INFORMATION RESOURCES FOR TOMORROW'S ENGINEERS

BY

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Tomorrow's engineers may be doing their work quite differently and may even have functions significantly different from today's engineers, partly because of the existence of new methods of handling information.

Engineers will continue to serve the basic functions they do today. They will continue to conceive, design, build, install and operate machines whose purpose is to improve man's productivity and to extend his physical and mental horizons. But in carrying out those basic functions tomorrow's engineers will assume some new responsibilities, and they will give up some responsibilities that they have now. Their daily work habits may be considerably different from today's.

Reponsibilities: Plus and Minus

The new responsbilities will lie in the directions of greater innovation and overall systems planning and design. The responsibilities they will give up will lie in the manual processes of drawing lines, doing arithmetic, and carrying bundles of paper from one place to another. To put it simply, the profession of engineering has the opportunity to upgrade itself by putting new information-processing technology to work for engineers. If we fail to grasp this opportunity, because of tradition and job security, and if we try to compete with the new machines, we will suffer the fate implied in Norbert Wiener's statement: 'He who competes with a machine is himself a machine'.

By judicious and alert adoption of new machining processes to upgrade the conduct of engineering work, the engineering profession must make full use of the chance to increase its responsibilities and its productivity if it is to survive in the long term. Accordingly, we can assume that engineers of all kinds will act in their own self-interest. This will involve speeding up the rate at which engineers analyse and experiment with new concepts and materials that are emerging from the great push in science during this century. Engineers must no longer rely on the tried and proved solution when scientific studies have provided a host of new alternatives that await practical evaluation. Unless the engineer deliberately embarks upon the course of greater and swifter innovation, the scientist on one side of him and the man in the street on the other side of him will seek and find ways to join hands without the aid of the engineer. This why tomorrow's engineer will be more of an innovator and better versed in a wider range of scientific principles or discoveries.

The second major expansion of engineering responsbility is in what is sometimes called systems engineering: the organization of the whole from individual components. Until a few years ago, the synthesis of an operating system was the function of a manager who applied certain financial tests to the various component proposals, perfected and presented to him by teams of engineers.

Then, engineers began to seize the initiative for evaluating interaction of the whole system with the function it is designed to serve. The evidence seems clear that engineers will continue for some time along this path of expanding their responsibilities to include the inter-disciplinary organization of systems and the planning of total systems.

In the other direction, the engineer must do an effective job in divesting himself of some responsibilities that modern technology has made sub-professional. Any engineer today who transfers lines from one sheet to another, who sits at a desk pounding a calculator or wearing out his slide rule, who conveys information by merely transmitting, without evaluation, the work of others will not be called an engineer tomorrow. To preserve his right to be called an engineer, he will voluntarily give up these activities to technicians and to machines.

Information Please

From this speculation about tomorrow's engineers, you should now be able to detect what will happen to their need for information resources. If an engineer is engaged in design, he will need faster and more complete access to scientific discoveries not only at his interface with other disciplines but also within those deep disciplines. If an engineer is engaged in design, he will need faster and more complete access to experimental data and past experience to expedite the evaluation of alternatives and to formulate plans for further experimentation. If an engineer is engaged in production or sales, he will need a clearer picture of how his unit's performance is affecting the overall performance and profitability of the enterprise. And finally, if he is one of the newly emerging systems engineers, he will need far more accurate data and correlations than he has now on subjects ranging from the effect of chemical structure on physical properties to the effect of military planning on inter-industry flow of commodities.

In short, the intelectual content of his day-to-day work will be higher, he will have more direct responsbility for the output of technicians and machines, and he will have less time than ever to make decisions. Tomorrow's engineer will operate effectively in this climate because tomorrow's information resources will make it possible for him to do so.

A piece of data or new idea is not of use to engineers in general; it is useful to one particular engineer at a particular moment in time. If we state the task ahead of us in all of its full-blown complexity, it seems hopeless. On the grand scale, we are trying to ensure that the benefit of past work by millions of scientists, technologists, economists, social scientists, administrators, jurists, and many others is available to some one of the many thousand engineers at a specific time dictated by his personal work schedule.

Knowledge in Transit

Information systems operate from author to reader. The steps involve the origination, organization, storage and retrieval of information. The chief man-machine operations will occur in these stages. It is important that we understand how much our technology still has to learn about the interface between men and the machines in such information-processing operations.

The crucial stages of information retrieval, however, are what the recipient does with the information. These stages involve evaluation, secondary dissemination, and use of information. The person receiving it must evaluate whether or not it is new, accurate, or useful. He must determine who else should see it, how to circulate it, or whether to make copies. And in using it, he must determine where, when and how. These are not trivial questions, and few are really answered in today's information-processing technology. It may be that we have so few answers because engineers and scientists are not taking sufficient personal interest in the handling of technical information and are leaving to others the design and installation of information systems.

The principal machines are: text reader, word-association counters, network transmitters and remote printers. Elementary text readers and document storage devices are now available commercially. The rest of the machines are only in various stages of development. To provide adequate and effective communication between the machines and the people they serve, systems and procedures are needed for language translation, vocabulary control, indexing and microform storage. In addition, extensive data-processing programmes are needed to provide for finding, transmitting and printing the pertinent documents. The first elementary procedures of accomplishing these functions with the aid of today's digital computers are already in existence.

Origination of information involves saying it; writing, drawing or typing it; or building a physical model of it. There are machines already available today to convert voice into machine-processable format. Intensive development in the area of reading text indicates that the rudimentary techniques used today are going to be improved tomorrow.

Storage Techiques

Storage concepts and equipment are available today in full range from Project Walnut with its tens of millions of documents on micro-microfilm to the simple hand-operated card punch that an engineer can use at his desk for making a record of individual data points. There is no lack of equipment proposals for any conceivable file size, up to and including the prospect of recording the contents of the Library of Congress in a cubic inch or so of material. The question of what storage technique to use will boil down to a selection on the basis of overall system compatibility and unit costs; in other words, straightforward economics.

Retrieval processes involve both search and delivery operations. As indicated here, today's search strategies are implemented through equipment ranging from the unit built by the National Bureau of Standards for locating and reading pages of text by locating coincident holes punched in large cards and up to the largest computers programmed to carry out complex searches and produce bibliographic listings of pertinent materials.

Equipment exists for transmitting all forms of digital and image information from one location to another. Equipment exists for simultaneous display and production of hard copy of such information at any location remote from the central storage unit. Today, such transmission and remote print-out equipment is expensive and far out of economic reach for use by the individual engineer. Tomorrow, this may not be the case.

When a document is received at a station on tomorrow's information network, it will be given a serial number and fed into an electronic scanner that will reduce its contents to mechanically processable form. At some future time this electronic scanner will include facilities for translating the document into English if necessary.

Word associations, including word counts and syntactical relationships, will be noted and summarized and automatically compared with words in a thesaurus.

Abstracts and index-term lists will be prepared either automatically or manually and transmitted electronically for storage at each processor on the network. If the abstracts and index lists are published at source, this operation can be fully mechanized at this point.

Interest profiles of all the customers in the system will be matched as each processor to the index lists of new acquisitions, and customers with a predetermined level of match between interest and document content will automatically be sent abstracts of the pertinent documents.

Serving the Customer

When a customer wants information from the system, he will dial, type, or dictate his inquiry into the network through one of the processing machines.

Title lists and abstracts will be assembled in machine-readable format and these will be transmitted on the network to the customer in some man-readable form such as a closed ciruit TV receiver at the inquiry station.

The customer will request the documents he wants from the network, specifying the urgency of the delivery. The processor will place the order with the storage containing the document and cause the full amount to be transmitted by mail, by messenger, or by electronics, as the needs require.

The Engineers Joint Council has drawn up a time-table calling for design, installation and operation of such a system by 1968. Such a time-table is technically feasible, but is it economically feasible? The cost of such a system has not yet been determined, but it will be high.

Savings will come from two sources: the cost of technical manpower to do a particular job, and the cost of the physical product created from the engineer's designs and specifications. While our cost sheet tells us how much it costs for an hour of an engineer's time, no one has yet come forward with a cost sheet that tells us whether he wasted that hour doing work that had already been done somewhere else. While our cost sheet tells us how much it costs to manufacture a product or construct an engineering work, no one confronts us with a cost sheet that tells us how much less the job would have been if we had used certain engineering data reported elsewhere but not discovered by our engineers on this specific job.

If we are ever to provide objective data to evaluate new methods of information handling, we will have to pin down the mechanisms by which different types of engineers use various kinds of information. The ultimate evaluation of competing approaches will depend upon objective appraisal of the 'efficiency' of engineers, as individuals and as a profession, in the use of known science and technology. Even the most casual investigation of the subject will show that we simply do not know today how to describe, let alone measure, what an engineer does with information. It would seem reckless (and possibly dangerous) to assume that yardsticks already exist for determining the economics of information processing.

The New Communication

The greatest change which must occur in the writing of technical results for communication with others is a reduction of the physical volume of such communications. Today's authors assume that their readers have not taken the trouble to search the literature on their subject, so they devote from 25 to 75 per cent of their report or article re-stating what has already been published. In fact, there is a tendency to glorify published pieces which consist entirely of previously published information or data. Tomorrow's authors will record and publish only what is new and previously unrecorded, operating with the full knowledge that those who seek out their work will also be provided essentially all related work on the subject.

However, this forecast reduction in volume of recorded information will not occur unless today's incentives for multiple publication are removed. The academic man whose salary and professional stature are directly related to the number of his publications, rather than their quality, will not be impressed by tomorrow's information systems. Neither will the organization which uses a wide variety of journals to reach a broad audience with the certain knowledge that few people will notice that the same material has been presented in several journals under slightly different titles.

This leads to the second forecast, involving primary journals. Tomorrow's 'publications' will be reports of work about to start, or under way, and of work completed. These reports will be prepared in a myriad of convenient forms and will be fed directly into the information system without going through a long waiting period for dissemination through traditional publications. Anyone who needs to know that the information has become available will be notified by means of index lists or abstracts.

A third prediction is that secondary journals for publishing abstracts will expand in size and number for a few more years and then die out in favour of review journals. Today's engineers are just beginning to appreciate the value of effective abstracting services, and this is why the Engineers Joint Council has promoted the publication of abstracts at the time of issuing each report, article or book throughout the engineering profession. This surge of easy, economic availability of abstracts will cause further expansion in the secondary publications. But in the longer range, tomorrow's engineers will not be satisfied with unevaluated material. They will want to know what some recognized expert has to say about the author's work, and they will prefer to pay for reviewing journals or the state-of-the-art reports incorporating these expert evaluations.

Role of the Library

A fourth prediction involves storage and retrieval of technical information Yesterday's storage and retrieval concept was a library or a local filing cabinet. Today we have regular libraries and special libraries; we have technical information centres and document centres; and we still have the filing cabinets. If the system described earlier becomes operational by 1968, it will have an economic impact on today's library. The network and large systems will be designed, tried and evaluated by the technical people who will use them, and, if an aggressive library wants to take on these added functions, it will have the opportunity to compete for the business of providing technical information.

What of our engineers themselves? Tomorrow's engineers will be trained in college to use information resources (today's are not), and they will demand access to a wider range of resources in their daily practice. Tomorrow's engineers will consider it a natural part of their day-to-day work to prepare abstracts or extracts of their work as they complete it and to initiate index lists. Some of tomorrow's engineers will be attracted to assignments in which they will serve exclusively as information specialists for their fellow engineers. And finally, tomorrow's engineers will know much more than today's about how best to use data in the perforamce of their work.