INDUSTRIAL DATA PROCESSING APPLICATIONS REPORT

Applications	Reservations and Message Switching System
Type of Industry	Airline
Name of User	Eastern Air Lines Charlotte, N. C.

Equipment Used *	Two Univac 490 Real-Time Computers One Univac 1004 Card Processor/Reader/Punch IBM Punched Card Equipment Teletype Units Uniset Console Agent Sets * (See text for complete list)

Synopsis

Eastern Air Lines, one of the largest air carriers in the United States, is presently using two Univac 490 Real-Time computers to handle reservations and message switching at its Charlotte data center.

One of the Univac 490 computers is active around the clock while the other is used for routine maintenance and standby. The system uses 14 Univac FH-880 magnetic drums having a capacity of more than nine million words of ordinary text.

The central computer is connected to Eastern's eight regional reservations offices and to the centralized offices of other airlines by high speed data communications circuits, which are tied in to numerous individual agent sets. All transactions are carried out in real time.

The message switching system uses a separate communications network of nearly 180,000 miles. The daily input of teletype messages is about 55,000; the daily output is about 80,000.

In addition, the system performs a number of other functions such as keeping track of catering activities and maintaining a Flight Watch Display system.

In July 1958, Eastern Air Lines installed a Univac File computer in its New York reservations office to handle reservations seat inventory and flight information for a limited number of flights.

A complete 10-day computer inventory was maintained on those flights which operated primarily into and out of New York. Beyond the 10th day the inventory was maintained on punched cards. Each night the "future date" punched cards were summarized and a report was created listing those flights on which bookings exceeded a predetermined limit. These flights were then added to the computer inventory.

In 1960 Eastern Air Lines formed a study group to evaluate a computer system based on a total system concept of an airline reservation system. Delving into the problems of expansion, it became apparent that the Univac File computer was incapable of handling the total reservations system.

The Univac 490 chosen to be at the hub of the new system was able to provide real-time operation 24 hours a day, could be linked to communication devices and could handle future expansion of reservations into the foreseeable future. Transaction time at the remote input/output devices was to be less than one second and dual computers with duplicated mass storage for reliability were to be installed.

In January 1961, a committee was formed to write a reservations system definition to include availability, inventory and flight information. The system was to be completely workable from the user's point of view. The final systems definition was a description of 44 transactions (later expanded to 48 transactions) that could be initiated on an agent set from any remote location. These transactions completely encompassed all phases of availability display, inventory control, flight information update and display and flight capacity adjustments. The new system was activated at Charlotte, N.C., in March 1962.

Eastern Air Lines is among the largest air carriers in the U.S. The airline serves over a hundred cities in the eastern half of the United States and Canada and operates nearly 1,000 flights daily.

Eastern employs 20,000 persons and carries more than 16 million passengers annually.

The new definition prescribed a vast improvement over the File computer which offered only 12 transactions. The definition also required the delivery of computer-produced messages directly into the Teletype system and the production of certain reports for management.

The main function of the system at Charlotte, N.C., is the handling of seat reservations and associated data including seat availability, bookings by leg and segment and flight information such as early or delayed arrivals and departures.

In regard to another application, message switching, Teletype messages originating at Eastern teletype transmitters addressed to other stations are received by the computer at Charlotte concurrently over the 60 or so input lines. The messages are analyzed for format, priority and valid addresses, timed in and out, counted, numbered in and out for each station, retransmitted to the designated addresses and logged in a permanent record.

A number of other applications is performed at the Charlotte data center. Most of these are related to the two major functions of reservations and message switching.

THE SYSTEM

The Reservations System

At Eastern Air Lines' Charlotte data center, one of two Univac 490 computers is active and on duty around the clock while the other is on routine maintenance and standby. A large storage system of 14 Univac FH-880 magnetic drums, having a capacity of more than nine million words of ordinary text, contains duplicated records of reservations and seat inventory for each flight operated for up to 333 days ahead. A particular record for a specific flight and date can be located for interrogation, reference or updating in an average time of 17 milliseconds.

The central computer is directly connected to Eastern's eight regional reservations offices -- Charlotte, New York, Montreal, Chicago, Atlanta, Houston, Tampa and Miami -- and to the centralized offices of Mohawk Air Lines in Syracuse, Allegheny Airlines in Pittsburgh, Ozark Air Lines in Peoria, Ill., and North Central Air Lines in Milwaukee. The connections are all via high speed data communication circuits, branching at each remote location to encompass scores of individual agent sets. The agent set can be used to compose messages to the computer by means of pushbuttons and to receive answers by a system of colored lights. Including the usual "sell," "ask," and "cancel" functions, there are 48 separate transactions that can be initiated by use of the pushbuttons. At present, there are over 900 agent sets active in the reservations system including Eastern and four local service carriers. Close to half a million transactions on a peak day are initiated from the agent sets. Responses are received in an average time of eight-tenths of a second.

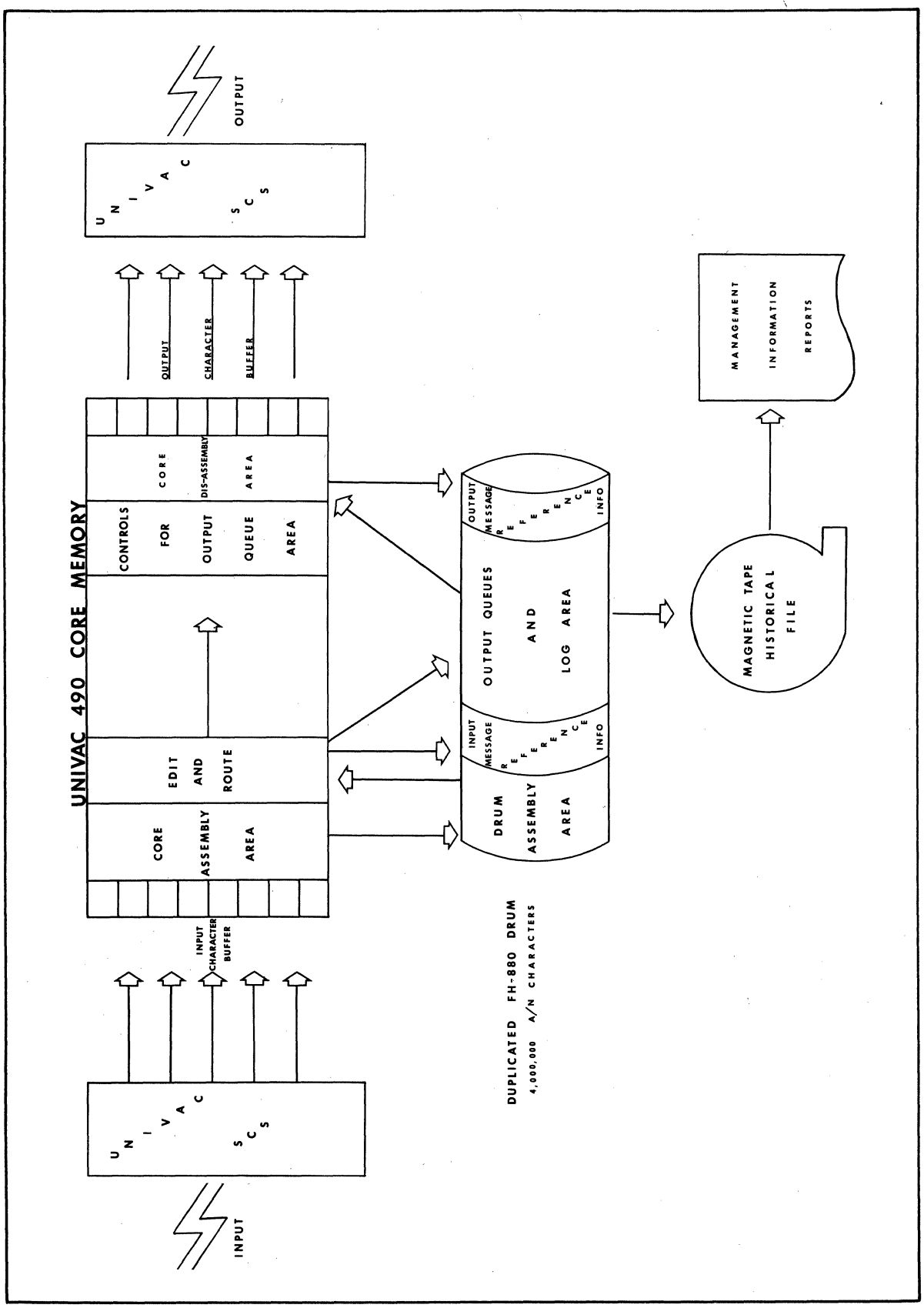
These operations all take place in a real-time mode; each time a transaction affects a stored record, the record is instantly updated. This means that whenever a reference is made to a stored record the information extracted is up-to-date as of that instant. If two transactions require the same record at the same time, one transaction will inhibit further access to the record for a fraction of a second until the updating is completed.

Flight records are kept for each leg and segment of a flight. A flight leg is that portion of a particular flight route from one station to the next. A flight segment is that portion of the route from one station to each succeeding station. Thus, a flight starting at A and serving B, C and D will have three legs -- A-B, B-C and C-D -- but there will be six segments -- A-B, A-C, A-D, B-C, B-D and C-D. A six leg flight will have 21 segments.

All this has a bearing on the size of storage required to maintain an up-to-date flight schedule. Each set of flight records contains, among other things, the flight number, cities served, arrival and departure times, city teletype codes, capacity for each leg and segment, seats sold for each leg and segment, effective and terminating dates and indicators for showing the existence of flight information and time changes through time zones. More than seven and a half million alphanumeric characters of drum storage space is allocated to reservations functions. Any flight record can be accessed in 17 milliseconds.

The agent set used by remote locations to interrogate or update computer records was specifically designed by Univac to fit Eastern's requirements. The set is activated by insertion of a numbered plastic slide indicating to the computer what portion of the indexing system is to be used, followed by depression of pushbuttons for flight, date, number of seats, origin and destination and type of transaction intended. Proper selection of button combinations makes possible a large number of different transaction types that can be performed. Responses to all transactions take the form of colored lights and/or illuminated panels on the agent set.

The computer programs related to processing of agent set transactions are permanently stored in memory and occupy about 8,000 words of the 40K core.



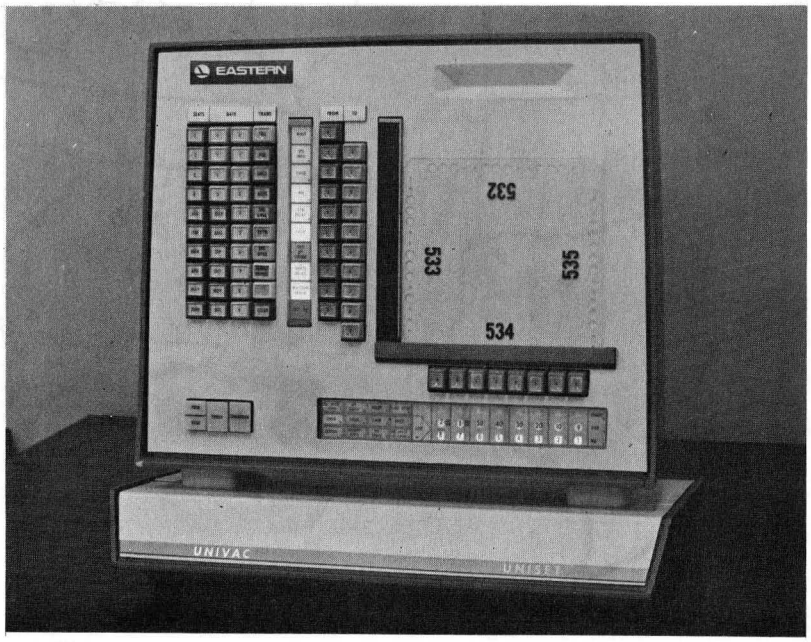
MESSAGE SWITCHING DATA FLOW.

A simplified version of a "sell" transaction is described here in order to show the sequence of events that takes place. The computer accepts an input message from the remote agent set, examines and validates each character for parity to preclude transmission errors and assembles the message in a working area in core. The agent set number is translated and validated; the slide number is translated into a flight index area; the flight and date are recognized; the origin, destination and number of seats are determined; and the type of transaction analyzed.

The appropriate inventory record is transferred from drum to core and further access to that drum record is inhibited temporarily. The record is examined, and, assuming the seats desired are available, that number is added to the segment bookings and a like number subtracted from seats available in the appropriate leg records. If the record is for a current day flight, the record is examined for the existence of flight information and, if any, that special information is extracted from the flight information record in the form of numeric codes, possibly indicating a delay in departure, how many minutes, and the reason for the delay. The inventory record is updated, refiled on the drum replacing the old record, the temporary inhibition is removed and the proper signals to light the appropriate response lights are returned to the inquiring agent set.

If the seats requested on the flight desired are not available, the computer forms a "no space" response, automatically invokes the "ask" routine, examines up to seven other flights on the same slide for the same segment and includes in the response (green or red, yes or no) lights for each of the other flights. The sales agent then knows what alternates to offer without initiating another transaction. The time elapsed between depression of the transaction key and display of the response averages about eight-tenths of a second. Each record is changed, corrected or updated at the time of the transaction, and any reference to stored data will find that data correct as of that instant.

Once each day, during slack night hours, all stored reservations records must be corrected to allow for the new day starting at midnight. The day of the year is changed, all "yesterdays" are deleted, "todays" become "yesterdays," "tomorrows" become "todays" and a new "tomorrow" appears. Slides and schedule controls are deleted if termination date is reached and new slides and



UNIVAC

UNISET

CONSOLE

AGENT SET

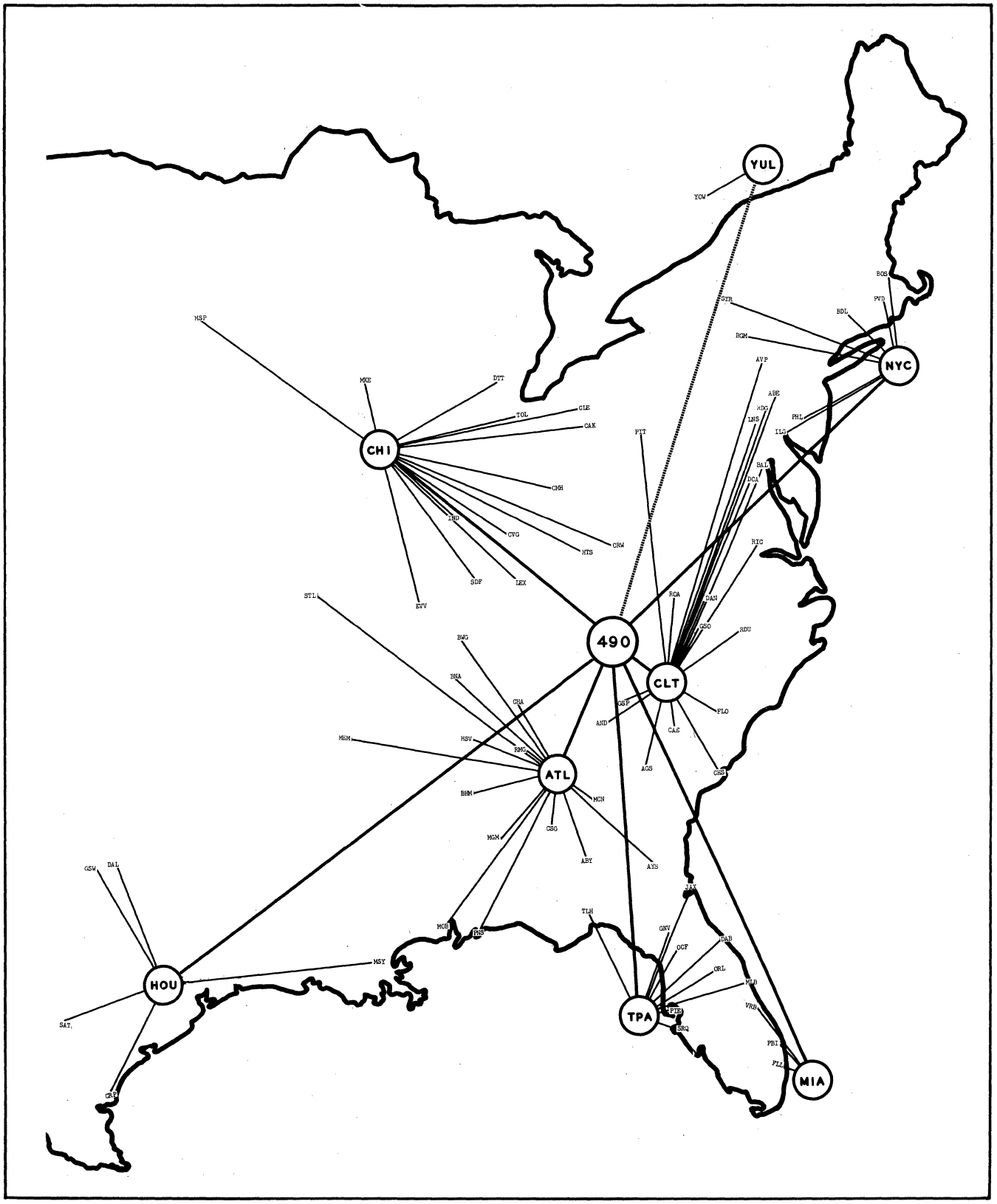
controls activated. One day is deleted from all inventory and flight information records and a new day added at the end. Similar corrections must be made for any special schedule flights. The series of nightly update routines is automatically initiated by the control program.

The system has the ability to process agent set transactions at the rate of 40,000 an hour. This capability can be extended to 100,000 an hour. Each day more than 300,000 transactions are processed. In addition to agent set transactions the computer accepts for action each day about 7,700 Teletype messages and automatically generates and transmits about 15,000.

Message Switching

The message switching system incorporates a separate communications network of nearly 180,000 miles. About 60 input and 70 output lines connect the computer with some 120 Teletype transmitters and 235 receivers. Message switching operates continuously -- concurrently with reservations and other on-line applications.

DISTRIBUTION OF TELETYPE STATIONS IN MESSAGE SWITCHING SYSTEM.



RESERVATIONS SYSTEM.

In the message switching application Teletype messages originating at Eastern Teletype transmitters addressed to other stations are received by the computer at Charlotte concurrently over the 60 or so input lines. The messages are analyzed for format, priority and valid addresses. They are timed in and out, counted, numbered in and out for each station, retransmitted to the designated addresses and logged in a permanent record.

Many messages are multiple addressed so that 70 output lines are used concurrently. Depending upon the length of message and existing traffic load the normal relay time for a message is from one to four minutes.

In the handling of Teletype messages the system takes advantage of program control by interrupt and processor time sharing. In the time that it takes to assemble the pulses to form a single Teletype character the processor might perform a complete agent set transaction. Stated differently, it is entirely possible that during the transmission of a 25-word Teletype message the computer might handle completely 100 different agent set transactions without a delay in any function.

The daily input of Teletype messages is about 55,000 messages; the daily output is about 80,000 messages. In a recent month total Teletype traffic in and out amounted to 3.4 million complete messages.

Control Program

The control program is stored in core and uses about 5,500 words of memory. It is comprised of a group of more or less separate routines, each designed for a specific function but working as a coordinated whole as circumstances require.

The prime function of the control program is to assign the processor work to do in stages on as many as 20, 30 or more jobs at the same time -- concurrently, not simultaneously. Among other functions, the control program performs these tasks:

1. Provides for polling of input lines for work to do.
2. Establishes job queues according to 10 priority groups.
3. Assigns working areas in core memory for each job in which are recorded the contents of registers and the next program step when a program is temporarily interrupted.
4. Controls allocation of peripheral units.
5. Initiates, executes and terminates transfers to and from drum, tape, console, card units, printer or Teletype.
6. Recognizes and analyzes interrupts by peripheral units or communication channels, scans the job queues or interrupts and gives program control to the highest priority job waiting.
7. Monitors the execution time of each program in progress to detect possible program errors.
8. Scans the day clock for scheduling time-initiated routines.
9. Maintains a common memory pool for assignment as required.
10. Delivers messages to the console printer indicating areas of possible developing trouble.
11. Insures the orderly processing of the work load.

As an example of program control, assume an agent set transaction is Job A. Under the control program, at the point where retrieval of the drum record is required, the processor is pulled from Job A and assigned to Job B while the retrieval is in progress. Even though the retrieval might be done in 17 milliseconds or so, the processor could execute possibly 2,000 program steps on Job B instead of waiting. When the record has been transferred, the processor is pulled from Job B, resuming work on Job A where it left off.

In addition to the program scheduling feature, the control program is used to improve efficiency in operation in other ways. There are some 150 to 200 programs of lesser importance than the agent set routines and used less frequently. These include general service and utility routines, file maintenance and nightly update sequences, loading and dump procedures, conversions, tables, program self-analyzers, schedule data preparation routines, etc. These programs, which take up about 60,000 words, are drum-stored and called into core by the control program as needed.

Flight Watch Display

A dispatcher is charged by Federal Air Regulations with "operational control," which means the exercise of authority over initiation, continuation, diversion or termination of a flight. To meet this obligation, a dispatcher needs continuous information regarding the various conditions affecting those flights for which he is responsible. He must receive this information while there is still time to take whatever action is necessary to maintain the operational control. Other departments also have need for much of the same information.

Most of flight watch information is made up of air-to-ground radio contacts serviced by Aeronautical Radio centers in New York, Atlanta, Miami, Chicago and Houston. Prior to installation of Flight Watch Display, the radio operator would type the contact directly on to a Teletype transmitter, sending the message to certain dispatch and ground services offices over exclusive circuitry. However, limitations of the circuitry denied the full dissemination desired. Recipients on the exclusive circuits as a rule had to retransmit the message over the regular system after determining where else it should go. Messages received directly at the proper dispatch office were still not useful until they were removed from the receiver, torn apart, sorted by flight and time, posted by hand on large flight boards and delivered to the dispatcher concerned, often in slow moving batches. When the computerized Flight Watch Display becomes fully operational it will eliminate the former weaknesses of the system and it is expected to achieve the following objectives:

1. A system capable of immediate and automatic delivery of flight watch information from point of entry to a Teletype printer serving the dispatcher involved.

2. A system designed to type out periodically at each dispatcher's position a Recap Report -- a recapitulation of currently useful information about each flight for which he is responsible, arranged in flight number sequence.

3. Computer storing of current flight plan messages whenever desired.

4. Computer calculated estimated times of arrival (ETA), determined by adding the OFF time from a given station to the stored flight plan flying time to the next station. ETAs so established would be available to the dispatcher.

5. Dispatcher ability to obtain, on demand, a printed readout with ETAs of all flights expected to arrive over a specified airport within the next hour.

6. Improved flight information to the customer by providing full dissemination to all ground services offices desired from the single entry.

Implementation of Flight Watch Display has been divided into phases. The first phase encompassed only communications linkage for moving flight watch information. Instead of operating in an exclusive circuit all radio operator positions have been linked directly to the Univac 490 computer at Charlotte, forming a part of the normal Teletype and message switching system. Dispatch offices and ground services offices are part of the same system and no manual relay of messages from circuit to circuit is necessary. Flight watch information is now directed to the computer, is automatically analyzed and is redirected to all the desired recipients. Computer records for flights operating are constructed and updated automatically by Teletype messages.

The second phase of Flight Watch Display produces a periodic recap report on a trial basis for a few dispatch positions. Eventually, all dispatch positions will be equipped with individual receivers using a unique paper take-up reel displaying 21 inches of flight watch information and will be automatically receiving their recap reports every 20 minutes.

Other Applications

There are a number of other applications that are performed at Eastern's Charlotte data center. For example, when a schedule is published, a program automatically matches old flights with the same or similar new flights, transfers the bookings to the new inventory record and produces a printed list of those bookings so that they can be given individual attention.

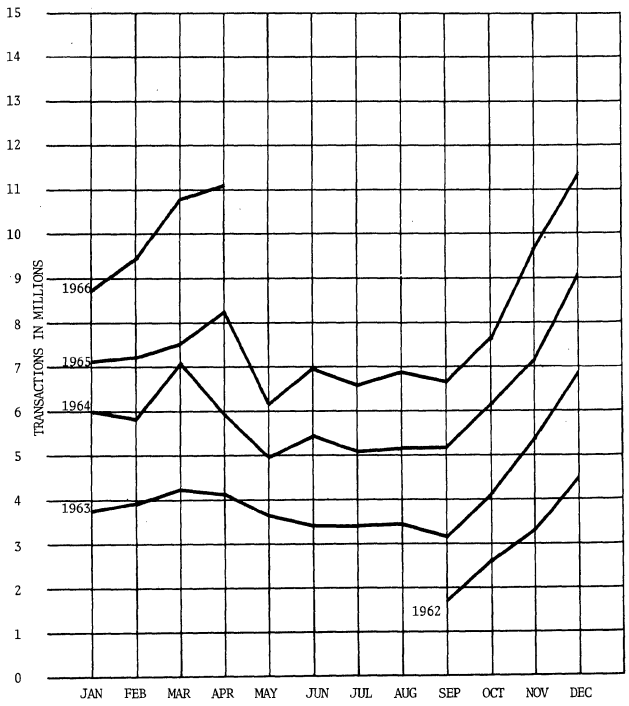
The computer also compiles a sales guide that lists in alphabetical order all the services to other cities including desirable connecting flights along with fares, etc. The guide usually takes about 350 pages, and is produced on the high speed printer.

In addition to full inventory records for Eastern Air Lines, (Lake Central is being added) Mohawk Airlines, Allegheny Airlines, North Central Airlines, and Ozark Airlines, the system also stores space availability records on flights of 14 other airlines. The records are updated directly by the other airlines' computers or Teletype and can be interrogated by any agent set in the system.

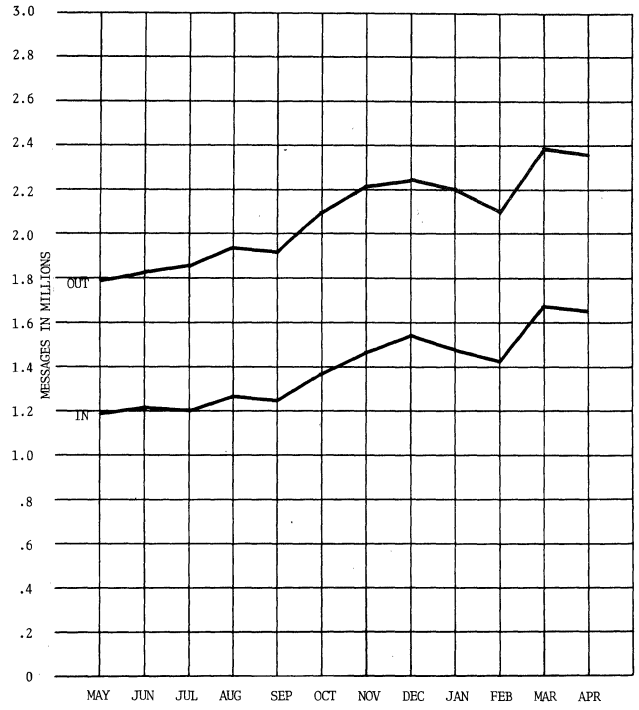
In another application, Eastern arranges for catering services with a number of caterers. As the service is provided for each flight, the caterer's delivery receipt becomes a message and is copied onto Teletype and addressed directly to the computer. The computer accepts the message; edits it for validity; checks it against the proper station, caterer and flight for services authorized; performs a verification as to types and quantities of items supplied, and assembles and files data. If any error is detected, the message is rejected and the station advised automatically by return message that there is an error and in which item. Periodically, the accumulated information is transmitted over high speed communication lines to computers in Miami for further processing.

A consolidated report is produced each Monday for the previous week. This report indicates the catering cost for each flight on a daily and weekly basis, station cost and total catering cost. In addition, the report indicates the number of meals over-ordered, under-ordered and refused. With this information, management can take steps to remedy problems as they develop. Formerly, a period of two to three months would pass before the information would be available; by that time it was generally too late to take effective action.

In addition, these reports are accepted as invoices by Eastern and the caterers. Thus, monthly payments are accomplished in several weeks rather than several months.



TOTAL AGENT SET TRANSACTIONS MONTHLY.



MESSAGE SWITCHING -- NUMBER OF MESSAGES INPUT AND OUTPUT MONTHLY.

Equipment

The Charlotte computer center has at the hub of its operation two Univac 490 real-time computers, each having a memory capacity of 40,000 computer words. For storage purposes there are 14 Univac FH-880 magnetic drums. At remote sites there is a total of 915 Uniset agent sets through which agents can communicate with the computers. A complete equipment list follows:

Major Items at the Central Site

2	Univac 490 Real-Time Computers
14	Univac FH-880 Magnetic Drums
7	Drum Control Units
6	Uniservo II A Tape Units
3	Univac Scanner Selectors
1	Uniset Programer
2	Uniset Console Agent Sets
1	Univac 1004 Card Processor/Reader/Punch

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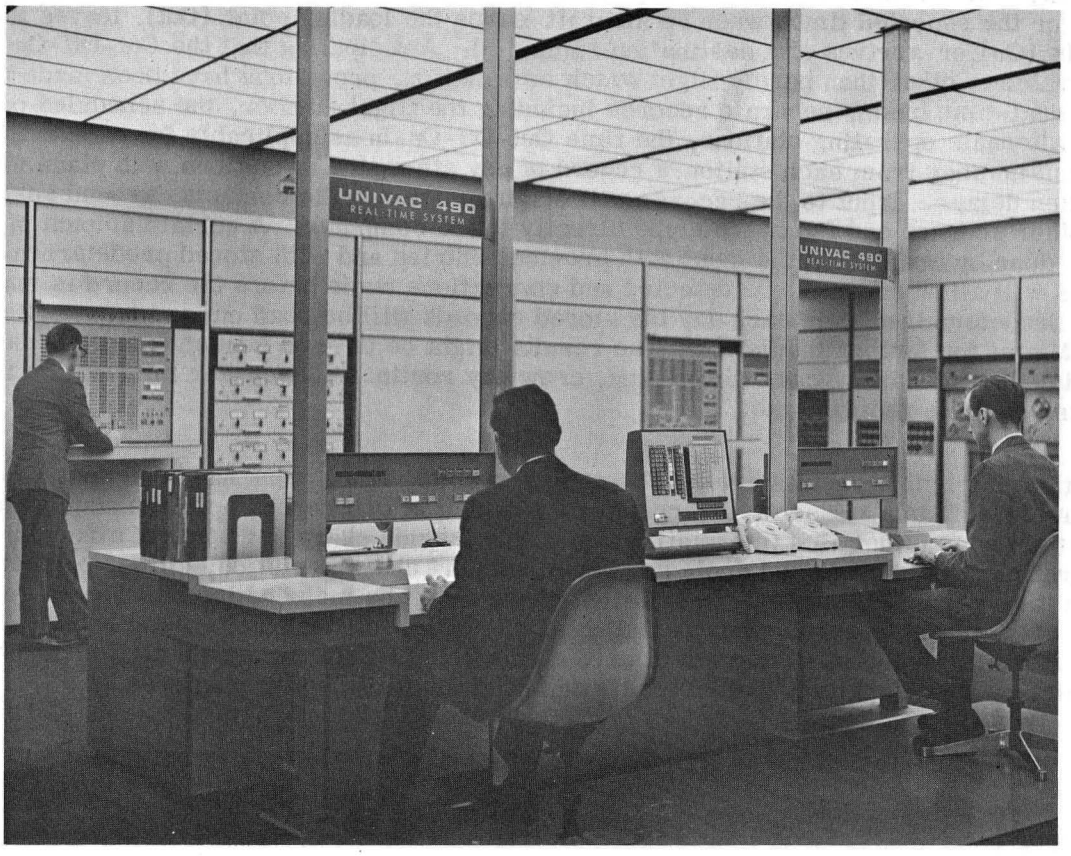
1	IBM Card Punch/Interpreter
1	IBM Transceiver Printing Punch
1	IBM Card Verifier
1	IBM Card Sorter
5	Univac Standard Communication Subsystem/Multiplexers
17 prs.	Communication Line Terminals -- High Speed I/O
15 prs.	Communication Line Terminals -- Medium Speed I/O
71	Communication Line Terminals -- Low Speed Input
86	Communication Line Terminals -- Low Speed Output
2	Communication Line Terminals -- Parallel Input Pairs
1	608 Teletype Monitor Board
1	Teletype ASR Unit
12	Teletype RO Monitors
6	Teletype ROTR Monitors

Major Items at Remote Sites

30	Univac Communication Control Units
6	Univac High Speed Scanners
33	Uniset Scanners
187	Uniset Programers
915	Uniset Console Agent Sets
Approx. 120	Teletype Transmitters, generally keyboard/tape combinations
Approx. 235	Teletype Printer Receiving Units

RESULTS AND FUTURE PLANS

Eastern management considers that its system, which has cost several million dollars in purchases and rentals, has already paid for itself, taking into consideration economies in reservations facilities and the improvements in quality and speed of service to customers. Perhaps more important is that Eastern is doing a volume of work that would have been virtually impossible under the old manual system.



UNIVAC 490 COMPUTER INSTALLATION AT EASTERN AIR LINES.

The Charlotte computer system has been consistently operating productively for more than 99.5 percent of total available time. Even at this rate of efficiency, a near saturation point has been reached in workload. The present Univac 490 computers will be replaced by later Model 494 processors with an increased capacity and six times the operating speed. Shortly thereafter Eastern's portions of the reservations system will be improved, expanded and assigned to a new computer system in Miami. The Charlotte computer system will be the center of a communications and data collection network. Direct communications to the computers at Miami will speed interchange of data for analysis and production of management reports.

In the near future the necessary new equipment will be installed to activate the Touch-Tone input system, this being the final phase of Flight Watch Display. Touch-Tone is a telephone device with numbered pushbuttons instead of a dial and includes a card dialer, or ability to translate a number from a punched card. With the Touch-Tone device a dispatcher will place a call directly to the computer, insert the prepunched card, coded to represent his position and type of information desired, and in a matter of seconds initiate a reply to his own individual printer. He will be able to call for a special recap, a current flight plan message, a tabulation of flights due to arrive at a designated airport in the next hour, or to change a computer-stored position assignment table for combining positions within a dispatch office.

Incorporated into Flight Watch Display is a feature called "OOOI," an abbreviation for Out-Off-On-In or the reported times when an aircraft leaves the loading point (Out), leaves the ground (Off), lands (On) or arrives at a destination ramp (In). Anticipating that the Out-Off-On-In times will be of value in other than purely flight watch information, provisions have been made to accumulate, on a real-time basis, separate records including the flight number, the scheduled operating stations, the alternate operating stations, the time Out-Off-On-In as applicable for each station, the departing plane number from each station, a record of any attempted operations with plane number and coded station delays. Input to the records will originate from radio contacts, ground services, dispatch or other sources and fed by Teletype directly to the computer. A certain amount of data checking will be done by comparing the input with previous entries and with stored predetermined parameters. This will allow errors to be detected and corrections made before the record is made permanent. At a predetermined time each day the stored records will be read out and transmitted to computers in Miami for further tabulation. The results might be used to furnish operating data for aircraft routing, maintenance, crew scheduling, crew pay routines, passenger information reports, delay reports, on-time reports, etc.

Although tangible results are just beginning to show, much work has been done on a program of corporate simulation. Essentially, corporate simulation will depend upon the acquisition and storage of vast amounts of detailed information that might include characteristics of aircraft, composition of the operating fleet, routes and route segments, airport characteristics, cities, population, travel characteristics and market areas. In addition, there might be included information on competition and share of business, revenue sources and volumes, operating cost factors and levels. Ultimately, Eastern's planning department expects to have a complete, fictitious, model airline constructed by the computer on which analysis and forecasts can be made for planning purposes.