# Documentation for systems design

*By* P. H. Vince*

The value and limitation of documentation for systems work are first reviewed. The importance of recognizing the goals of the system and the self-contained activities by which these are achieved are stressed. Then documents which present a systems model and a resource usage chart are described, followed by activity and operation charts and supporting documents for these, based on an information matrix format. These are intended to help systems analysis and evaluation before more detailed and familiar forms are used for implementation. This paper was originally presented to the British Computer Society in London in November 1963.

## 1. Purpose of documentation

One characteristic of the establishment of a new field of science or technology is the need to codify accumulated knowledge and to teach it constantly to new entrants to the profession. This is exemplified both recently, as in the case of electronics, and on many previous occasions, such as the work of Linnaeus over two centuries ago. It is therefore highly appropriate that, as the application of digital computers to data processing becomes increasingly widespread, the British Computer Society should organize a conference on documentation for computer systems.

Data systems analysis and design is not an exact science for which universally applicable procedures can be prescribed. Techniques and documents can only be suggestions which each individual will adapt to the particular circumstances he encounters, but without any such guidance he is liable to spend so much of his time planning how to perform his task that the quality of his constructive work may suffer. The approach to this problem which I shall suggest derives of course from my own experience in proposing and installing IBM machines and that of hundreds of my colleagues in IBM, but it is presented as a synthesis of my own from the techniques I have tried and discussed, intended as a basis for thought and discussion, and does not in any sense constitute a standard course of action officially recommended by IBM. No such recommendation exists, because the individuality of each data-processing application is recognized to be paramount.

Documentation should never be presented as in any way constraining the systems analyst's approach. He should feel free to use, adapt or ignore each document suggested, remembering the three purposes they are intended to serve. They firstly facilitate his own work, enabling him to record concisely and comprehensively the data he gathers and the conclusions he reaches. Then they enable him to communicate his ideas and recommendations to other members of the study team, to the staff of the departments whose work he is investigating and, above all, to the management of the organization for which a new system is being proposed. Finally, every successful systems study should lead to

implementation of new equipment and procedures and, although some reconsideration is inevitable because the dynamic nature of business concerns will have imposed new requirements during the evaluation of the proposal, detailed pre-installation planning should grow naturally out of the broad design proposed, and this is possible only if that design is well enough documented to avoid frequent reference back to the original study team.

## 2. Concepts of systems design

The successive stages of development of a new business are study of the requirements and designs of a system which fulfills them, implementation of this system and its operation. Because of the continual change characteristic of a successful business, these stages comprise a recurrent cycle, with the feedback on the operating performance of one new system providing the basis for study and design of the next. In this paper I am concerned with the first stage in this cycle, which covers three phases of systems study:

1. analysis of the present business;
2. determination of systems requirements;
3. design, evaluation and communication of new system alternatives.

The purpose of these studies may be to create a new and more comprehensive system for much of the organization's work, to improve an existing system or to mechanize specific applications. The basic approach will be the same, although it will vary in scope and in the degree of detail necessary in the initial study. In the early phases the procedure will be much the same whatever the application area, and should not be constrained by preconceptions of the machine system to be used, which should be decided objectively in the light of the study.

The analyst first needs a model of the organization, of the form shown in Fig. 1. This displays the functions of the business as the operations which convert inputs from suppliers into outputs sold to customers by using the resources at the firm's disposal—its staff, its plant and equipment, its funds, its inventories of raw materials

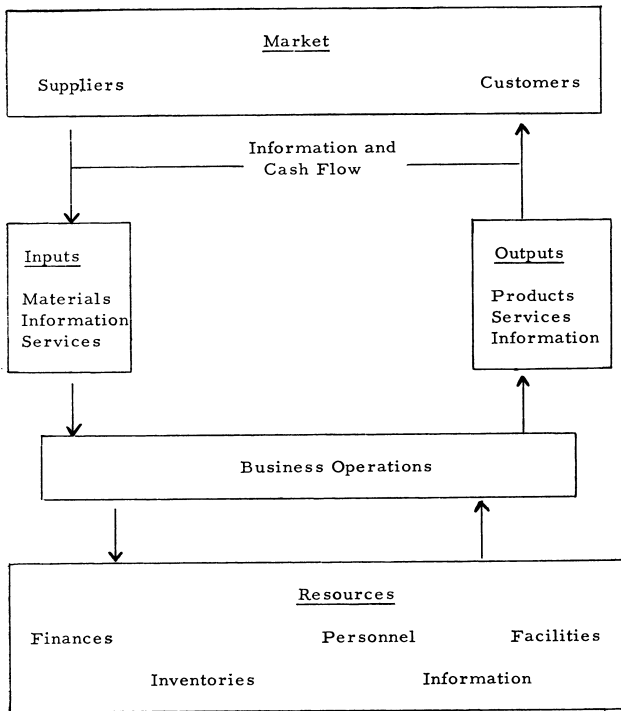* IBM United Kingdom Limited, 56 Newman St., London, W.1

**Fig. 1.—Systems model**



**Fig. 2.—Documents used for systems design**

and work in progress and its files of information. It is important to notice that inputs and outputs are not thought of only as goods but embrace services and information as well. In many instances such as banking, the services are paramount and often the goods are of little use unless information in the form of technical handbooks is also supplied. The computer business is an outstanding example of the need for manufacturers to supply not only goods but engineering maintenance, programming support and publications and formal training to their customers.

The next step to be taken by the systems analyst is to agree with management upon a precise definition of the goals of the business. In a few cases detailed growth rates may have been established for each facet of the business and be suitable, but more often the first statement of objectives will read something like this: "A major objective of this company is to expand sales and profits, which will guarantee a proper return to shareholders and offer continued opportunity to employees." This may do very well as the prelude to the announcement of an increased dividend at a shareholders meeting, but it will not suffice for the systems analyst. In the instance of a precision-engineering firm, careful thought led to the specification of the following goals:

1. To manufacture and sell standard equipment and accessories.
2. To design and manufacture other equipment to individual order.
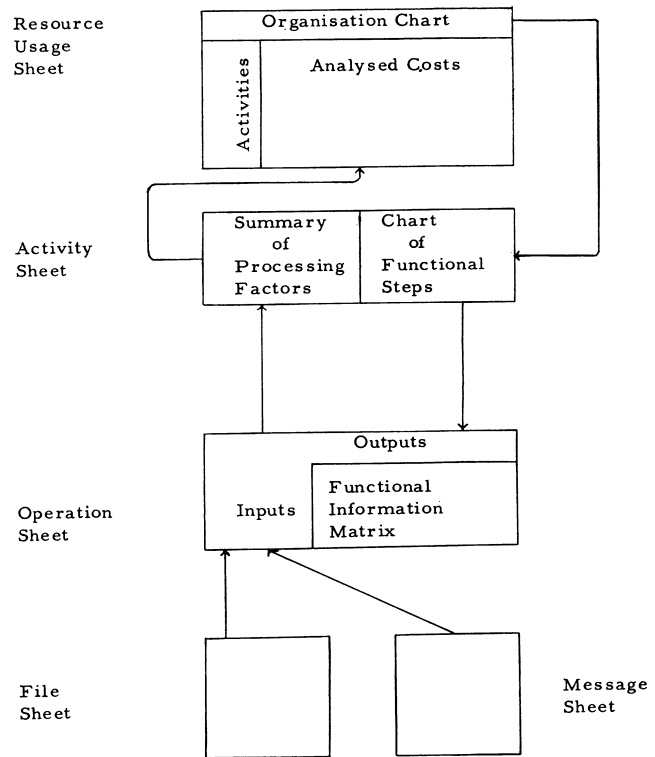3. To offer engineering services and consultation on a fee-paying basis.

4. To manufacture spare parts and components for sale to the trade.
5. To repair and maintain installed equipment.
6. To carry out research and to develop new products.
7. To compensate employees and suppliers for services and provide a satisfactory return to investors.
8. To demonstrate a competence and quality superior to that of any competition.

## 3. Activity structure of a system

Once the goals of the business have been precisely defined in this way it is possible to formulate the activities which enable them to be achieved. Activities are defined as self-contained series of operations directed towards the fulfilment of these goals. They will not necessarily be related to the existing structure of the organization or to currently mechanized applications. This often makes it quite difficult to recognize them, and the subject of activity formulation is a very intricate one which needs a separate treatment. However, it may be more practicable in some cases to observe the processes or operations which at present occur and infer how these should be grouped into activities. Operations are defined in this context as related acts of processes which use resources to convert inputs to outputs when initiated by triggers. In any case, it is unlikely that all the activities will be distinctly recognized directly. Two or three will probably be selected for fuller study, during which these and the others are likely to be defined more clearly.

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**Resource Usage Sheet**
**IBM**

Study __Butopale Electronics__
Analyst __R. L. Casey__
Date __1 March 1961__
NOTES:

ORGANIZATION CHART

NOTES

1. ORGANIZATION CHART DOES NOT INCLUDE COMPUTER CENTERS OR FOREIGN OPERATIONS, A TOTAL OF 97 PERSONS.

Fig. 3.—Resource usage sheet

Fig. 4.—Activity chart (right sheet)



| | Progressive Outputs | | | | File Output |
| --- | --- | --- | --- | --- | --- |
| | Bid Sheet | Bid Cost | Bid Profit | Lay-out Sheet | Quote Folder |
| **Active Input** | | | | | |
| Request for Quotation | T | I | | I | T |
| **Passive Input** | | | | | |
| Quantity Required | T | C | C | | T |
| Quote Folder | U | U | | U | T |
| **File Input** | | | | | |
| Identification Card | T | | | | |
| Price Catalogue | | C | C | | |

**Fig. 5.—Functional information matrix**
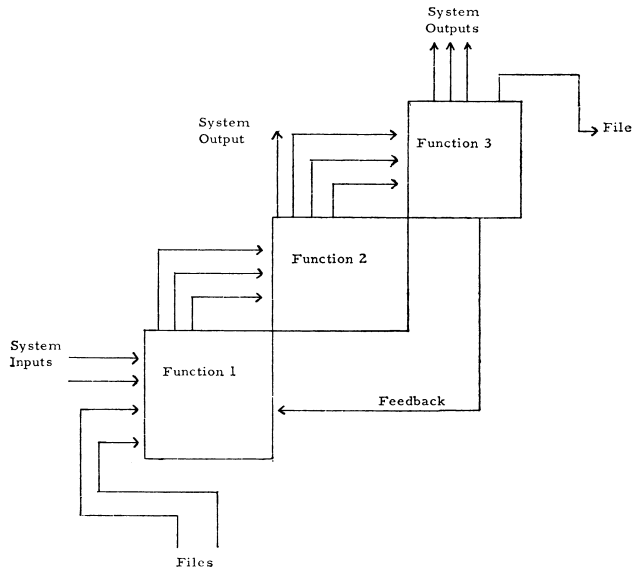
The significance of these definitions will become clearer when the documents used are explained. Fig. 2 shows what they are and how they relate to each other. The resource usage sheet shows how the costs of the business are distributed. To relate these costs to activities rather than to departments, activity sheets are prepared to show diagrammatically and numerically each function to which the resources are devoted. Then each step in each activity is described by an operation sheet, and these are supported where necessary by file sheets, which describe the informational resources contained in the files used, and by message sheets, which describe the input data and the results of the operations. Use of these documents will generally help the analyst, in gathering data from records and in interviewing to ascertain not merely the ledger costs but those of whole activities, not only the time for each process but that which elapses during each cycle, and not just the occurrence of events but their flow.

Fig. 3 shows how a resource usage sheet is prepared. First an organization chart is prepared, with a column for each department for which separate financial information is available and useful. This will generally be for a recent complete year but can be a budget forecast, provided this is used consistently, if the development of the business is at such a rate that analyses of the past would be misleading. For each department the cost of personnel, equipment, materials and each other major item of expense is tabulated. At this stage that is as far as the sheet is filled in, but we shall refer to it again in order to use it when each activity has been formulated and studied.

Fig. 4 shows the structure of an activity chart. This illustrates the interrelation of the successive functions or operations within an activity. In the example I previously used of a precision-engineering firm one activity would be the production of equipment to individual order, and the successive functions might be: request quotation, prepare quotation documents, design product, cost product, prepare and transmit quotation. Each function is a "step" in the chart, and they are linked by the intermediate outputs which are inputs to the next function. The format enables one to indicate the inputs which are files within the system. Provision is also made for showing feedbacks. A limited amount of alternative routing can be displayed, but the objective is to emphasize the main flow of operations within the activity. For reliable systems selection, let alone successful pre-installation planning, it is essential to consider all significant exceptional procedures, which dictate the capacity of the equipment required and give rise to most of the programming effort, and for this purpose flow charts or decision tables should be used to show the logical decisions to be taken and the alternative paths to be followed. However, producing a flow-chart early in a system study can often obscure the main features of the activity, so an activity chart of the sort described should often prove helpful in the first instance.

## 4. Functional information matrices

Each "step" in the activity chart is a functional information matrix, illustrated in Fig. 5. This shows graphically for each operation the interaction between its inputs and outputs. First it shows the active input or trigger which causes the operation to begin. This may be the arrival of a particular message or the coincidence of two related messages. I use the word "message" to describe anything entering the system from the environment or from the system's resources and, as an example of the second type of trigger, could quote the arrival of a customer in a shop and the availability of a shop assistant to serve the customer as two related "messages" needed to trigger the operation concerned there. However, the

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| Rate: Vol/Day | | 100 | 900 | 400 |
|---|---|---|---|---|
| Functional Time:Minutes | | 10 | 3 | 15 |
| | Output Name | Back Order | Invoice | Dues in Cleared |
| Rate Vol/Day | Non-functional Time:Minutes | Input Name | | |
| 1000 | 15 | Issue | X | X | |
| 425 | 2 | Receipt | | | X |
| No. of entries | Maintenance Rate:Daily | Resource Name | | |
| 12000 | 380 | Stores | X | X | X |
| 1150 | 560 | Dues Out | X | | |

**Fig. 6.—Annotated functional information matrix**

trigger need not be a physical entity. It could be, in any batch-processing operation, the accumulation of a prespecified quantity of some input or the occurrence of a particular time of the day or week.

Each item of passive or consequential input is also allocated a row of the matrix; it may be either a message from the environment or a file within the system. Each column of the matrix is assigned to a particular output, either one which progresses to a subsequent matrix or loops back to a previous one or returns to a file. Thus there is a unique position in the matrix which corresponds both to a particular input and a particular output. This

**IBM**      **File Sheet**

| FILE NAME | | | | FILE NO. | | |
|---|---|---|---|---|---|---|
| LINE ITEM FILE | | | | F 3404.1 | | |
| LOCATION | | STORAGE MEDIUM | | | | |
| TAB ROOM | | IBM CARD TUB FILE | | | | |
| ACCESS REQUIREMENTS | | | | | | |
| DATA FOR ORDER MUST BE AVAILABLE WITHIN 2 MINUTES. | | | | | | |
| SEQUENCED BY | | | | | | |
| STOCKROOM LOCATION WITHIN CUSTOMER NUMBER | | | | | | |
| CONTENT QUALIFICATIONS | | | | | | |
| NAME AND ADDRESS CARDS AND LINE ITEM CARDS FOR PICKING | | | | | | |
| TICKETS IN PROCESS OR BACK-ORDERED. | | | | | | |
| HOW CURRENT | | | | | | |
| 1 TO 5 HOURS OLD WHEN ENTERED. REMAIN IN FILE UNTIL | | | | | | |
| STOCKROOM HAS ATTEMPTED TO FILL PICKING TICKET. | | | | | | |
| RETENTION CHARACTERISTICS | | | | | | |
| DATA NORMALLY REMOVED UPON RECEIPT OF PICKING TICKET. | | | | | | |
| SPECIAL PURGE RUN ONCE EVERY 2 WEEKS. | | | | | | |
| LABELS | | | | | | |
| REMARKS | | | | | | |

| SEQUENCE NO | MESSAGE NAME | VOLUME | | CHARACTERS PER MESSAGE | CHARACTERS PER FILE | |
|---|---|---|---|---|---|---|
| | | AVE | PEAK | | AVE. | PEAK |
| 01 | CUSTOMER NAME CARD | 320 | 400 | 61 | 19,520 | 24,400 |
| 02 | CUSTOMER ADDRESS CARDS | 640 | 800 | 65 | 41,600 | 52,000 |
| 03 | LINE ITEM CARDS | 2250 | 2800 | 52 | 117,000 | 145,600 |
| | TOTALS | 3210 | 4000 | 178 | 178,120 | 222,000 |

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**Fig. 7.—File sheet**

**IBM**      **Message Sheet**

| MESSAGE NAME | | MESSAGE NO. | |
|---|---|---|---|
| LINE ITEM CARD | | R 3008 | |
| OTHER NAMES USED | | LAYOUT NO | |
| PARTS CARD | | 02 | |
| | | FORM NO | |
| | | D 17130 | |
| | | NO. OF COPIES | |
| | | 1 | |
| MEDIA | HOW PREPARED | | |
| IBM CARD | KEYPUNCHED — FROM MASTER ITEM CARD① | | |
| OPERATIONS INVOLVED IN | | | |
| 030-001, 030-007, 030-010, 030-017, 030-020, 030-021, | | | |
| AND ACCOUNTING DISTRIBUTION | | | |
| AND STOCK ANALYSIS | | | |
| REMARKS | | | |
| ① ORIGINALLY PREPARED FROM MASTER ITEM CARD (OPERATION 030-001). | | | |
| LATER ENTRIES ARE KEYPUNCHED OR CALCULATED. | | | |

| NO. | DATA NAME | FREQUENCY | CHARACTERS | A/N | ORIGIN |
|---|---|---|---|---|---|
| 01 | ITEM NUMBER | 1 | 6 | N | 030-001 |
| 02 | ITEM NAME | 1 | 10 | AN | 030-001 |
| 03 | DEPARTMENT CODE | 1 | 1 | AN | 030-001 |
| 04 | COMMODITY CODE | 1 | 1 | AN | 030-001 |
| 05 | UNIT OF MEASURE | 1 | 2 | A | 030-001 |
| 06 | QUANTITY ORDERED | 1 | 5 | N | 030-001 |
| 07 | QUANTITY FILLED | 20 | 5 | N | 030-007 |
| 08 | QUANTITY BACK ORDERED | 20 | 5 | N | 030-007 |
| 09 | UNIT COST | 1 | 5 | N | 030-001 |
| 10 | TOTAL COST | 1 | 6 | N | 030-010 |
| 11 | UNIT GROSS MARGIN | 1 | 4 | N | 030-001 |
| 12 | TOTAL GROSS MARGIN | 1 | 5 | N | 030-010 |
| 13 | UNIT SELLING PRICE | 1 | 5 | N | 030-001 |
| 14 | TOTAL SELLING PRICE | 1 | 6 | N | 030-010 |
| 15 | CUSTOMER NO. | 1 | 4 | N | 030-001 |

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**Fig. 8.—Message sheet**

can be used to show simply whether or not any relationship exists, or to contain a short narrative description of any process relating the input to the output or, as in Fig. 5, be coded to indicate what sort of relationship (if any) exists. In this example I have used C to mean compute, I to mean indicate, T to mean transcribe and U to mean update. Thus, looking again at the precision-engineering firm's functions, there is one which occurs at random, being triggered by a request for a quotation. This indicates the need to produce bid cost and layout sheet, while the request data are transcribed on to the bid sheet and into the quote folder. Reading down one of the columns, for example, we see that a request for quotation indicates the need to prepare a bid cost, which is then computed by reference to the quantity required and to the price catalogue, and used to update the quote folder.

Fig. 6 shows how these matrices can be used to summarize the salient characteristics of the inputs and outputs. This is a greatly simplified case of an operation in a stores application, and the matrix itself is used only to show whether or not there is any connection between respective inputs and outputs. The margins of the matrix are used to show the daily volume of each input and its non-functional time, i.e. the time which elapses between the previous process involved (some form of data transmission, for example) and entry to the present

**FUNCTION: QUOTATIONS**
**INPUTS: 2000, 2010**

| KEYS | AVG | PEAK | NOTE |
|---|---|---|---|
| 1-2 | 1H | 1D | |
| 3-4 | 2H | 6D | 1200 |
| 4-6 | 1D | 2D | |
| 7-8 | 1H | 4H | |
| 8-11 | 1D | 6D | 1200 |
| 12-13 | 2D | 5D | |
| 13-14 | 1D | 2D | |
| 14-15 | 1D | 2D | |
| 15-16 | 12D | 30D | 1210 |
| 16-17 | 3D | 10D | 1200 |
| 17-18 | 2D | 5D | |
| 20-23 | 2D | 5D | |
| 7-11 | 2D | 5D | |
| 14-16 | 14D | 30D | |

**FUNCTION: ORDERS**
**INPUTS: 2020**

| KEYS | AVG | PEAK | NOTE |
|---|---|---|---|
| 25-28 | 4D | 10D | |
| 28-29 | 2D | 4D | |
| 29-31 | 1D | 3D | |
| 25-31 | 7D | 20D | 1220 |

**INPUTS**

| KEY | NAME | SOURCE | AVG VOLUME | PEAK VOLUME | NOTE |
|---|---|---|---|---|---|
| 2000 | QUOTE REQUEST | CUST | 50/w | 70/w | 1020 |
| | FREQUENCY | | 46 w/yr | 4 w/yr | 1030 |
| 2010 | BID REQUEST | CUST | 10/w | 12/w | |
| | FREQUENCY | | 42 w/yr | 10 w/yr | 1040 |
| 2020 | ORDER | CUST | 16/w | 20/w | 1030 |
| | FREQUENCY | | 44 w/yr | 6 w/yr | |

**OUTPUTS**

| KEY | NAME | DEST | AVG VOLUME | PEAK VOLUME | NOTE |
|---|---|---|---|---|---|
| 3000 | QUOTATN | CUST | 15/w | 20/w | 1030 |
| | FREQUENCY | | 40 w/yr | 10 w/yr | |
| 3010 | ACKNOW | CUST | 16/w | — | 1050 |

**FILE USAGE**

| KEY | NAME | MSGS AVG | MSGS PEAK | ACCESS | USAGE TIME | NOTE |
|---|---|---|---|---|---|---|
| 4000 | PRICING | 240K | 300K | RANDM | 8H/D | 1100 |
| 4010 | COST | 1000K | — | RANDM | — | 1110 |
| 4020 | RATE | 2500 | 2800 | RANDM | 8H/D | |
| 4030 | INSTALLED SYSTEMS | 400K | — | RANDM | 4H/D | 1120 |
| 4050 | CONTRACT REGISTER | 1500 | 2100 | SEQ | 8H/D | 1130 |
| 4060 | CUSTOMER INDEX | 4000 | 5500 | SEQ | 2H/D | |
| 4070 | PROJECT INDEX | 1500 | 2100 | SEQ | 1H/D | |
| 4080 | ASSIGN'T SHEET | 20 | 80 | RANDM | 10H/D | 1140 |

**Fig. 9.—Activity chart (left sheet)**

operation. For each file the number of entries and the daily activity rate are given and for each output the daily rate and the functional time.

In many cases much more detailed information is needed about the files and messages used in the activity. Moreover, many of these may feed into several different operations and even be used in different activities. In these cases it is valuable to have documents for recording their characteristics comprehensively. Fig. 7 shows a file sheet on which can be recorded the file name and serial number, its location, the storage medium used, the labels which identify it, access requirements, sequence, currency of its contents and their retention characteristics and anything else of importance, together with a list of the messages which constitute it, their average and peak volumes and lengths. Fig. 8 shows a message sheet, which can be used to record the name, form no., number of copies, medium and method of preparation, and to list the operations in which it is involved and the names, frequencies, origins and number and type of characters of each field in the message.

## 5. Review of documentation

I stressed previously the extent to which these documents are used, and the way in which they are used must be at the discretion of the systems analyst. I have described one method, working from the general to the particular, but another frequently adopted is to examine all the output currently produced from the system, determine which of it is needed to achieve the stated goals, and then work back to examine the inputs and the processes necessary and group the latter into operations and activities. In any case, after going into as much detail as is appropriate, it will be necessary to summarize the salient characteristics of operations, files and messages in order to evaluate the activities. For this purpose the activity chart which has a "staircase" of matrices on the right provides on the left for tabular information to be entered. Fig. 9 illustrates how this might be done for some of the operations in the activity of precision engineering to order previously discussed. I shall not attempt to describe the entries in this diagram in detail

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as I think more consideration must be given to improving the layout of this particular document. However, it will give some idea of the factors to take into account.

With information about each activity consolidated, it is possible to turn again to the resource usage sheet, illustrated in Fig. 3. Now a realistic assessment can be made of how the functions in each activity are distributed between departments, and so of how the costs in each department are allocated between activities. These costs can then be entered and used to show which facets of the organization can most profitably be redesigned, and where the boundaries between the system and the environment will not be too artificial. This has great value in clarifying which applications can most profitably be carried out using a new system with the minimum of repercussions on undeveloped areas of the business, and for indicating short-term improvements which may give better information at reduced cost before any new equipment is introduced.

These systems-study documents that I have described will, it is hoped, facilitate the evaluation of alternative systems and the design of the selected one, and guide the pre-installation work. As systems design proceeds, they must be supplemented by flow-charting, tabular presentation of logic, and extensive reference to check lists. Much thought is being given to codifying the whole process of systems study, and many other procedures and documents have been and are likely to be suggested. All this work tends to formalize the training of systems analysts which too often in the past has been a rather haphazard process. However, we have a long way to go both in the elaboration of techniques and in the accumulation of an extensive body of case studies before we can regard systemology as an established profession in the proper sense of that word. I hope that the British Computer Society and its members will continue to work towards this objective.

## Acknowledgement

## References

Fuller particulars of some of the documentation techniques described in this paper will be found in the following IBM manuals:
Study Organization Plan Documentation Techniques Reference Manual (C 20–8075).
Basic System Study Guide (F 20–8150).

# Authorization and control of input in the Royal Army Pay Corps Computer Centre application

*By* Major A. Taylor-Smith, RAPC.\*

This paper, read to the British Computer Society in London in November 1963, relates to the Royal Army Pay Corps Computer Centre, which was described by Lt.-Col. D. W. Moore and Major W. S. Caskey in the *Computer Journal*, Vol. 5, No. 4, and should be read in conjunction with those earlier papers.

## Introduction

The accounts of all British soldiers stationed in Western Europe are maintained in magnetic-tape form at the Royal Army Pay Corps Computer Centre, Worthy Down. Eventually the accounts of all soldiers, wherever they may be stationed in the world, will be maintained by the Computer Centre.

Input to the Royal Army Pay Corps Computer Centre is by punched cards. The cards are prepared by regimental pay offices in the United Kingdom, from information received from the soldiers' units, dependants and other sources. The information is checked, coded and converted into suitable punched cards for processing by the system.

A diagrammatic layout of the Royal Army Pay Corps computer system is shown at Fig. 1.

The method of control adopted in the Royal Army Pay Corps application is designed to cover the following three aspects:

(*a*) To safeguard the system from unintentional error and to prevent fraud.

(*b*) To control the work flow.

(*c*) To facilitate audit.

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