M-1212 Copy 18

Quarterly Report, Contract N5ori-06002,

January through March, 1951

Project NR 232-001

Submitted to

Office of Naval Research

Report by

Robert A. Nelson

Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

Project DIC 6782

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

SUBJECT: QUARTERLY REPORT, Contract N5ori-06002, January through March, 1951

To: Head, Computer Branch, Office of Naval Research

From: R. A. Nelson

Abstract: This report describes work performed during January, February, and March 1951 on Contract N5ori-06002, covering research in digital techniques in naval anti-aircraft fire control. Programming of the Mark 47 equations for digital solution was completed. Work on making firing table data available to the computer was completed; the two most practical methods of those considered are function generation by polynomials and function interpolation using magnetic drum storage. Study of prediction of target position (including criteria for switching from one prediction law to another according to tactical conditions) was continued. The Mark 25 radar system was studied to help in our consideration of input problems. Two small demonstration programs were started. The remaining time until the expiration of the contract on 30 June 1951 will be spent 1) completing work already started, 2) considering in an exploratory way some of the topics which cannot be thoroughly studied, and 3) preparing a final report.

1. INTRODUCTION

This is the Third Quarterly Report submitted under contract N5ori-06002, covering research performed during January, February, and March 1951 in digital techniques in naval anti-aircraft fire control. The specific tasks prescribed in the contract are listed in the first quarterly report, Memorandum M-1118 of the Electronic Computer Division of the Servomechanisms Laboratory. The personnel are the same as mentioned in M-1118.

The contract ends on 30 June 1951, and it will probably not be extended because of the priority of other work in the Laboratory. The effort during the remaining quarter, then, will be chiefly directed at completing research previously planned (see the second quarterly report, M-1169) and writing an integrated report on the work.

2. STATUS

2.1 Technical Status

Work during the first quarter was basically orientation. During the second quarter, in addition to increasing our background knowledge to the point where we felt prepared to plan our future work more definitely than previously, we made progress in some of the explicit tasks set forth in the contract. In the third quarter we continued work on the program described in M-1169.

Early in the quarter actual coding of the Mark 47 solution for a digital computer was completed and gone over. The general preliminary conclusions and computer requirements set forth in the second quarterly report are still valid -- that a computer of the capacity and speed of Whirlwind I can do the job. Writing of the section of our final report that will cover this phase of the work has been started.

Work on the problem of making firing table data available to the computer, mentioned in the second quarterly report, has been extended. Approximation of the superelevation function by a polynomial was completely worked out with what appears to be acceptable precision (greater precision could be obtained if necessary). An examination of the other firing table functions was made which revealed that none of the other functions required polynomials of order greater than three to obtain the precision considered adequate for the superelevation function. Some time was then spent considering the possibility of storing the firing tables on a magnetic drum and reading portions of them into electrostatic storage as required. This method depends on the ability to know long enough in advance the range and elevation for which information will be needed. Although we have no detailed system requirements (orders, synchronizing needs, etc.) to judge by, it seems that the use of a magnetic drum for making tabular data available might be practical.

The possibilities of using magnetic tape or film similarly were dismissed as impractical; so also was the idea of "wiring in" the tables (the objection here being that too big a selection matrix would be required for the amount of data involved).

Study of prediction of target position was continued, mostly on the initial assumption that smoothed observational information was available to the computer. For purposes of illustration, the cases discussed in one of the Mark 65 reports were most thoroughly examined. The BTL people developed graphs showing optimum conditions for switching from helical to linear prediction for various amounts of intentional maneuver and flight unevenness. (Although parabolic prediction achieves a higher kill probability than linear prediction under certain conditions, it is generally inferior to helical prediction except in the ease with which it is accomplished.) We concentrated on two aspects of the above problems. One was the way in which a digital computer would be coded for the various prediction laws; it was found cumbersome to determine from observations the constants for helical prediction. The other aspect was the criteria for switching from helical to linear prediction, and a simply coded hyperbolic expression was found to represent the Mark 65 graphs quite well. Late in the quarter a little study was made of prediction linked with smoothing; the work here is not yet complete.

Some time was spent studying the Mark 25 radar system as it is described in OP 1788. This information will be used when we consider in an overall way the requirements and features of the input and output ends of a digital fire control system, with the effects of quantization, sampling periods, etc.

Toward the end of this quarter we spent some time in operating on the computer certain smoothing programs of another project in the Laboratory in order primarily to gain experience in operating the computer. As a result we started the development (toward the demonstration prescribed in our contract) of two display programs based on the Mark 47 computer solution, one to smooth in 3 dimensions and the other to smooth and predict in 2 dimensions. These programs should serve as a check on the digitalization of the Mark 47 solution, and, it is hoped, should provide interesting displays.

Some effort was devoted to the preparation of a preliminary draft of a discussion of the firing table data problem.

2.2 Financial Status

At the end of March $15,387 had been spent of the $32,000 available.

3. FUTURE WORK

The second quarterly report listed and discussed briefly several areas in which future research should be conducted. It was pointed out there that this would not all be accomplished if the contract expired in June 1951. It appears at the present time that most of our remaining effort will have to be given to finishing work already started and preparing a final report of the whole program. There may be some exploratory thought given to the considerations involved in topics which cannot be studied.

The final report itself should aim toward exposing the usefulness of digital techniques in fire control. Because of this aim and the low level of activity, the report must necessarily deal with broad outlines for the most part; except for the Mark 47 coding, the firing table approximation, and some coded sequences for prediction, most of the work has been fairly general. It is intended, however, that the report give an idea of where further work might be done.

Signed Robert A. Nelson
Robert A. Nelson

Approved R. R. Everett
R. R. Everett

RAN/jcl