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A Memorandum from Jay W. Forrester

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PROJECT LINCOLN

Division VI Program

July 1952-June 1953

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There are two principal objectives of Division VI of Project Lincoln. The first, known as the Cape Cod System, is a joint effort of Division VI, Division II, and the Digital Computer Laboratory of MIT. The Cape Cod System will be built, operated, and evaluated as a model of a complete air defense system. The system is based on the use of a large number of small radar sets with a high-speed digital computer (Whirlwind I of the Digital Computer Laboratory) to process the radar data and control interceptors. The second objective of Division VI is to design and build a high-speed digital computer (Whirlwind II) which will have the characteristics desired for a future operational air defense system.

The work which we hope to accomplish in these two fields between July 1952 and June 1953 is outlined in the following paragraphs.

Cape Cod System

The Cape Cod System is an outgrowth of three earlier activities: (1) the development of the Whirlwind I computer for automatic combat information center research, (2) the long-range research program of the Air Forces ADSEC Committee, and (3) of the Project Charles study. The Whirlwind I computer had been under development to study the speed, storage, and reliability characteristics required for military control applications. The ADSEC Committee arranged to connect the Whirlwind I computer to a search radar set at Bedford for preliminary evaluation of automatic digital radar data processing. This processing includes track-while-scan, the smoothing of aircraft data, the prediction of future aircraft positions, and the generation of weapon control orders.

In the Project Charles study no other solution to air defense data processing was found equal in long range value to the digital transmission and automatic analysis of data. Successful demonstrations with one radar under the ADSEC program led to undertaking the construction of a model of a realistic air defense network. This model system is to be located in eastern Massachusetts and Cape Cod and, although small, will stress completeness. It is important that most of the functions of an air defense system be incorporated in order that the complex interplay of information from different sources can be studied. The proposed model air defense system calls for many new devices. Detailed planning for incorporating these will be one of the major tasks during the next year.

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The work of the Cape Cod System group may be divided into three parts: (1) Construction and operation of a three-radar network, (2) Construction of a 14-radar network, and (3) planning for a future operational system. Operation of a multiple radar network with the Whirlwind I computer involves two broad problems, namely, data screening on the one hand and tracking and control on the other.

During fiscal 1952 the single radar and digital computer experiment is being expanded to a three-radar network. The work in fiscal 1952 is aimed at learning how to track an aircraft through a network of radars having overlapping coverage. The results will lay the foundation for the 14-radar network.

At the beginning of fiscal 1953, the 14-radar network will be under construction and during that year the magnetic drums will be completed and installed in the Whirlwind I computer to expand its capacity as required for the full Cape Cod System. Before June 1953 it should be possible to commence operation with the 14-radar network with automatic data handling capacity for data screening, automatic track-while-scan and the control of a large number of aircraft.

In fiscal 1953 the data processing procedures will be extended to use height data in converting the present two-dimensional tests into a realistic three-dimensional experiment. An automatic ground-to-air link will be used to permit fully automatic high-speed flow of information in the system.

In the Cape Cod System the Division VI responsibility is for the air defense center planning, automatic information processing (including data screening and automatic tracking), the computation of control orders for weapons, and the provision of the digital equipment necessary in the air defense center. This necessarily includes study and analysis of the behavior and objectives of an air defense system.

As work progresses on analysis and design of the 3- and 14-radar Cape Cod System, the group will spend a certain amount of time projecting their results into planning for a future operational air defense system. In addition to processing the information transmitted by the radars, the computer must also process CAA Flight Plan Data and weather information, transmit information to AA batteries and Civil Defense Agencies, present the displays necessary to an Air Defense Center, and be prepared to handle new weapons and guided missiles.

#### Whirlwind II Computer

Existing digital computers can be looked upon only as experimental models. The second principal responsibility of Division VI is the design of a digital computer and associated terminal equipment having the characteristics required for an operational air defense system. For such a military use a digital computer should be simplified, made more reliable, and designed for increased data handling capacity. Design of such a machine will require about three years, and, as it progresses, it can incorporate results obtained from the Cape Cod System. Many new techniques not yet used in digital computers

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are available to make possible a machine suitable for military use. We anticipate that magnetic core storage will replace the more expensive and less reliable electrostatic storage tubes used in Whirlwind I. Experimental models of the new three-dimensional magnetic memory system now exist and are being evaluated. Transistors, magnetic cores, and other new components will be used for computing and switching circuits to the extent indicated by technical performance and time schedules. Simplification can be expected from more efficiently designed machine logic.

A staff for Whirlwind II design is now being assembled. In the first half of fiscal 1953 the characteristics of the machine will be established and the selection of components made. The latter part of fiscal 1953 will be devoted to machine design. Very close liaison with the Cape Cod System studies will be necessary to incorporate in the computer at that stage the characteristics best suited to an air defense system. Work will be divided among four groups to carry on four major efforts:

- (1) a study of new components and circuits
- (2) the determination of optimum machine logic to utilize these new techniques
- (3) the development of new magnetic materials for reliable high-speed storage and for switching purposes
- (4) close liaison with the Cape Cod System to formulate the computer characteristics peculiar to air defense data processing.

It seems clear at the present time that a new machine can be designed which is much smaller than Whirlwind I and has a lower power consumption without giving up service accessibility. For a practical military use the machine must have a higher reliability and require a smaller amount of maintenance than any existing digital machine. It appears that these objectives can be achieved.

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