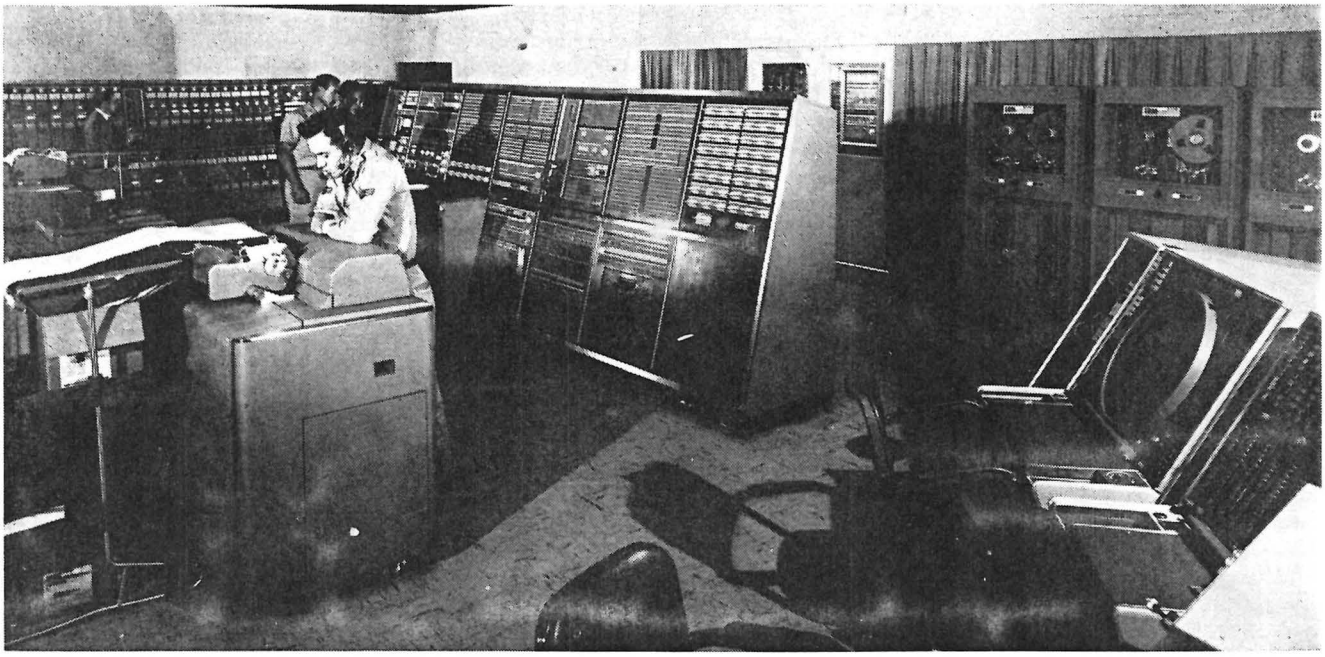


SAGE TROUBLE SHOOTERS. Maintenance and programming room monitors system. Malfunctions are reported automatically.

SAGE System

NORAD Breeds Electronic Watchdog

By Ernie Hemphill

Every 15 seconds, 24 hours a day, a complex combination of electronic devices linked in a system which now envelopes the New England seaboard wracks its light-speed reacting "brain" for clues in the atomic age's most critical game of hide and seek.

That's the time it takes the Semi-Automatic Ground Environment system being superimposed on North America's air defense detection and direction network to take electronic cognizance of the air situation in any one sector of operational control.

At the present time, two SAGE centres are in operational use. Future installations are planned throughout the 29 sectors where contiguous radar coverage is available, including two Canadian centres providing SAGE for areas north of main concentrations of industry in Ontario and Quebec.

The basic defense concept under which the SAGE system has become a requirement is the necessity to observe all aircraft flights over and in the vicinity of Canada and the United States. Not only must these flights be kept under surveillance, there must be some fast, foolproof method of distinguishing friendly from potential hostile aircraft. When it is realized that there are upwards of 35,000 scheduled flights in Canada and the United States every day, plus a great number of non-scheduled operations, it is obvious some method of automatically sorting out the air picture is essential.

SAGE does not represent a new air defense system. It is the application of high speed digital computers to the task of processing and projecting the wealth of information gathered into the defense system.

The electronic "brain trusts" of the SAGE system sectors are giant computers designed by International Business Machines Corp. in co-operation with the Massachusetts Institute of Technology's Lincoln Laboratory.

Information reaches the SAGE computer from a variety of sources. Vital facts are fed into the system by heavy surveillance radars in the Pine Tree complex which covers Southern Canada and the United States; gap-filler radars which plug holes between areas of heavy coverage; special height-finding radars usually located in conjunction with the heavy surveillance equipment; the Mid-Canada and Distant Early Warning lines, as well as additional heavy surveillance radars located in Alaska; radars installed on Airborne Early Warning aircraft (Super Constellations), Texas Towers and specially equipped picket ships. Until recently, the SAGE computer also had information on the existing air situation rounded out by reports from the Ground Observer Corps. These units were de-activated in the United States effective Jan. 30, although the Canadian counterpart is still being maintained.

In order to evaluate the air situation and detect a potential enemy presence, the computer must also have information depicting anticipated friendly air operations in the sector concerned. This is provided from civilian and military flight plans relayed to the SAGE centre from points of filing.

To properly assess the situation, in the event an intercept or attack mission becomes necessary, the computer must also have such vital information as sector weather and state of readiness and location of the variety of weapons systems which might be employed. This information is readily available from the appropriate sources.

As an aircraft enters a sector long range radar registers a signal return. In a SAGE-ed sector, this return is picked up by a photo-electric cell situated above the face of the radar scope.

The photo-electric cell acts as the sensing device for a Co-ordinate Data Transmitting Set which processes significant radar returns and automatically makes up a digital message concerning them. This message is transmitted by phone line to the SAGE Direction Centre where it goes through a digital data receiver and is read into the computer via the Long Range Input frame.

The computer decodes the digital message converting the range-azimuth information to the appropriate sector co-ordinates for visual location on the Situation Display Console. At the initial Situation Display Console the return is picked up by a photo-electric tube mounted above the console. This is the Automatic Initiation Area Discriminator which observes subsequent returns of data and establishes a track.

Once a track has been definitely established and identification is required, the computer automatically labels the track as a "Pending."

The "Pending" track at this stage begins to be shown on Situation Display scopes in the Identification Room. This is the location at which the track may be correlated with flight plan information which the computer has on tap.

Flight plan information is transmitted to the SAGE Direction Centre's Manual Inputs Room via teletype. Here it is punched out on an IBM card which is then inserted in a card reader to transfer the information into computer storage where it is available for visual display.

If the "Pending" cannot be correlated within one minute it must be labelled as an "Unknown." This decision is conveyed to the computer by the Identification Officer through switches on the console. The "Pending" track to which it applies is designated by the process of literally shooting the track with a light-gun (photo-electric cell). The computer system reacts to the light shot and initiates the process demanded by coincident switching at the console.

In addition to displaying radar returns and flight plan information as tracks on what amount to a simulated area radar scopes, or the Situation Display Consoles; the computer will also supply specific information on a particular track or flight plan in message form. This is shown on a small panel located at each Situation Display Console.

For example, an operator, through appropriate light shooting and switching at his console, can request the computer to message specific information such as height, speed, heading, etc., on a "Pending" track and the flight plan with which he believes it may correlate. In a matter of seconds the pertinent information shows up in message form on the small panel, which might be best described as a small light-sensitive memo pad.

Getting back to our original radar return (which has now become a "Pending" track in the Identification Room) there are a number of processes which the computer initiates automatically during the period in which the attempt at identification is being made. New radar data from the long range site is being continually correlated with the track, keeping the information supplied by the computer current. The SAGE system is cycled to check the computer for new information every 15 seconds.

Immediately a track is established in azimuth and range, the computer automatically makes up a height message request which is sent to the appropriate long range site over a phone line. This query is received by the Co-Ordinate Data Transmitting equipment at the site and through it activates the height antennae to the designated azimuth and range for the track. An operator at the site makes fine adjustments to be certain the height finding apparatus is "on target" and then presses a read-in button. A message covering the height of the object making the track is made up by the Co-ordinate Data Transmitting set and sent to the SAGE Direction Centre for insertion in the computer and display.

Intercept Direction

Assuming that our track is classified as an "unknown" in the Identification Room, it immediately becomes the responsibility of operators in the Weapons Room. Here, the Senior Director assigns the specific track to one of the Weapons Directors on duty before a Situation Display Console.

The Weapons Director, through a series of switching at his console, asks the computer for a Weapons Assignment Display on the unknown track. This information will be displayed on the small panel mentioned earlier and will indicate points of intercept and times to points of intercept for squadrons which have aircraft available to carry out a mission on the track under investigation. On the basis of this information, the Weapons Director selects the squadron which can make the most advantageous intercept and initiates a scramble.

He then assigns the entire operation to one of his Intercept Directors.

At the Intercept Director's Situation Display Console the assignment shows up in the form of symbology giving pertinent information on the operation, plus an audible and visual alarm to make certain he knows he is in business.

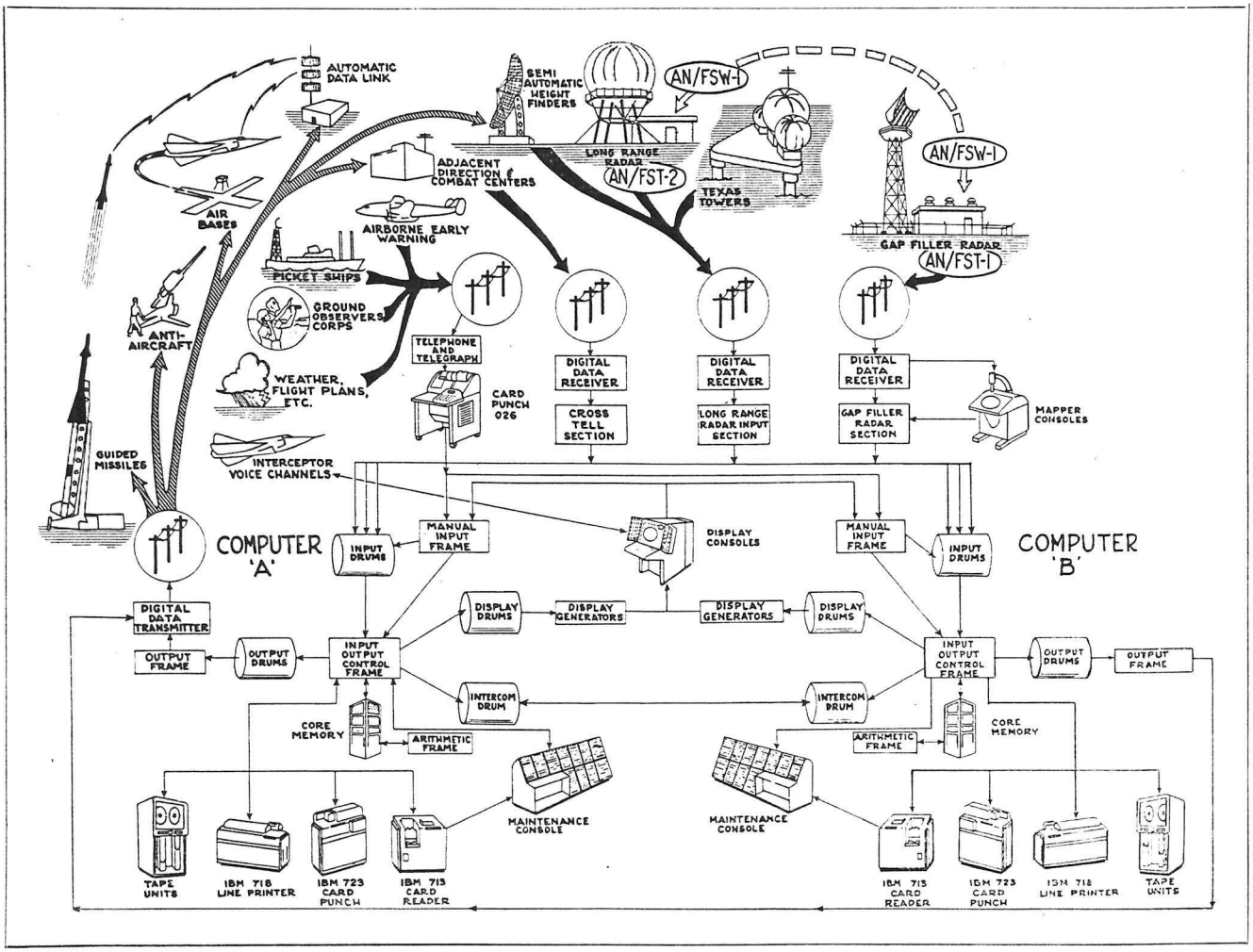
A scramble display is shown at the assigned console and as soon as the interceptors are airborne the Weapons Director inserts this information into the computer by switching. The computer then begins to work out the intercept problem providing information which will send the interceptor on the correct heading for an optimum intercept. This information may be passed directly to the aircrew of the interceptors involved through a Data Link System, or it may be relayed by the Intercept Director from his console position.

As soon as the interceptor begins to show up on the Situation Display Console and is definitely identified as such through uncorrelated Identification Friend or Foe data, the Weapons Director selects the tactics he wishes to employ. Switching passes this decision to the computer, which then takes this into account in computing the track for interception.

Throughout the operation, whether the intercept is being carried out under a Data Link hook-up in which computer information is relayed directly to the aircrew or under directions from Intercept Director to aircrew, the Intercept Director monitors progress and reads detailed information messaged from the computer on his demand.

When the intercept has been completed, the Intercept Director changes

COMMAND POST. Ringed by Situation Display Consoles which are SAGE trade mark, a sector commander's staff sits in for operation. Desks also have displays.



DATA FLOW. Flow of information and instructions is graphically shown in above diagram. Information cycles every 15 seconds.

assignment of the interceptors from Interception to Return to Base. The computer then begins working on the optimum track to get the aircraft back to base. Pertinent information is relayed to the aircrew by the Intercept Director immediately it is messaged from the computer.

The above rather brief description is by no means the complete SAGE story. But it serves as a basic example of the considerable advantage, in speed and accuracy, which use of the SAGE computer offers over the manual handling of the work load associated with identification and interception.

There are any number of important side operations involved in making certain the computer presents a clear picture at the Situation Display Consoles. For example, the elimination (mapping out) of unwanted radar returns from ground, sea and cloud is necessary to make sure the computer has a clear (uncluttered) picture of the track under investigation.

There has been little reference to the wealth of weapon information which must be stored in the computer memory. Performance data on aircraft and their armament, on ground to air missiles and their capability are vital if the computer is to present the Weapons Director with an accurate assessment of the intercept or kill potential he has available.

The computer is, of course, capable of computing and directing (through Data Link) a missile intercept in the same manner as was described for the aircraft interception.

While the bulk of computer information concerns the air situation within the specific SAGE sector served, the system is also capable of absorbing information from other sectors and from early warning radar networks so that the over-all air battle and developments in adjoining sectors may be taken into consideration.

Civil Application

Although it has been designed specifically to fill the military requirement for fast, accurate processing of information relating to air defense, the SAGE system quite obviously has a tremendous application in the civilian field of air traffic control. Surveillance direction of the type possible with a SAGE system is unquestionably a must if North American air traffic is to avoid a hopeless snarl in the future.

Backbone of the system is a reliable communications network which makes certain that vital information is passed to the computer for absorption and processing. To this end communications links with all information sources are backed up by physically separated lines and microwave systems.

Co-incident with installation of the SAGE computers is the move to provide more extensive radar coverage so that tracks may be maintained once they are initiated into the system. This is one of the major cosiderations associated with installation of SAGE sectors in Canada where the government has already indicated intention to extend northward coverage of the Pine Tree System and install additional gap fill automatic radar sites to cover holes in the present network.

A recent government announcement indicated that negotiations are proceeding under which it is hoped that Canadian industry will be given more opportunity to share in contracts for equipment required for joint Canadian-U. S. defence project. The current build-up of SAGE and related strengthening of NORAD's radar network is seen as a project on which Canadian companies will be making strong bids.