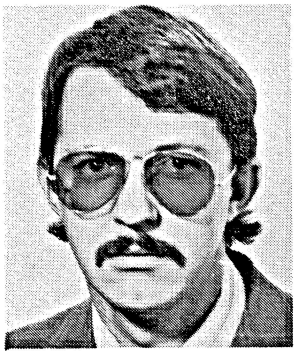
TECHNOLOGY TRANSFER



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In hierdie artikel postuleer die skrywers 'n definisie van tegnologie as 'n spesifiek skeppende kuns. Uitgaande van hierdie definisie, word die metodes waarvolgens tegnologiese oordrag geskied, bespreek. Die intieme verband tussen tegnologiese oordrag en tegnologiese innovasie word beskryf, terwyl vertikale en horisontale tegnologiese oordrag uitgesonder word as moontlike maniere waarvolgens tegnologiese oordrag kan plaasvind. Afgesien, egter, van die wyse waarop oordrag geskied, moet sekere voorwaardes nagekom word om suksesvolle tegnologiese oordrag te verseker. Hierdie voorwaardes word onder sewe subhoofde in die artikel bespreek. Die metodes en maniere, waarvolgens tegnologiese oordrag plaasvind, sowel as die voorwaardes vir suksesvolle oordrag, is almal afgelei van die gepostuleerde omskrywing van tegnologie. Die skrywers dui ten slotte aan hoe huidige begrippe en die omvang van die tegnologie en tegnologiese oordrag waarskynlik in die toekoms sal verander vanweë die snelle tegnologiese ontwikkeling wat spruit uit die mens se begeerte om sy omgewing te begryp en te bemeester. Die artikel bied 'n goeie inleiding tot dié veld, veral ten opsigte van die verdedigingsektor waar pionierswerk in hierdie verband gedoen word.

INTRODUCTION

The transfer of technology is a highly controversial and seriously important matter for any country but even more so for the rapidly developing RSA with its limited human, technological and financial resources and because of the increasing attempts to isolate it being made by the world community. The process has, however, often been sadly inefficient and sometimes unsuccessful because of a lack of understanding and/or recognition of the basic principles involved. The prime purpose of this paper is to illuminate these general principles and to highlight some important conditions for successful technology transfer. An attempt will be made to illustrate how technology — transfer is destined to become of critical importance over the next few decades.

DEFINITIONS

Terms such as "technology", "research", "innovation", like "horror", "beauty", "happiness", often have different meanings for different people and many misunderstandings and malpractices can be traced back to irreconcileable premises about such terms or even a total absence of any attempt to arrive at common definitions or concepts. When talking about technology, technology transfer, and so on, we will use certain concepts and assume that others have the same concepts. One has but to ask a few people at random to define technology to realize how divergent the definitions are.

What we understand by "technology" will greatly determine how we see technology transfer. It is clearly more important to use a consistent concept than to employ a universal (and probably cumbersome) one, so the following definition will be taken as a starting point for this paper:-

Technology is the art of applying know-how for the development, manufacture, use and/or maintenance of articles of utility. Technology is therefore a complex of knowledge and skills that people employ to execute certain technical tasks which have as an objective the creation, utilization and maintenance of user items. (Compare this definition with the concise "science of the industrial arts" given by the Oxford Dictionary and with the popular term, "state-of-the-art").

Recognizing that technology is a creative art, one should realize that the ultimate sources of technology are human beings. Modern technologies are often multidisciplinary and may also cover multiple levels of the systems hierarchy; such technologies are invariably founded in a group or team of people. This being so, technology transfer entails the transfer of a complex of knowledge and skills from one person (or, more likely, a group of people) to another. Often enough, technology transfer is regarded as the semi-natural process by which scientific ideas and philo-

sophies are disseminated by universities and other research laboratories to industry. Without failing to appreciate this subtle diffusion of technology, it should be stated that this paper deals with the deliberate and premeditated transfer of technology which usually is, therefore, a formal exercise.

Technology transfer is intimately related to the process of technological innovation. Although this topic has been widely discussed before (Bright, 1972) and certainly deserves all the attention a technical manager can give it, a synopsis of the main attributes will serve here:-

1. Technological innovation is the process whereby technical ideas, (or scientific ideas, if you prefer) are developed into products that are used by society.
2. Technological innovation progresses through a number of sequential stages which can be broadly identified as the conceptual, verification, development, engineering, manufacturing, marketing and proliferation stages.
3. Technological innovation processes take much longer to complete than most people think, usually of the order of 8 to 12 years. The first four stages are normally far more time and money-consuming than the rest of the process. The initial stages are, of course, high-risk phases where many would-be innovations are terminated because of cost and time prohibitions or non-feasibility with the current state-of-the-art.
4. Here again, process of technological innovation is often differently visualized (or described) by different people but most agree that generally the different stages require different complements of people, each group with a different complex of skills, attitudes and objectives.

Having noted these main characteristics of technological innovation, the first, and often most ignored category of technology transfer is identifiable as the flow of know-how and skills from one stage to the next or from one group of people to the next, in the technological innovation process and will be described by the phrase "Vertical Technology Transfer" (Morton, 1969). Examples abound – let us think, for instance, of the laser. In 1958 Schawlow and Townes postulated the principle of laser operation, but it was not until 1960 that a Hughes team of researchers under Dr Maiman developed the first successful experimental laser. Since then many different kinds of lasers have been conceived (e.g. the gas laser in 1961 and the current injection laser in 1962) but it was only in the latter part of the last decade that some of these lasers came into practical use. Laser technology has since diffused into many applications ranging from accurate distance measuring through fabric cutting to telecommunication, but each individual innovation has to progress from its initial conception, usually in a scientific laboratory, through development, engineering and production before it becomes a marketable product.

There is another nominal category of technological transfer that enters the process of technological innovation at a stage later than the conceptual and has as its main objective the saving of the time and money that would have been spent on the initial (expensive and long duration) stages of this process. This category will be described by the term *"Horizontal Technological Transfer"* and there are two main types:-

Inter-institutional Technology Transfer; where technology is transferred from a conversant donor to a recipient who is usually a new comer to the field and who wishes to produce the same or similar products. The recipient could, for example, be a company in a developing country which wishes to embark on the production of a specific type of laser fabric cutter. It would then approach a suitable donor company of some renown to negotiate a technology transfer agreement for the local production of fabric cutters under licence at an arranged remuneration.

Intertechnological Technology Transfer; where technology is transferred from a conversant donor in a specific (usually rather monodisciplinary) technology to a recipient in quite another (usually multidiciplinary) technology who wishes to incorporate this technology in his systems design. The recipient could, for example, be producing aircraft bombing systems and realizing that a laser range-finder could substantially upgrade the performance of its bombing systems, wishes to incorporate this innovation to supplement or substitute its distance-measuring equipment.

Clearly, these are nominal categories and many technological transfers are a mixture of more than one of these processes. There are however some universalities in all technological transfers and the general principles are of great importance. These commonalities spring from the fact that

1. Technology is a creative art constituting a complex of know-how and skills.
2. Technology transfer takes place from a conversant donor (where the expertise is possessed by a group of experienced people) to a less knowledgeable recipient where it has to be inculcated into another group of people.
3. Transfer media are generally limited to
   - documentation (including films, video and computer tapes)
   - hardware examples (prototypes)
   - interpersonal communication (including, notably, "on-the-job" training)

Important conditions for a successful transfer of technology:

When considering a technology transfer and particularly when drafting a technology transfer agreement it should be borne in mind that the available media are limited and the greatest use should be made of all three. It would seem, for example, that the purchase of a process manual alone is a very inefficient way to transfer technological know-how. The following factors could prove detrimental to technology transfer and therefore merit special attention when considering any such transfer:

1. QUALITY OF DOCUMENTATION

Care must be taken to ensure that documentation is concise, comprehensive and complete. Assurance

must also be given that consultation with the donor is available should the recipient have any trouble interpreting the documentation, and, if necessary, supplementary documentation should be obtainable on request. Wherever possible audio-visual aids and other compatible electronic information transfer techniques should be used.

2. ABSORPTION CAPABILITY OF THE RECIPIENT

A lay recipient will experience many difficulties in absorbing a sophisticated technology. A recipient well developed along the line of technological innovation may waste time and money by a technology transfer. A careful trade-off should be made to decide just how much in-house technology is necessary to provide an "absorption threshold".

A point to note is that technology transfer is usually a two-way process in that both the receiving and donating teams benefit through interactive cross-fertilization. A recipient of recognized status in the transfer or related fields is an attractive technological partner and has distinct "bargaining power" when negotiating a technology transfer.

3. SUITABILITY OF THE DONOR AND HIS TECHNOLOGY

The recipient should be adequately informed so that he can define exactly what he wants, and select the donor best suited to his purposes. It goes without saying that the recipient should also be able to judge whether he is buying current state-of-the-art and technology with growth potential. There are numerous examples of disappointed recipients who only realize, after the completion of a technology transfer that the contemporary technology remains out of reach. This remark is particularly valid for a rapidly developing field such as semi-conductor electronics.

Not all international technological resources are available to the RSA and some potential technological partners may prove to lack permanency because of the international political climate.

4. "ON-THE-JOB" EXPERIENCE

Technology vests in people and technology can best be transferred by transferring people between donor and recipient (accompanied, of course, by documentation and prototypes). The recipient should, therefore, mobilize a technology transfer team made up of a suitable complement of people with an adequate mixture of expertise and having the ability to absorb the technology in the environment in which it is applied by the donor. A technology transfer agreement may, however, specify that a technology transfer team be drawn by the donor from his own staff to establish the transferred technology *in situ* in the receiving industry. The recipient's transfer team should, as far as possible, include the technologists, engineers and technicians who will actually be responsible for execution in local industry. The success of the transferred technology in industry is dependent upon supporting functions such as management, marketing, contracting, etc. Very often specialized technologies will demand specialized knowledge in these areas. Suitable "collar-and-tie" men may have to be included in the transfer team.

Technology is a creative art and being exercised with the tools of its trade in a specific environment it is best absorbed by the recipient in this environment. As we are dealing with subjective perception, "to get the feeling of things" certainly has major significance. There is a definite "incubation period" necessary for the technology transfer team to achieve some level of competence. Note that "on-the-job" experience is taken to imply "shop-floor" interaction between donating and receiving teams. A top management or middle management visit to an overseas donor is simply not enough.

5. LANGUAGE AND INTERPERSONAL RELATIONSHIPS

There are probably few greater impediments to technology transfer than hindering interpersonal relationships between the donating and receiving teams, and few barriers are worse than a language barrier between people. When selecting a suitable donor and a suitable technology transfer team, these factors should be given serious consideration.

6. QUALITY OF PROTOTYPES

The objective of technology is to develop, manufacture, use and/or maintain articles of utility; without these products, technology is meaningless. Just as the evaluation and appreciation of sculpture is virtually impossible in a two-dimensional representation, actual hardware examples are necessary during the process of technology transfer.

Prototypes of systems, subsystems, modules, components and sometimes even materials should be selected with circumspection, and care should be taken to ensure fidelity.

7. ESTABLISHING THE TRANSFERRED TECHNOLOGY

In the initial stages of a technology transfer the technology is passed mainly by the technology transfer team and no effort should be spared to prevent this team from disbanding before the technology is properly established and transmitted to other members of the technological community. This remark obviously implies a secondary technology transfer, but this process is the natural diffusion that takes place in any technology and during any stage of the innovation process. When establishing the local technology the following should be kept in mind:

- Transferred technology cannot be shelved until required; it will deteriorate if not exercised and the technology transfer team will probably disintegrate.
- Technology has as its objective the development, manufacture, use and/or maintenance of articles of utility and as such belongs in an industrial culture. Wherever possible transferred technology should, therefore, be established directly in its designated local industry.

CONCLUDING REMARKS

An attempt has been made to rationalize technology transfer and its intimate relationship to the process of technological innovation by assuming a specific meaning for the word "technology". In retrospect this definition may seem inadequate. Recall, for example, that the objective of the Apollo programme, probably the ultimate technological achievement of mankind to date, certainly was not to develop, manufacture, use and/or maintain articles of utility in the real sense of the word. The diffusion of technological spin-off from the Apollo programme into various fields and levels of society, did, however, instigate a "technological" revolution comparable to the industrial revolution of the previous century.

In a philosphical sense, therefore, it would seem that this definition of technology, implying that the objective of technology is to enhance the quality of life by providing society with always better and more articles of utility, falls short because it does not recognize the basic compulsion of mankind to understand and master the environment. This compulsion, it must be realized, will always be accompanied by technological advances. In fact, it is in this arena that technology will have to play a decisive role in the next few decades if humanity is to avoid the terrible calamity of an overburdened and lethally contaminated planet with exhausted resources.

This finite earth cannot support unlimited growth for an indefinite period (Meadows, et al, 1974). By the nature of things mankind will have to steer more technology programmes towards the curbing and controlling of growth and the more efficient utilization of the natural resources. Picture, for example, the effect of a concentrated effort over the next few decades to achieve the following objectives:-

- An effective birth control programme.
- Solar and nuclear energy as practical substitutes for petrochemicals.
- Availability of the natural resources of Antarctica.
- Optimal utilization of the ocean's food resources.
- Economical sea floor mining.
- Effective pollution and urbanization control based upon the full comprehension of the ecological system.
- Effective urban commuting systems.

These few remarks point towards a wider future overlap and a more intimate interplay between "science", "technology" and "industry" which we have so often pigeon-holed with scientific precision. With this in mind, technology transfer acquires a status of critical importance and the new generation of technologists into whose hands the future of the world is now committed, will have to become masters in the creative art of technology transfer – which is, incidentally, by definition, yet another technology.

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Happiness is...

WHAT CAN BE ADDED to the happiness of a man who is in health, who is out of debt, and has a clear conscience? This was written by Adam Smith, the famous eighteenth century economist. What could also be added to happiness is the sense of achievement – and by his death at 67 in 1790, Smith certainly had that. *The Wealth of Nations* went through five editions in his lifetime at a price equivalent to R60 a copy – many thousands of copies a year are still sold today. Some more philosophy from his pen:

- **On work and leisure:** Great labour, either of mind or body, continued for several days together . . . requires to be relieved by some indulgence, sometimes of ease only, but sometimes too of dissipation and diversion. If it is not complied with, the consequences are often dangerous, and sometimes fatal.
- **On lotteries:** The world neither ever saw, nor ever will see, a perfectly fair lottery . . . because the undertaker could make nothing by it. In the state lotteries the tickets are really not worth the price, (yet) the soberest people scarce look upon it as a folly to pay a small sum for the chance of gaining ten or twenty thousand pounds . . . In a lottery in which no prize exceeded twenty pounds . . . there would not be the same demand for tickets.
- **On human equality:** The difference of natural talents in different men is, in reality, much less than we are aware of. The difference between the most dissimilar characters, between a philosopher and a common street porter, for example, seems to arise not so much from nature, as from habit, a custom and education.
- **On sympathy:** To seem not to be affected with the joy of our companions is but want of politeness; but not to wear a serious countenance when they tell us their afflictions, is real and gross inhumanity.

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