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6673  
Memorandum M-2073

Page 1 of 6

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

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Auth: DD251  
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SUBJECT: BI-WEEKLY, PROJECT 6673, OCTOBER 13, 1950

1. ANALYSIS

(W. G. Welchman)

John Salzer has joined the Analysis Group of Project 6673.

The immediate priorities for Project 6673 were agreed at a meeting on Monday, October 2nd, and were recorded in Memorandum 2071, dated October 4th.

A visit of Mr. Constock, Mr. White and Mr. Close from A.I.L. was encouraging in that they are seriously worried by the things that worry us, which confirms our own opinion that we are not making a fuss about nothing. They are thinking, however, in terms of a radar system that will really work, whereas we are at present concerned with an experimental tie-up of Whirlwind with the radar set and conversion equipment that happen to be available. In view of the difference of objectives we are not as depressed as they by the characteristics of the data that we expect to get from Bedford.

A.I.L. has put a lot of time into a study of optimum methods of cleaning up raw data provided by a radar set, and the accuracy that they believe to be possible is encouraging for the future. They aim at obtaining a fairly good estimate of velocity from two observations ten seconds apart and reckon on getting a good smoothed velocity after four or five observations. They have interesting ideas on non-linear smoothing and on the use of a weighted record of recent errors to control the coefficients in a smoothing formula.

At a 6673 meeting on October 9th it was agreed that the project can use Whirlwind for short periods at mid-day when satisfactory data has been obtained from Bedford. Israel and Walquist discussed tracking programs and made the suggestion that storage might be saved by the introduction of some order that will provide easy access to each of two 8-digit words stored in the same register. Subsequent discussion indicated that a convenient order for this purpose would be an optional modification of shift right giving a cyclic shift in which the content of BR 15 is re-introduced in AC 0. J. Salzer and others have looked into this and into alternative possibilities.

Consideration of programs for guiding an aircraft to a prescribed target and for a collision course interception is being considered as a by-product to a feeling that easily computable formulas for  $\arctan \frac{y}{x}$  and  $\sqrt{x^2 + y^2}$

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M-2073

1. ANALYSIS (continued)

(W. G. Welchman) (continued)

would be valuable. A simple formula has been found for  $\arctan \frac{y}{x}$ . This formula is valid for all quadrants, has a maximum error of about  $4^\circ$ , and requires about fifteen orders. Consultation with Professor Franklin led to further ideas which will be mentioned in the next Bi-Weekly. In particular Professor Franklin produced a far more accurate formula for  $\arctan \frac{y}{x}$ .

(J. M. Salzer)

In the way of familiarizing myself with the project work, I studied the basic tracking program. Also considered the problem of guiding one airplane and developed an arctan sub-routine (requiring 32 orders and 9 storage registers) for calculation of the heading of the guided airplane.

(D. R. Israel)

An S. M. thesis--"The Application of a High-Speed Digital Computer to the Present-Day Air Traffic Control System"--is being written, with an expected completion date of February, 1951. In order to meet this schedule it will be necessary to devote about two days a week to this work; no project time has previously been used for this purpose.

During the past Bi-Weekly period the computer has twice been successfully used for the display of recorded data. At the present time no data of a high quality has been recorded.

A program to track a single aircraft in (x, y) coordinates with the use of velocity smoothing has been written. This program is tentatively named, "Radar Tracking Program II". A more general version of this program which will track more than one aircraft is being written by R. L. Walquist. It is expected that Program II will enable studies to be made in connection with the efficiency of various tracking schemes. A general description of Program II will be available shortly.

The recent visit of Warren White and Dick Close of A.I.L. was extremely enlightening, and provided much new information and material for consideration. When time permits, it is hoped that certain refinements suggested by White and Close can be incorporated into our programs.

The plans for the next two-week period include some modification of Program II, the preparation of a flow diagram and description for Program II, and the commencement of work on a tracking program for two aircraft--one the target, the other the interceptor. With the impending availability of WWI, a number of technical details concerning the actual operation and use of prepared programs will have to be worked out.

6673  
Memorandum M-2073

Page 3

1. ANALYSIS (continued)

(R. L. Walquist)

Radar Tracking Program-III (tracking "n" targets, where "n" is greater than 2) is nearing completion. The program, as it now stands, has sufficient storage capacity in ES for tracking 6 targets. However, the program time for this many targets appears too long and modifications will have to be made which will probably reduce the number of trackable targets to around 4. Considerable thought is being given to this time problem and how it and a limited storage capacity can best be reconciled. An afternoon was spent in discussion with D. R. Israel and J. A. Arnow over the problem of using separate time counters for each tracked target. The use of a single time counter, while saving some registers in storage, would lengthen the present program time (which is even now too lengthy) considerably.

(J. Arnow)

A program to record the first 12 digits of selected storage registers was written for the purpose of extracting and preserving data from the tracking program. It will be possible to use this data later to examine the contents of any aircraft box or boxes at various stages of tracking and determine the relative efficiency of the prediction formulae. The program requires eighteen orders and three storage registers.

A program to simulate the radar data was written for the purpose of checking Radar Tracking Program I. Through use of the Manual Intervention Program and the adjustable constants switch, it will be possible to adjust (r,  $\theta$ ) increments to simulate a lost target and, to a limited extent, quantization errors similar to that found in the radar set at Bedford. In essence, one (r,  $\theta$ ) reading followed by 750 zero ranges are inserted into PF4. There is an allowance for a suitable time delay between zero ranges to give approximately one target indication every 15 seconds. The program at present writing requires 40 orders and 9 storage registers.

Consideration was also given to a shorter form of an input program.

CONFIDENTIAL

6673  
Memorandum M- 2073

Page 4

2. ENGINEERING

(C. R. Wieser)

A good radar test pattern has been read into WMI and displayed satisfactorily. This checks the satisfactory operation of the demultiplexer, read-in test equipment, display, and display interlocks. Some old recorded radar data were read in and displayed. This data is obviously bad, but it was still possible to "track" moving targets on the display scope. The scope persistence is satisfactory; in fact, the persistence is so long that an infra-red "eraser" has been built to facilitate changing the scope picture when it desired to shift the display position or change scale.

We have not yet been able to record any good target data. The radar equipment has been shut down either because of bad weather (excessive cloud echoes) or maintenance. Target data are promised as soon as the equipment is operative on a good day.

The construction of a digital PPI display similar to the one at Bedford has been investigated. The most difficult part to build is the scope itself. If we want an inexpensive display, we should use a commercial 5-inch oscilloscope (a DuMont 304-H is satisfactory) and build only the decoders and r,  $\theta$  display circuits. This would amount to about 50 tubes in circuits already designed. The circuits are not critical (audio bandwidth) except for decoder calibration. Nothing further will be done on the PPI display until its usefulness has been definitely established.

Harrington of AFCHL has suggested reducing the antenna rotation rate to 2 rpm (it is now 4 rpm) in an effort to make the MTI work. He estimates that the lower rate, which could double the number of echo pulses per target, would make the MTI worth-while. The size of the quantizing increments would not be affected. Once the MTI is working the shift from 2 rpm to 4 rpm or vice versa, would be about a one-hour job.

If no other changes except antenna rotation speed are made, the result would be frequent double reports on target position; that is, two sets of identical target coordinates would be sent consecutively. Harrington is investigating a method of eliminating this by changing the video storage timing circuits to integrate 24 radar pulses at 2 rpm instead of integrating 12 pulses as is now done at 4 rpm. If this change can be made, the period of integration will still be

CONFIDENTIAL

6673  
Memorandum M-2073

Page 5

2. ENGINEERING (continued)

(C. R. Wieser) (continued)

roughly equal to the period necessary for the antenna to rotate through one azimuth quantizing increment, and successive identical target reports will be eliminated. The work required to make the integration period adjustable at 12 or 24 pulses has not yet been determined.

(D. A. Buck)

Steps have been taken towards more accurate control of display persistence. Work has progressed in two directions:

1. Internal control by changing the intensification gate length. A remove intensification gate length control has been mounted at the darkroom viewing position. Intensification can be varied continuously from zero to 165 microseconds.

2. External control by infra-red irradiation of the phosphor. Radiations with wavelengths above 590 millimicrons have a de-energizing effect on the phosphor. A 250-watt red-faced heat lamp with eleven layers of red celophane as a filter has been used successfully to erase the phosphor. The minimum erase time at this beam intensity for a near-saturated phosphor is about fifteen seconds. A push-button operated delay has been constructed to time the scope face erase source.

The two systems of persistence control are ready for evaluation. A pencil-size infra-red source could be constructed if individual points were to be erased.

The end-carry has been restored to the M-scopes and an amplifier-inverter constructed and installed within the scope for the Z-axis input. A switch (access via snap-plug on right side of scope) has been provided which, when in the up position, restores the scope to original positive unamplified Z-axis input, and when down, puts the amplifier-inverter in the circuit. See SA-36177.

A low-speed  $2^6$  counter has been substituted for the former analogue-type delay which operates in conjunction with the IOC interlock. This counter, gated on by a QD or QF order, counts restorer pulse generator end-carries. The counter end-carry either clears the IOC interlock or starts the main computer clock. The pulse, by nature, is correctly synchronized for the latter function. The entire system is described in M-1108 and SC-36146.

CONFIDENTIAL

6673  
Memorandum N-2073

Page 6

2. ENGINEERING (continued)

(H. Kirchner)

Investigation is being made of the possibility of use of a so-called "Light Gun" for target acquisition. Both photomultiplier type and vacuum phototubes are being considered for the light detector.

A chassis has been constructed employing a type 931A photomultiplier, but has not as yet been evaluated. A type 1P42 vacuum phototube has been procured and associated circuits for its employment are being designed.

It is felt that if sufficient light is available to excite the 1P42, its employment would be highly desirable since it would enhance the design of a compact size, light weight "Light Gun".