Data preparation and transmission in the Royal Air Force integrated supply system

By Wing Commander L. B. Davey, O.B.E., R.A.F.

By means of data transmission over the existing telegraph and radio networks, the supplies for over 200 R.A.F. stations in the U.K. and abroad will be controlled by the R.A.F. Supply Control Centre at Hendon.

An automatic data processing system is planned to be installed, in the R.A.F. Supply Control Centre (S.C.C.) at Hendon, to control centrally all R.A.F. stocks of equipment and their distribution throughout the world, and to accumulate data on which future requirements will be calculated. Records will be maintained for some 750,000 items which may be stocked at up to 200 different locations at home and overseas. About 80,000 input messages relating to demands and stock movements will be processed daily. The average message will contain about 80 characters.

Effective stock control is dependent on up-to-date and accurate records. It was therefore decided that all computer records must be up-dated within 24 hours of each transaction taking place and that priority demands should be processed within one hour. A rapid and accurate means of creating and transmitting data was essential. Advice was sought from the General Post Office and R.A.F. Signals Staff, and it was decided that the existing R.A.F. telegraph and radio network should be used to transmit all data to and from the S.C.C.

Preparation of data for transmission

All R.A.F. stockholding units will have keyboard accounting machines to maintain conventional visible record cards for local stock control and management. The machines are fitted with paper tape punches and, as a by-product of the maintenance of the local records, will punch into paper tape selected data for transmission to the S.C.C.

To reduce to a minimum the risk of errors in the preparation of input data a series of automatic checks, together with the automatic entry of some fixed data, have been built into the keyboard accounting machine operation. The failure of any one of these checks causes the machine either to automatically clear all its registers or lock the keyboard before it either punches or prints. The checks are based on a system of check and proof totals designed to prove thirteen of the sixteen fields of data.

Data transmission in the United Kingdom

Each stockholding unit and depot in the United Kingdom will be equipped with standard G.P.O. auto-transmitters and teleprinters; the depots will also be equipped with modified printing reperforators which will give a fully punched tape without printing. This equipment will be used solely for data transmission. Units will be linked to the S.C.C. by the R.A.F. telegraph automatic switching system, and depots by point-to-point private wires.

When a data tape from the keyboard accounting machine has been prepared, the unit will dial one of two numbers which will give a direct connection through switching centres to either the *routine* or *priority receive* position at the S.C.C. As soon as the connection is made, the unit will transmit its data direct to the S.C.C., where a copy of the tape will be produced on a reperforator. Because there will be a point-to-point connection between the unit and S.C.C., the messages will be transmitted backwards and normal routing instructions will be unnecessary. Tapes received need not therefore be re-wound and the data will be ready for input to the computer.

Outputs from the computer, such as issue orders, advices of issue and other urgent messages will be punched onto five-unit paper tape. These output messages will be transmitted to units and depots by the S.C.C. in a similar way to the incoming traffic. Units will receive the messages on page copy teleprinters, but the depots will receive messages in punched paper tape on reperforators. To identify the addressee for each batch of output messages, the dialling number of the addressee will be punched at the head of each batch in visual plain language form using a 5×5 matrix for each numeral.

The depots will process the punched paper tape outputs, received from the S.C.C., through a document printer. The printer will produce the various types of issue sets and other forms on preprinted stationery; it will also number serially the issue sets and produce a voucher register on a second printer. The printer is mainly controlled by a program tape which contains static data and such control symbols as *carriage returns* and *line feeds*; the content of the output message can therefore be kept to a minimum.

It is considered necessary to have error-detection in transmission. The G.P.O. has developed equipment which will ensure that the undetected error rate should not exceed one character in error in every million characters transmitted. This employs a "round the

loop" system to compare the transmitted signal with the received signal and will stop the transmitter if the two signals are not identical.

Data transmission to and from overseas areas

Data messages to and from overseas areas will be transmitted over the R.A.F. radio network. Overseas units and depots will produce punched paper tape input on keyboard accounting machines but, unlike United Kingdom units, will not be equipped with data communications terminals. The transmission of all data from overseas areas will be undertaken by specialist R.A.F. Signals staff. The data tapes will either be transported physically to the main area communications centres or will be transmitted to them by local Signals sections. The area communications centres will patch a radio circuit direct to the S.C.C. at Hendon and transmit the data messages. The S.C.C. will receive the data on reperforators in much the same way as they receive data from U.K. units. Because of the problems associated with patched radio circuits, the receiving consoles at the S.C.C. will have a facility for monitoring the transmissions on a page copy teleprinter.

Priority messages to and from the S.C.C. will be dealt with as normal plain language administrative signals and not as data messages. The plain language messages received at the S.C.C. will be punched into tape as data input messages on keyboard reperforators and will then be verified.

Punched output messages from the computer will be transmitted from the S.C.C. direct to each overseas area communications centre over a patched radio circuit in a similar way to the incoming traffic. The overseas centres will receive the output messages on page copy teleprinters for local units, and in reperforated tape for re-transmission to remote units.

The radio circuits will be protected for accuracy of transmission by error detection and correction equipment which operates on the Van Duuren system. The undetected error rate using this equipment is not expected to exceed one character in error in every million characters transmitted.

Medium-speed data communications

The volume of data traffic between the S.C.C. and individual units and depots in the United Kingdom will vary from about one hundred to several thousand messages a day. The time required to transmit these messages, using the standard 50-baud telegraph system, will vary from a few minutes to several hours each day. Consideration has therefore been given to the possible future introduction of a medium speed data communications system, operating at speeds of 500 to 800 bauds, for the heavily loaded units and depots. To this end, the R.A.F. Signals staff have been conducting evaluation trials with the various medium speed communications systems which are either currently available or under development. It is, however, unlikely that a satisfactory medium speed system will be available for overseas areas in the foreseeable future.

Summary of discussion

Mr. R. V. Olsen (*Pfizer Ltd.*): In view of the fact that you are receiving input information on a world wide basis between 8 a.m. and 6 p.m. U.K. time, how do you get over the difficulty of "local time," particularly on Eastern stations?

Wing Cdr. Davey: We expect to receive the bulk of our data from units and depots between 8 a.m. and 6 p.m. The whole communications system will, however, be open for the transmission of data throughout the 24 hours of each day. Since all our overseas units are east of the United Kingdom we expect to receive all data from these units in time for processing on the same day as it is transmitted.

Mr. J. F. T. Pritchard (*I.C.I., Slough*): During "normal" hours you are presumably dealing with priority messages.

Wing Cdr. Davey: Priority message tapes will be cleared from the receive reperforators and processed at least once every hour throughout the 24 hours every day. Where necessary the priority process will be operated in parallel with other processes.

Mr. P. Eden (*S.P.D., Ltd.*): Do the depots, etc., ring in, or does the centre ring them? Is there any queuing problem?

Wing Cdr. Davey: Each depot is linked with the S.C.C. by point-to-point private wires; the problem of queuing does not therefore arise. Units are linked through the R.A.F. telegraph automatic switching system to a number of reperforators. When a unit has data to transmit it will dial one number for routine traffic which will give access to any one of the reperforators. If all the reperforators should be engaged the unit will receive a "busy" signal and have to wait a few minutes before attempting to transmit again. We will not be using the normal overflow system, associated with T.A.S.S., for data traffic. We have provided sufficient terminals at the S.C.C. to reduce queuing to a minimum.

Mr. R. M. Paine (*C.E.I.R.* (*U.K.*)): What is the cost of the total data transmission system compared with the cost of the computer? Do they both amount to several hundreds of thousands of pounds?

Wing Cdr. Davey: The cost of the data transmission system is about the same as the cost of the computer system and does amount to several hundreds of thousands of pounds.

Mr. R. M. Paine: Do you have the problem of many small lengths of paper tape at the Hendon, S.C.C., and if so, how do you combine them for input to the computer? Are all the tapes received dealt with by the same computer program?

Wing Cdr. Davey: The receive terminals at the S.C.C., Hendon, have been designed so that transmissions are always received and automatically spooled on the first of a battery of reperforators; only when that one is engaged will the second reperforator be brought into use, and so on down to each perforator in the battery. We should therefore have to deal with very few short lengths of tape. We do not propose to splice tapes; each length of tape will be read in

individually. All the tapes received will be dealt with by the same computer program.

Mr. R. E. Cox (*Ministry of Aviation*): Your internal U.K. transfers from R.A.F. units into the S.C.C. are protected by the "round the loop" error detection system. The transfers from overseas area communications centres into the U.K. radio terminal are protected by the seven-unit error correction system. Are you intending to provide any similar protection of any overseas local tails and of the local tails in the U.K. between the radio terminal and S.C.C.?

Wing Cdr. Davey: All overseas local tails used for data transmission will be protected by error detection and correction equipment. The link between the U.K. radio terminal and the S.C.C. will also be protected.

Mr. I. F. C. Shepherd (*Iraq Petroleum Co. Ltd.*): Is large-scale transmission to the overseas depots expected, e.g. inventory listings at intervals, lists of critical items, etc., and, if so, what method of transmission and print-out will be used?

Wing Cdr. Davey: There will be no large-scale transmission to overseas depots. The only transmissions to these depots will be in relation to issue orders, advices of issue and queries on input. These instructions and advices will be received on page copy teleprinters at the main communications centres and despatched to the depots by road.

Mr. M. J. Calle (*I.B.M. U.K. Ltd.*): The undetected error rate was stated to be 1 in 10^6, and some seven to eight million characters are transmitted each day. Does the speaker consider this satisfactory, and if not what steps does he propose to take to remedy the situation?

Wing Cdr. Davey: No, we are not satisfied with an undetected error rate of 1 in 10^6, but this was the best we could expect from the equipment available when our system was planned. We have built a number of checks into our computer program and these will cause inputs to be rejected if they contain errors. We will consider ourselves fortunate if we receive only seven or eight messages a day containing errors.

Mr. A. J. Cobb (*I.C.I., Reading*): When collecting a series of messages end-to-end on a large reel how do you take care of a fault in the transmission such as occurs when a tape jams in the reader and must be restored?

Wing Cdr. Davey: Each input message contains a beginning and end of message marker and the messages on one reel of tape will be separated by about one quarter inch of tape "run-out". If a tape jams in the reader or transmission stops for any other reason, the operator would pull back the tape to the beginning of the message in which the stoppage occurred and recommence transmission. The computer has been programmed to reject incomplete messages and duplicate messages from the same source.

Mr. D. P. Davis (*British Cellophane*): Why was it considered necessary to keep conventional visible record cards for local stock control produced from keyboard accounting machines? The obtaining of data on punched paper tape as a by-product of an accounting machine function is a slow process compared with direct punching methods. Furthermore, is it really necessary to do this where a system of progressive audit of stores item balances could be controlled by the central computer? One would also think that reference to bin card records would be sufficient for all local requirements, even in an emergency.

Wing Cdr. Davey: There are three main reasons for keeping local visible stock records.

(*a*) Local stock records are required for the Air Ministry system for auditing stores accounts. The audit branch is not prepared to accept a central computer controlled system of audit until some experience of computer operations has been gained.

(*b*) A local record is necessary to enable units to continue operating efficiently in the event of a major breakdown or destruction of the central computer. A history of past consumption is required for the calculation of local stock requirements and for bulk reprovisioning for the R.A.F. as a whole. The units will not have bin record cards; the only record of stock will be that produced on keyboard accounting machines.

(*c*) Our station commanders are responsible for all equipment on their station and it would be unreasonable to give them this responsibility if they did not have some form of record of the stocks they should be holding.

Because all arithmetic functions are carried out automatically and because of the number of checks built into the keyboard accounting machine operation to ensure accuracy, we feel that the use of these machines will produce more accurate data than would be possible by direct punching methods. We are prepared to sacrifice some speed for greater accuracy.

Mr. E. J. Guttridge (*S.T.C. Ltd.*): The message received, after computing, at the outstation is to be printed on a page printer using pre-printed forms. The data tape will carry correct information and incorrect information indicated by cancel signals. How will this unwanted information be eliminated to ensure correct printing on the pre-printed forms?

Wing Cdr. Davey: Computer output messages to units will be received on plain paper on teleprinters and, where necessary, will be manually transcribed to the required forms. Outputs to depots will be received in the form of reperforated tape which will be used to operate a document printer. Most errors that can occur in an output tape would cause only one pre-printed form to be incorrectly printed; all subsequent forms would be correct. Some errors in the tape could, however, cause all subsequent forms to be printed incorrectly. If this type of error occurs the printer would have to be stopped and set up again. Since the forms will be printed off-line we do not expect any undue difficulties.

Mr. W. L. Absalom (*A. E. Reed and Co. Ltd.*): You mentioned that you did not think you would be installing medium speed communication systems for two years—why?

Wing Cdr. Davey: Our evaluation trials of medium speed equipment using the R.A.F. telephone network are not yet complete. Any equipment which meets our requirements will have to be accepted by the G.P.O. for use with automatic exchanges. Time will then be required to obtain financial approval from Treasury and for the normal tendering procedure before an order can be placed. If production time from the date of the order is added, it is unlikely that the equipment could be installed within the next two years.

Mr. G. S. Dorey (*United Glass Co. Ltd.*): As I understand the speaker each local depot will maintain its own stock records and there will be a separate central stock record. As no lists of stocks will be transmitted to and fro, how is it proposed to ensure that the two sets of records remain identical?

Wing Cdr. Davey: Each input message created on the keyboard accounting machine will contain the transacted quantities, the line number on the stock record on which it was posted and the stock balances for the item after the transactions were posted. The inputs will be sorted into item catalogue number, unit number, and transaction number by

the computer before processing. Before accepting an input, the computer will check that the transaction line number is next in sequence to that recorded in the computer record and that the new computed balances after posting the transactions agree with the balances reported. There will thus be a check that balances on the unit record and balances on the computer record are in agreement at the end of every transaction.

Mr. R. E. Cox (*Ministry of Aviation*): For obvious reasons, you have designed your system on the basis of using a five-unit code (ignoring the special use of the seven-unit system on radio circuits for error correction purposes). Have you felt cramped by this; have you felt that it would have been advantageous to you in any way if you could have used a code with a greater number of information bits per character?

Wing Cdr. Davey: We have not felt unduly cramped by using the five-unit code. Only numeric data is transmitted from units and depots. We would have preferred to use our computer code rather than the Telex code, but the cost of modifying the standard G.P.O. equipment we are using was prohibitive.

Mr. J. T. Whittaker (*H.M. Treasury*): It is understood that very large amounts of paper tape will be read in by way of 1,000 characters a second punched paper tape readers. The condition of the paper tape is therefore of prime importance. Paper is prone to stretch or shrinkage under certain atmospheric conditions. Tolerances might be exceeded. Were any steps being taken to ensure that the reperforators were in an air-conditioned area of the building?

Wing Cdr. Davey: This problem has been recognized. To overcome it, arrangements were made for conditioned air to be circulated through each reperforator cabinet by way of trunking from the main air-conditioning plant.

Mr. R. K. Chisham (*I.B.M., U.K. Ltd.*): Has the speaker considered on-line connection of (at least) high priority demands direct to the computer, thus eliminating the reperforators, obtaining faster response, and saving the manpower required for manipulation and transfer of paper tape?

Wing Cdr. Davey: On-line connection to the computer was considered but rejected for the following reasons.

(*a*) At the time our system was planned no equipment capable of receiving data on line was available for demonstration.

(*b*) The use of reperforators is simple and meets our needs.

(*c*) The cost of equipment under development was high.

The views of the Data Transmission Committee

By K. L. Smith

It is argued that only by adopting a systems approach to data transmission can the full value of data transmission in data processing systems be developed. The argument is developed by considering the current trends in data processing systems development and is illustrated by reference to the principal types of data transmission system employed. The factors to be considered in the choice of data transmission systems are also explained and attention is drawn to certain systems problems requiring attention.

In 1825, Sturgeon invented the electro-magnet and so provided the detector needed for Morse's celebrated telegraph system of 1837. This was the forerunner of over a century of development leading to the complex communication and data transmission facilities we have available today.

Spurred on by this competition, Rowland Hill began his famous campaign which led to the introduction of the Penny Post in 1840 which rationalized the scale of charges for postal services, which then became, and still remain, the cheapest form of data transmission available in terms of characters per mile per penny.

In 1823, Charles Babbage started work on his Difference Engine, which he never completed because of financial and technical difficulties and which he finally abandoned in 1842 in favour of the Analytical Engine. This was the forerunner in concept of modern computers, although it was not until 1937 that the availability of suitable components, coupled with the urgent need for such machines, allowed Prof. Aiken at Harvard to build the Automatic Sequence Controlled Calculator (A.S.C.C.) in 1944.

During their intensive development during the last few decades, each of these two major techniques of communications and computation have used similar components, such as the stepping switch and relay, the valve, and more recently, the transistor.

Similarly, they have often interchanged major systems concepts such as switching-circuit logic, sequential networks and logical control. Yet, only in the last few years, have they come together as entities into a single systems concept. The manner in which this union is sometimes admitted though, leaves grave doubts as to whether an effective amalgamation will be achieved. The cause of this possibly stems from a failure to appreciate the effective part which can be played by each in an integrated system.

It is the major purpose of this contribution to discuss the more profitable and valuable use of data transmission in data processing systems and to show how the full potential of such combinations can be realized. The theme will be to show how the systems approach allows the full value and performance of these integrated systems to be properly developed.

Thus, the current trends in data processing systems towards integrated operating systems is considered and it is shown that one of five key factors necessary for the implementation of these operating systems is a com-