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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

CAPE COD SYSTEM AND DEMONSTRATION

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SECURITY INFORMATION

The Cape Cod experimental air defense system dates from digital data processing tests initiated by the Air Force's Air Defense Systems Engineering Committee. In early 1950 a program was started to combine the Whirlwind I computer built at MIT for the Office of Naval Research with digital data transmission equipment built at the Air Force Cambridge Research Center. The experiment was to test digital track-while-scan, radar data correlation, air situation presentation methods, and weapon control.

The Project Charles study in the first half of 1951 recommended that the experiment be expanded to a realistic model which has been named the Cape Cod System. The Cape Cod System was conceived as a proving ground to test a multiple-radar network which automatically transmits data to the Whirlwind I Computer for automatic processing and guidance of interceptors.

The system would serve several purposes:

a. Develop system concepts for a high-track-capacity system.

b. Test new components.

c. Furnish specifications for digital computers designed specifically for air defense.

d. Verify the soundness of the whole concept by experiments using live radar data and controlling live aircraft.

Since the Cape Cod System is aimed at getting system experience as early as possible, many of its component parts are chosen by expedient. They can, however, be replaced as more suitable equipment is developed.

The present objectives of the Cape Cod System require that it be developed into a complete model air defense system. It should be highly flexible so that ideas can be tested; as a result, the radar network can operate either as a network of small radars or can operate as a large radar (GCI Station P-10 at Truro, Mass.) with some of the small radars used as gap fillers. The Whirlwind I computer, which is of the general-purpose type, allows freedom in testing various methods of processing data to generate the air situation and to control weapons.

The Cape Cod experimental system is not yet complete, but it is still possible to obtain valuable experimental data from the existing equipment. In the system in use today, the radar used most is an MEW (about 10 years old) at Bedford, Mass., equipped with a digital radar relay (DRR) link built by Air Force Cambridge Research Center (AFCRC) prior to the formation of Project Charles. The data link is not the newer slowed-down video (SDV) type, and the DRR can transmit only a small fraction of the whole radar picture. In the summer of 1953, the MEW will be replaced by SDV data from the operational Air Force CPS-6B search radar at North Truro, Mass. Two smaller radars (at Rockport and Scituate, Mass.) equipped with SDV data transmission links have also been used for some tracking experiments. In addition, there is an MPS-4 nodding-beam height finder at Rockport which is controlled by voice telling of instructions and data. Since all this data is transmitted over voice telephone lines, it is frequently recorded on magnetic tape and used to reproduce flight-test radar data for purposes of analysis and training.

The radar data is fed into the Whirlwind I computer at the Barta Building in Cambridge, which processes the data to provide 1) vectoring instructions for mid-course guidance of manned interceptors and 2) special displays for people who monitor and direct the operation of the system.

In processing data, the computer automatically performs the track while-scan function, which consists of 1) taking in radar data in polar coordinates, 2) converting it to rectangular coordinates referred to a common origin, 3) correlating or associating each piece of data with existing tracks to find out which pieces of data belong to which aircraft, and 4) using the data to bring each track up-to-date with a new smoothed velocity and position, and 5) predicting track positions in the future for the next correlation or for dead reckoning if data is missed. Once smoothed tracks have been calculated, the computer then solves the equations of collision-course interception and generates and displays the proper vectoring instructions to guide an interceptor to a target.

This process is not, however, wholly automatic. The initiation of new tracks can be done automatically or manually, or both methods can be used, each in different geographical areas of the system. Also the decision as to which aircraft tracks are targets and which tracks are interceptors is made by people and inserted manually into the machine by means of a light gun. The light gun is a photocell device which is placed over the desired blip on the display scope and then sends a pulse into the computer to indicate to the computer that action (for example, "start tracking") is to be taken on that particular aircraft. The action which the machine takes is defined by manually setting a selector switch, which the computer automatically senses and interprets (for example, "handle this aircraft as an interceptor"). The human beings make decisions and improvise while the computer handles the routine tasks under their supervision. In order to facilitate human supervision, a rapid, flexible display system is required. The principal means of display is the cathode-ray tube, which can accept information very rapidly and present both symbols and geographical positions of aircraft. Flexibility is achieved by programming the computer to display various categories of information on different display cables. The human operator can switch these cables at his scope and thus select at any time the type of information (or combination of types) which he wishes to observe.

The demonstration planned for today illustrates two types of experiments which have been performed. The first is an interception, in which a target aircraft is sent on a simulated raid. An interceptor is then assigned and both the target and the interceptor are tracked automatically. The computer generates collision-course vectoring instructions to guide the interceptor to the target. These instructions are displayed numerically on a cathode-ray tube and relayed to the interceptor by radio telephone. (In previous successful experiments, heading commands have been relayed to an interceptor by means of an experimental automatic ground-to-air digital data link developed by AFCRC. The data link has also been used to feed directly into an experimental autopilot developed by the MIT Instrumentation Laboratory so that control of interceptor heading is done automatically by the computer.)

The second experiment illustrates automatic tracking of up to sixteen aircraft. The initiation of tracking is manual (by means of the light gun) in part of the operating area and is automatic in part of the area. In the automatic initiation zone the computer stores all radar returns which do not fit existing radar tracks and waits for further data to form a new track. At present, the arbitrary criterion for a new track is two pieces of data received in five consecutive radar scans. Once a track is established, a vector (arrow) is displayed on the scope to show the direction and approximate speed of each track. An additional feature of the program allows the operator to call for information (by means of his light gun) on any track. The computer then displays numerically the track position, speed, and heading.

These experiments are only a few of the many that have been carried out. Experiments of this type, carried out with live aircraft, live radar, and an operating computer have already proven very valuable in planning an advanced air defense system.