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

SUBJECT: BI-WEEKLY REPORT, PROJECT 6673, AUGUST 4, 1955

1. ANALYSIS

(W. G. Welchman)

D. R. Israel and C. W. Adams are arranging to keep an operations log for all programs run on the computer and for all punched tapes used in connection with the programs. The records and tapes will be filed by Miss Dorothy Lenihan. The first record of computer operation is attached to this Bi-Weekly Report. The appropriate circulation, if any, of these records will be considered later, after several records have accumulated.

Planning for the early experimental use of the computer with radar data has continued. The first objective is still to obtain simultaneous operation of 3 programs. The first is a main display program which will display all incoming (r,θ) data after conversion to (x,y) coordinates. The second is a spot selection program which enables an operator to move a spot that is produced on the scope by the computer and to tell the computer when the spot reaches a desired position. The third is a box tracking program which follows a target selected by the manual operation of the spot selection program. It now appears that the second scope may not be available for the first experiments, so programs will have to be prepared in which the main display is discontinued whenever tracking is initiated.

The first programs will be as simple as possible. A "box" will be stored in the computer as the coordinates of a point (the center of the box) and the distances that the box is to extend on either side of its center. A box is initially put into the computer by the spot selection program. Once the box is established, any target appearing in the box is displayed on the tracking scope and causes the center of the box to be moved to the observed position of this target. This gives a crude form of tracking which fails when aircraft get too close together.

Some consideration is being given to refinements in the above method of tracking that will deal with aircraft whose paths cross, and with the case of close formations of aircraft which will probably be observed as single targets. Consideration will soon be given to a program for the automatic acquisition of targets for tracking, but it is most desirable to avoid the examination of every (r,θ) measurement to see if it represents a target. It

1. ANALYSIS (continued)

(W. G. Welchman) - (continued)

has been suggested by D. R. Israel that the automatic pick-up might be restricted to a suitable region of space, for example a circular ring. Aircraft would be picked up as they cross the ring and it would be important to insure that they will not be lost while they are inside the ring. In particular, when aircraft cross the ring in formation and subsequently follow divergent tracks, the computer must be able to discover that a single target has become several targets. It seems possible that good results may be obtained by making the computer observe all cases in which two targets appear in the same box and all cases in which one target appears in two boxes. (This approach will be complicated by the fact that the same aircraft may be reported by the radar equipment with four different (r,θ) coordinates.) It seems likely that synthetic (r,θ) data on punched tape will be useful in trying out such schemes of dealing with conflicting tracks.

A visit to the radar site helped to get the present phase of the problem in perspective. It was a fairly fine day, but a storm cloud caused the equipment to saturate and produce a lot of erroneous data. A target would be recorded twice either with two azimuths or two ranges almost as often as it would be recorded separately. The lack of a grid on the scope made it impossible to judge whether there is jitter in the quantized radar measurements, which appear at 15 second intervals.

The radar set in use was not designed for this application and it is not considered worthwhile to spend more time trying to improve its performance. Instead the men who have been working on the set intend to switch their attention to a reconsideration of the entire design of a radar system for this special purpose. It looks as if the set as it stands will give us plenty of opportunity for experiment and for demonstration of computer programs provided that we deal only with ranges of more than 40 miles, and choose favorable weather conditions.

A start has been made in the study of methods of smoothing and prediction that might be suitable for the radar data. A quick look at the report by Christman, 3 reports of Project Thumper and the report by R. B. Blackman, H. W. Bode and C. E. Shannon confirmed our guess that the particular features of our problem have not yet received much attention. Existing theory is largely concerned with cases in which at least 40 measurements can be obtained before an attempt is made at smoothing for accurate prediction. With our rate of data acquisition this would take 10 minutes which is far too long. Further we must continuously identify each aircraft in order to accumulate data for smoothing. Our first requirement is a method of obtaining the best prediction of position on the next few rotations of the radar, that is for the next 15, 30 or 45 seconds. A method suggested in Project Thumper Report #55781

1. ANALYSIS (continued)

(W. G. Welchman) - (continued)

looks like a good starting point, but will have to be tested under the peculiar conditions of our problem in which the quantizing units and the errors are of the same order of magnitude as the longest distances likely to be travelled between observations.

It is quite possible that the computer will be used to test methods of approximation, such as the one just mentioned, by using synthetic (r,θ) data derived from typical flight paths by superposing errors with the same general characteristics as those occurring in the actual radar data. It is possible also, that the computer may be used to analyze the (r, θ) measurements of a tracked aircraft in order to derive information about the nature of the radar errors. This information is important but hard to obtain because the true positions of the aircraft are unknown. These two uses of the computer, the first to study the relative merits and ranges of usefulness of different methods of approximation, and the second to attempt to deduce the nature of errors from an analysis of measured data based on some general assumptions about true behavior, might well provide good subjects for thesis reports and good experimental programs for Whirlwind.

(D. R. Israel)

Some consideration has been given to the problem of keeping adequate records of the use of the computer and to problems associated with the storing and maintaining of paper tapes, magnetic recordings, films, and other such material. At present this planning affects only the 6673 project; however, through coordination with C. W. Adams it is hoped that more general and flexible arrangements can be made.

A careful search of the library facilities has made available several pieces of literature dealing with the smoothing and predicting problem. A start has also been made on a bibliography of this material. A memo concerning this bibliography and the handling of such material has been distributed.

The trip to the Bedford site last week was highly instructive, and served to stimulate thought on several lines -- particularly with respect to noise display scope persistence, multiple returns, etc. As a result of this trip several changes have been made in the main display program.

The persistence of the display scope in the computer room was tested on July 28. The test indicated that the persistence was too low, at least with the present operation of the scope and vertical decoder. It was possible to obtain satisfactory results by repetative displays; however, this is too time-consuming for consideration as an actual solution.

1. ANALYSIS (continued)

(D. R. Israel) - (continued)

In light of the rapid progress on the telephone line demultiplexers and on the joy-stick, plans have been formulated for use of the computer in testing programs employing these facilities. In conjunction with Samario and Walquist programs have been written to test the following:

a) Spot persistence
b) Spot separation
c) Spot movement by joy-stick
d) Spot movement by rate of change of heading
e) Radar display without coordinate conversion

As regards e), the idea is to display r as a function of θ, the θ being plotted horizontally, the r vertically. This display should prove valuable not only in testing the input program (without the coordinate conversion the program is short enough for test storage) but also in the alignment of the input equipment.

The spot movement program appears to have more potential value than was at first thought. The program can be used to initiate tracking, to selectively stop tracking, to select a portion of the scope display for magnification, and to measure the (r,θ) or (x,y) coordinates of any target. If the spot is moved by rate of change of heading rather than by changing x and y components of velocity a smoother curve can be obtained. This will be valuable in generating synthetic data.

Some preliminary work has been done on investigating the effect of quantizing of radar data. In particular an attempt has been made to determine the optimum procedure for obtaining the velocity and position of a target moving in a straight line given only the quantized position measurements.

In conjunction with C. W. Adams further thought and study has been given to the M.I. (manual intervention) program. Priority has been given to this program inasmuch as it appears to be essential for the use of the computer with new or experimental programs. It is expected that a note describing M.I. and the program to be used for its implementation will be issued on the next bi-weekly period.

(R. L. Walquist)

Several possible forms for a display and tracking program have been considered. A flow diagram has been drawn for displaying all incoming data and tracking a single aircraft. Tracking is accomplished by increasing the aircraft tracking block when the target is not interrogated.

1. ANALYSIS (continued)

(R. L. Walquist) - (continued)

Several coded programs have been written in conjunction with D. Israel. All of these fit into test storage. One of the coded programs is for use with the joy-stick in spot movement; another program displays incoming (r,θ) data on the scope with θ as the horizontal axis and r as the vertical axis.

(E. J. Samario)

The greater part of the bi-weekly period was used in familiarizing myself with programing techniques and in reading R-180.

Some time was spent in a study of the various input-output elements with special emphasis on elements used in this project.

2. ENGINEERING

(C. R. Wieser)

A visit was made to Bedford to see the radar in operation. The efforts to use the Moving Target Indicator have been abandoned. The most serious difficulties noted are (1) excessive ground clutter, which sometimes saturates the relay link and (2) multiple indications of targets. The latter difficulty shows up as 2, 3, and sometimes 4 indications of one target. The range quantizing is worse than anticipated, and the zone of uncertainty is about $\pm$ 500 feet. The differentiating circuit, which was previously used to reduce the uncertainty to $\pm$ 50 feet, had to be removed because of insufficient receiver gain.

Radar target tracking and test pattern data have been recorded and played back to Bedford for display. The magnetic recording equipment appears to be satisfactory, and it has been very helpful in adjusting the demultiplexer equipment.

There has been trouble with the ACRL equipment which converts the demultiplexed tones into gating pulses. This trouble has been traced to defective 1N34 crystals. Apparently, failures are caused by overheating the crystals from adjacent tubes and resistors.

The lack of persistance of the 304-H display scopes has led to the decision to increase the intensification time to 100 μsec. in order to get 15 seconds persistence. Experiments at 10 μsec. indicate that sufficient beam intensity cannot be obtained. Raising the intensity merely destroys the focus and results in a larger spot with no increase in persistence. This modification will require that the holding time of the multivibrator-type decoder be increased to 100 μsec.

2. ENGINEERING (continued)

(C. R. Wieser) - (continued)

So far, the only cabinets located for 12-inch display scopes are Navy PPI assemblies. These units are large and heavy, and require that the observer stand up to view them. It will probably be more satisfactory in the long run to house each scope tube and its amplifier in a small box about 14 x 14 x 30 inches. These can be set on a table, and the observer can sit while viewing them. It will also allow the two tubes to be placed close together, which is desirable for target selection. The face of the tube should be inclined from vertical for easier viewing.

(D. A. Buck)

Mounting of the joy-stick microswitches and the various mechanical linkages is complete. Each microswitch has been made individually adjustable, and indicator lights have been mounted on the joy-stick for this adjustment. Wiring is complete. Further mechanical construction awaits the delivery of springs.

A relay panel for converting the numbers generated by the microswitches into numbers of a form suitable for input to one of the flip-flop storage registers in the computer has been designed and constructed. The panel consists of eight relays with associated voltage-dropping and suppression circuits, and will be mounted in test control beneath the marginal checking unit.

(L. S. Bensky)

A switch panel was constructed for obtaining the several combinations: sending incoming information immediately to the computer, recording incoming information, sending recorded information to the computer. Stray signal feed-through and oscillations were encountered when the Magnecorder was connected through this switch panel to ACRL equipment; shielding leads and careful parts placement resulted in satisfactory operation.

Several more preliminary tests were made on the Magnecorder's frequency stability. A test oscillator signal tuned to the center frequency of one of the nine channels used in sending target information was recorded. This recording was played back through the ACRL demultiplexer in Room 138. This test was made on all nine channels. The filters in the demultiplexer were relatively insensitive to frequency shifts initiated by the Magnecorder. An ACRL engineer commented that this unit would, by far, be the most stable frequency element in the system made up of the coder, multiplexer, phone line, recorder, and demultiplexer.

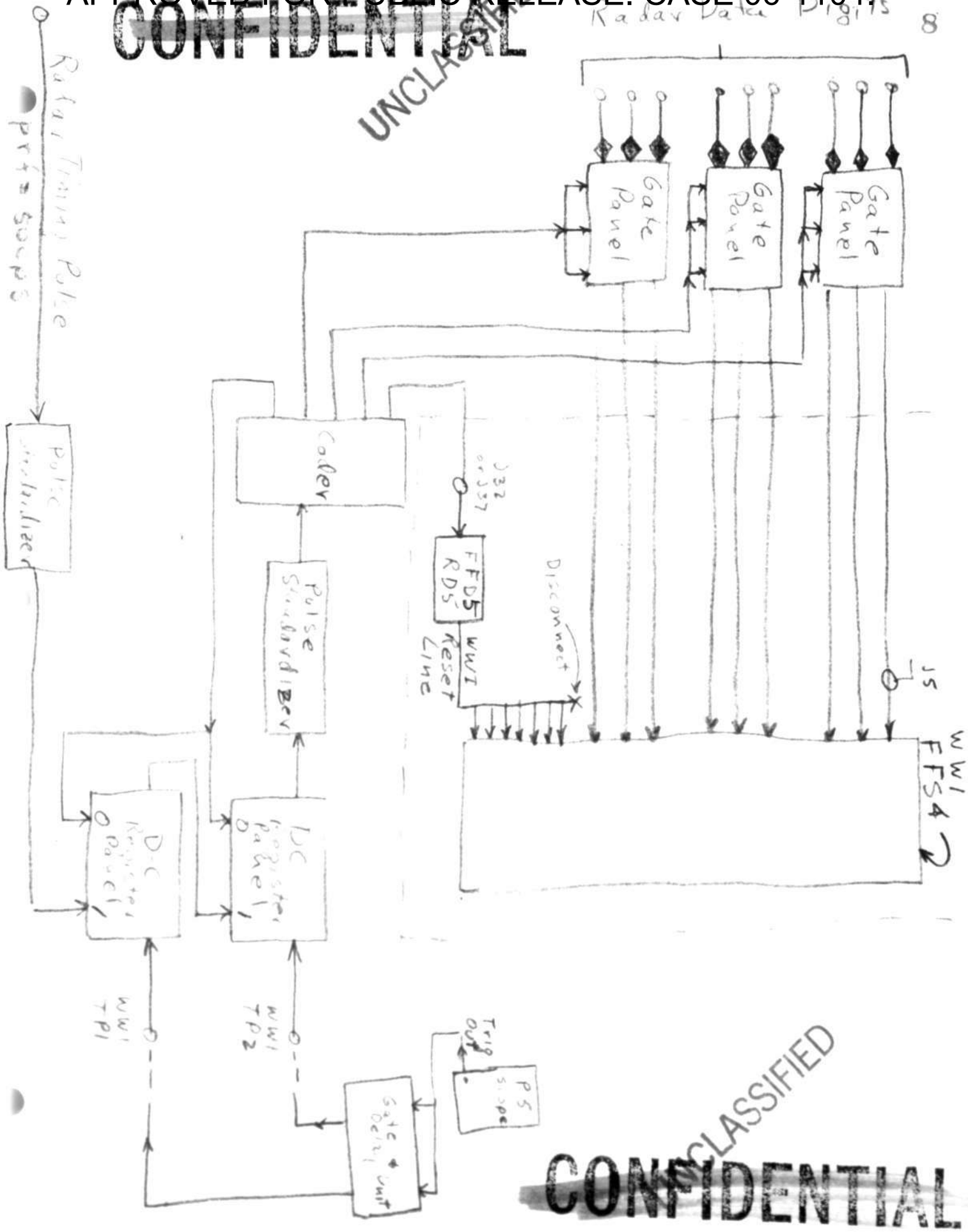
To convert the coded target signals coming from the ACRL demultiplexer into standard WWI pulses the system shown in the

2. ENGINEERING (continued)

(L. S. Bensky) - (continued)

block diagram was set up. The P5 Synchroscope trigger and the Gate and Delay Unit were used to simulate the computer's TP1 and TP2, pulses about 7µs apart (the highest p.r.f. available from the P5 is 4Kc.) Until it is possible to send a recorded test pattern into the computer, it is contemplated that a timing signal and an oscillator tuned to one of the nine channel frequencies be fed into the demultiplexer. This should give a series of pulses in the output of the corresponding gate panel.

* See page 8.



RECORD OF COMPUTER OPERATION

Exp. No.	
Program No.	8
Performance No.	1

I Identification:

Date: 7-28-50 Time Started: 12:10 PM Time completed 1:30 PM

In charge: D. R. Israel Assisting: R. L. Walquist

II Description of Facilities Used:

Program No. 1 Program Tape No. _____

Data Tape No. _____ Recording No. _____

Additional Facilities Used:

Note: Program was revised during experiment; modification is numbered 1a.

III Brief Description of Nature and Object of Experiment:

To obtain data on persistency of display scope, in particular to determine the adequacy of the display of a point on the scope once each 15 seconds. The program used simulated the movement of a target along a straight line inclined at 45°. The target was moved one unit in the x and y decoders and also displayed once each 15 seconds.

IV Remarks Pertinent to Operation of Computer and other Facilities:
(List any observations regarding operation of computer, display scopes, tape reader, tape punch, etc. Note any pictures taken or tapes prepared.)

see below

V Data, Observations, and Remarks Pertinent to Operation of Program:

The program as first introduced into the machine displayed the spot only once each 15 seconds. Although the initial display of the spot was just visible, there was no afterglow or trace on the scope despite the fact that all the overhead lighting in the computer room was extinguished, a light shield was used with the oscilloscope, and all the neon flip-flop indicators were covered. Increasing the scope intensity control resulted only in the display of a horizontal line, this being due to the non-holding effect of the vertical decoder.

The program was changed so as to display the spot a number of times at the end of each 15 second interval (see program 1a). Displaying the spot 256 times in succession at the end of each 15 second interval produced a satisfactory trace on the scope. Lack of time prevented further investigation.

VI Brief Statement of Results:

Under the present set-up the persistency of the scope display is much too low for our purposes and steps should be taken to improve conditions. Action should also be taken to improve the lighting conditions in the computer room.

E. R. ISRAEL (signed)