6673
Memorandum M-2070

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Cambridge, Massachusetts

SUBJECT: BI-WEEKLY, PROJECT 6673, SEPTEMBER 29, 1950

1. ANALYSIS

(W. G. Welchman)

The immediate policy of Project 6673 has crystallized during the period under review. We shall concentrate first on obtaining several programs suitable for use with the Bedford radar in addition to the one that has already been completed. These programs are to include some experimental forms of collision course interception. Variations of the first tracking program will be prepared to provide rate tracking and to allow at least two aircraft to be tracked. It seems probable that the use of a light gun instead of a joy stick will make this easier. With several versions of this tracking program we shall be able to carry out experiments with whatever traffic shows up in the radar data supplied by Bedford. As a preliminary to experiments in interception we shall need programs to guide an aircraft to a prescribed point. It should be possible to do this adequately in 256 registers of storage. For a collision course interception, however, we shall probably have to simplify the problem in order to get programs in 256 registers. For example it seems certain that we could work a collision course fairly well if we neglect wind and assume that the two aircraft concerned have equal speeds. We must also estimate how many additional storage registers would be required to enable us to introduce the subprograms that are needed for a satisfactory interception control program suitable for the simultaneous handling of several interceptions.

This concentration on the preparation of demonstration programs will be at the expense of detailed study of such matters as the nature of errors in radar data, methods for dealing with crossing tracks, and the use of synthetic data prepared by the computer to test the effectiveness of different formulae for rate tracking. We shall of course return to these matters at a later date.

(D. R. Israel)

Two early-morning sessions with the computer were undertaken during the past two-week period. In addition to the actual time spent in attendence at these sessions, a good deal of time was also spent preparing programs with which to test the vertical

1. ANALYSIS continued

(D. R. Israel) continued

decoder, the display interlock, and the joy stick, and to isolate digits of the radar input and display them. Progress during these sessions has not been rapid, and as yet there has been no chance to test the digits of the radar input and compare them with the visual display in Room 138.

Two recent changes have been made in Bedford equipment. We now receive the complements of the azimuth readings, while the range readings have been shifted one channel to the left. This first change will enable a saving of 3-4 orders in the Main Display Program.

A joint effort by Walquist and myself resulted in the writing of a description of Radar Tracking Program I and in the preparation of a reproducible flow diagram. This program was of the simplest type possible--with zeroth order prediction and with provision for tracking only a single aircraft. A good deal of thought has since been given to the problems of multiple target tracking.

The method of "Aided Tracking" described by J. W. Forrester has been studied, the equations written, and programs for the prediction prepared. A comparison with Walquist's work on the Thumper method has revealed the "Aided Tracking" to be a more general case, and one which is readily susceptible to study and modification. The "Aided Tracking" equations as formulated are a set of linear difference equations, and as such can be solved for a given type of aircraft motion. Some work has been done along this line to determine the optimum values for certain coefficients appearing in these equations. It appears that programs in test storage could be used to facilitate this work.

(R. L. Walquist)

A thesis proposal (M-1098) has been written covering my thesis topic--"Analysis and Design of a Digital to Voltage Decoder". One-half of my work on the project is to be devoted to this thesis. A theoretical analysis is being carried out in order to evaluate three various methods of producing a binary-weighted decoder. The three methods being studied are the following:

1. The Ely decoder which uses a set of binary-weighted current sources.
2. The method used by Smith in which voltage sources rather than current sources are used.
3. Equal current sources connected to a binary-weighted attenuation network.

1. ANALYSIS continued

(R. L. Walquist) continued

Of these three methods, the first appears to be the least satisfactory for high accuracy decoding with a usable voltage output. The other two methods are being studied to see which can be made to operate with the least reliance on vacuum tube and crystal stability.

The flow diagram for Radar Tracking Program I and a typewritten explanation of this program have been completed.

Consideration is being given to a second tracking program which will be entitled Radar Tracking Program II. This program is to incorporate several desirable features which are lacking in Program I. A few of these features are:

1. Prediction of the target's future position by some method similar to that entitled "Aided Tracking".
2. Choice of that input data which falls nearest to the predicted position of the target, or the use of some probability consideration to choose the input data which has the highest probability of being the target.
3. Multiple target tracking instead of single target tracking.

Consideration has been given to each of the three items listed above. Several methods of smoothing and prediction have been studied, and it appears that most of them are almost identical. The Project Thumper (Report No. 55381) method of smoothing was found to be exactly the same as the exponential smoothing mentioned by J. Dodd in M-1100 (Project 6782). The method of "Aided Tracking" is also the same as the Thumper method of prediction except for the introduction of an additional weighting constant. If the two weighting constants used in the "Aided Tracking" method are made equal, the method is identical to that mentioned in the Thumper Report. In conjunction with D. R. Israel, further consideration is being given to this problem of prediction.

A preliminary study of the quantization errors as compared to the possible errors in prediction due to the target turning seems to indicate that any probability considerations used in the choice of input data falling near the predicted position would be masked by the magnitude of the quantization errors. It appears that a choice made on the basis of that data which falls nearest to the predicted position should be as good as (and much simpler than) a method involving probability considerations of the target path.

1. ANALYSIS continued

(R. L. Walquist) continued

Brief consideration has been given to several of the problems introduced when tracking multiple targets. No definite conclusions have been reached as to the best method of programming this situation.

(J. Arnow)

Programs designed to fit in test storage were written for determination of the recurrence of the following types of errors in the radar data:

1. Successive azimuth readings with no intermediate range
2. A decrease in azimuth readings
3. Too large an increase in azimuth readings
4. A range reading followed by a smaller range reading
5. Zero range readings

The ultimate aim of these programs is to write a program to act as a filter to eliminate spurious readings caused by overloading of the storage tube, errors in the radar set, etc.

2. ENGINEERING continued

(C. R. Wieser)

The group working on the Bedford radar has resumed work after their vacation. First, the radar was connected to generate a test pattern. The pattern was studied in Room 138 and found to have quite a few errors. These were traced to Channel 5, which was adjusted to improve operation. The system was then readjusted to set the proper signal levels throughout the loop from Bedford to Room 138 and return. This resulted in improved operation, and a test pattern was recorded. This pattern was then played back to Bedford and displayed on their PPI. Only one mistake was observed in a 30-minute run.

The display system (including qf and qd orders) is now working except for the display interlock. This should be fixed within the next few days, and then experiments on reading radar data into WWI will be resumed.

One of the weaknesses of the radar data system is overloading, which is caused by ground clutter and clouds. An excessive number of adjacent echoes fills the radar digit storage tube and causes rewriting over words which have not been erased by the read operation. This results in meaningless numbers, which appear to the computer to be new targets. It would be much better for our purposes if writing could be stopped when the storage tube is full or nearly full. Jack Harrington at AFCRL has been informed of this and is looking into methods of preventing the transmission of random signals.

Work will be started to investigate techniques of building a light gun for manual target acquisition. The light gun is a photo-cell device which is placed over the desired spot on a display scope. The next intensification of that spot illuminates the photo cell and then sends a pulse into the computer to identify the coordinates of the spot being illuminated.

It may be desirable to borrow or duplicate the digital PPI display now in use at Bedford. This would be a very valuable piece of equipment for experimental work with programs which do not include any conversion from polar to rectangular coordinates; i.e., programs which operate wholly with polar quantities. (Our existing display system will not produce a PPI picture unless conversion to rectangular coordinates is included in the computer program.) We will contact AFCRL and try to determine the best way to get a PPI display unit for our own use.

(D. A. Buck)

Because the circuit element responsible for starting the clock (after having stopped the clock for special display) must

2. ENGINEERING continued

(D. A. Buck) continued

be extremely reliable so as not to put spurious start-clock pulses into CPC, it was directed that the device should be of the digital type rather than the analog type. It was felt that a device such as a phantastron or a gate and delay unit might possibly run free, and, although the output pulses were correctly synchronized, the clock could be started during an arithmetic operation and create a trouble most difficult to analyze.

To obtain the required delay and to obtain properly synchronized pulses at the same time, it was decided that restorer pulse generator end-carries would be counted, and the counter end-carry be used to start the clock. One of the low-speed 2^6 counters was obtained to do the job.

A shorted crystal in the Vertical Decoder was responsible for the erratic operation encountered in the last test periods, and replacement of the unit cleared the trouble. Poor operation of the interlock during these same test periods was traced to bad synchronization of the continue-operation pulse, and the above changes should remedy the situation.

Consideration was given to the possibility of having several intensification gate generators for the special display. This would give the programmer a choice of using a short persistance spot for data that comes at short intervals and a long-persistance spot for data that comes at long intervals. The selection could be made by two or three of the digits in the accumulator which are not used by the vertical decoder.