SAS aids for the jet age:
Telecommunication for electronic reservations

By A. F. George

Using two different but complementary systems of teleprocessing, "Telepunch" and electronic reservations by remote enquiry, SAS has established an integrated data-processing system for seat reservations covering sales offices throughout the world. An extensive teleprinter network, operated by SAS for many years, formed the foundation upon which these systems were built. In the "Telepunch" system, punched-card techniques are employed. Sales offices report their reservations by teleprinter to a Central Control in Copenhagen where the messages are automatically transcribed into punched cards before being fed to an IBM RAMAC 305 computer holding the aircraft-seat inventory. In the electronic reservations system, a number of interrogator key-sets are installed at various sales offices which communicate via standard teleprinter circuits to a computer, in Central Control, Copenhagen, holding the aircraft-seat availability. Thus the teleprinter circuits carry conventional message traffic, in punched-card format and data exchanged between key-sets and the computer.

Data Collection and Transmission

Before I deal with the central theme which covers our experience with Data Collection and Transmission, it is necessary to give an outline of the Operational problems involved in the control of seat reservations, which the introduction of data-processing techniques has been designed to solve.

You do not have to be connected with the aviation industry to know it is an inescapable fact that mass transportation (however much we may dislike the term) and the speed of aircraft will continue to increase. These two factors combined form the basis for continued expansion at all levels in an airline organization. Among those predominately involved are the Reservations and Communication systems.

To many of you, airline reservations may seem a rather specialized field; however, the principles employed in the system can be easily adapted to other fields where the problem is also essentially one of control, at a central point, of transactions performed by a network of offices spread over a large area.

We have had the joint systems of "Telepunch" and Electronic Reservations by remote inquiry in operation for about four years, and when we were invited by the Programme Committee to present a paper at the Cardiff conference we thought that, perhaps, the experience gained during that time might be of interest to others who contemplate similar systems.

The problem

Let us first take a quick look at the airline reservations control problem itself and the philosophy underlying its solution. Reservations are made at a large number of airline selling offices spread throughout the area over which the airline operates. In the case of SAS we have approximately 180 such offices covering Europe, the Near, Middle and Far East, Australia, Africa, North and South America.

Now the ideal reservations situation exists when each of these offices is able to sell seats on any flights operated by the airline as long as seats are still free on the desired flight.

In ordinary retail business, the normal method is to keep an assortment of goods at each selling store and to let each store in the chain sell from its local stock. Airline seats are, however, a too perishable form of merchandize for such a system. Seats which have not been sold by the time of departure suddenly lose their entire value at the moment the aircraft rolls out from the tarmac. There must, therefore, be *a Central Control at one point* for all seats of a particular flight, and this requires in turn that each selling office, as soon as a sale has been made, reports the seat reservations to the Reservations Control Office. We have thus established a need for communications from each selling office to a central control point, and for a registration and filing process of all reservations at that point. To prevent oversale (i.e. sale of seats by some office after all seats have actually been sold for a particular flight) both the transmission of the reports and the processing of them must be fast and continuous. The answer to this problem is real-time teleprocessing by "Telepunch" and Electronic Remote Inquiry.

Telepunch

In SAS the "Telepunch" system consists of teleprinters at the selling offices, an integrated network of teleprinter circuits, and, at the Central Control (CPH) IBM equipment comprising a tape-to-card machine (047), RAMAC 305 with perforated-tape attachment and remote type-out stations, sorters, collator, tabulator and card-to-tape machines (063).

Basically the function of these components in the system is as follows. The teleprinter at a selling office is connected directly to the telegraph network for the transmission and reception of various messages. Details of each reservation transaction are typed in a standard format, including an address to indicate delivery at

Central Control. Normally, each selling office does not have an exclusive teleprinter line direct to Central Control; instead the reservation message is relayed mechanically by perforated tape through one or more Relay Centres before it finally arrives at its destination.

All major SAS offices throughout the world are linked to the telegraph network. In Europe and North America the teleprinter lines consist of landline voice-frequency telegraph circuits operating at 50 baud. Elsewhere they are normally radio teleprinter circuits at 50 baud or less, most of them error-protected by means of the ARQ system. Except for ARQ on radio circuits there are no error-protection features built into the teleprinter transmission system. The Reservations messages are sent to Control in straight 5-letter code, where they are immediately transcribed into punched cards. The purpose of this transcription is to provide input to the RAMAC and to serve as storage media for Reservations Records.

The RAMAC 305 holds the seat inventory count for all flights under control, and extracts the quantitative information from the punched cards for updating the seat inventory of the flights concerned. When the seat count for a particular flight reaches a pre-set level (indicating flight full) the RAMAC will generate a message addressed to a selected number of selling offices advising that no further seats can be sold on that flight without prior request to Control. When the selling office, for this reason, needs a reply to its reported reservation, before confirming the seat to the customer, the corresponding punched card will carry an appropriate indication causing the RAMAC to generate the reply in the form of a perforated tape which is then transmitted back over the teleprinter network to the selling office concerned.

At a predetermined time before flight departure the RAMAC produces teleprinter messages addressed to the Flight Kitchens en route giving details of the number of meals to be loaded.

The sorters, collator and tabulator are used for maintaining the punched-card file, and for search of individual cards which are to be cancelled as a result of cancellation reports from the selling offices. They are also used for detecting duplicate bookings.

Transcription from punched cards to perforated tape is used on the day of departure to produce, in teleprinter form, lists of the passengers who will board at the various points along the route. Transmission of these lists also takes place over the teleprinter network.

Errors

For the detection of errors caused by the transmission system we have two main checking points in operation, one in the Relay Centres interconnecting the teleprinter network and the other in Central Control where two stages of automatic checking are employed. In the first stage the 047 performing the tape-to-card transcription is programmed to detect errors which cause column displacement. In the second stage the RAMAC 305 makes a complete validity check of the essential items such as flight number—related to—route segment—class—date—, etc.

Most errors caused by the transmission system and detected by the 047 or the RAMAC are of the single-character type in which one or more bits have been reversed. Bursts of errors resulting in several consecutive incorrect characters are normally intercepted in the Relay Centres by circuit monitors, and a repetition of the mutilated message is then requested before it arrives at the 047 position.

In our experience, landlines introduce, as a rule, fewer single-character errors then radio circuits—even if the radio circuits are protected by means of the ARQ System. This is contrary to the general belief that ARQ protected radio circuits are "infallible."

We have also found that careful maintenance and adjustment of the teleprinter equipment is far more important when operating this kind of teleprocessing system than when using the teleprinter network for conventional message traffic. In particular the mechanical tape readers and the reperforators are critical, and are likely to produce single-character errors when the mechanical tolerances are not within the prescribed limits. By analysis of the cards rejected in the 047s and RAMAC we are able to a large extent to determine which errors are attributable to the transmission system and which errors have been caused manually at the origin point.

We also find that where messages are originated and transmitted over an area of good quality landline telegraph circuits, with reasonable teleprinter maintenance, the number of rejected cards caused by transmission errors averages one card in 96 (1·04%), whereas, in an area with differing quality of landline circuits and with several radio circuits the corresponding figure is as high as one card in 45 (2·24%). Taking an average length of the reservations record of some 50 teletype characters, and assuming there was only one wrong bit in each case of detected single-character errors, these statistical figures would indicate a bit error rate for the transmission system in the ratio of 3 : 100,000 and 6 : 100,000 respectively. In actual fact the error rate must be somewhat higher because there are certain elements in the reservations record which are not validity checked at the receiving end (names for example).

Our over-all error rate for the system, including both manual errors at the originating point and those created by the transmission system, amounts to a card rejection of 4·22%.

So much then for teleprocessing by means of what we have called "Telepunch."

Electronic Remote Enquiry System

You will have gathered by now that it is of prime importance in this competitive aviation business, with its attendant narrow cost-ratio margins, to sell all available seats on a flight. Our chances of doing this are vastly improved if we provide all major selling offices with instant reservations status for every flight operated by or in pool with SAS, thereby enabling us to lower the booking "cushion" level which determines when a flight must be closed for selling without request to control. The "cushion" level operates on a percentage of the seat capacity of the aircraft to avoid over-booking.

This requirement for instantaneous seat availability information has been met by the provision of the Electronic Remote Enquiry System, manufactured by S.E.L. of Stuttgart, and which, since the first stage came into operation at Copenhagen during 1958, now extends to cover 90% of our sales throughout Europe.

The system consists of an electronic computer at Central Control, Copenhagen, which maintains all availability information in its memory. The status for each flight-segment is kept up-to-date by control-sets installed at the RAMAC type-out position. (The RAMAC you will remember is holding the seat inventory count.) Interrogator key-sets are placed in the selling offices from where status enquiries are made to the computer. These sets are connected to the computer by ordinary 50 baud telegraph circuits.

An important aspect of any electronic system working over a large area to a central computer is of course the availability of suitable communication facilities at a reasonable price. Our extensive teleprinter network makes it possible to extend the system from Copenhagen to many selling offices in different countries at relatively low cost. Clearly an advantage of the system is the possibility of utilizing existing teleprinter circuits additionally for electronic data-processing.

The flow of data between our London office and the computer in Copenhagen takes place in the following way. The impulses, corresponding to data entered—in on the interrogator key-set, are transmitted in parallel over multi-wire connections to a relay buffer store in the control equipment housed in the same building. In addition to the buffer store, the control equipment consists of two concentrators. These provide for a number of key-sets and associated buffer stores to be connected on a queueing basis to our Hamburg teleprinter circuit, and perform the function of a serializer. That is to say, they convert the parallel impulses stored in the buffer into serial impulses in the form of teleprinter characters. When the data corresponding to the complete enquiry are ready to be transferred, a special switching device interrupts the normal teleprinter traffic in both directions (by stopping the tape transmitters) allowing the teleprinter circuit to be used exclusively for the Remote Enquiry System.

At Key Relay Centres in the SAS teleprinter network, special concentrator equipment is employed which receives data from several leased teleprinter lines serving selling offices in various cities, and re-transmits the data over another telegraph line, used solely for this purpose, to the computer in Copenhagen. Hamburg is one of these Key Centres and apart from London serves Amsterdam, Paris, Frankfurt and Dusseldorf.

When the data are received in Copenhagen, conversion from serial to parallel impulses takes place before they are fed into the input registers of the computer. In the reverse direction (i.e. data from computer) the conversion sequence is the same.

In London we are using six interrogator key-sets with a basic response time (i.e. no queueing) of only 5 seconds to and from Copenhagen.

The degree with which we are able to utilize the London–Hamburg circuit may be appreciated from our practical operating experience where we have found that there is adequate capacity to handle efficiently 1,000 enquiries and the same number of teleprinter messages during normal office hours. The figure of 1,000 enquiries represents 1 hour and 20 minutes in circuit time, or an average of 8 minutes per hour when the circuit is in use exclusively for this form of data transmission.

The system incorporates a number of built-in checking programs. For example, all enquiries must contain a standard number of characters—usually in the two out of five code—so in the event of data arriving distorted due to line transmission trouble, or perhaps as a result of incomplete keying-in on the interrogator-set, a warning light indicating "check and repeat" will be shown. If the keying-in is complete but incorrect (i.e. wrong date—no-op., etc.) another warning lamp is lit indicating "not available." When the computer is out of service a U/S lamp is shown on all sets.

Reliability

A comprehensive test program has recently been conducted at seven of our sales offices and I should like to give you some positive information as to the overall reliability of the error detection features and of the system as a whole.

The test program produced the following interesting results.

	OFFICE	ENQUIRIES MADE	CORRECT ANSWERS	DETECTED ERRORS	UNDETECTED ERRORS
At our	PAR	16,715	16,519	193	3
	GVA	22,229	22,158	68	3
	ROM	14,443	14,232	193	18
	DUS	18,116	18,048	64	4
	STO	20,219	20,175	41	3
	SVG	19,963	19,815	131	17
	MAD	2,569	2,562	7	NIL

From these figures we can of course determine the distorted bit ratio. For every 100,000 bits transmitted, including detected and undetected errors and assuming one bit is distorted per enquiry, the ratio for three of these offices covering a wide area in the system is only 0·2 for Stockholm, 0·3 for Geneva and 1·35 for Rome.

This gives an overall average ratio of 0·6 which is itself somewhat distorted by the Rome figure. Indeed, as you have heard, a number of offices served by good quality landline circuits enjoy a reliability ratio as low as 3 : 1 mil.

It is significant that the distorted bit error rate is substantially less than the error rate for the "Telepunch" system. We can, therefore, deduce that the teleprinter equipment, isolated from the Electronic Remote Enquiry System, is responsible for introducting the additional errors.

At a later stage the electronic system will be further developed to provide our sales offices with the facility of booking seats through the interrogator key-sets to the computer, which will then store the complete seat inventory in its memory—adding and subtracting from the current seat count for each flight as applicable.

To sum up the various aspects discussed into an overall picture, it is apparent that the seat inventory system will eventually be merged with the seat availability system, with one computer processing both types of "message" formats which, at present, are handled by two different computers.

Looking to the future we are confident that with the advent of the supersonic era our organizational capacity to meet the demands of these new air transports will be geared to an even greater "Mach" on the ground.

Experience in the practical use of data transmission

By D. J. Dace

This paper is concerned with the Commercial Union Group's experience with, and the results obtained by, high speed data links between its branches and the computer centre in Exeter.

History

Before 1953 the preparation of renewal notices and accounts had been largely a manual process at the branches. During 1953 a completely integrated punched-card system was introduced to handle all our insurance work. The preparation of punched cards for an organization comprising many branch offices naturally lends itself to the establishment of centralized punching and verification of data, on economic grounds. The source documents were sent to the central units from the branches daily, and the tabulated results of the processing were returned to the branch concerned.

Our first method of data transmission was therefore by post. It was cheap and fairly reliable; the only transmission errors occurred when a branch forgot to reverse the address card in the transparent aperture of the mailing bag and promptly received their mail back again the following morning.

The punched-card system proved very efficient, but with such a system it is inevitable that there is a delay in getting source documents from the branches, punching, verifying, printing and sending the printed documents back to the branch. It was realized the immense speed of a computer would be wasted unless this time was considerably reduced. The only way in which this objective could be achieved was to decentralize data preparation, that is have the data translated at the branch into a medium which could be fed directly into the computer system, and then to ensure that this medium reached the computer in the minimum of time.

Data transmission seemed the answer to the last problem.

Telex

Early in 1959 the G.P.O. were approached on the question of data transmission. At this time telex was the only facility available and so we started thinking how we could best use this to give us practical experience in operation procedures and to discover all we could on the type of errors that this form of data transmission would produce.

The eventual result was to establish a link between our London City Office and our punched-card unit at Croydon. Tape was prepared on the teleprinter keyboard by the branch, verified by a call-over of the hard copy produced against the original source document, and then transmitted to Croydon. At the Unit the tape was fed directly into an I.C.T. 1036 tape-to-card converter, the necessary cards being thus automatically produced.

In this way we took our first step towards achieving our aim of data, decentrally prepared, being transmitted to the machine centre. Results achieved by this experimental link were very encouraging and showed that, over short distances, the use of telex was practical.

High-speed transmission

In 1960 the Company ordered an English Electric K.D.P. 10 computer. This brought to light disadvantages in the use of telex:

(*a*) The Computer was designed to work with seven-channel tape; as telex uses a five-hole code, all paper tape would need conversion, either at input or by program.

(*b*) The low speed of 50 bauds would mean a total theoretical transmission time of some 60 hours per day for our needs.

(*c*) The telex code had no parity bit or other provision for correcting or detecting errors.

By this time several manufacturers were working on high-speed transmission systems, and a survey was taken of all equipments which were available or likely to be available by the time the computer was delivered in January 1962.