higher speeds seemed to involve a lot of work for little result. The simplest suggestion was to switch the recording magnecorder on and off so that it will only record data in a small sector containing the targets that are to be studied. The possibility of using EK units was also considered.

The meeting also discussed progress that had been made with programs for tracking, guidance and interception. R. Walquist had worked out a simple method of computing the lead angle for a collision course.

It seems that we have now reached a stage at which it will not be worthwhile to put much more effort into preparation for an experimental interception. Now that the computer is beginning to become available with ES there is plenty of experimental work to be done in trying out tracking programs. The 6673 group can also turn its attention to such problems as:

A. an examination of the effectiveness of different formulae for smoothing and prediction using synthetic data prepared by the computer.

B. programs to analyze imperfections of radar data.

C. the automatic acquisition of targets in limited areas and the variation of extent of these areas in accordance with the load of the computer.

D. study of tracking under difficult conditions such as crossing targets, formation splitting up, target missed on several successive sweeps etc.

E. programs in (r, θ) coordinates.

1. ANALYSIS (continued)

(J. M. Salzer)

Work on subroutines is continuing. I have started writing a note for editing them.

I am studying the effect of wind on guidance and interception. Assuming the wind velocity components are known, one can take proper account of it with about 15-20 orders. The problem is more difficult to cope with when the effect of wind must be derived from tracking data, since quite a delay might have to be introduced before it is possible to obtain an acceptably smoothed aircraft velocity.

Work on the doctorate thesis crystallized my ideas sufficiently and, consequently, I have written the first draft of a thesis proposal.

(D. R. Israel)

During the past bi-weekly period the testing of the storage tubes reached a point where it became feasible to read programs into ES from punched paper tape and to attempt actual computer operation with the ES registers. Both as an aid in testing ES under actual program conditions and as a means of checking parts of our programs, several punched paper tapes have been prepared with parts of 6673 programs. Two versions of the Main Display Program (separate range and azimuth data; convert to (x, y) coordinates; and display) were prepared on paper tape. One version — Tape 6 — generates its own data corresponding to an equiangular spiral; the second version — Tape 1 — uses the actual data from Room 138.

Tapes 6 and 1 were tested during the early part of last week, and on one occasion the program on Tape 6 operated successfully except for faulty action of the display decoder. Tape I could not be operated successfully; both tapes generally indicating operating difficulties in digit column 4 of ES. Following the replacement of the storage tube in column 4 on Friday, satisfactory operation of Tape 6 was obtained over a period of more than 1/2 hour. The program of Tape 6 was manually altered while in ES to correspond to Tape 1, and satisfactory operation of the program with recorded radar data was achieved.

Much of the time during the past bi-weekly period was spent in connection with the activities above — both in preparing the programs and in obtaining the punched tape, and in operating or observing operation of the computer with electrostatic storage.

1. ANALYSIS (continued)

(D. R. Israel) (continued)

The work in programming for the initial experiments of guidance and tracking have reached the end of a first phase -- this being the actual preparation of the program. It is now definite that an interception can be achieved with the available storage. The second phase -- that of checking parts of the program on the computer and obtaining some ideas of operating conditions, etc. is now underway. During a discussion with Arnow and Walquist a tentative schedule and priority has been assigned to programs for these testing purposes. First on the list is a program by Arnow for manually-controlled simulated radar data. Other programs are:

1) Tracking Prediction
2) Determination and Display of Guidance Course
3) Computation and Display of Collision Course.

The testing of these major elements plus smaller bits of programming should enable early operation of RTP II-(Single a/c), followed by the "Guidance of a Single Aircraft", and then by the "Two-Aircraft Interception".

Preparations have been made for a test of the light-gun in the near future. A program has been written to test its operation and to measure the delay introduced in returning a pulse to the computer.

(R. L. Walquist)

A written explanation of RTP-III (tracking "n" targets where "n" is greater than 2) has been completed. The explanation relies heavily upon information previously given for RTPI & II; major emphasis is upon the particular difficulties arising when more than 2 targets must be dealt with by the computer. Included are 3 diagrams: 1, an elementary flow diagram of RTP-III. 2, a diagram showing the method used in searching for the target and the use of the time counter; 3, the storage requirements for each target.

1. ANALYSIS (continued)

(R. L. Walquist) (continued)

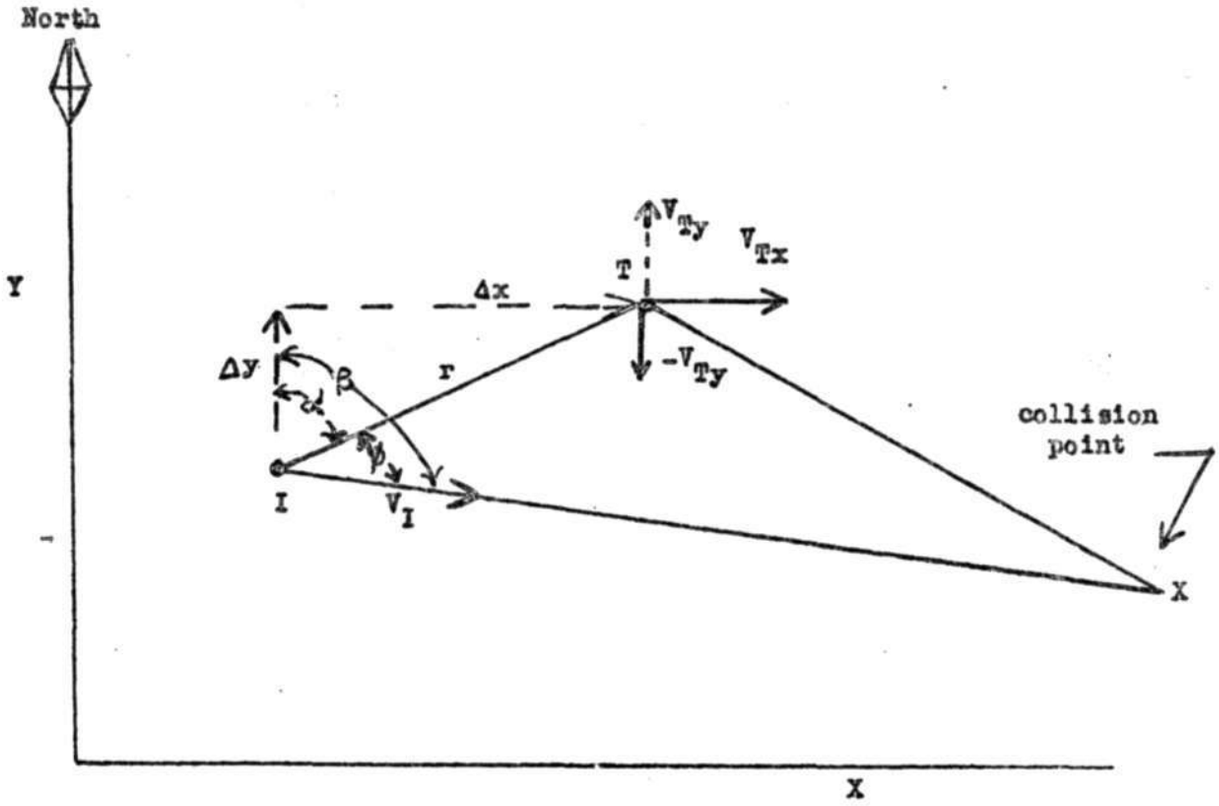
Considerable effort has been spent on a method of calculating a collision course for interception programs. The method being considered is shown on the accompanying diagram along with an explanation of the symbolism used. The formula for sin α is straight forward enough; the formula for sin ϕ is obtained by noting that the components of the interceptor and target velocities which are perpendicular to the line r must be equal for an interception to occur. Note that $-90^\circ < \phi < +90^\circ$. No restriction is placed on the target and interceptor velocities other than that $|V_I| > |V_T|$.

Determination of "β" from the formula given requires the use of arc sine and square root subprograms. It does not appear as if scale factoring will be necessary since $r \longrightarrow 0$ only when the two aircraft coincide in position. Reiterative procedures for the arc sine and square root are being considered since time is not a restriction when calculating the collision course bearing angle.

This method of calculating the bearing angle for the interceptor might prove quite useful, since it also gives the distance and bearing of the target with respect to the interceptor. The separate determination of "β", the lead angle, readily allows the magnitude of this lead angle to be weighted by some factor proportional to "r" and/or the time of smoothing for the target and interceptor, if such a procedure appears advantageous.

1. ANALYSIS (continued)
(R. L. Walquist) (continued)

Determination of Heading for Collision Course



I = Interceptor
V_I = Magnitude of interceptor velocity
T = Target
V_{Tx}, V_{Ty} = X and Y components of target velocity
$r = \sqrt{\Delta x^2 + \Delta y^2}$ = radial distance of target from interceptor
α = bearing angle of target with respect to interceptor
ϕ = lead angle for interceptor
$\beta = \alpha + \phi$ = bearing angle for flight path of interceptor
$\Delta x = X_T - X_I$

$\Delta y = Y_T - Y_I$

$$\sin \alpha = \frac{\Delta x}{r}$$

$$\sin \phi = \frac{V_{Tx}\,\Delta y - V_{Ty}\,\Delta x}{r\,V_I}$$

$$\therefore \beta = \sin^{-1}\frac{\Delta x}{r} + \sin^{-1}\frac{V_{Tx}\,\Delta y - V_{Ty}\,\Delta x}{r\,V_I}$$

1. ANALYSIS (continued)

(J. A. Arnow)

Two programs were written for the computation of the heading angle to be used by an interceptor in a collision course, following the approach suggested by D.R.Israel in the last bi-weekly report. These programs differ only in the manner in which they obtain a quantity of the form

$$A \sin \theta + B \cos \theta.$$

The first accomplishes this by approximating the solution of the differential equation

$$y'' + \lambda y = 0$$

with suitable boundary conditions. This method is longer by about 25 registers than the second which utilizes an available subprogram for the computation of the sine and cosine and which takes about 40 registers over and above the allotment for the subprogram. Both methods are slow in time but have an advantage over a more direct approach to the problem in that there is quite a considerable saving of storage.

A punched paper tape was prepared for a program which will convert a standard sexadecimal tape to a 6-6-4 reversed mode as described in M-2076. Another tape for the data simulation program is in the process of preparation.

(H. Saxenian and C. Gaudette)

The program for optimization of the arctangent formula, $f(b, x)$, is nearing completion. One portion of the program displays the error curves for manually varied values of b, and the maximum error of each curve in decimal digits. The other part of the program displays a curve of the maximum error of $f(b, x)$ as a function of b and displays the optimum value of b in decimal digits.

An approximation of the arcsine by a fifth degree polynomial is being investigated for John Salzer.

2. ENGINEERING

(C. R. Wieser)

In order to speed-up the observation of radar data and tracking programs, the Magnecorder will be modified to record only during the time the radar beam sweeps over a given sector (probably about 90°). The rest of the time the tape will be stationary. This mode of operation should speed up the data display by a factor of 4, or more if the size of the sector is reduced. If preliminary manual tests are successful, we will consult the AFCRL group to see if they can furnish an antenna position signal for automatic switching.

Harrington and Rader of AFCRL were here for a conference on techniques for early experiments with interception. Probably a C-45 (130 to 160 mph) will be used for the target and an A-26 (about 260 mph) as the interceptor. They will probably install transponders in both planes, and operate these at some frequency other than the radar. This should provide positive identification of the two aircraft.

During the last two weeks, no flight tests have been run. However, as soon as conditions permit a flight test will be made.

The AFCRL group at Bedford has discovered a source of difficulty with the radar. Receiver crystals have been getting damaged frequently by intense radiation from another nearby radar set. The two sets have now been synchronized so that both may operate simultaneously without damage or jamming.

(D. A. Buck)

It was found that a reduction of horizontal abberation in the existing five-digit display system is possible by the addition of three-microseconds to the end of the restorer blanking gate in the intensification gate generator. This allows the horizontal decoder a little more time to relax to the analogue equivalent of the binary number it is decoding after having been complemented by the restoration.

A delay of four microsecond was added to the start of the intensification gates to allow the vertical decoder more time to set up.

2. ENGINEERING (continued)

(D. A. Buck) (continued)

Improvement in viewing of the M-scope was made possible by the installation of a front-plate.

Design is underway on a filter for the protection of the multiplex channels from interference due to the projected voice-modulated carrier at the upper end of the frequency spectrum.

Work has been slowed by a plague of component failures in the display system.

(H. J. Kirshner)

Successful operation of the "light gun" was achieved during this bi-weekly period. Tests were conducted with the unit which indicated probable successful operation when connected to WWI. Should operation with the computer prove to be satisfactory, the equipment will be rebuilt in a more permanent and better packaged form.

A switching circuit for quick starting and stopping of the Magnecorder was constructed and tested. This device allows for disablement of the recording circuits until the drive motor is up to speed. Tests on the switching circuit indicated that when the "STOP" switch was depressed (motor stopped and amplifier disabled) a transient was initiated which caused some of the demultiplexing filters to ring. It is believed, however, that this feature will not prove troublesome. The transient will produce only one random word following a switching operation.

It is anticipated that operation of the switching circuit will be controlled automatically and remotely from Bedford. For the present, switching may be accomplished manually.

(R. L. Best)

A masters' thesis proposal has been issued in M-1129, titled "A Direct-Coupled Amplifier for Magnetically Deflecting an Oscillograph Tube".

A Tektronix Type 420 High Voltage Power Supply has been received, and the driving circuits for it are now being built. It will supply + 15 KV, regulated, for the K 104P7 tube (a 16 inch oscillograph tube), which has also been received.

Auxiliary circuits for testing the amplifier are being constructed, including sweep and un-blanking circuits.