The problems of data transmission systems in a general manufacturing data processing installation

By D. G. Russell

The paper discusses the concept and objectives of a Management Reporting System in an automobile manufacturing complex with three main plants separated geographically. The suitability of data for input to the system is determined by its importance to the final reports produced.

Vauxhall has three plants. The main plant at Luton manufactures cars and vans, seven miles distant is the Truck Plant, and at Ellesmere Port is a plant manufacturing major units for vehicles. The Data Processing Department is centralized at Luton reporting to the Comptroller; it has about 110 employees, uses two IBM 1401 systems with eight switchable 729 tape units and three 1405 disc units with a capacity of 60 million digits. An IBM 1620 computer is used for engineering calculations. A further IBM 1401 Tape/Ramac is located in the Parts and Accessories Office at Dunstable, used solely on parts processing. Our two central computers are presently used for a total of 600 hours per month.

Until recently our effort has been directed at application processing—the capturing of data and processing of functional procedures such as Production Schedules, Material Control, Payables, General Ledger, Dealership Reporting, Vehicle Distribution, Warranty and Policy, Manpower Forecasts, Budget Forecasts and Expense Control Reports, etc. Within the limitations of the power and specification of the computer we have integrated as far as possible, but not as much as we would have liked.

By the end of 1963 all applications suitable for computer processing will be implemented. This we regard merely as the preliminary stage of our computer usage—the end of Phase 1.

We feel that the real payoff will come with any successes we may achieve on Phase 2—the definition of a *SYSTEM* of management reporting based on computer processing and collection of data (where necessary) by transmission and other more sophisticated systems than the bicycle and keypunch.

Those of you working in large companies (over 20,000 employees) will know the problems facing our group, groping for basic facts for such an analysis.

Answers must be found to such questions as: What information do we put into our system? From what existing forms is it prepared? Can we reduce costs on these forms? What analysis is required for reports? Are subsequent reports "background" reports or "action" reports? At what level are reports used to generate action? In discussing these questions we feel that few facts are known. A project has been commenced to find these answers. We estimate it will take about ten man years work in a cycle time for completion by December 1963. With these answers we hope more readily to determine what types of data merit mechanical collection by transmission systems and the relationship of report content to management decisions.

We try not to be enamoured of large computers. In our view it is vastly more important to complete a mechanization programme based on small/medium computers than have an incomplete programme based on a large machine. It is into this climate, that our thoughts on *data collection* fit.

Our future plans, therefore, revolve around a company-wide telecommunication installation for data transmission and communication. Passing of input data from an IBM 1440 computer at Ellesmere Port via G.P.O. lines to a 1401 at Luton for processing, output being in magnetic tape for output printing locally at Ellesmere Port's 1440. A review of our reporting system was made in an attempt to classify a management reporting system using transmission where necessary for exception reports. With the latter we have had little success, possibly, we feel, because we have not put sufficient effort into creating a system of reporting, as distinct from a miscellany of reports.

Our plans are based on the principle of "get your feet wet"—learn by experience, but work out your planning in detail to a convenient stopping point. Many of our plans cannot be achieved on our present smallish computer, BUT we will have defined WHAT we are trying to do and determine by experience WHERE we are falling short. We feel that far too much emphasis has been put on hardware and theoretical systems. At some stage the TALK must end and ACTION begin. Here at Vauxhall we (by not acknowledging the impossible) reach for the ultimate theoretical system and very often get a very good practical alternative. We feel that too much attention is given to technical jargon. It is up to the manufacturers to prove that their "black boxes" work. We insist that this is their responsibility. Our basic consideration is what goes INTO the system and the efficiency of what comes OUT.

The following is a summary of the system concept on which we are now working. It is, however, liable to change, as our knowledge and experience grows, and as we can determine on a more factual basis, management's requirements of a system of reporting.

Table 1

System objectives

1. (i) Receipt of material in Stores
   (ii) Movement of material between machining operations
   (iii) Fabrication of major units on the assembly line
   (iv) Movements in and out of Factory Stocks
   (v) Movements in and out of Dealer Stocks
   (vi) Movements in Customer Sales.

2. Such material receipts and movements to be subjected to inspection for quality and quantity to ensure:

   (i) Availability of material
   (ii) Quality of material
   (iii) Efficiency of labour

are organized for optimum efficiency under the period Production Plan. Data collected, to be transmitted for processing to a centralized computer into exception reports received at outstations for local control on a decentralized basis.

3. Specified control reports are:

   (i) Receipts Record by Receiving Stores
   (ii) Quality Control of Bought-Out Parts, by Supplier
   (iii) Labour Control by Production Foreman Group
   (iv) Quality Control of Finished Stock
   (v) Production Reports
   (vi) Material Progress chasing Report
   (vii) Warehouse Shipment Schedule
   (viii) Special Equipment Status Reports
   (ix) Vehicle Availability Report.

4. So to organize the flow of data, that inputs to the control system can be used for further data-processing applications.

System inputs/outputs/and master files

Inputs

(i) Goods Received Notes
(ii) Material Inspection Report
(iii) Scrap and Inspection Dockets
(iv) Inspection Reports—Material
(v) Vehicle Build Card
(vi) Spares Shipment Tags
(vii) Vehicle Build Card and Finishes Report
(viii) Vehicle Release.

Outputs

(i) Material Receiving Report
(ii) Quality Control—Material
(iii) Labour Efficiency Report
(iv) Quality Control—Finished Parts
(v) Production Report
(vi) Material Progress Chasing Schedule
(vii) Warehouse Shipment Schedule
(viii) Special Equipment Status Report
(ix) Vehicle Availability Report.

Master and processing discs/tapes

(i) Part No. Breakdown File
(ii) Part No. Master File
(iii) Total Requirements Schedule
(iv) Labour Times and Cost
(v) Material Cost.

Concept

Over a twenty-four hour period many thousands of data transactions take place in a company. Material is received, inspected, passed or rejected. Invoices are received, payments initiated. Production is scheduled. Products at Dealerships are sold. Material supplies are chased when behind on delivery schedule.

The results of these data transactions are (as regards time) sometimes ineffectually injected into the processing system by keypunching and verifying. Thus the processing system is slow to react and pinpoint areas where problems are germinating.

Data transactions, therefore, require segregation into two main types, classified mainly according to output.

(i) Those inputs requiring immediate processing for exception reports.
(ii) Those inputs for processing into applications from which exception reports are not immediately required.

To produce a fast reacting system, therefore, outstation equipment must have:

(i) Card/paper-tape transmission of static and keyed variable information.
(ii) Where required, the facility to prepare add-listing control tapes.
(iii) On-line connection to a computer for storing data transactions for processing and inquiry.
(iv) Printing-out mechanism for outstation reports on an exception basis and checking of input data.

This conception dictates, therefore, the requirement for transmitting data on an immediate basis direct to a computer, in such a manner that the data input is controlled where necessary. The processing of this data takes place in a central computer and reports are generated to the outstation printer for action, with an outstation inquiry feature for historical and/or master file information.

The principal objectives of the system are set out in Table 1.

Principles for defining input suitability for data collection

The "Total Systems" approach requires, not a job-by-job approach to a computer—but rather the determination of the relationships of all jobs to each other. This entails many programming and systems problems and most D.P. installation managers review the total system in two or three major blocks, as it is virtually impossible for the human mind to envisage a total system. One, if not the major, aim of D.P. is control of the business. This means decision. Decision needs analysis of facts. Analysis means the collation of facts in a Report. The same facts are contained in different reports, thus there must be a system of reporting. If data collection is to have any meaning, it must be related to the reporting system, not merely used as a time saver. Surveys must be made of the data which are collected

to ascertain their relationship to the reports which they generates.

Of the various data collection methods and processing techniques, we have basically four different types of report. It is with the last—Exception Reporting— that data collection is mainly concerned. Thus, the processing technique determines that criteria are set and input information is balanced against these criteria. If the limits are above or below, a print-out of the exceptions is created *at the point of control*, not necessarily at the outstation which initially collected the input.

If this principle is accepted, a Company-wide survey of data input (existing and/or proposed) requires analysis against the reporting system as in Fig. 1.

Detail of input analysis

The survey of input data was designed to show:

(i) Total number of input types (cards)
(ii) Geographical factory location of input types—Factory, Block, Floor, Stanchion Area, etc.
(iii) Volume of input per day by type
(iv) Content of data cards—alpha, numeric, prepunched, etc.
(v) Proposed input for future D.P. applications.

Matching this analysis against our existing report set-up shows the major areas where Data Collection is of possible assistance. These areas are:

(i) Inventory Reports—Tools, Production Material, Spares
(ii) Vehicle Assembling—Factory Production Orders
(iii) Material Receipts—Chasing Schedule
(iv) Quality Control—Material, Parts in Process, Finished Stock
(v) Labour Efficiencies—Productive Labour Efficiencies
(vi) Spares Warehousing—Shipment Schedule Stocks
(vii) Optional Equipment—Status of Special Equipment Usage and Orders
(viii) Production Report—Assembly Line Output
(ix) Vehicle Sales—Availability of Models by Dealer.

A more detailed analysis of the data involved is given in Table 2.

Table 2.—Details of input

(i) *Inventory Reports*

(*a*) *Tools*

40,000 Part No. Master file: 2,500 transactions per day: 23 Tool Cribs and 1 Tool Bond: 3 Plant Locations, 7 miles and 150 miles from Data Processing Division. Outputs to show Ordering Control: Financial Control: Inventory Control: inquiry feature required.

(*b*) *Production Material*

16,000 Bought-out or Fabricated Parts from Raw Material to Finished Assemblies: Outputs of receipts against requirements: Parts peculiar to Models.

(*c*) *Spares*

43,000 Master File, 22,000 line items per day. Outputs of Advice Notes, Invoices, Warehouse Picker Tags, Spares Forecasts, Receipts, Inventory Balances as enquiry.

(ii) *Vehicle Assembly*

1,000 Models per day. Provision of proposed build details from Sales and matching with Orders from Dealer. Outputs of Build Sheets, Production Order, Factory Stock.

(iii) *Material Receipts*

23 Stores: 2,500 Receipts per day: Receiving Log by Stores output of Chasing Schedule.

(iv) *Quality Control*

Inspection Dockets from Stores, Machining, Assembly and Dealers. Output of Supplier ratings and Statistical Report on quality as vehicles are being assembled. Inputs not yet defined.

(v) *Labour Efficiencies*

Productive Groups: input of manufacturing orders as passed Inspection. Output of Machining Schedule progress and Labour efficiencies. 42 Production Control centres as input.

(vi) *Spares Warehousing*

Spares shipped after manufacture in machining areas to Parts Warehouse. Actual against requirements. Chasing Schedule during last production week.

(vii) *Optional Equipment*

Analysis of 250 Special Options derived from Assembly line Broadcast. Outputs of usage against forecast.

(viii) *Production Report*

1,000 Vehicles per day on three assembly lines. Output of Production by Model against target. By-Product of invoicing summary and Receivables Ledger.

(ix) *Vehicle Sales*

Average Dealership Stocks 10–18,000. Advice of Sales and manipulation of Stock at Factory and Dealerships. 22,000 transactions per month. Outputs of Availability and Dealer Stocks, on demand.

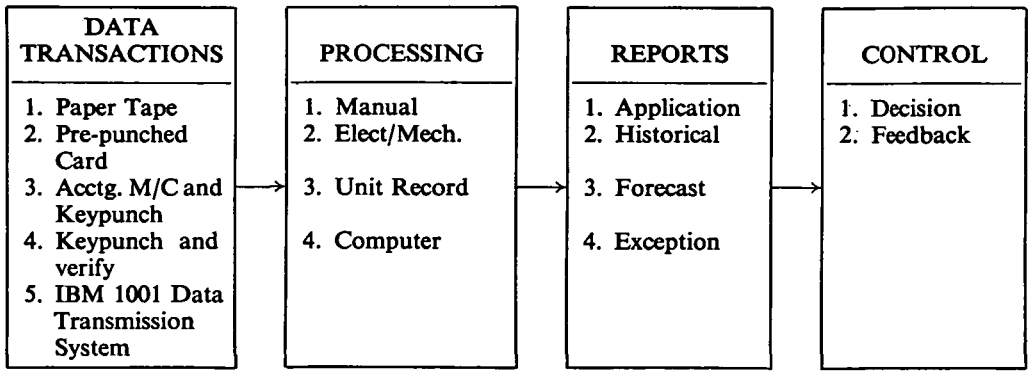

Fig. 1.—Headings for analysis

Summary of discussion

Mr. S. Lucas (*Monotype Corporation*): I would like to thank Mr. Russell for the honesty with which he has dealt with this difficult problem.

Mr. H. Ward (*Consultant*): Looking back, did you put in your computer far too soon?

Mr. Russell: No. Our computers were installed to solve specific problems, such as decreasing time on our conventional tabulating procedures and getting greater processing accuracy. The fact that we have not attained our ultimate system does not detract from the successful introduction of computers into our Company. Further, we feel that the experience on small-scale computers is necessary before advancing into large-scale systems.

Mr. P. Eden (*S.P.D. Ltd.*): What form of transmission is used by the outposts to send data to the centre?

Mr. Russell: Teleprinters will be used and we have started various development projects on 1001 equipment. We have found, however, that many areas which appeared to be theoretically fruitful for data collection and transmission, are in fact barren.

Mr. A. H. Derbyshire (*ICI London*): What is the bandwidth, cost and estimated working speed of the magnetic-tape link between Ellesmere Port and Luton?

Mr. Russell: The cost of the Ellesmere Port project linking that factory with a Luton central processing department will, including leased lines and all equipment, be £24,000 per year. If management reporting is to be effective, such a link is vital, unless of course a more expensive method of locating an additional computer at Ellesmere Port is adopted. As I have already stated I do not feel that data processing people are qualified to pass technical judgments on black boxes and electronic devices. If we require a G.P.O. link connecting various IBM equipments, it is up to these two categorically to state the accuracy, servicing problems and reliability. If in practice, limitations are not met, then action should be taken against the manufacturers. In the computer field, we have got to accept that a reputable manufacturer makes a piece of equipment complying to a certain standard. How it does this is not our concern, we should only be concerned with the fact that it is reliable and efficient to a stated degree. In principle, I feel that data processing people are too enamoured with the technical jargon of how it works, instead of concentrating on making the black boxes produce reports which have some effective use in management control. If we concentrated more on the system and a lot less on technical jargon we would, I am sure, make considerably faster progress.

Mr. J. T. Whittaker (*H.M. Treasury*): Data transmission over land lines is bound to result in errors of input to the A.D.P. system. To what extent is the computer used to correct these by building credibility checks into the programs?

Mr. Russell: Our computer programs have been written to check and edit the validity of the input data as far as is possible. During the first few months of our computer experience we found that many errors were getting into the computer system through inefficient editing. As our experience has grown, however, so we have been able to determine more exactly what data can be edited, printing or punching out such items as necessary for review by the section supplying the input.

Mr. B. S. Wilson (*Esso Petroleum, Fawley*): You mentioned the IBM 1620 for technical calculations. Is this located at Luton? Is it used by Ellesmere Port and Dunstable personnel and, if so, what methods are used for the transmission of data?

Mr. Russell: The 1620 is located at Luton and is used mainly by our Engineering Department; the research section of this Department is located some five miles from the computer. Teleprinters have now been installed to transmit data. We plan to develop this link in an attempt to see if we shall simulate real-time processing on certain physical tests.

Mr. J. A. Kline (*Australia House*): What period is taken up daily in transmission of information over connecting lines? Does the speed of transmission of 50 bauds give a restriction affecting the overall efficiency of the system?

Mr. Russell: At present the teleprinter system is just being installed. Its primary initial use will be communications, with a gradual build-up of data transmission. It is expected that as we have a card-oriented computer our data-collection equipment will tend to use this form of input, rather than paper-tape. It should be stressed that many of the data-

collection systems we are experimenting with require considerable future development in the light of practical experience and as this experience is gained, many of our fundamental ideas will also change.

Mr. C. Harris (*S.C. Johnson Ltd.*): Why are output reports produced "On Demand" rather than at regular times?

Mr. Russell: I have already mentioned the problem of reduction in paperwork. At Vauxhall we regard the printer as one of our basic enemies, only to be used when it is essential. So far, we are just as guilty as most other computer installations of excessive use of stationery.

We are continually searching (so far without very much success) for the answers to the systems problems relating to reports on an exception basis. Reports produced at regular times in our experience tend to be application reports (such as supporting Payroll lists and Invoice lists etc.) Present development is concentrated on producing reports "On Demand" as a result of feed-back of information. These feed-back reports should generate action, whereas regularly produced reports tend to be historical. This, I am sure you will appreciate, is a complete subject in itself and I cannot give you as detailed an answer as I would like.

Use of large computers at a distance

By F. G. Chapman

By means of magnetic-tape data transmission links the Atomic Energy Establishment at Winfrith Heath is able to use the IBM Stretch Computer at Aldermaston and the IBM 7090 at Risley with reduced delays. Small computers are used at each end of the links to edit the data and change tape density. Priority is given to program-testing traffic and a turn around time of four hours is achieved over the link compared with three hours at the computer site. Details are given of operating experience with the link for data, and the special problems which have been faced and solved.

The Atomic Energy Establishment at Winfrith is concerned with the theoretical and experimental development of nuclear power reactors. The ready use of a large amount of time on digital computers is very important to an establishment of this nature because of the complexity of the processes occurring inside a nuclear reactor. Indeed, it has been said that prior to the advent of large-scale digital computers, no really adequate description of the processes inside a nuclear reactor had been obtained.

The requirements for computing fall into two main classes. On the one hand, there is the interpretation of experimental data, curve fitting and statistical analysis, much of which can be done on the Mercury computer which the establishment itself operates.

On the other hand, there is the theoretical prediction of the behaviour of reactor systems, or of particular parts of reactors. This may be done for comparison with the results of experiments, but most frequently is undertaken as part of the assessment of the feasibility of proposed reactor systems. This latter type of problem places great demands on digital computers and though some of them can be done on the Mercury, generally much larger and faster computers are needed.

The Atomic Energy Authority has two larger computers suitable for the calculations which Winfrith wishes to undertake—an IBM 7030 (Stretch) computer at Aldermaston and an IBM 7090 computer at Risley, and has decided that it would install data transmission facilities between Winfrith and the establishments with the large computers.

Historical

Computing started at Winfrith during the summer of 1959. As the Winfrith Mercury was not commissioned until September 1960, use was made of the Mercury at Harwell. In July 1959, a G.P.O. reperforator link was installed between Winfrith and Harwell for the transmission of five-hole paper tape. This operated at five characters/second and together with the ordinary postal service, was used until the Winfrith Mercury was commissioned.

From March 1960 to June 1962, use was also made of an IBM 704 computer at Risley. Traffic for this computer was handled in two ways. Input data for programs was transmitted to Risley by an IBM punched-card transceiver system. This enabled 80-column cards punched in the Hollerith code to be read at the transmitting station and reproduced at the receiving station. By this means cards would be transmitted at the rate of ten cards/minute. Clearly, only a limited amount of traffic could be handled in this manner, and use was also made of a daily air service between Hurn and Ringway airports for the transmission of larger decks of Hollerith cards, for binary cards which cannot be sent over the transceiver, and for printed computer output.

In October 1960, an IBM 7090 was installed at the Atomic Weapons Research Establishment, Aldermaston. A punched-card transceiver system was installed between Winfrith and Aldermaston, together with a Mufax facsimile transceiver for the transmission of operating instructions and for receiving a limited amount of