



Chapter 2 – Technology Transfer

2.1 Introduction

The laws of nature ultimately limit technological improvement in any field. For example, the number of transistors that can be placed on a silicon chip is limited by the crystal structure of silicon. Most industries are however far from these limits, and they are much more likely to come up against practical technological limits. For instance the efficiency of today's car engines can greatly be improved, when the operating temperatures can be increased. Current alloys however cannot withstand these temperatures, but there are materials such as ceramics that can operate at these temperatures. The problem, however, is that ceramics are not practical to use because of characteristics like their strength. Ongoing research is taking place in this field.³

Researchers therefore strive to narrow the gap between the current technology and the limit be it practical or physical. This gap is called the *technical potential of technology*. Many believe that the technology with the greatest potential, will take control of the market. Researchers must realise that technological advancement is not only achieved by improving current technology, but also through the development of new technology. Often there are gaps between current and new technology, and that is what makes developing new technology so difficult. These gaps may also be just big enough for people not to see the benefits of the new technology. This blindness has effected almost every industry. Aspects that may stand in the way of adopting new technology and discarding the old may include³:

- Incorrect perspective of technical limits
- Inability to measure technological progress
- Faulty interpretations of market signals
- Misinterpreted customer needs
- Culture

- Gap between old and new technology is too big.

Senior personnel very often mis-time their investigations into new technology, because they believe that the growth experienced halfway through the lifecycle of a technology, will continue. On the well-known S-curves (Figure 1.2) it is clear that this growth is not indefinite and the development reaches a plateau at some point. It is estimated that investigations into new technologies can be as late as 5 to 7 years in a technology with a lifecycle of 20 years.

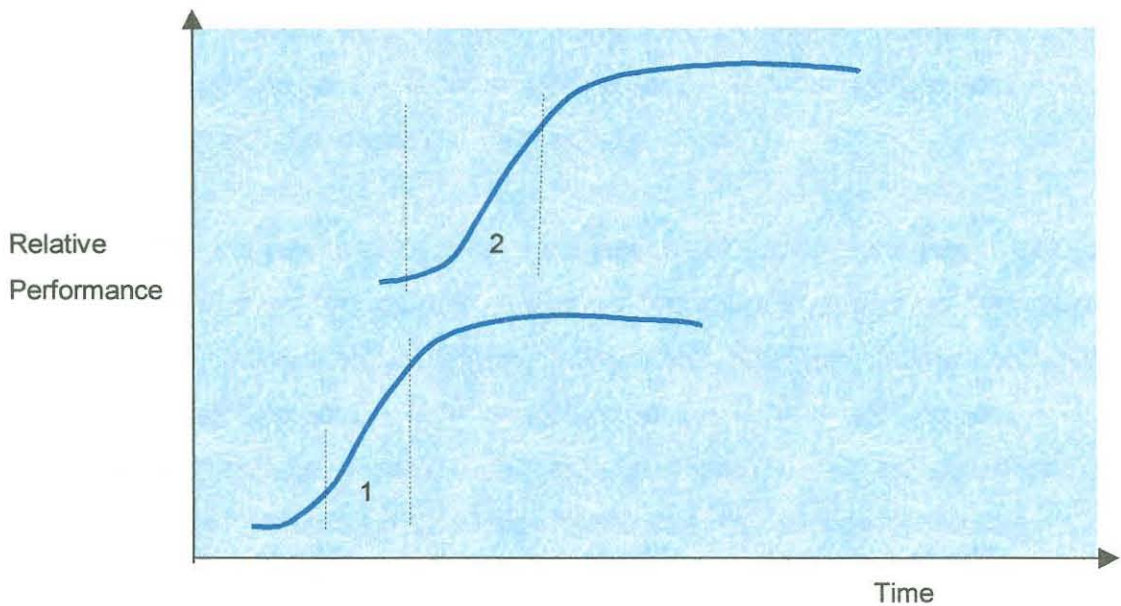


Figure 2. 1: S-Curves

It is very important to know when to start looking at new technology. It does not seem economically sound to start looking at new technology when the current technology, used by the organisation, experience rapid development and improvements (indicated by no.1. in Figure 1.2). But as the S-curves indicate this is not sustained. If an organisation opts to stay with current technology and do not investigate what is available to them, the growth phase in the replacing technology (indicated by no. 2 in Figure 1.2) can easily be missed, as indicated in Figure 1.2 by the two S-curves. The biggest problem lies in a competitor seeing the window of opportunity and they move into the market with the new technology. If management then decides to stick with the current technology and exploit any small advances, the competitor will still

have the advantage enabling him to develop his product/service unhampered with regard to competition and he has the additional projection of development in the technology employed.

Can an organisation really sit and wait for market clues before they change their technology? Certainly not. An organisation must realise that the clues from the market are signalled to all competitors in the market. Organisations must also be aware of the fact that the market is becoming more and more sophisticated and educated. This means that they want their needs to be satisfied in a unique way. The strategy to copy the competitor's way of satisfying needs might therefore not be enough, and such organisations will act as followers to the leaders in the industry.

The biggest impediment in the introduction of new technology into an organisation is company culture. People do not like change and they would rather stick to what they are familiar with, rather than introducing something new. Another obstacle, which can also be associated with culture, is the mindset to introduce a new technology and then put a lot of effort into protecting and defending it. This might not be the best strategy. An organisation is not married to the technology it employs. Organisations must see technology as an expendable tool and if the need change, so must the tool.

The question may then be asked, "what is the best strategy"? There is not one strategy that can be classified as 'best', but the following aspects should be incorporated in a strategy:

- Knowing the technology welfare of your organisation
- Knowing the technology position of the competition
- Knowing what technologies are available

Since the shift to new technology can take as long as a decade, companies need an early warning system of advancing new technology. One way is to

identify technological alternatives on a continuous basis. People in decision-making positions should stay abreast of developments in their industry. They must therefore be aware of what is available to them, what their current technological position is and in what technological position their competitors are³ in.

Technology can therefore play a major role in business and is an aspect that is receiving growing attention. Acquiring the most appropriate technology can therefore place an organisation in a very competitive position.

The need to initiate a technology transfer project can originate from two forces⁴. The first can be described as a technology push. In this case a technology has been developed and is 'searching' for an application. This is very often a spin-off from another research program, and the technology was not developed with an application in mind. In essence the technology was identified before the need.

The second situation is a demand-pull. In this situation the need is identified before the technology is developed. The technology can either be developed exclusively to satisfy the need, or an existing technology can be transferred and customised in order to satisfy the need.

It is clear that the strategies will differ between a technology push and a demand pull situation. In the first case a company will transfer technology, because they feel they can usefully apply the technology. The technology can be applied either in a new application or in a current application, thereby updating older technology. Senior management, however, must have the vision and insight to employ such a strategy, because they must make the connection between the technology and the application thereof.

In the second case a solution to a problem is sought and that will be the motivation for transferring the appropriate technology. For the purpose of this investigation the focus will be on a demand-pull situation.



Technology can be broken down into three main areas. The three areas are knowledge, skills and equipment⁵. For the purpose of this investigation technology transfer is defined as the process where all three these aspects are transferred.

Given the three areas of technology, all the mechanisms of transfer can be categorised in two main categories. Those that are external to the organisation (also referred to as formal) and those that are internal to the organisation (also referred to as informal). External transfer of technology can be controlled in a far easier way than internal transfer. External transfer is the result of conscious decisions (e.g. going to seminars, attending conferences etc.) and can therefore be controlled and managed. External transfer also has a greater strategic intent than internal transfer. Certain aspects of internal transfer can also be controlled, but there are aspects like informal discussions in the workplace or the obtaining of information from experienced co-workers that cannot be controlled. The transfer of only one of the areas will, for the purpose of this research, not be seen as technology transfer, but only as a part of the whole process. Because of its growing importance, a brief look will be taken at knowledge transfer and the management thereof. Complete technology transfer, therefore, takes place when knowledge, skills and equipment are transferred from developer to user.

2.2 Technology Transfer Process

The transfer process of technology can be coupled to the general innovation process. Technology transfer is, however, not present in every step of the innovation process and we will only look at those steps where transfer is involved. The steps can be defined as follow⁵:

- Identifying appropriate technology
- Evaluate the technology
- Secure the technology
- Protect the technology

- Produce prototype
- Obtain technology awareness training
- Product specific training

In order to apply these steps in a more general environment Cooke and Mayes⁵ defined the major steps of the technology transfer process as being:

- Searching
- Finding
- Evaluating
- Acquiring
- Customising
- Operating

It is important to note that in the transfer process, extensive use is made of project management principles. A transfer project is a unique endeavour until the technology is operational in the company. Companies should therefore ensure that they are familiar with project management principles in order to ensure a smooth transfer process.

In the remainder of this chapter each aspect of the transfer process will be looked at in greater detail.

2.2.1 Recognising a need or opportunity

As mentioned before, the initial step in the transfer of technology process is the recognition of a need. This need must be satisfied by current technology applied differently, or it must be satisfied by new technology. Needs can arise from the following⁵:

- Scientific changes
- Competition
- The market

- Legislation
- Human inquisitiveness
- Innovation as company policy

Scientific changes can bring about new products, utilising new technologies. An example would be the development of nylon, which made it possible to solve needs in a technologically advanced way.

Competition together with the market may be one of the greatest initiators of the need to transfer new technology. The market is becoming increasingly fragmented and more sophisticated. This means that an organisation's products or services must be tailored to address the specific needs of individuals. If an organisation does not have the technological capability to do so, it will lose that market to its competitors. Technology can give a business the competitive advantage it needs, to secure its position in the market.

Legislation may also create a need that has to be solved by obtaining new technology. If we think about the aviation industry in general there are, for example, restrictions on the noise levels of aircraft over populated areas surrounding airports. This legislation disqualifies older aircraft from using these airports. A new need arose and subsequently engine noise was reduced by developing 'hush kits', which at that stage was a new technology in the aviation industry. Human inquisitiveness together with innovation as company policy (R&D), always ensures advances in technology.

2.2.2 Searching for technology

After defining a need, an organisation must search for appropriate technology that will best satisfy the need. There are several strategies that can be followed and they can be divided into two major groups. The first is developing the technology yourself and the second is looking for the technology outside the organisation. We will look in more depth at the second case.



Information plays a big role in the search for new, or the most applicable technology. Organisations are particularly interested in information on products, research activities, finance and patent information. One of the successful sources of information and co-operation is higher education institutions in the form of universities. Partnerships with these institutions help companies to:

- Access new technologies
- Keep abreast of new technologies
- Access consultancy skills
- Develop new technologies jointly

The transfer of technology from university to industry can be established in several ways. One must keep in mind that knowledge, which is part of technology as explained in the introduction to technology transfer, is part of a person and resides in their mind. Therefore technology can be transferred through the movement of people.

The first of the transfer mechanisms is graduate employment. At university level people build up a knowledge base in their respective field and this knowledge base is then transferred to industry by employing that person. Industry will often make grants available for people to complete their university studies. In this way they assure a smooth transfer process. A second mechanism is through sabbaticals. Sabbaticals enable university lecturers to work in a company. This is a reciprocal transfer mechanism. The lecturer's knowledge is exploited in the company and the university is exposed to the industry, through the lecturer's practical experience. Further very successful and often used mechanisms include consulting services offered by the universities, contract research, industry/university research units, university or industry liaison units and forums for the exchange of information.

Another major source of information and assistance is technology transfer agencies. These agencies offer a wide variety of services from searches on



information, products and patents, to legal advice and consultancy. These agencies can be very useful for some of them specialise in certain industry areas and therefore have extensive knowledge in that area of industry. For an organisation that does not have specialised skills in the area of technology transfer, this is an excellent alternative to consider. In some cases an external party has a more objective view on the industry and can therefore deliver a more objective opinion, as opposed to individuals inside an industry.

A tremendous amount of research goes into universities, research bodies and industry. For any organisation it is essential that this research be exploited and transferred, in order to strengthen their technological function.

Organisations that do not have the capability of doing their own research should seriously consider partnering with these institutions, in order to have access to relevant research.

2.2.3 Identify and Monitoring Information

Before a technology can be identified that may satisfy a newly identified need senior personnel (managers and above) must have an accurate knowledge of not only the company's technological position, but also knowledge about the market and competitors. This strategy will insure a well-organised approach in obtaining new technology.

Cooke and Mayes⁵ identify the prominent roles found in companies concerning the knowledge of technologies. The first is the *godfather*. This is the person, usually in a senior position in an organisation that watches over the technology transfer process. This person often introduces other senior staff members to the idea of new technology. This is the person that is up to date with the latest developments in his field or market segment, although it is not part of his work description. The role of the godfather may be limited to the development phase of transfer project, or even just the role of initiator. The role might, however, continue throughout the whole transfer project.



The second role found in companies is that of *champion*. The champion is often found at the middle-management level. The people in this role are often highly skilled and will most probably oversee the implementation of new technology programs initiated by the godfather. The role of champion may eventually mature into the role of godfather. The champion has excellent knowledge on internal politics and skills. The person in this role also has great people skills and is a good communicator.

Out of these two roles we see that the godfather's role has knowledge on the internal (to the organisation) state of technology, but even greater knowledge on the external state of technology. If a need arise this is often the person you go to, to ask "How are we going to solve this?" A person can fulfil the godfather role in an unofficial capacity, but with organisations, which realise the importance of technology and the acquiring thereof, this is very often an official role. Where the godfather's main role is over-seeing the transfer process from the external environment, the role of the champion is mostly concerned with the internal environment. His role does not include the identification of new technology, but he is an excellent evaluator of chosen technology, because of his knowledge of internal affairs. The champion will be able to comment on the appropriateness of the technology. Again, the champion's role can be official or unofficial. The role of the champion can be seen as that of a gatekeeper, who not only has excellent technical knowledge, but also has great people skills and excellent leadership qualities.

For organisations that are concerned with keeping up to date with technology, it is important to identify people that might unknowingly fulfil these roles of champion and godfather and exploit their capabilities. It might even be feasible to give these people official capacity in an organisation to fulfil these roles.

2.2.4 Evaluating the Technology

When identifying technology it should be evaluated in order to find the most suitable technology. Aspects that should be addressed in the evaluation process include:

- Strategic implications
- Effect on market and customer
- Operational changes
- Personnel
- Training

Before starting the transfer process an evaluation criterion should be defined in order to evaluate each identified technology. The team responsible for the transfer of the technology, should define aspects to be evaluated and the measurement criteria for each aspect. It is important to involve as many people as possible, especially those that will work with or will be effected by the new technology. By involving all concerned, an objectively defined opinion should be possible and the most appropriate technology can be selected. It must be stressed that the evaluation criteria should consist of objectives and specifications already defined, after the identification of the need. This will aid in the transfer process, for each aspect in the transfer process will be measured or evaluated according to the defined criteria.

2.2.5 Transfer

Transfer of technology takes place via certain mechanisms. These mechanisms can be identified per area of technology as follow⁵:

Technology in the form of knowledge can be conveyed through the following mechanisms:

- In print through technical journals



- In print through learned journals
- Scientific magazines
- Patents
- Orally at conferences
- Orally at learned societies
- In discussions with colleagues
- In discussions with acquaintances
- In discussion with consultants
- On television or radio
- Courses
- Service bulletins
- Data packs
- Specifications

Technology in the form of skills is acquired by doing something. It can be conveyed by:

- Watching someone doing something
- Watching a video of someone doing something
- Demonstrations at courses
- Hands on training

Technology in the form of equipment is conveyed via the following mechanisms:

- Products
- Trade magazines
- Trade conventions
- Sales representatives
- Advertisements
- Direct mail
- Contacts in other companies



2.2.5.1 Company-to-Company Transfer

Technology can be transferred between countries or regions, but most technology transfer happens between companies. Not only is research and development done by institutions in the public domain like universities, but also by private companies outside the public domain. Research done by private companies not always delivers the results they anticipated. For instance technology was developed to be used in a product that does not fit in with their current product portfolio, or the return on a product is too small. This potential product may however, be suitable to another company to develop further. Somehow the cost of research must be covered and if a company cannot properly utilise a product, the cost of research will be lost.

A good strategy would be joint ventures with other organisations, which benefits both parties. Company-to-company transfer is usually beneficial to both parties, except in the case where transfer is attempted between a large established company and a small start-up company. Larger companies are reluctant to put effort into a smaller company to help with their development without a proportional stake. Many governments, however, believe that the future prosperity of their countries, will depend on the speed and effectiveness of small companies to implement technology spin-offs from larger private and public institutions. The success will therefore be dependent on the relationship between the companies.

It is clear that the collaboration between companies is the major technology transfer mechanisms in the private to private domain. There are several forms of collaboration, but for the purpose of this research we will focus on technical collaboration. One form of technical collaboration is where partners increase their expertise through sharing knowledge, skills and equipment. Another form is where one partner is in possession of technology, which the other needs for it's new product. Cooke and Mayes⁵ identified the main aims of collaboration between companies as follows:

- Sharing risk
- Sharing cost

- Growing of technological knowledge
- Helping in product development
- Developing industry standards together
- Acquiring and/or penetrating new markets
- Improving speed to market

Developing new products is a risky and costly business and therefore companies will rather share the risk and cost involved in these projects. Companies also feel more assured if they concentrate on a business area they are familiar with, while leaving other aspects to partners that are more familiar with business in those areas.

Collaboration in itself can be risky because of the fact that companies differ in several aspects. The biggest of the differences may be company culture. Despite all the differences there are several examples of successful collaboration between companies. One of these examples is the Renault Company in France. They are researching together with six partners, new material technology to be used in their products. The six partners are all leading manufacturers of materials. Renault might not see this as one of their core competencies, therefore the partnerships. Collaboration can be a major strategy in an organisation in obtaining relevant technology. One of the most promising collaboration agreements is one where you move away from the traditional client vendor partnership, into a more mutually beneficial relationship. Remuneration will still be sought, but the main benefits for both parties will be the technology transfer between the parties. The transfer will not be one way, but both ways. This is called reciprocal technology transfer⁶. Each party will have an active role to play in negotiations and in decision-making. These partnerships are characterised by mutual goals. Often the one party will be strong in the knowledge field and the other in implementing the knowledge. They will therefore not compete for the same technology, but rather work together applying their specialised expertise to reach the communal goal. These partnerships are often found between universities and industry. Universities need industry in applying their knowledge, and industry

needs universities to effectively apply their skills. Both parties need each other and this factor may have very positive effect on any partnership. Again the greatest stumbling block, also for reciprocal transfer partnerships, is the cultural differences

2.2.5.2 Modes of Transfer

All transfer models can be divided into two major categories. The first category is passive and the second is active². This classification refers to the level of activity in applying the technology in the transfer process. If the technology transfer mechanism presents the technology to the potential user, without assistance regarding it's application, then the mode is said to be passive. In the passive mode only the knowledge part of technology is transferred. The skills surrounding the technology are not transferred. These mechanisms can include presentations in a report. If, on the other hand the provider of the technology assists with the application of the technology, then the mode is said to be active. These mechanisms include training, etc. The boundaries between passive and active are not easy to define and therefore a semi-active mode is also defined.

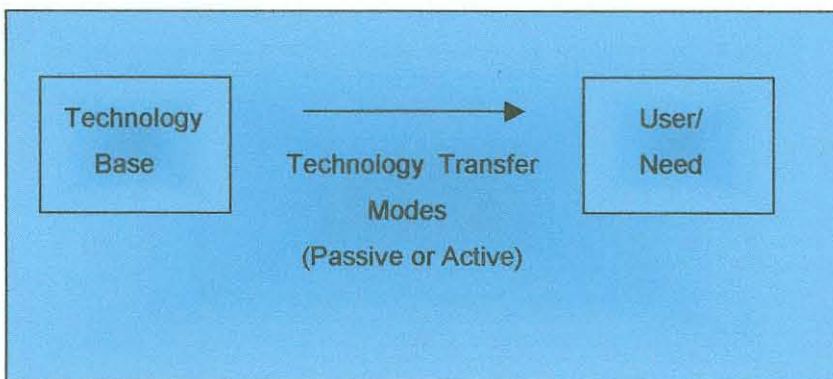


Figure 2.2: Transfer modes
(Adapted from: Louis N. Mogavero and Robert S. Shane²)

Passive Mode²

The most widely used mechanism in the passive mode is the instruction manual or “cookbook” approach. This is the only contact between the originator of the technology and the user. Millions of products are made and sold with transfer occurring in this form. Just think of one’s own motor car. These self-teaching manuals used in this mode all have one thing in common: they presume that the user has some level of knowledge and competence in the specific technological area. It is an important point in this mode of transfer. A mechanic can assemble a component perfectly from an instruction manual. This becomes more intricate when we think of other technologies like glassblowing, sheet metal work and woodwork. In these areas the skill that lies with the user must be far greater. This is important to keep in mind if you want to transfer technology. The skill resting in the user of the technology must be clearly defined by the originator, because this will have a definite impact on the success of the transfer process. If you give someone who does not know how to drive a motor car, that technology, it will be useless to the person, because it cannot be used.

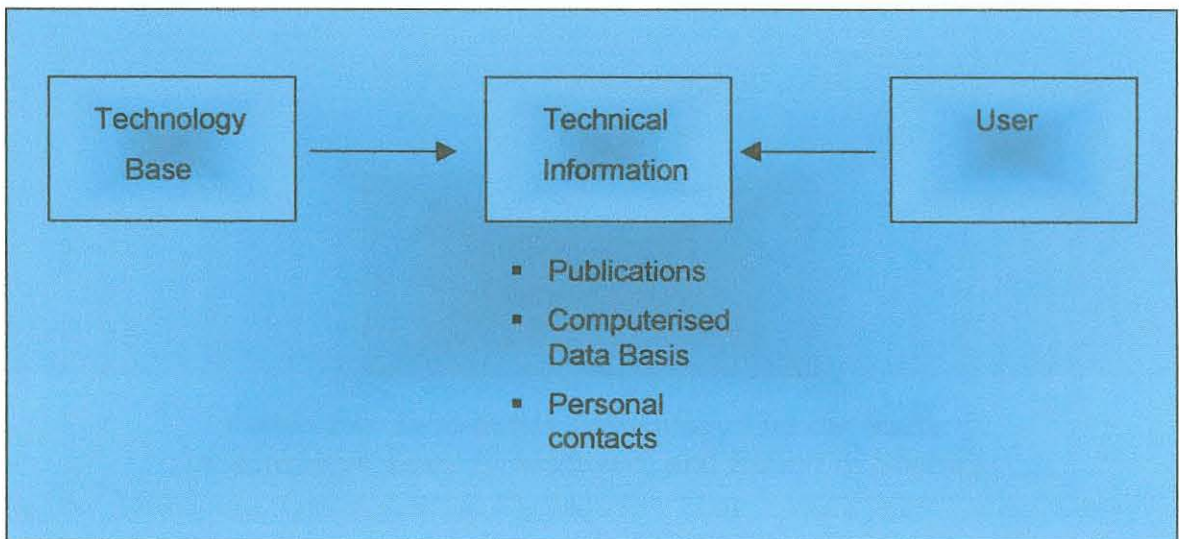


Figure 2.3: Passive Technology Transfer Mode
(Adapted from: Louis N. Mogavero and Robert S. Shane²)

Semi-Active Mode²

In the semi-active mode there is intervention from a third party in the transfer process. This is usually in the form of a transfer agent. In the semi-active mode the role of the transfer agent is limited to that of adviser. Very often in the semi-active mode, the transfer agent only screens information in the relevant field of interest and passes it on to the final user. He therefore ensures the relevance of the information, because of his knowledge, not only about the user's needs, but also because of his knowledge about the technology. The role of the transfer agent is therefore one of communicator between the technology and the user. If his role is beyond this, then the mode of transfer becomes active.

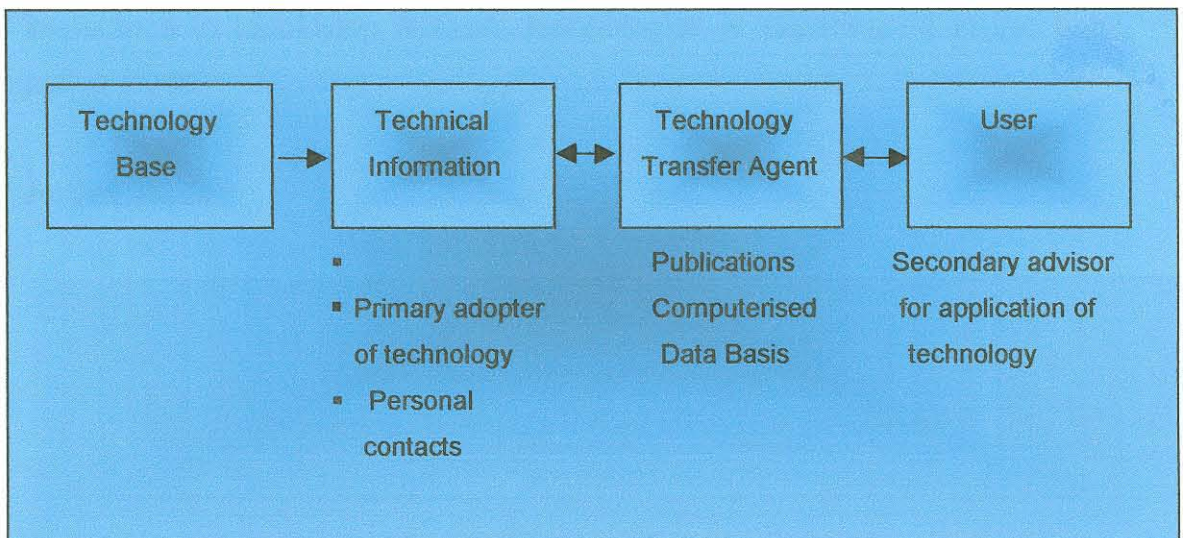


Figure 2.4: Semi-Active Technology Transfer Mode
 (Adapted from: Louis N. Mogavero and Robert S. Shane²)

The most widely used source of technical information is in the form of written technical documentation and therefore the passive mode of transfer is the most widely used. Because of this, care should be taken in the writing of these documents. Very often data banks and published material are searched

in order to obtain information on relevant subjects. Experience has shown that what the first would-be user wants to read is a non-technical description of the technology. Because the reader will be trained in one or more technical disciplines, it will be easy for him to judge the relevance of the document. Because of the increasing amount of data this becomes more relevant. This is a time consuming effort and often it is 'outsourced' to a transfer agent. He will then be responsible for identifying relevant information and transferring it to the user. The transfer agent can be in the form of one or several people working in a team, each within their own field of expertise. An additional benefit of using a transfer agent, is that the user of the technology may have interpreted the problem incorrectly and this is leading them along the wrong path in their search for a solution. Here the agent can be of help because of his knowledge of the user's needs.

The passive and semi-active modes are therefore recognised by the fact that no third party participates in the application of the technology. Only limited assistance in identifying relevant technologies is experienced in the semi-active mode.

Active Mode²

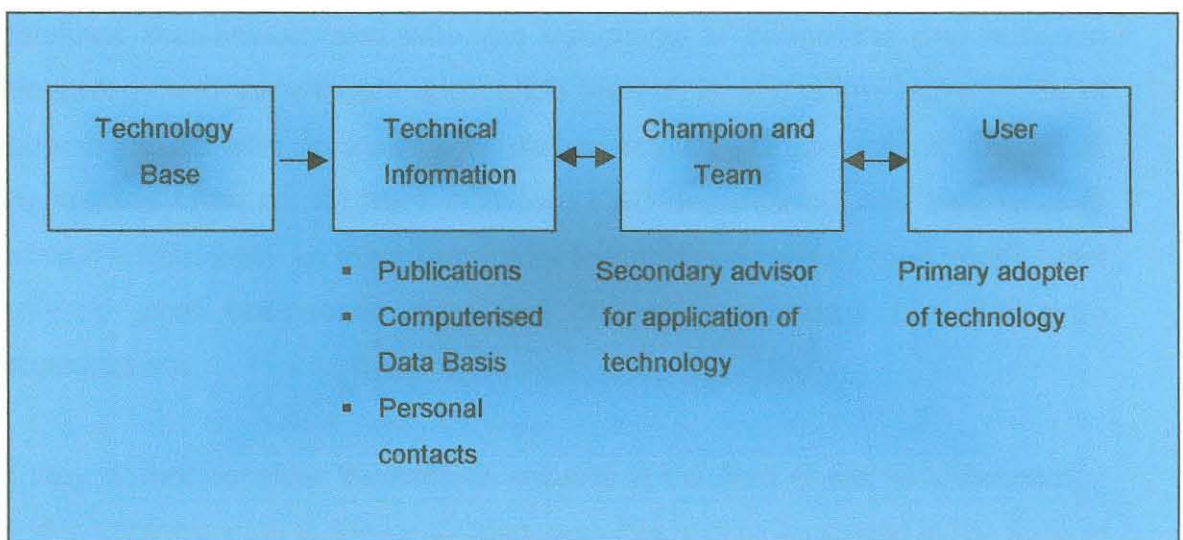


Figure 2.5: Active Technology Transfer Mode
 (Adapted from: Louis N. Mogavero and Robert S. Shane²)