Editorial

High technology management

Human Systems Management, in the complex environments of post-industrial societies, is increasingly becoming high technology management along various dimensions:

(i) management of technological externalities in terms of long-run social impacts, e.g., displacement effects in the labor force or changes of lifestyle;

(ii) management of risk for large scale technologies by advanced information processing methods;

(iii) management of innovation and diffusion for high technologies.

I shall describe in order, in a paradigmatic fashion, these three main areas. The gist of the reasoning is that high technology management covers a broad area that should be given special consideration in shaping *HSM* editorial policy.

Technology management and social impact

We are at the greatest momentum of exciting technological developments often referred to as the information revolution. This revolution has been created by the rapid succession of innovations in information technology, communications and computers. The most dramatic innovations stem from recent developments in microelectronic technology leading to the introduction of the microprocessor, an integrated circuit on a tiny chip of silicon, as the major building block of a microcomputer. It has extended the range of electronic processing to many economic applications in industry, communications, data processing, office equipment, consumer goods and services, transportation, recreation and medicine, in fact, almost every area of human activities has been affected.

In most Western countries 50% to 70% of all employment is in the service sector. The highest disemployment and greatest organizational impacts are expected to be borne by this sector, particularly the information-handling aspect, sometimes referred to as the quarternary sector. Up to 50% of all employment is estimated to be involved in information work, depending on the definition of information (but this share is still increasing). Out of this, 40% of all employment is said to be accounted for by office work. The office of the future, or the automated office, is expected to be composed of a variety of microprocessor-based equipment, including smart copiers, optical character readers, word processors and communicating computers. Services such as electronic mail, automatic information processing, and internal telecommunication abilities are expected to characterize the office of the future. Large institutions in particular are expected to be affected by such developments: for instance, the postal services, telecommunications, insurance, banking and finance, accounting and legal services, and public administration. Other services expected to be affected by information technology are education, distribution (e.g. retail and whole sale) and medicine and health care.

There is scant evidence to show a great displacement of labor in the information handling sector, and most figures are extrapolated from what is known about increases in productivity through the use of word processors. In some instances a speed-up in productivity has meant a reduction in secretarial staff, in other cases improved service and corporate growth have created greater demand. There is a still slight but growing reaction to automation in the service sector, pointing to the barriers in institutional diffusion of this technology. The reaction is coming from those workers who increasingly feel that a larger system is monitoring their activities, and from middle management people who find that there are fewer functions to manage and fewer decisions that need

North-Holland
Human Systems Management 4 (1984) 141–144

to be or can be taken at their level. The uncertainty caused by economic anxiety and possible loss or adverse redefinition of work is probably the greatest single impediment to the continuing automation of the service sector or of the economy in general. Mechanisms and policies must be formulated to alloy these fears so that implementation can proceed in an orderly fashion.

The effect of microelectronics on employment will at first depend on the weight of diffusion of the technology, including the successful application of this technology and the institutional or societal acceptance of this technology in particular sectors or on a global scale. Thus, diffusion will be a function of a large number of factors, including institutional, attitudinal and, of course, cost and productivity considerations. For example, to know the weight of diffusion one must have some appreciation of the availability of a skilled labor force, resistance by unions, status of the corporation, availability of capital, cost of equipment, international competitive standing, government policy and the desire to promote the technology as part of an industrial strategy. Whereas in the USA the microelectronics industry has not been actively promoted, in other countries it has, like in France, West Germany, Japan and Canada.

Unless it is possible to introduce some kind of international agreement on technology diffusion and technology transfer, world economic pressure and the desire of most industrialized countries not to be left behind in the high technology race could spark off advances in technology that lead to major displacements in key sectors of the economy. There is an imminent danger that an increasing number of countries will fall back on protectionist policies – which we already observe these days – with substantial decreases in national and international social welfare.

Management of risk

Much of the modern concern with risk arises form the building of what we might call 'risk-creating' installations of high technology. Such installations may comprise off-shore oil drilling, oil storage or hazardous waste facilities, airports or (nuclear) power plants.

Consider the following myth of treating risk adapted from the 'Lady or the Tiger', as reported by the British novelist T.R. Stockton (1884).

A young man stands in a room and could open easily either door he pleases. If he opens the first one, there will come through it a hungry tiger, the fiercest and cruelest that could be procured, which will immediately tear him to pieces. But, if he opens the other door, there will come forth from it a lady, the most suitable to his years and station His Majesty could select from among his fair subjects. Which door to open?

The first man refused to take the chance. *He lived safe and died chaste.*

The second man hired risk assessment consultants. He collected all the available data on Lady and Tiger populations. He brought in sophisticated technology to listen for growling and to detect the faintest whiff of perfume. He completed check-lists, and drew fault trees. He developed a utility function and assessed his risk averseness. Finally, sensing that in a few more years he would be in no condition to enjoy the lady anyway, *he opened the optimal door and was eaten by a low probability tiger.*

The third man took a course in tiger taming. *He opened a door at random and was eaten by the lady.*

Now, this situation makes clear how we try to cope with the unknown (i.e. the 'risk').

– The first approach is neglecting the problem and pretending to live in a risk-free environment.

– The second approach comprises all stages of analytic risk assessment. Measure the requisite probabilities, make the trade-offs and calculate the social risk-benefit function.

– The third approach is a kind of professional engineering approach.

All of these approaches have one thing in common: to cope with the unknown and establish a more predictable world by risk management.

Risk management as high technology management could use advanced information processing tools as is exemplified by the description of HAZARD (Health Assessment of Zonal And Regional waste Dumps).

HAZARD is an expert system (ES) under development at our Institute, assisting environmental regulators and public health personnel in detecting potential hazards at waste-sites of environmental chemicals. Expert systems are programs (i.e., software products) that model expertise in a specific task domain to achieve a high level of performance for problems that are considered difficult and require a great deal of expertise. An ES normally uses one type of knowledge representation, e.g., production rules or semantic network frames. One perspective of our research is to test the outcome of the interaction of different types of representation methods.

HAZARD contains a *program architecture* characterizing a general purpose ES, e.g.:

(i) a *knowledge base* (KB) that consists of scientific facts on a limited number of high priority toxicants, exposure information, and expertise on plausible reasoning, e.g., a set of 'IF–THEN' decision rules that associate with certain premises and facts certain conclusions;

(ii) an *inference engine* (IE), consisting of a set of recursive chain rules that:

(a) produce an exhaustive depth-first search based on an optimal search algorithm,

(b) are judgemental to permit inexact inferences and Bayesian updating;

(iii) *a communication system* which is responsible for interaction with the users. It is able to explain HAZARD's decisions upon request, and to understand and use nearly natural language, which is a sine-qua-non-condition for high acceptance by users;

(iv) *a modifier system* which enables a user to change and enlarge the knowledge base and/or the decision rules.

The KB is the program's store of task specific knowledge, the IE is an interpreter (or control structure) that uses the KB to solve problems at hand. The KB is accessible to the extent that additional expertise would enhance the KB of a program. The responsibilities of an inspecting team of health and environmental monitoring can be compared with those of other diagnostic tasks. The hazard potential of chemical dump-sites, emission sources of air and water pollution is composed of the 'exposure degree' of the population at large and of the 'hazard potential' represented by a set of structural parameters on toxicants (e.g., the degree of toxicity, biodegradability, accumulation, etc.). Intelligent monitoring of such sites involves quick and efficient diagnosis and possible treatment or 'action-planning' in case of emergencies, or accidents.

If diagnosis and action-planning are effective, most incidents can be terminated without serious consequences, also preventive steps can be taken against newly produced chemicals as to their health and environmental impacts. Such a preventive scheme is envisaged by the OECD's Minimum Premarket Data (MPD) Hazard Assessment Scheme.

The purpose of HAZARD is to monitor a hazardous waste facility (including a rad-waste facility), to detect deviations from normal operating conditions, to determine the significance of the situation, and to recommend an appropriate action. It performs these tasks by operating on a large KB, such as one derived from a chemical information system, with an IE that reasons recursively in a basic identification system. HAZARD is similar to the interactive structure of MYCIN's rule-based consultation and explanation system; however, unlike MYCIN, it belongs to the category of second generation ES-Technology (EST) or *deep* systems, or systems of high structural complexity. It reasons explicitly on the basis of causal rules of judgement and model-based assessment as determined from impact-modelling.

HAZARD's KB contains two types of knowledge: *function-oriented* knowledge and *event-oriented* knowledge. Function-oriented knowledge concerns the composition of environmental chemicals at a particular source and how they interact synergistically or antagonistically over time. Event-oriented knowledge describes expected acute or long-run consequences if certain threshold limits on certain parameters are exceeded. Event-oriented knowledge is represented by 'if–then' rules. HAZARD is implemented in LISP.

Management of innovation

Consider an R&D management department in a technology driven firm that is struggling for survival in a competitive market environment. Managing projects for successful market adoption and diffusion would constitute the best technological strategy available to the firm – the penalty for failing to implement this strategy could result in loss of market share, unprofitability, diseconomies of scale and in a negative change of other key economic parameters of the firm. It would be very interesting to combine such an approach with some case study or descriptive approaches along the lines of a Rand Corp. Study (1976) which lists essential technological, institutional and environmental attributes, responsible for the identification of innovation successes of advanced technologies: technological uncertainty, cost uncertainty, demand uncertainty, institutional uncertainty, uncertainty about externalities, degree of 'maturity' of technology, presence of cost and risk, sharing with local units, initiative for project from private or communal sources, a strong technology delivery system, absence of tight time constraints.

The major approach has involved development of demonstration projects – prototype systems intended to establish that the technology can be used to perform a valuable function, before widespread diffusion and application of the technological innovation can take place.

Many factors besides technical feasibility per se determine the rate and extent to which any innovation is applied. What these factors are and how they operate in determining the diffusion rate of innovations is poorly understood.

Hans W. GOTTINGER
GSF–MEDIS