MAINTENANCE TECHNOLOGY TRANSFER IN THE SOUTH AFRICAN AVIATION INDUSTRY

by

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Summary

Title: Technology Transfer in the South African Aviation Industry

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The importance of technology and the management thereof is increasingly being recognised as an important strategic consideration by organisations. Technology underlies every aspect of modern organisations. Specialised personnel should therefore be responsible for the management of technology. The technology used by organisations should be competitive in order for the organisation to be competitive in an increasingly educated market. Organisations should therefore endeavour to manage technology and the aspects surrounding it effectively.

One of the important aspects to be considered in the management of technology, is the transfer of the most appropriate technology to the organisation. Technology is most often developed outside an organisation or as a separate function of the organisation. This necessitates the transfer of the technology from a developer environment to a user environment. The knowledge of technologies used by an organisation, the technologies available to organisations and the technologies used by competitors, may assist decision-makers in selecting the most appropriate technology.

Technology resides in three key areas namely that of skill, equipment and knowledge. Technology residing in these respective areas may enter an organisation via different mechanisms, and some are more effective than others. This study was launched because of the suspicion that aspects surrounding technology are being neglected in the South African aviation

industry. In view of the fact that technology is widely applicable in any organisation, this study will be limited to the maintenance function in the aviation industry.

The study is divided into three main sections namely, an extended literature study, research in industry and a discussion on the findings of the research with reference to the literature study.

The literature study introduces the reader to the aspects surrounding technology, and especially the transfer of technology. Aspects surrounding the transfer of knowledge, which is becoming an increasingly important part of technology, is also addressed. The reader is then further introduced to the aviation industry and to the aspects involved in the maintenance function in the industry. The literature study is concluded with a look at technological developments in the industry.

The research involved the gathering of information through the completion of a questionnaire, by individuals working in the industry. The questionnaire was concerned with aspects surrounding the transfer of technology.

This investigation found that technology transfer occurs internally and also externally to local companies. The perceived effectiveness of the transfer efforts was higher than anticipated. The investigation identified a gap between the technologies utilised and the technologies available to the companies. The investigation also indicated that there was uncertainty to whether formal transfer strategies existed in the companies and whether dedicated people were overseeing such programs. Finally barriers to the effective transfer of technology were identified.

The findings of the research are presented graphically and are then discussed with reference to the literature study. The most important main aspects involved in the transfer of technology are then summarised in a generic model. The purpose of the model is to serve as a reference in the early

planning stages of a technology transfer project, and also to serve as guide against which the progress of the project can be measured.

Aspects considered in this study are felt to assist organisations in the proper management of technology with special reference to the transfer of appropriate technology. By identifying aspects to be considered in the transfer of technology process, this study provides useful inputs to the strategic decision-making and planning process.

Key words: technology transfer; technology management; technology transfer mechanisms; appropriate technology; technology transfer process.

Opsomming

Titel: Tegnologie Oordrag in die Suid- Afrikaanse Lugvaart Bedryf.

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Die belangrikheid van tegnologie en die bestuur daarvan, word toenemend erken as 'n belangrike strategiese oorweging deur organisasies. Tegnologie onderskryf alle aspekte van die moderne organisasie. Gespesialiseerde personeel moet daarom verantwoordelikheid aanvaar vir die bestuur van tegnologie. Die tegnologie in organisasies moet mededingend wees sodat die organisasie mededingend kan wees in 'n toenemend ontwikkelende mark. Organisasies moet, om hierdie rede, tegnologie en aspekte rondom tegnologie behoorlik bestuur.

Een van die belangrike aspekte wat oorweeg moet word in die bestuur van tegnologie, is die oordrag van toepaslike tegnologie na die organisasie. Tegnologie word dikwels buite die organisasie ontwikkel, of in 'n aparte afdeling van die organisasie. Dit noodsaak die oordrag van tegnologie vanaf 'n ontwikkelaar omgewing na die gebruiker-omgewing. Die kennis van die tegnologie wat deur 'n organisasie gebruik word, die tegnologie wat beskikbaar is aan die organisasie en die tegnologie wat mededingers gebruik, kan besluitnemers help met die uitsoek van die mees toepaslike tegnologie.

Tegnologie word aangetref in die drie sleutel areas, naamlik bekwaamheid, toerusting en kennis. Die tegnologie wat in die drie areas aangetref word, kan 'n organisasie binnekom via verskillende meganismes, waarvan sommige meer effektief is as ander. Hierdie studie is geloods omdat die vermoede bestaan dat aspekte rondom tegnologie verwaarloos word in die Suid Afrikaanse Lugvaart bedryf. Omdat tegnologie 'n baie wye toepassing het in

enige onderneming is hierdie studie beperk tot die instandhoudingsfunksie in die lugvaart bedryf.

Die studie is in drie hoofdele verdeel naamlik: 'n uitgebreide literatuurstudie, navorsing in die industrie en 'n bespreking van die bevindinge uit die navorsing, met verwysing na die literatuurstudie.

Die literatuurstudie stel die leser bekend aan aspekte rondom tegnologie en veral die oordrag van tegnologie. Die oordrag van kennis wat 'n al meer belangrike deel van tegnologie word, word ook aangespreek. Die leser word verder bekendgestel aan die lugvaartbedryf, asook die aspekte betrokke in die instandhoudingsfunksie in die bedryf. Die literatuurstudie word afgesluit deur te kyk na nuwe tegnologiese ontwikkelings in die bedryf.

Die navorsing het behels die insameling van inligting deur die voltooing van 'n vraelys deur individue wat in die bedryf werk. Die vraelys het gehandel oor aspekte rondom die die oordrag van tegnologie. Hierdie navorsing het gevind dat daar wel interne asook eksterne tegnologie oordrag plaasvind in die onderskeie maatskappye. Die gevoel is dat die effektiwiteit van die tegnologie oordrag projekte hoër is as wat aanvanklik vermoed is. Die navorsing het 'n gaping geidentiviseer tussen die tegnologie wat tans deur die maatskappye gebruik word en die tegnologie wat beskikbaar is aan die maatskappye. Die navorsing het ook aangedui dat daar onsekerheid is of daar enige formele tegnologie oordrag strategië in die onderskei maatskappye bestaan en of daar toegewyde mense is wat omsien na die tegnologie oordrag funksie. Laastens is daar verskeie hindernisse geidentifiseer wat in die pad van gladde tegnologie oordrag staan.

Die bevindinge van die navorsing word dan grafies voorgestel en bespreek met verwysing na die literatuurstudie. Die belangrikste oorhoofse aspekte wat betrokke is by die oordrag van tegnologie, word dan saamgevat in 'n generiese model. Die doel van die model is om as verwysing te dien tydens die beplanningsfase van 'n tegnologie oordrag projek, asook 'n maatstaf waarteen die vordering van so 'n projek gemeet kan word.

Die gevoel is dat aspekte wat oorweeg word in hierdie studie, organisasies kan help in die behoorlike bestuur van tegnologie, veral in die oordrag van toepaslike tegnologie. Met die identifisering van aspekte wat oorweeg moet word in die tegnologie oordrag proses, voorsien hierdie studie bruikbare insette tot die strategiese besluitneming- en beplanningsproses.

Sleutel woorde: tegnologie oordrag; tegnologie bestuur; tegnologie oordrag meganismes; toepaslike tegnologie; tegnologie oordrag proses.

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"Winners do what losers don't want to do."

- Dr. Phillip C. McGraw –

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Chapter 1 - Background

1.1 Purpose of the research

The purpose of this research can be divided into four main objectives:

- The first objective of this project is an investigation into the South African Aviation industry, with reference to the technology transfer activities and the resulting strategies.
- The second objective is to investigate the mechanisms used in the transfer process.
- The third objective is to focus the role-players in the South African industry's attention on the important role technology can play in their industry.
- The final objective is to introduce the technology transfer process and provide a model that describes this transfer process. The model identifies the main activities involved in technology transfer and can be used as a measuring tool, for output or for the progress of the transfer project.

Similar studies have been done internationally and in other industries. No similar studies however, have been done specifically in the South African Aviation Industry. The feeling is that not enough emphasis is placed on technology and the role technology can play in creating a competitive advantage. Technology underlies every business area and a company will have a clear disadvantage when competing against new technology. This is especially true for highly competitive industries like the aviation industry. It becomes even more important when one remembers that South Africa only recently entered the international arena and concepts like competition, profit and competitive advantage, are becoming increasingly important. Technology is underlining every aspect of the modern business. Therefore each organisation should have a thorough knowledge of technology relevant to their organisation. The benefit of transferring appropriate technology may

result in an increased market share and higher growth rates. Technology can also provide a competitive advantage.

1.2 Technology Transfer

The purpose of this section is to define exactly what 'technology transfer' means. Let us start with the concept, 'technology'. For the purpose of this investigation 'technology' is defined as "specialised knowledge applied to achieve a practical purpose". In other words, scientific knowledge is applied to develop a product or service in order to satisfy an existing or new need. Technology is therefore the culmination of intellectual and physical ingenuity, in order to augment human skill[1]. It is clear that knowledge forms a very important component of technology. In fact, if knowledge is removed, you do not have technology anymore[2].

The second concept is 'transfer'. For the purpose of this investigation, transfer not only retains its defined meaning of "moving something to another location", but also includes the use of the transferred item. This concept is illustrated by the following example. If a computer program is bought, the intended functionality has not been transferred to the buyer of the programme. Even if the programme is installed, the functionality has not been transferred. Only when the buyer uses the programme, then certain functionality has been transferred.

Technology transfer therefore means movement of technology, consisting of knowledge, skills and equipment, from an originator's environment to a user's environment. No transfer has however taken place unless the transferred technology is used.

Technologies can be found in a wide range of business areas like manufacturing, marketing, customer service, etc. This investigation will focus on the technologies used in the maintenance function.

1.3 The Aviation Industry

Since 1994 major changes have taken place in South Africa. These changes have affected many industries and the South African aviation industry, is no exception. In a very short period of time new markets have opened that were previously inaccessible, and a number of foreign operators have extended their services to South Africa. Subsequently, Johannesburg International Airport has become the largest airport in Africa in terms of the number of passengers and amount of cargo handled annually.

In the past the aviation industry was forced to be self-sufficient and to operate without any assistance. This effected most areas inside the aviation industry, including the maintenance function. Parts necessary to service aircraft were not always available and skills were developed to repair most parts used on the aircraft. Very unique skills were developed during this time in order to ensure the availability of aircraft. Due to the unique circumstances, company cultures were established, which could be described by an attitude of 'we can do anything' and this was necessary in order to survive and continue operations.

The major role players in the South African aviation industry were state-owned and profit was not the main objective of these companies. Concepts like 'competition' and 'competitive advantage' did not receive the same attention as in companies operating in an open market. Many international carriers were not allowed to operate routes to South Africa and this limited the competition that South African carriers faced. It is clear that the industry functioned in an artificial market, where the market forces were different from what is traditionally expected. Companies in the industry became large organisations, which incorporated every aspect of the aviation industry 'under one roof'. The reason being that it was expected of these companies to be self-sufficient and diversified enough to handle anything. Traditional sources of technology were not available/accessible and this resulted in the heavily relying on their skills and customised knowledge to keep the operations going.

This all changed after 1994 when South Africa was accepted back into the world community. One of the first industries to be exposed to the new dispensation was the aviation industry, as a result of the nature of its service, namely transporting passengers and cargo nationally and internationally. Suddenly the industry experienced competition because large international carriers were allowed to service South African routes. The South African industry was forced to re-evaluate its position and no longer had to be self-sufficient, but had to be competitive in a global market. Even individual functions like 'maintenance' had to re-evaluate their position and objectives, as they too were faced with direct competition. The industry also started with privatisation talks and suitable international carriers were sought as partners. Time and cost began to play a more important role, as these are competing factors in international competition. The industry also started to follow international trends in a bid to become more competitive. Airlines started to focus on their core business of transporting passengers and goods, while outsourcing other functions like maintenance. Sources of technology also started to open up and become more accessible.

The military industry too began to move away from the way things were done in the past. Maintenance, for instance, began changing from a mainline function to a support system. Because of the relative small local market and an industry that requires very specialised skills, many specialised tasks will in future be outsourced. This is due to the fact that it is expensive to retain these specialised personnel and a company is not able to fully exploit the specialised skills of the workforce, because the skill is only needed once or twice a year. In short there is not enough work to employ a specialist and train him/her for a specialised procedure.

The support system being implemented by the military industry, aims to ensure mission-ready and mission-capable aircraft. In order to reach this objective, the following four main functions were identified:

- Mission preparation

- Servicing
- Repair
- Mission functionality

Mission preparation

Before each flight (mission) the support system ensures that the aircraft will be able to complete the flight and accomplish all its mission goals. Third party involvement will be restricted to optimisation of this function regarding its cost-effectiveness.

Servicing

This includes the traditional functions associated with servicing parts and aircraft. Outsourcing will play a bigger role in the function of servicing.

Repair

This includes the repair of components and aircraft with much of the work being outsourced.

Mission functionality

Military aircraft are used as platforms to fulfil many different functions. Outsourcing will not play a major role in this function.

In order to execute the support system effectively, knowledge of the product is necessary up to a certain level, in order to complete certain tasks. The military aviation industry has therefore defined the level of knowledge needed for each function, in order to perform their work effectively. In Table 1.1 the level of knowledge on a scale of 1 to 10 required, for each task is indicated. One on the scale of the knowledge base (KB) indicates 10 % of the total knowledge of the system, while 10 indicates 100% knowledge of the whole system. In Table 1.1 it is indicated that between 10% and 20% knowledge of the whole system is needed, in order to operate the system effectively. By defining the knowledge needed to complete a task successfully, 'redundant' knowledge

can be removed from the support system. Tasks that fall outside the current knowledge base are outsourced. This is a good way to manage knowledge.

Task	Description	KB
Operate	All activities, procedures, processes and resources required to operate a product.	1 – 2
Measure	All activities, procedures, processes and resources required to measure the performance of a product.	1 – 3
Maintain	All activities, procedures, processes and resources required to maintain a product.	2 – 6
Analyse	All activities, procedures, processes and resources required to analyse a product.	4 – 7
Change (physical)	All activities, procedures, processes and resources required to change a product. Functional requirements remain the same, while form and fit might change.	6 – 7
Change (functional)	All activities, procedures, processes and resources required to operate a product. This entails both functional and physical change.	7 – 8
Re-Specification	All activities, procedures, processes and resources required to re-specify a product. Re-specification will lead to re-design, including both physical and functional change	8 – 10

Table 1.1: Knowledge Base

It is clear that the civil and military aviation industries are adapting to a new environment with different forces and they are utilising new strategies. This is necessary, because they face new challenges each day and in order to survive in a competitive market, new innovative ideas are needed.

1.4 Overview

The objective of the overview is to serve as a guide for the various chapters. It includes the motivation for each chapter and a short description of the contents.

1.4.1 Chapter 2 - Technology Transfer

Chapter 2 describes in detail all the aspects involved in the technology transfer process. This is an in- depth look at the theory behind the transfer of technology. Some tools are presented in this chapter, which may help in aspects like determining the technology portfolio of an organisation. The chapter is concluded with an example of a technology transfer project between two companies.

1.4.2 Chapter 3 - Knowledge Transfer

Chapter 3 covers some aspects concerning the transfer of knowledge. As we enter the knowledge age, knowledge is becoming an increasingly important aspect of technology. This is the motivation for this chapter and some aspects in the transfer of knowledge are highlighted. Two models are presented, which describes some of the aspects involved in the knowledge transfer process.

1.4.3 Chapter 4 - The Aviation Industry

Chapter 4 is divided into three parts. The first part looks at maintenance and factors that influence maintenance. The second part presents trends in the aviation industry. The leaders in the industry set these trends. The trends are divided into the four main areas namely: training, collaboration, maintenance and outsourcing. The third part of Chapter Four presents technological developments in the aviation industry. Some of the technologies used in the

aviation industry are presented in this section together with the latest technological advancements.

1.4.4. Chapter 5 - Research

Chapter 5 describes the research that was conducted in the industry. This chapter starts off with the research problem and a number of hypotheses. The research methodology is then presented, followed by the results and the discussion of the results.

1.4.5 Chapter 6 - Transfer Model

Chapter 6 describes the newly proposed model. The aim of the model is to identify the major aspects involved in the technology transfer process. This model may act as a guide in assisting people involved in the management of technology, especially in the area of technology transfer. The model identifies all the phases in the transfer process and indicates how the project moves through these phases.

1.4.6 Chapter 7 - The future

Chapter 7 is a look into the future. It describes a possible scenario of what the future may hold for the Aviation industry. The aim of this chapter is to introduce possible scenarios to the major role players in the industry, and to stimulate thinking into what technologies may be used in the future.

1.4.7 Chapter 8 - Conclusions and Recommendations

Chapter 8 contains the conclusion based on the previous chapters as well as recommendations on possible future research.

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 include[3]:

- 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.

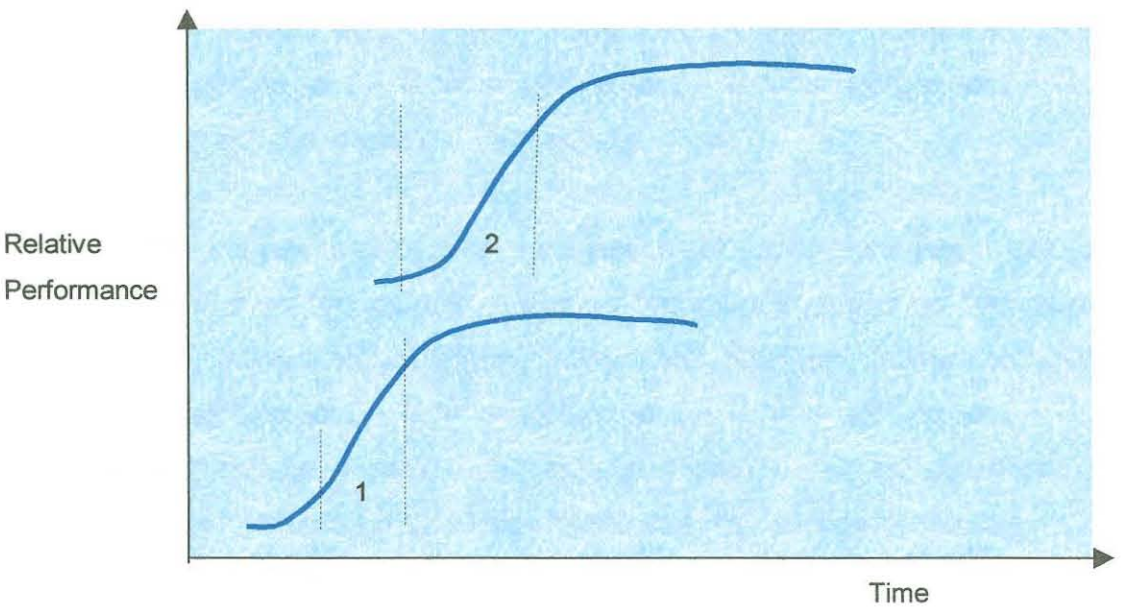


Figure 2. 1: S-Curves

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 are[3] 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 forces[4]. 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 equipment[5]. 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 follow[5]:

- 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 Mayes[5] 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 following[5]:

- 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 Mayes[5] 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 follow[5]:

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 Mayes[5] 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 transfer[6]. 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 active[2]. 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.

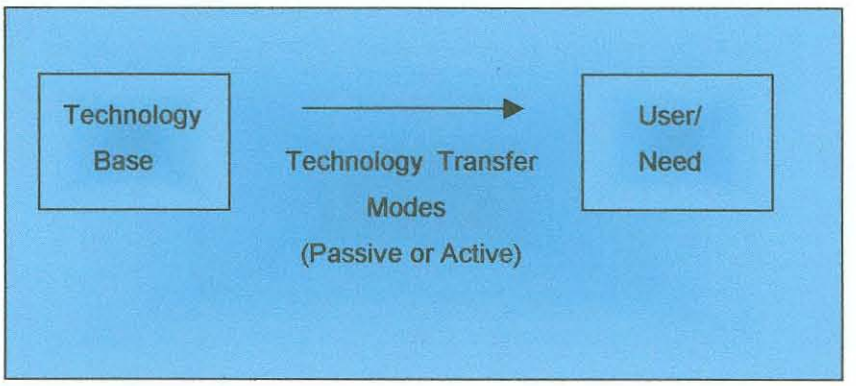


Figure 2.2: Transfer modes
(Adapted from: Louis N. Mogavero and Robert S. Shane[2])

Passive Mode[2]

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.

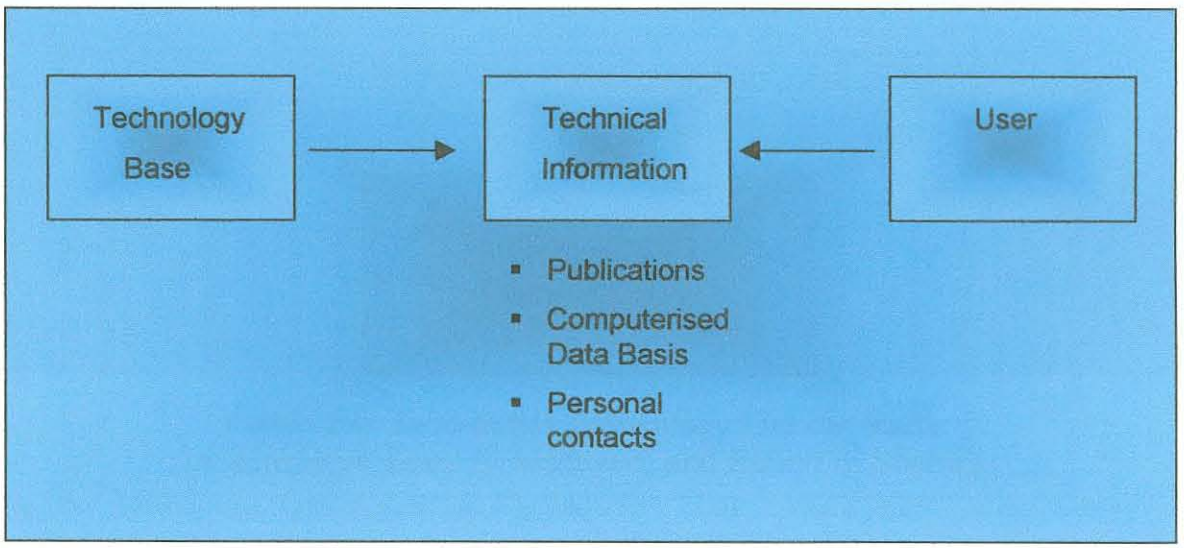


Figure 2.3: Passive Technology Transfer Mode
(Adapted from: Louis N. Mogavero and Robert S. Shane[2])

Semi-Active Mode[2]

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.

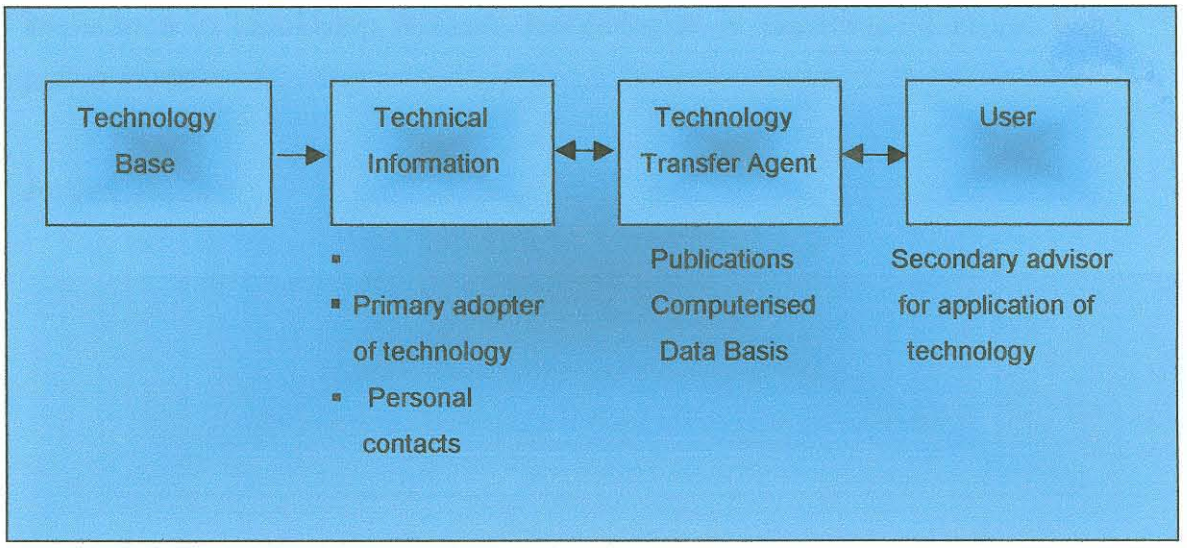


Figure 2.4: Semi-Active Technology Transfer Mode
(Adapted from: Louis N. Mogavero and Robert S. Shane[2])

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 transfering 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 Mode[2]

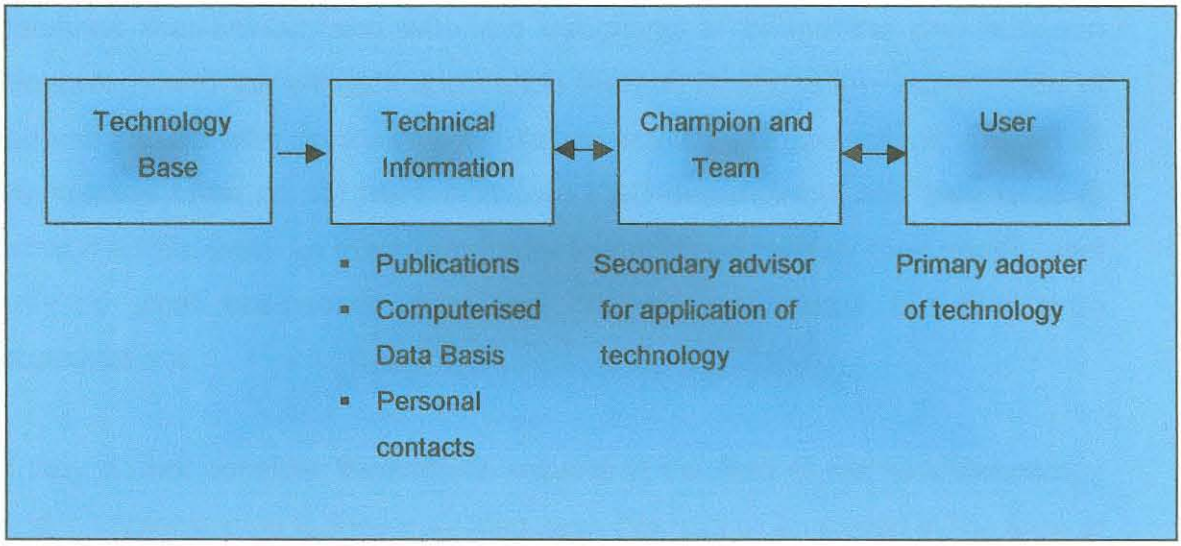


Figure 2.5: Active Technology Transfer Mode
(Adapted from: Louis N. Mogavero and Robert S. Shane[2])

In the active mode not only knowledge is transferred, but the process is carried through to an actual demonstration of the technology. In this mode of transfer not only words and pictures are transferred; a working system is installed and demonstrated to the users thereof. The transfer process even goes further than this. The user is trained to use the technology. It is clear that the technology transfer agent plays a key role in this transfer mode. The agent does not only identify relevant technologies, but also help with the identifying of the most appropriate technology. He then helps with the implementation of the new technology and the training of personnel that will be using the new resources. In order to do this successfully, the agent must have a clear understanding of what the user's needs are. The agent must also have a very good understanding of the technology, or must be able to quickly get up to speed in familiarising himself with the technology. The agent must be able to interact with the non-technical and/or technical user on the one hand and the very technically orientated developers of the technology on the other hand. The agent is no longer a feeder of information as in the semi-active or passive modes. The agent has become a technologist, who seeks, evaluates and implements technology in order to satisfy a need or solve a problem.

Under certain conditions organisations with problems implementing technical solutions themselves, and who are struggling to bridge the gap between technology and the ultimate application thereof, is where the active mode of technology transfer is most likely to be found. Organisations like small businesses often do not have their own R&D departments and they have to consult a third party on introducing new technology to satisfy their needs. Not only do small businesses make use of the active model, but also large organisations.

If they do not consider themselves experts in the field of the new technology and in implementing it, they may also seek the help of an expert in the form of the transfer agent. The transfer agent will also be able to customise the

technology in order to be user friendly in the environment, it is to be implemented. The transfer agent is expected to understand each aspect of the technology, while the user is only expected to understand aspects of the technology in order to use it successfully to their advantage. The success of the active mode of transfer is measured by the degree the ultimate user of the technology is satisfied. Louis N. Mogavero and Robert S. Shane[2] have identified seven aspects, (as a minimum) that must be present in order to assure the success of the transfer process. These are:

- Firm statement of user needs
- Clearly stated and understood boundary of solutions
- Firm commitment by the user to remain actively associated during and after the transfer
- Participation of representatives of influential interested organisations.
- Market analysis
- The manufacturer
- The Champion

The user is responsible, together with the transfer agent to clearly state the needs of the user. If one does not know exactly what the problem is, one will not find a solution, or you might find a solution, but to the wrong problem. The number of solutions to a problem may vary dramatically and therefore a boundary must be defined, within which the ultimate solution must fall. The constraint on the solutions may be of cost, weight, size, etc. The responsibility of defining the solution boundary lies with the user. This should be done as early as possible in the transfer process.

As the transfer process evolves, there is a probability that the selected technical approach may lead to a dead end or it may require a new concept. It may even lead to a whole new solution. A firm commitment is therefore needed by the user, to remain actively involved in the transfer process. There must be certain flexibility in the thinking of, not only the user, but also the transfer agent. Pursuing one solution may bring forth another solution and

both parties must be aware of this. Both parties cannot allow a setback to deter them from finding a suitable solution.

The user must also ensure, beforehand, that the search and implementation of the new technology is well accepted by organisations within the user's environment. These include labour unions, management associations', etc. The more actively these organisations can be involved in the transfer process, the greater the probability of success will become. The user must show how the implementation of the new technology will benefit all concerned. If this is not done, a group can derail a transfer project that would have brought major benefits to the user.

One of the factors that may have the most negative impact on a transfer process may be something that lies outside the process. This factor is market acceptance of the new technology. Every aspect of the transfer process may be executed to perfection to bring forth a solution, but if the market does not accept the solution all the effort would have been wasted. This is the reason why a good market analysis should form part of any good transfer process. The effect of the technology on the market place can therefore not be ignored. Another big role player in the transfer process is the manufacturer or developer of the product or solution. It is important to identify and consult him/her as early as possible in the transfer process for they can play an important role in the development of the ultimate solution. The last of the seven aspects, is the champion. This is the motivator for the whole project from the user's side. This is the person that gives direction to the project and keeps people motivated to see the project through.

2.3 Barriers to transfer

The following can be seen as barriers to technology transfer or factors that may have a negative impact on the transfer of technology[5]:

- Management attitudes

- Resistance to change
- Poor information flows
- Poor communication
- No time
- Too expensive
- Current product/procedures meet the needs
- Too much red tape
- Knowledge and skills adequate

Some of these aspects may have a greater influence on the transfer of technology from outside an organisation, than on the transfer process inside an organisation. Management attitudes can greatly impact on the transfer of appropriate technology from outside the organisation, because they are in a decision making position on the part of the organisation. The impact of management's attitude will not have the same effect on the transfer process inside the organisation, and the effect may be especially small when looking at the informal side of the transfer process.

Resistance to change has a greater effect inside the organisation than from the outside. If top management does not steer the company in the correct direction, the organisation may cease to exist and the reluctance to change may mean the end of the organisation. When one looks at the situation inside the company, there is far greater reluctance to change. Unwillingness to change inside a company does not necessarily mean that the organisation will not succeed. It is difficult to change the mindset of people if procedures have not changed for the past 10 to 15 years. 'I have been doing this for 10 years, why must I change now', is an often heard comment in the workplace. Therefore the reluctance to change increases as one moves down the hierarchy of the company, because change may secure the future of the company and not all levels in the company may see it that way.

Poor information flow and poor communication may be one of the greatest barriers to transfer experienced in the South African Aviation industry. Poor communication inside an organisation may be the killer of innovative ideas on

aspects like productivity. Very often the people working with a certain technology are not consulted when management starts looking for more effective ways of applying technology. It is also of great importance that management knows the state of the industry their organisations have to operate in. Internal communication channels must be developed inside their industries in order to stay familiar with the latest advances in technology in their industry. By doing this they can identify gaps between the technology they use and the technology available in the industry and try to narrow these gaps. In the current competitive environment, organisations cannot compete with old technology.

As we saw, the transfer process takes time and many managers see this as lost time. They must however keep in mind the benefits of the new technology, compared to the old technology. If a proper transfer model, however, is in place the effort and the time may be reduced substantially, especially if there are dedicated people that are responsible for the technology transfer projects.

The issue of cost may also be a barrier. Again proper care must be taken and the pros and cons of new technology replacing older technology, must be weighed against each other.

If the current knowledge base or products/procedures meets the current needs, there is no reason for transfer of new technology. This cannot really be seen as a barrier, especially when looking at the short term. It can however become a barrier when looking further into the future, especially when current technologies are still fulfilling their function. The reasons for looking at new technologies are not easily justified in this situation.

Too much red tape may also be a barrier to the transfer process. Red tape may be a combination of one or more of the other barriers mentioned. The attitude of people towards the transfer of technology, may also play a big role as a barrier to transfer.

2.4 Internal technology review (audits)

Internal technology reviews are a very important exercise for any organisation in order to define their technological position. A review of this kind usually covers three important aspects. These aspects are:

- Review of the company's technological position
- Review of competitor's technological position
- Review of state-of-the-art technology

These three aspects translate into 'what they've got, what we have, and what we could have.' A review of this nature has a few benefits, apart from defining an organisation's technological position. It helps to create an awareness of people concerning technology. It also keeps people informed and this may translate into better decision-making. The difference in technology used by an organisation and its competitors, may translate into competitive advantage or disadvantage, as seen by the organisation. A review of this nature can therefore have a great impact on the realisation of competitive advantage and an organisation can see, as a result of the review, where they are, or why their competitors have the competitive advantage. Another outcome of the technology audit is the technology portfolio of a company. The portfolio is a list of technologies used by an organisation. A review also defines an 'external' portfolio. This is a portfolio of technologies that is available to the organisation.

Great care has to be taken when launching a review of this kind. The biggest problem is always to obtain an objective view. For this reason special care must be taken in selecting the individuals that will participate in the audit. It should be people across the organisation and from all hierarchies, which are directly involved or effected by the technology and the change it will result in. A proper workshop should explain the goals of the exercise, and all participants should have a clear understanding of the process. Internal as well as external views can be obtained from suppliers and/or customers. The

difficult part is obtaining information concerning technologies used by the competition.

Cooke and Mayes[5] propose the following checklist that a review should ask of any organisation.

What is the current situation?

- What are the key technologies and know-how on which the business depends?
- What is the company's status in these technologies? Are we leaders or followers? What technology may be developing outside, which may adversely affect the current situation in the market?
- How did the company acquire these technologies? Were they made in-house or brought in?
- Have we looked at everything to do with our current technology? Are there no new things we could do with it?
- How do the company and its existing products compare with its customers' expectations?
- How much longer is the current technology going to last?
- What processes and policies are in place to identify product life?
- What relative technological strengths and weaknesses are there in comparison to the competitors? Are there some products or technologies held onto merely for historical reasons?
- What presently drives technological management? Quick fixes? Operational profit? Strategic considerations?

What does the company intend to do?

- What is the proposal for the new technology?
- Can the company sell the existing technology and gain from being "ahead in the game"?

- Has the company optimised its exploitation of the technologies beyond integration into products? Has it maximised the technologies through strategic alliances, licensing, joint ventures or co-operative R&D?
- Have strategic alliances been developed to obtain basic or distinctive technologies?

What can we make the situation become?

- How will continuing with the new technology affect the company's status in the market? Will it enhance differentiation? Technological lead? Product or service uniqueness? First-mover advantages?
- Has this sort of thing ever been done before? If so, what is the track record, or what can be learned from the previous experience(s)?
- How effective is internal transfer of technology? What communication networks are in place? Are they formal of informal?
- Have the barriers to effective transfer of information been identified and removed?
- Are the technical personnel available to fully exploit the technological opportunities?
- Is there a process in place to integrate the technology and strategic business planning? If so, how effective is it?
- Is the full support of all of the management of the company in place? This is a key milestone in achieving the goal of the new technology.
- Does the company fully believe in the technology and its success?
- Have the technology audits been effective in highlighting areas not previously covered?

Technology Space Maps

As we have seen, it is important to know what technologies are available to the company and what technologies the immediate competition employ. G. De Wet[7] suggested a technology space map (TSM) as a tool that can be used in auditing a company's technological position. A technology spacemap is a

practical tool for assessing technological capabilities. It is therefore an ideal tool to use in a technology audit. By looking at this map the experienced technologist can determine the scope and content of technology and this act as launch pad to initiate appropriate transfer projects.

Figure 2.7 indicates a typical spacemap with the one dimension being the system life cycle and the other, the system hierarchy. These maps are very flexible and any two dimensions can be specified in order to customise the map for individual companies.

The TSM can be expanded to include a third dimension as shown in Figure 2.8. The third dimension defines the technology or technologies used in each of the areas specified on the TSM. For instance the identified area in the matrix Product-Maintain will have certain technologies associated with it, and so for each area in the matrix the technologies can be listed. If a company wants to extend their business into new areas, it is indicated on the TSM and the additional technologies needed to expand their business can then be listed.

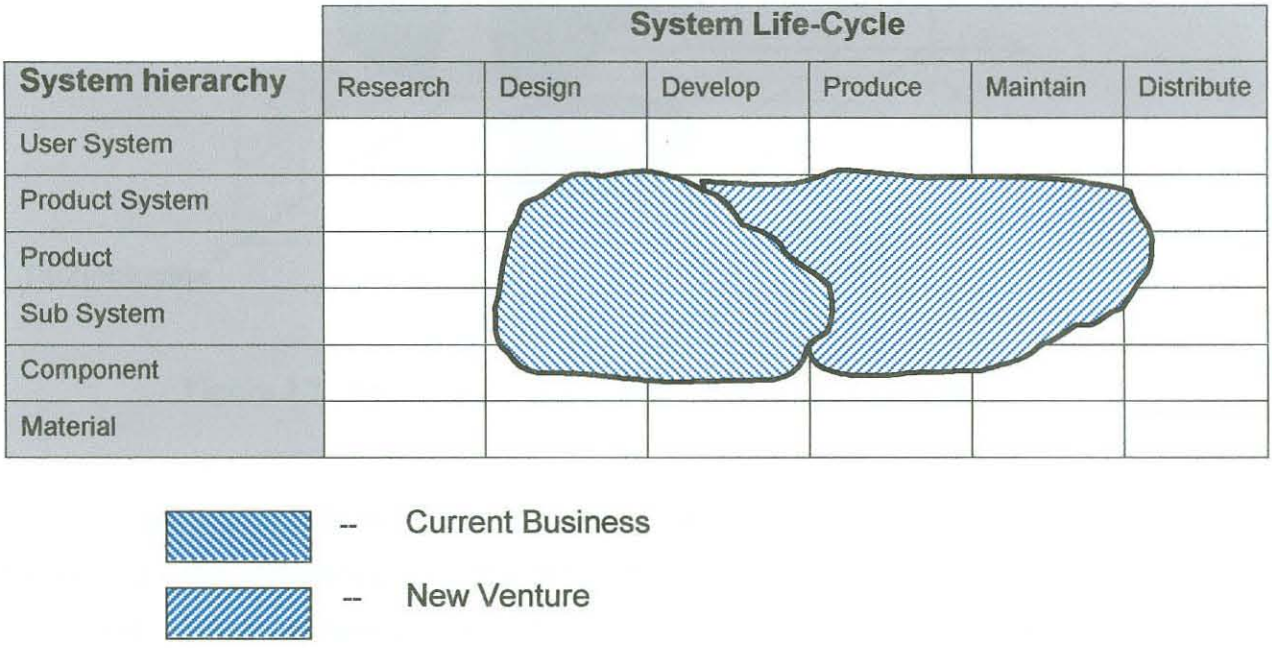


Figure 2.6: Technology Space Map – Two dimensional
(Adapted from: G. De Wet[7])

Technology Balance Sheets

Another very useful tool also suggested by G. de Wet[8] is the technology balance sheet. The technology balance sheet provides a snap shot of where a company stands and where to go concerning technology. One of the main functions of a TBS is providing a list of technologies relevant to the current business. The TBS also gives an indication of which technologies available to the company, may be relevant to the company when expanding into new products or markets. In Figure 2.9 we can see that the products with their relevant markets, processes and technologies are indicated.

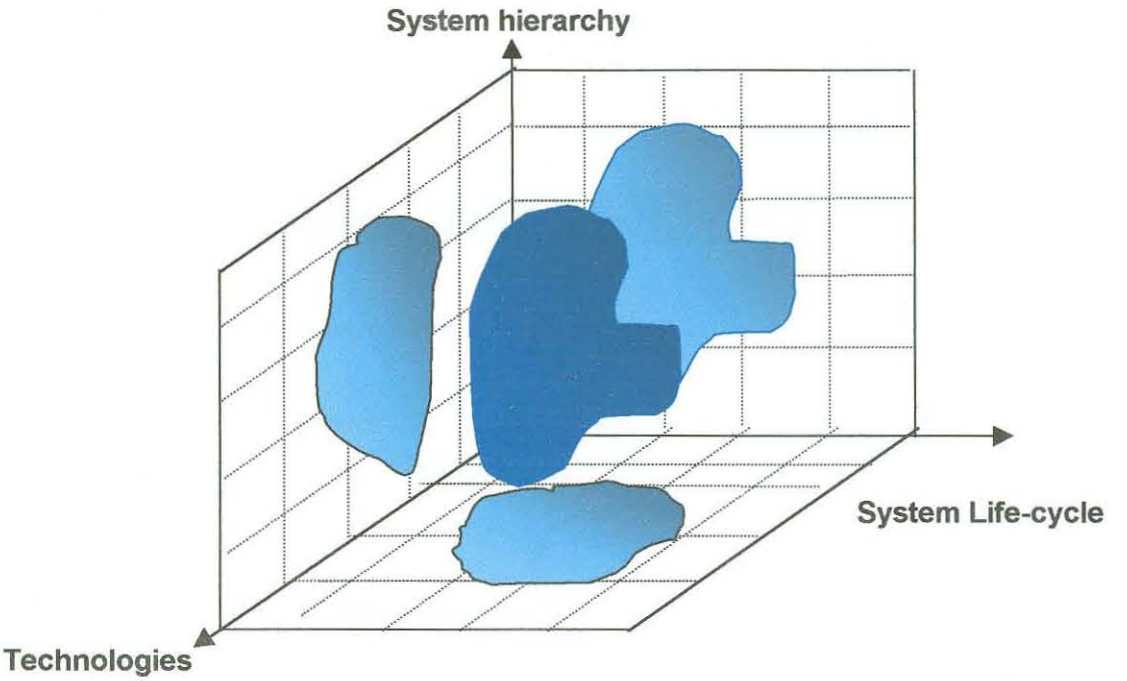


Figure 2.7: Technology Space Map – Three dimensional

The TBS also indicates the ease with which new technologies can be identified when expanding into any of the dimensions in the TBS. It can also help with identifying new products and markets when a new technology can be obtained or developed in-house.

Any company involved in a technology audit should consider the use of these two excellent graphical tools in order to define their technological position. A good intelligence strategy can help you to learn from the best practice of competitors. It also assures that an organisation obtains new technologies that are available and also ensures good internal communication.

				Product 1	Product 2	Product 3	Product 4
			Market 1	x		X	x
			Market 2	x	x	X	x
			Market 3	x		X	
Technologies							
T0	T1	T2	Processes				
	x	x	Process 1	x	x	X	x
	x	x	Process 2	x		X	x
x		x	Process 3		x		x

- New product introduction

Figure 2.8: Technology Balance Sheet
(Adapted from: G. De Wet[8])

2.5 Managing Change

In order to be successful in implementing new technology into an organisation, a certain level of change must take place. New technology means doing things in a new and different way. Many organisations are not geared to incorporate these changes in their organisations. An excellent technology can fail in its application due to the fact that it is not well accepted. Companies that will be successful are those who will be able to adapt fastest to newly incorporated technology. In their book, Cooke and Mayes[5] compare traditional companies to innovation companies. The comparison can be seen in Table 2.1.

It is clear that the traditional (old) way of doing things is very rigid and inflexible. This type of company does not like change. A culture of 'change is bad' exists and with this attitude any change will feel as if it is forced upon the company. This can become a vicious circle, because forcing change on people, will only make them more negative towards change. The fact that people do not have control or say in the process of change acts as contributing factor towards a negative attitude.

Criterion	Traditional	Innovative
Culture	▪ Closed ▪ Directive ▪ Based on attitudes derived from the past.	▪ Open ▪ Explores new approaches ▪ Facilitating
Strategy	▪ Rigid ▪ Formal representation and justification of status quo	▪ Proactive ▪ Focus on opportunity ▪ Identification of desirable change
System	▪ Inflexible ▪ Optimised to run tight inflexible ship	▪ Flexible ▪ Able to accommodate change but still maintain a tight ship
People	▪ Servants ▪ Perform tasks allotted to them	▪ Initiators ▪ Business involvement
Orientation	▪ Internal (Focussing on avoiding internal disruption)	▪ External (Focussing on meeting customer needs)

Table 2.1: Comparison between traditional and innovative companies
(Adapted from: Cooke and Mayes[5])

In the innovative company far more flexibility towards change is present. People are involved from the beginning when change are planned. A culture of 'change is necessary' exists and people are made aware of why they have to change. Technologies drive business and technology is dynamic. Technologies are improved or even substituted by newer technologies on a continuous base, therefore companies should also be dynamic in order to stay competitive.

In the light of this companies should start out with the correct mindset, for culture is something that is not easily changed. Attitudes from management must rub off on the work force and it is important for management to actively encourage the correct culture in a company. For older companies that are stuck in the wrong culture, it is important to realise the importance of change. 'Adapt or die' is very often the scenario they face, but many companies do not even recognise this fact. Companies in this situation embark on big renewal programs after realising what the position is that they find themselves in. These programs can only be initialised after a commitment to change has been made. This is the most difficult step in the whole process. In these companies very often mangers and directors have the same mindset and in this case the company should seek help outside the company.

To be competitive, companies should strive towards an innovative culture and they should break away from the burdens of a traditional outlook. Cooke and Mayes[5] suggest the following basic rules for moving towards an innovative culture:

- Turn specialists into generalists
- Pool knowledge and make it accessible
- Break down traditional hierarchies of control
- Improve communication through the company
- Ensure that people understand that some mistakes will be made and it is alright, as long as they learn from those mistakes
- Allow time for thinking

2.6 Value of technology transfer to the company

The benefits of transferring appropriate technology has been categorised by Cooke and Mayes[5] as follow:

- Increased competitive advantage
- Improvement in quality

- Cost savings
- Flexibility
- Reduction in lead times
- Better service to customer

Identifying, transferring and implementing appropriate technology can be beneficial to a company in the above mentioned areas.

2.7 Risk of failing when introducing new technology

In any technology transfer project there is a certain element of risk involved. The risk element stems from uncertainties. These risks can be of a technical, commercial, economic, timing or human nature. However, with good management and proper planning, the risks can be reduced. Factors that can reduce risk are good screening processes, proper risk assessment programs and scenario planning.

2.8 Technology Transfer effectiveness measure

As we have seen, technology transfer can be a transfer in an organisation itself or transfer from outside. These transfer projects must not only be managed, but the effectiveness of such projects must also be looked at. Successful projects can be used as guidelines for new projects of this nature. The following is a list adapted from Cooke and Mayes[5] proposing possible effective measures for technology transfer:

- Number of technology transfer projects currently underway;
- Number of licenses signed for external technology transfer in the last year;
- Rating of the success of the new technology at meeting its intended requirements;
- Rating of lead times in technology transfer-based products, compared with non-technology transfer-based projects;
- Rating of efficiency of company information scanning systems;

- Findings in the technology audit comparing technology-transfer practices with benchmarked competitors;
- Percentage of new products using technology developed outside the company;
- Percentage of sales due to products using technology developed outside the company;
- Profitability of products (as a percentage of all profits) due to products using technology developed outside the company;
- Rating of the degree of understanding within the company for the importance of technology transfer;
- Investment in technology transfer as a percentage of sales.

For the internal research/innovation process (and its transfer to the production process) the following measures can be considered:

- Rating of performance of the company at selecting successful projects to pursue;
- Evaluating the success of company at producing ultimately successful projects (i.e., on time, within budget, meeting specified requirements);
- Rate new ideas are generated;
- Rating of the success of team work;
- Number of customer contacts per research staff;
- Rating of internal communication;
- Staff turnover rate;
- Rating of staff morale;
- Relevance of produced documentation to what is required;
- Documentation availability as a percentage of the number of occasions that documentation was required.

2.9 Training

In any transfer endeavour there will always be a training aspect. From technology transfer to knowledge transfer, there will be varying degrees of training. In a transfer project something new or different is introduced in a company and as a result personnel are trained on how to use the new technology. The receiver of the new technology receives training from the developer of the technology. This can happen in two different ways. In the first case the developer can go out to the location of the installed technology and train the people that will be working with the technology. In the second case a team from the receiver can be trained at the developer's site, usually instructors and they go back to their company and train the company's personnel in the use of technology. In the case of knowledge transfer the training will only be theoretical and no practical training will take place.

It is clear that training plays a major role in any transfer project. It is therefore important for companies to ensure proper training for all their personnel. In many technologies especially in aviation the need for 'retraining' is satisfied by 'refresher' courses offered. Many companies have schools of their own for the sole purpose of training personnel and maintaining the level of knowledge required. Transfer of technology without training will mean that the technology cannot be utilised to its fullest potential.

Training very often has to do with the transfer of knowledge concerning the application of technology. Training is therefore a very important aspect in the transfer of technology. Without knowledge transfer, complete technology transfer will not be possible.

2.10 Example of Technology Transfer Process

The following is an example of a technology transfer process between NASA and Sonix[9]. The two partners developed an ultrasonic imaging method. The technology is used in non-destructive testing and can therefore be applied in quality control of materials. The following describes the steps of the

technology transfer process, from inception to completion of the final beta version.

I. NASA contacted Sonix to gauge their interest in the technology transfer effort.

II. NASA and Sonix agreed in principle to a technology transfer effort and determined that a "shared cost" co-operative agreement was the best mechanism for execution of the effort, since both parties were to benefit.

III. As a legal requirement, NASA wrote a "Sole Source Justification" to articulate the reasons for executing this agreement with Sonix as opposed to any other company interested in commercialising ultrasonic velocity imaging method. The main reason given for wanting to work with Sonix was that NASA owned a Sonix scan system and therefore NASA would not have to buy a new scanner to have access to the product developed, i.e., the government would save a significant amount of money. Another reason given was that NASA and Sonix had developed a good working relationship as a result of a prior informal agreement in which NASA was a beta test site (debugger) for any new versions of Sonix general scan system software developed.

IV. NASA and Sonix negotiated and implemented a formal Co-operative Agreement in which financial aspects, timelines, and the responsibilities of each party were defined.

A. The responsibilities for NASA were as follows.

1. To provide to Sonix with a flow chart and specifications detailing algorithms and methodology related to the immersion of ultrasonic velocity imaging.
2. To provide copy of FORTRAN coding used in NASA's prototype ultrasonic velocity imaging system.
3. To determine some of the experimental conditions for which accurate velocity imaging can be performed. This includes investigating the use of focused vs. unfocused transducers,

ultrasonic wave propagation in specific materials, and different software signal processing methods for calculating velocity.

4. To help debug the velocity imaging software module implemented by Sonix into their general C-scan software.
5. To write final detailed operating procedures for velocity imaging software module and to continue the debugging process.

B. The responsibilities for Sonix were as follows.

1. Program and implement algorithms required for immersion velocity imaging into present C-scan software. Create graphical user interface for velocity imaging. Help debug software. Provide interim versions to NASA to facilitate debugging process. Provide initial operating procedures for use of software.
2. Provide fully functional beta C-scan software including velocity imaging software module to NASA Lewis upon completion of co-operative agreement.
3. Continue to make modifications, as needed, based on NASA debugging exercises.

2.11 Conclusion

The most successful companies are those that are innovative in their thinking. Being innovative means that their clients needs are solved on time, cost effectively and innovatively. In order to be innovative an organisation needs to be informed about developments in the market and how to solve new needs. For this they have to transfer the most appropriate technology in the most efficient way. Cooke and Mayes[5] describe the following features that characterise innovative companies:

- A long term orientation
- A commitment to change from top management
- Creative and responsive to new ideas
- Identification, capture and transfer of new knowledge.

- The presence and encouragement of internal entrepreneurs
- A focus on user needs and receptive to user ideas
- A high level of communication, both internal and external
- Flexibility to enable rapid response
- An external orientation
- Strong strategic planning with progress monitoring
- Investment in education and training to support the change.

In his book 'Innovation Strategy', Alan West[10] provides what he calls "the golden rules of innovation". I feel that technology transfer underlines many of the ideas put forward in West's golden rules. An adaptation of the rules is:

- Think strategic:
  - Fit the resources of the organisation to the conditions of the market.
  - Control the market and the competition.

- Think novel:
  - Develop approaches to products, services, and customers that are demonstrably different form those currently being offered.
  - Use novel approaches to extend and promote old concepts and products.
  - Ensure that no possible avenue for both current and future development is ignored.

- Think customer:
  - What does the customer want?
  - What are the benefits the organisation can offer?
  - Define customer needs in all aspects of the product.

- Think detail:
  - Accurately define the components of each stage of the development process.
  - Create detailed specifications of the product or service.

- Develop a comprehensive engineering analysis program.
- Create a predetermined testing program that will identify the major potential problem areas.
- Create the correct balance in skills and personality of personnel in teams.

- Think betterment:
  - Analyse the work requirements in each task.
  - Build on existing strengths.
  - Assess where investment would be most appropriate.
  - Concentrate on long-term sales.
  - Look for real growth in added value per employee, rather than in total return on capital employed.

- Think people:
  - Create an enthusiastic and effective workforce.
  - Employ the right people in the right jobs.
  - Develop people.
  - Create a belief that changes are made to suit the workforce, rather than forcing the workforce to change to suit the organisation.

- Think adaptability:
  - Be more knowledgeable, more responsive, and quicker than the competitors.
  - Understand the customer.
  - Get change implemented without pain
  - Produce more added value
  - Act rather than reflect.

- Think future:
  - Plan ahead for contingencies
  - Be aware of the need to change or adapt.

In order to implement new technologies organisations have to create the proper environment. The proper implementation depend on the following interrelating elements:

- Corporate culture
- Strategy formulation, dissemination and feedback
- Organisational structure
- Managerial information and control systems
- Attitudes, motivations, and contributions of individuals

Chapter 3 - Knowledge Transfer

3.1 Introduction

As defined for the purpose of this investigation, knowledge transfer forms a part of technology transfer. As we move further into the knowledge age, organisations that can most effectively leverage their knowledge assets are the organisations that will stay competitive. Because of its growing importance two models will be presented on knowledge transfer. Knowledge is that part of technology that resides in the minds of people. The key to success is the harnessing and successful application of this very important asset. There is a factor of tacitness when dealing with knowledge. This factor complicates the transfer and management of knowledge, because of its strategic impact. It however plays a very important role in any organisation and it is receiving more and more attention from organisations, which realise the importance of knowledge.

"Companies inability to manage, focus and apply knowledge sources, will cost them dearly.[11]" This is according to the research group International Data Co-operation (IDC). The IDC estimates that the Fortune-500-companies will loose in the region $12 billion due to sub-standard intellectual performance and not identifying and tapping the right sources of knowledge. The IDC expects this trend to continue into 2003. Corporate knowledge sources are in danger, because of a lack of instruments and processes to manage these sources. The IDC estimate that 3.2% of knowledge becomes obsolete each year. They further estimate that 4.5% of knowledge is not accessible due to the high turnover in workforce, the mismanagement of information and the strategic retaining of knowledge. The group says that American companies are realising that proper management of knowledge is a core ability in the company that wants to survive in the information age. It is a prerequisite for dealing with customers, innovation and dealing with workers. In a recent study, more than half of the companies with 500 or more workers, indicated that they plan implementing systems in order to manage knowledge in their

companies. This percentage is far greater for larger companies. The IDC also estimate that the money invested in the management of knowledge will rise from $2 billion to $12 billion in the year 2003. Products and services designed for the management of knowledge will bring forth work environments in which the creation, accumulation, focusing and mixing of knowledge will be an inherent part

"Knowledge is power and shared knowledge is powerful to companies.[12]" This is a statement made by Ian McNairn one of Lotus's experts on knowledge management. In order to leverage knowledge successfully in any organisation, you need the tools to share, find and update the knowledge base of the company. Opportunities and infrastructure must be developed in order to aid the transfer of knowledge inside an organisation. Communication must be promoted and a 'open communication' culture must be established in companies.

3.2 Knowledge Transfer

3.2.1 Model proposed by O'Doll and Jackson Grayson[13]

The managing and transferring of knowledge brings dramatic results to companies large and small. Some examples are:

- Chevron has reduced its operating cost structure by more than $2 billion in the last seven years, due to their sharing best practice policy.
- Texas instruments generated $1.5 billion in annual increased fabrication capacity by comparing and transferring best practices among its thirteen fabrication plants
- Skandia has leveraged internal know-how to dramatically reduce start-up time for new ventures to seven months, compared to an industry average of seven years.

In their paper: "Knowledge Transfer: Discover Your Value Position", O'Dell and Jackson Grayson[13] propose the following model for transferring knowledge.

The model consist of three main components:

- Strategic value position
- Four enablers
- A four-step change process.

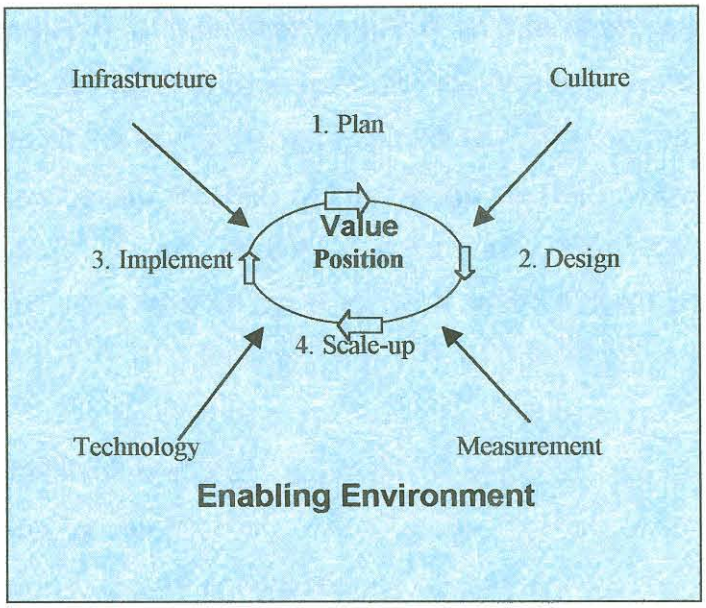


Figure 3.1: Knowledge Transfer Model
(Adapted from: O'Dell and Jackson Grayson[13])

The value position focuses on capturing knowledge in a specific area of interest. The value position, therefore, defines the area in which you concentrate your efforts. This for instance can be one business unit or one aspect of the business. Examples of defined value positions are: the increase of revenue, to reduce the cost of selling or increase customer satisfaction and retention. With this value position the organisation will focus on capturing knowledge about a customer's needs and preferences and transferring the knowledge to the relevant people in the organisation. The four enablers of transfer are as follow:

- Culture
- Technology
- Infrastructure
- Measurement

Organisational culture is one of the most difficult aspects to face when transferring new knowledge. Culture is the combination of previous experience, perceived ideas, shared history and unwritten rules that governs an organisation. Culture is something that you cannot alter overnight and if there is new knowledge entering the organisation that challenges the culture, it will non be accepted. Knowledge and the sharing thereof are social activities and one of the social barriers, is culture. Therefore the importance of culture in the successful transfer of knowledge cannot be stressed enough. If sharing knowledge is not part of a company's policy then O'Dell and Jackson Grayson[13] suggest that one must work on the following aspects in the company:

- Believe people want to share
- Prepare to lead by doing
- Rely on the twin forces of capitalism and democracy
- Develop collaborative relationships
- Install personal responsibility for knowledge creation and sharing
- Create a collective sense of purpose

Technology plays an important role in any aspect of business. It even plays a role in the transfer of itself and the underlining knowledge. One of the technologies that are pertinent in the transfer process is information technology (IT). Nowadays information channels are connecting people and it sets up the ideal environment for the transfer of knowledge between people.

A well-developed infrastructure can aid in the successful transfer of knowledge. O'Dell and Jackson Grayson[13] describe three design approaches for creating infrastructure that will support transfer. The first is the 'self

directed' approach. What this approach boils down to is 'here it is, now go out and find what you are looking for'. This infrastructure is in the form of databases or libraries found in companies. The information is there, but there are no incentives to change it into knowledge. The second approach is 'knowledge services and networks'. This is a step further than the first approach and knowledge management services are there to assist in the transfer process. The third approach is 'facilitated transfer'. This approach is a 'full service' approach and often includes a business unit looking after the whole transfer process. The final enabler is measurement. This is the evaluation of the transfer of knowledge process. This is a difficult aspect to measure and there is no clear way of doing it. One method is to measure the success of projects as a whole.

O'Dell and Jackson Grayson[13] suggest a four-phase process for transfer projects as shown in the model. The four phases are as follows:

Phase 1: Plan, assess and prepare

- Assess current opportunities for knowledge sharing
- Define your value position
- Find a champion for the initial project
- Inform and prepare the organisation
- Define the business case

Phase 2: Design the transfer project

- Decide the scale of the initiative
- Benchmark. Use the learning's from others in similar projects
- Create an action plan. Marshall all resources

Phase 3: Implementation

- Launch project
- Provide support for both content and process
- Observe and learn
- Achieve results

Phase 4: Transition and Scale-up

- Capture progress and publicise results
- Use knowledge gained to expand scale-up
- Create a new organisation structure to oversee the ongoing process.

3.2.2 Model proposed by Inkpen and Dinur[14]

Inkpen and Dinur[14] propose the following knowledge transfer classification framework.

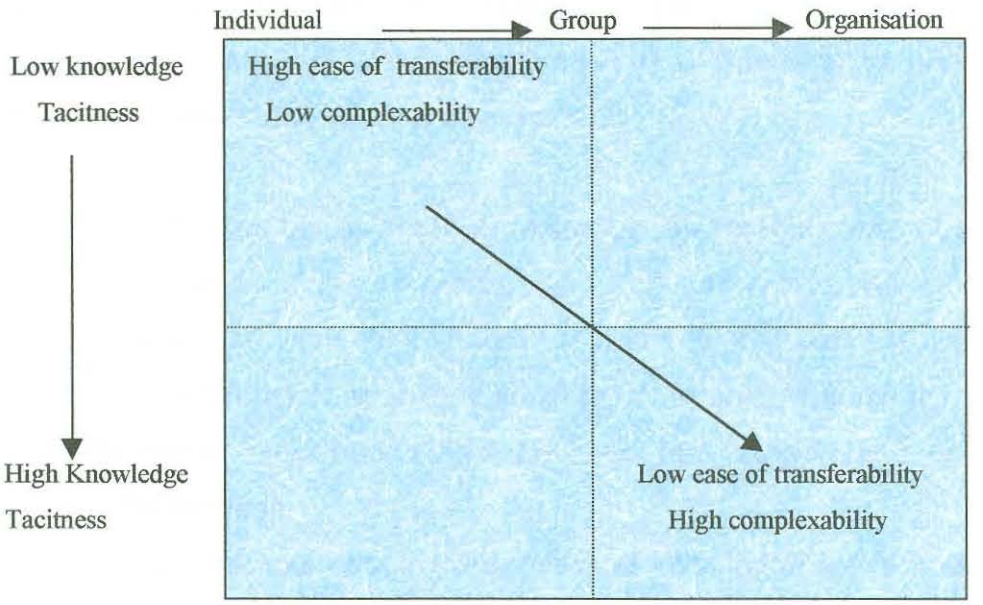


Figure 3.2: Knowledge Transfer Model
(Adapted from: Inkpen and Dinur[14])

In this framework the organisation is seen as a repository of various kinds of knowledge types, in different organisational locations. The vertical dimension refers to the tacitness of the knowledge and the horizontal dimension indicates the location in the organisation. Inkpen and Dinur's[14] model imply that the more tacit knowledge becomes the more difficult it becomes to teach and transfer it.

3.3 Culture

As we have indicated, the culture of an organisation plays a big role in the transfer of knowledge. Culture may be the greatest barrier to the transfer of knowledge. Perez-Bustamante gave a few pointers in his article "Knowledge management in agile innovative organisations[15]", on how one can go about developing and implementing a knowledge culture. One must keep in mind that a culture cannot really be 'implemented' nor can it happen overnight.

People can rather be steered in a way the company would like them to go. This is a long process and may take years to accomplish. Perez-Bustamante[15] suggest that companies pay attention to the following characteristics in their internal environment:

- Establish at all levels of the organisation a strategic intent of acquisition, creation, accumulation, protection and exploitation of knowledge.
- Encourage the worker's autonomy so that they may express their opinions and share the knowledge they possess, in a free environment
- Establish communication infrastructures that support and enhance the transfer of ideas.
- Enhance and encourage overlapping of knowledge ideas in the internal environment by introducing workers into new areas.
- Encourage assimilation of external knowledge with internal thoughts and experiences.

3.4 The Knowledge manager

As mentioned in the introduction of Chapter 3, a business unit may assume the responsibility for looking after the aspects concerning knowledge, and as we move further into the knowledge age, we will find that more and more people are employed with the aim of managing knowledge. One such person is the Knowledge Manager who's responsibilities will include the following:

- Audit the knowledge present and accessible to the organisation. Managers should know what knowledge exist, where it is located, where it is created and how it can be maintained and improved.
- Knowledge managers will decide on which investments will be made in order to improve the management of knowledge function. This may include investments in communication infrastructure or information handling.
- Knowledge managers will control the external flow of knowledge and information with all the pertaining legal aspects.
- Knowledge managers will act as knowledge creation catalysts.
- Obtain from top management the consideration of knowledge as the key competitive weapon.
- Monitor that human recourse policies have a strategic dimension towards knowledge.
- Provide both an internal and external communication infrastructure within the company.
- Plot and maintain the organisational knowledge map.
- Determine a clear knowledge management policy.
- Be the chief manager and leader of technological gatekeepers.
- Develop knowledge reservoirs and facilitate their success.
- Incorporate into financial statements the investment made in intellectual capital.

Chapter 3 covered a very important component of technology, the area of knowledge. In future this will become an increasingly important aspect of technology and the proper management of this component is very important. The following chapter is an overview of the aviation industry. Chapter 4 looks at the role maintenance play and introduces some of the technologies used in this function. Thereafter some trends and developments in the industry are highlighted.

Chapter 4 - Aviation Industry

4.1 Development of maintenance programs

It is necessary to develop a maintenance program for each new type of aircraft prior to its introduction into airline service. For this reason documentation exist, the purpose of which is to assist in the development of a proposal on the scheduled maintenance program for each new type of aircraft and/or power plant[16]. The intent of the program is to maintain the equipment. This program becomes the barrier to govern its maintenance policy. Some of the aspects addressed in a document of this nature are[16]:

- Objective of an efficient maintenance program
- The content of an efficient maintenance program
- The method by which an efficient maintenance program can be developed

The objectives of the maintenance program should be[16]:

- To ensure the realisation of the inherent safety and reliability levels of equipment.
- To restore safety and reliability to their inherent levels when deterioration has occurred.
- To obtain the information necessary for design improvements of those items whose inherent reliability proves inadequate.
- To accomplish these goals at a minimum total cost, including maintenance cost and the cost of resulting failures

The content of the maintenance program consists of two main tasks[16]:

1. A group of scheduled tasks to be accomplished at specific intervals. The objective is to prevent the deterioration of the inherent safety and reliability of equipment. These tasks include:
   - Lubrication

- Visual Checks
- Functional Checks
- Restoration

2. A group of non-scheduled tasks which result from:
   - Scheduled tasks accomplished at specific intervals
   - Reports of malfunction
   - Data analysis

The objective of these tasks is to restore the equipment to an acceptable condition. An efficient program is one that only schedules those tasks that will contribute to increase the reliability of the equipment.

The maintenance program document further suggests a method for developing a maintenance program. These programs are developed via a guided logic approach and will result in a task-orientated program.

From this, maintenance can be divided into two major departments. The first is often called the 'Engineering department' and the second the 'Maintenance department'.

The 'Engineering department, or the 'thinkers' will traditionally be responsible for the development of, and improvements in the maintenance systems as well as improvements in components which will increase the reliability of the equipment. In the aviation industry the later is greatly governed by the OEM's. Any major changes to components will therefore have to be approved by OEM's before it can be implemented on aircraft.

The 'maintenance department' or 'doers' is typically responsible for monitoring the condition of equipment and the restoration of components to acceptable levels. This function is often referred to as the 'front line' of the maintenance function.

It is clear that these two department focus on different aspects in the maintenance function. For this reason the individual departments will utilise different technologies in order to become more effective. It is important to note that these two departments have the same goal and that is to ensure the effective implementation and management of the maintenance function. The communication between these two departments should therefore be very effective. A breakdown in communication may lead to a barrier in effective technology transfer. Because an engineering department very often operates on a higher level as the maintenance department, the difference in perception of how the maintenance function should be applied may also be a barrier and cause a breakdown in communication.

The scenario described in chapter 4.1 is faced by every airline. It is clear that maintenance play a major role in the aviation industry and that many diverse technologies can be employed, in order aid the maintenance function in becoming more effective. In the light of this the rest of this section will take a deeper look at maintenance.

4.2 Maintenance - Overview[17]

Organisations exist to make a profit and this is accomplished by converting resources into product/services. Many sub-functions play an important role in the conversion, for example functions like marketing, sales and also maintenance.

Only in the last decade has maintenance been regarded as an important mainstream function of an organisation. The cost of maintenance may vary between 0% and 50% of the total operating cost. As a result more and more emphasis is placed on this important function. The maintenance function therefore has a substantial impact on profit margins and in today's competitive environment, this necessitates greater awareness and control over this function. Therefore, the management of the maintenance function in every organisation should have the same priority as the management of any other

mainstream function. The cost of maintenance certainly warrants a representation at the highest level in the company.

The importance of managing maintenance is emphasised by its recent recognition as an accelerating discipline at university level.

The application of general management principles like, planning, organising, staffing, leading and controlling brings the following advantages to the function of maintenance:

- Maintenance provides a structure for the efficient teaching of maintenance management;
- It provides the means for designing maintenance management systems in a more rational manner;
- It allows the auditing of existing maintenance departments/systems in order to identify problem areas;
- It provides for a cost effective, efficient operation of the maintenance function.

The advantages mentioned in the previous paragraph are not that easily obtained because of the complexity of maintenance. Kelly[18] states the following reasons for this complexity:

- Maintenance is one of many sub-systems of the organisation with complex relations with the other sub-systems.
- The focus is often secondary to the production or service functions.
- Maintenance is influenced by external factors like legislation and design specifications.

- The output of maintenance is difficult to define, as it is the relationship between inputs and outputs.

The average maintenance cost for S.A is estimated as approximately R 6800 million. It is ranked seventh after other major economic sectors i.e. manufacturing, finance/business services, general government, trade, mining and transport[19].

4.2.1 Maintenance.

The objectives of maintenance are to maximise equipment availability in an operating condition, which will result in the desired output and quality. In order to fulfil the maintenance objectives, skills are needed to integrate people, policies, equipment and practices. It also needs adequate engineering and technological skills in order to provide the best maintenance, repair and overhaul of equipment. Maintenance can actually be a profit producing activity rather than merely an unpredictable, ungovernable function of business.

Many companies all over the world realise that they have to be 'world class' in order to stay internationally competitive. For an organisation to be world class, individual business units should also strive towards 'world class'. This is also true for maintenance, especially if maintenance is your core business. Campbell[20] introduced the concept of continuous improvement to achieve a World Class Maintenance Organisation. This concept is illustrated in Figure 4.1

At the first level a practical vision for maintenance must be created. Management of resources plays an important role on this level, where the critical move towards a culture of continuous improvement enjoys attention. At the second level, improvement is obtained through proper planning, the scheduling of maintenance tasks and the measuring of maintenance performance, as well as the use of information management systems. On the

third level the implementation of a suitable maintenance philosophy can increase the asset productivity dramatically. In many situations however total re-engineering of the entire maintenance function may be necessary, to achieve the required maintenance performance.

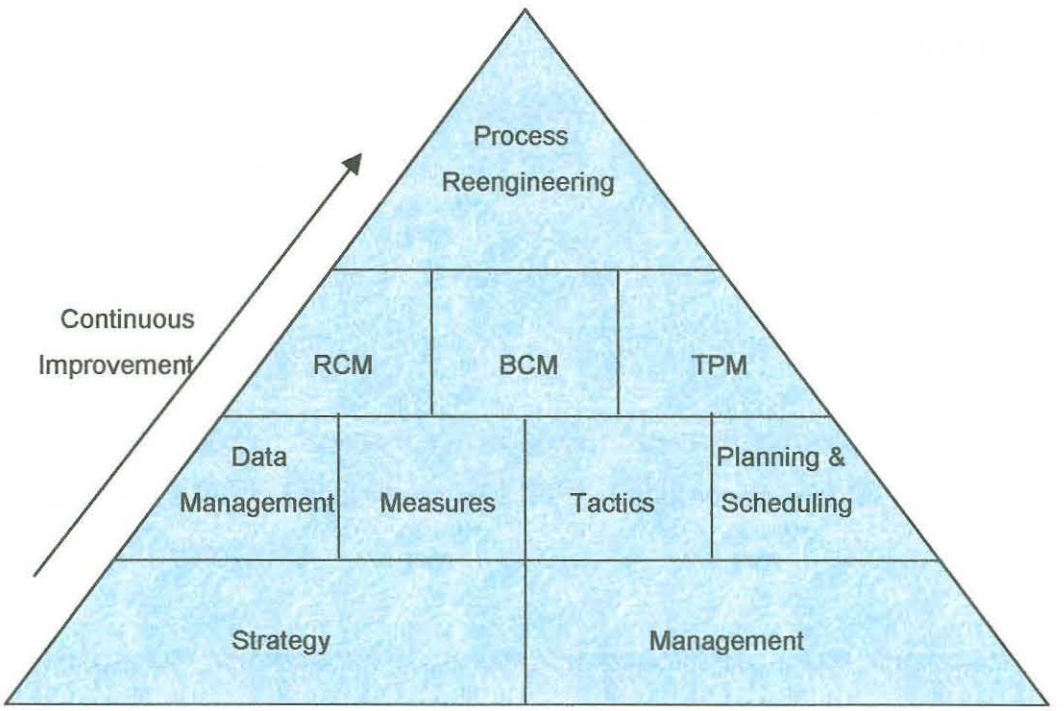


Figure 4.1 Toward World Class Maintenance
(Adapted from: Cambell[20])

4.2.2 Definitions[17]

- Maintenance Management – involves planning, organising and controlling of all resources/activities associated with the maintenance function. These activities include the repair, replacement, modification, adjustment and monitoring of a technical system in order to assure the availability and performance for a specific period.

- Planned Maintenance – is maintenance carried out with forethought, with the help of a predetermined schedule.

- Unplanned Maintenance – is maintenance carried out to no predetermined schedule.

- Improvement Maintenance – is maintenance carried out with the intent of improving equipment.

- Preventive Maintenance – is maintenance carried out at predetermined intervals or according to prescribed criteria and is intended to reduce the probability of failure.

- Corrective Maintenance – is maintenance that is carried out after equipment failure.

- Condition based maintenance – is preventive maintenance initiated as a result of knowledge about the state of the equipment because of routine or continuous monitoring.

- Time based maintenance – consists of periodically inspecting, cleaning and servicing equipment.

- Emergency Maintenance – is maintenance that must be carried out immediately in order to prevent failure and serious consequences.

- Running Maintenance – is maintenance, which can be carried out while the item is in operation (on line).

- Shut down Maintenance – is maintenance that can only be performed while the item is out of service (off line).

4.2.3 Five Main Functions of Maintenance Management[17]

1. Maintenance Performance

A system is created to provide some performance or to pursue a specific objective. A certain trade-off sought, is between making sure the system provides its performance, and the cost involved. One of the main functions involved in assuring that the desired performance is met, is maintenance. The maintenance function assures the availability and performance of the system. In order to do this at minimum cost proper management of the maintenance function is necessary. Therefore a close watch should be kept on the effectiveness of the maintenance function. In order to do this, performance indicators should be defined and the performance should be measured against the initial objectives, set for the maintenance function. These performance indicators include the following:

- Total equipment productivity
- Maintenance cost as percent of total sales
- Maintenance cost per unit of output
- Maintenance man-hours as percent of total man hours
- Downtime as percent of total time

2. Maintenance Planning

Maintenance planning involves three main activities namely:

- Defining appropriate objectives for maintenance
- Selecting strategies in order to attain objectives
- Defining detailed maintenance plan

3. Maintenance Organisation

The primary task of a Maintenance Organisation is to organise the

maintenance resources, which consists of people, money, facilities, technology, tools and information, around the maintenance tasks that have been identified by maintenance planning. It is important to note that this is not a static process and should be able to react to the dynamic nature of the enterprise. Activities in the organisation of maintenance include the following:

- Preparation of the maintenance workload.
- Resource scheduling, which includes:
  - Human Resources
  - Spare parts
  - Tools
  - Information
  - Facilities
  - Technology
  - Materials
- Work planning, scheduling, and control
- Administration of maintenance function

4. Maintenance Control

This is one of the main functions of maintenance management. The maintenance function's main aim is to properly direct all recourses towards achieving the maintenance objectives. One of the aspects that have to be controlled is the cost of maintenance and therefore the budget of maintenance. Other aspects that need to be controlled are availability, reliability and the workforce.

5. Maintenance leadership

The final main function of management is leadership, the objective of which is to harmonise objectives of individuals and those of the organisation. This is one of the most difficult functions, for there are as many objectives as there are individuals. Management is dealing with the human factor and therefore

management need not only be skilled technically, but they also need excellent people skills. One of the main tasks of management in this regard, is motivating the workforce and keeping them motivated.

4.2.4 Maintenance Management Information Systems

Because of the increasingly competitive local and international markets, organisations are striving towards a more effective maintenance strategy and the reduction of the cost in this function. This can be achieved by control of the maintenance function. In order to control the function better, more relevant information is needed to analyse what is going on in the maintenance function. Manually this requires a tremendous effort. For this reason companies are buying, developing and using computerised Maintenance Management Information Systems (MMIS) to assist them in the planning and control of maintenance. The advantages of these systems are:

- Improved maintenance efficiency
- Reduced maintenance cost
- Reduced equipment downtime
- Provision of historical data for planning and budgeting purposes
- Provision of maintenance experts

A comprehensive MMIS will contain the following modules:

- Equipment module
- Inventory module
- Purchasing module
- Work order module
- Reporting module
- Preventative maintenance module
- Personnel module

It is clear that technology plays an important role in the maintenance function. Technological developments should be tracked in the field of maintenance and any relevant technologies that would help an organisation with their maintenance should be considered.

4.3 Aviation industry

The purpose of this section is to highlight trends in the aviation industry. The trends are divided into four main areas. These areas are as follows:

- Training
- Collaboration
- Maintenance
- Outsourcing

4.3.1 Training

Predictions are that the aerospace industry in South Africa will experience shortages in skilled personnel to service the industry over the next few years. According to Me C Larkin[21], Aviation Training and Development Foundation executive manager, the factors responsible for this are closely linked to developments in the international aviation industry. During the past five years the volume of air traffic has increased dramatically and this trend is expected to continue. Fleet sizes have increased on the local domestic scene and more routes have been introduced, with more frequent flights offered. Larken believes that the demand for trained workers is not likely to diminish in the next twenty years.

Airbus and Boeing, the biggest suppliers of passenger aircraft in the world, forecast a tripling in world airline traffic by 2017 growing at a rate of 5% per year. According to their predictions cargo is expected to grow around 6% per year. The required increase in skills training has not yet materialised. This is due to the fact that training cost is high and employees would have to foot the bill. In an extremely competitive industry, this cost is not easily justified which

can only be described as a very short-sighted view. The demand can clearly be seen in markets in the USA. Regional airlines are experiencing shortages in pilots due to the increased volume of flights. These airlines have dropped their qualifying experience for pilots from 2000 flight hours to 800 and this is expected to drop to 600 hours. The reason for this is the shortages experienced and the fact that traditional sources of trained pilots like the airforce is drying up. Another factor is that airlines are slow to acknowledge the fact that there is an increasing demand for skilled personnel in the aviation industry. It is estimated that by 2006 the USA will need 155000 aerospace technicians, 13% more than the current 137000 employed in the industry.

In the light of this the South African aerospace industry must assure that these demands set by the increased volume of traffic, are met in order to stay internationally competitive. It is also of utmost importance that the levels of quality are maintained.

'Airlines in the USA are likely to face greater scrutiny of their programmes for training and managing mechanics, as the FAA responds to pressures to bolster maintenance operations.[22]" These comments were made after several campaigns to convince the FAA officials and airline executives to improve training of mechanics and to ensure that technicians performing repairs for customers are up to standard. These sentiments echo even louder after aircraft malfunction and crashes.

Some carriers find that closer collaboration with mechanics can help in improving the status of training and eliminate errors in the performing of the maintenance function.
Boeing in setting its sights on maintenance training for new growths and revenues as the world fleet grows and increasingly complex aircraft enter service. Boeing's predictions are that the maintenance training business is to "explode" due to changing airline markets and advances in learning technology. World civil aviation authorities also are edging closer to requiring training for maintenance technicians, similar to the initial and recurring training

courses airline pilots now receive. Boeing's research reveals mechanics at third party repair centres average less than forty hours of training each year. They also revealed that airlines have been reluctant to invest in maintenance training due to the high turnover of employees and their more modest pay scales, compared to that of pilots.

One of Boeing's new strategies is the scheduling of a wide range of geographically convenient maintenance training classes world-wide. Boeing has the capacity to provide maintenance training for 70% of the world's active commercial transport fleet. This comes to almost 10 000 aircraft[23].

4.3.2 Collaboration

There are several examples in the South African aviation industry of collaboration between organisations. Commercial Airways (Comair), one of the domestic operators and British Airways (B.A) has recently partnered together in the form of a franchise. In terms of this agreement Comair will operate in B.A livery while retaining its own management and ownership. B.A on the other hand, will be able to market its brand in the South African market through Comair. There will certainly be transfer in functions like marketing, sales and transfer in service-related issues. Technically however, there will not be any transfer of technology.

Another role-player in the South African aviation industry, the South African Airways partnered with several international organisations like Lufthansa and Swiss-Air. Again several opportunities for transfer will exist in several functions such as maintenance. S.A.A. has already performed major maintenance on some of Lufthansa's fleet. This is an ideal opportunity to transfer technology and know-how to S.A.A.

4.3.3 Maintenance

The following are examples of how technology was or can be utilised by different companies in order to help them with their operations.

In 1993 the FAA investigated charges of improper practices in the Maintenance division of one of the US's largest carriers. This followed after senior managers, anxious to control the cost of maintenance, pressured maintenance supervisors and mechanics to cut corners in performing maintenance[24].

It is incidents like this that necessitate tight control on the industry. The problem lies in the depth of the control needed. Every aspect of the maintenance function needs to be recorded and controlled. This kind of data can instantly accumulate to 'heaps' of data. Controlling and processing these huge amounts of data into useful information, is the challenge set to all large airline operators. The only way of successfully meeting this challenge, is by employing modern technology.

Individual carriers are experimenting with various ways of boosting productivity for maintenance workers. Many of the suggested strategies give individual employees greater control over the responsibility for how their work is done. "We have to improve our cost if we are going to expect to survive[25]" Robert Lutzinger, General Manager for United Airlines said. For this reason they, together with the FAA are looking into the role human factors play, in the maintenance function. FAA and airline officials quickly discovered many areas of improving how mechanics work, particularly through better communication at every level in the industry. Communication formed some part of more recommendations than any other topic addressed. Communication was one of the biggest motivations for including mechanics in the design of Boeing's new 777.

The FAA researchers visited several maintenance facilities to asses the environment in which mechanics work. They found that by increasing light, productivity could also be increased. This is evident in one of the hangers they visited at Boston's Legan airport. They increased the light in the hanger to levels where it is now possible to work under the aircraft without flashlights. The lighting in the hanger was something the mechanics often complained about in this particular case, but the complaints fell on deaf ears. Productivity

rose after the upgrading of lighting, again emphasising the importance of communication.

Subsequent improvements have been made in improving the mechanics ability to do their jobs more efficiently and productively. The biggest assets airlines have, are these highly skilled workers, and sufficient effort should be made in order to protect this important asset.

4.3.4 Outsourcing

A major trend emerging in the civil aviation industry is outsourcing. A growing number of airlines view outsourcing maintenance, repair and overhaul as a way to reduce costs and increase the productivity of their assets. The world air traffic is poised to grow and as airlines expand their fleets, outsourcing will become commonplace. Although competition world-wide between maintenance providers remain stiff, companies specialising in maintenance repair and overhaul (MRO) are already benefiting from the upsurge in air travel. These companies will benefit further as hundreds of new aircraft enter service during the next few years. Start-up companies will lease older aircraft and outsource both engine and airframe work, to concentrate on their core business - transporting passengers[26].

Outsourcing is becoming a more and more important strategy in the ongoing restructuring of the global airline industry. In the outsourcing strategy only those activities that add value to an airline's business will be kept in-house and everything else will be shifted to contractors. A growing number of airlines view outsourcing as a way to increase productivity of their assets, reduce cost and reap the benefits from focussing on areas like business, market access and penetration.

Outsourcing can save carriers enormous amounts of money. Airlines, which spend billions of dollars retaining large amounts of spare parts, could slash those costs by transferring ownership to suppliers for inventory management. Airlines like KLM Royal Dutch Airlines has a goal of eventually owning no spare parts at all. Estimations are that the airline industry hold about $20

billion worth of rotatable parts in stock and has another $25 billion of non-rotatable inventory. Some airlines that make use of outsourcing - a trend that is believed to grow, is *Southwest Airlines*. They outsource maintenance of all landing gear components. Outsourcing is expected to grow in the next few years, mainly because of the financial advantages such as reduced labour cost and administrative expenses. Labour unions however will strongly oppose attempts to outsource maintenance because they will feel that work is being taken away from them and they will fear job losses.

Outsourcing presents an opportunity for many start-up airlines. These companies do not need the expertise of maintaining aircraft. They also don't need to fork out massive amounts of money in order to train these personnel. If they maintain their fleets themselves, their maintenance departments as a function, will have to compete against third party companies specialising in aspects of maintenance. Between 1990 and 1995 the U.S transport department received more than 180 applications from would-be airlines. Although not all were approved and many failed to actually begin operations, the demand for low fare carriers is evident. It is believed that outsourcing will aid start-up companies and a greater percentage of applications will actually start operation.

Airline executives increasingly view maintenance as a non-core function of their operations and they would rather want to focus their attention on their core business. B.A has split their maintenance function from their organisation[27]. The business unit functions separately now and they offer clients (other than B.A) a total support programme which include complete maintenance services. One of the areas of maintenance that are experiencing major outsourcing is that of aircraft engines. Continental and B.A outsource all of their engine maintenance work. Continental expects a saving of around $200 million each year. In addition to MRO companies, original equipment manufactures such as Pratt & Whitney, General Electric, and Rolls Royce, are becoming more aggressive in challenging airlines for

engine overhauls. OEM's have now become major competitors in the market of repairing aircraft engines.

I am of the opinion that we will see a shift in the focus of maintenance in airlines. They want to focus on their core business - transporting passengers and providing them with an excellent service. Therefore major scheduled maintenance will be increasingly outsourced in the future. Even unscheduled maintenance may by farmed out to third party companies. I think the only part of the maintenance function that will remain in-house is that of co-ordinating the 'maintenance' function from the airline's side.

As airlines strive to lower fleet maintenance cost, several strategic moves are considered. One of these moves is considering whether or not a third party should be made responsible for maintaining a fleet. British Airways (B.A) for instance has set its maintenance and engineering unit apart with the expectation that the unit can generate profits for the carrier through third party contracts[27]. At the same time B.A has put the unit at notice that it will consult with third parties for maintenance work if prices for services were not competitive. This move has paid off for B.A's maintenance unit, as it now maintains aircraft for more than 100 airlines. This is a world-wide trend to separate airline's maintenance divisions from the airline and manage it as a separate business function. The following factors should however be considered before separating business units and considering vendors.

- Will the carrier avoid a major capital investment in tooling and training, or will it waste assets in which it has already invested in.
- Can people and equipment, freed up when work is farmed out, be sensibly re-deployed in order to speed up other maintenance functions.

- Will the use of outside vendors provide enough savings to offset the cost of terminating workers whose jobs are eliminated by the move?

- Can the vendor respond to sudden increases in demand for its services, such as compliance's with service bulletins and airworthiness directives?

- Reliability and certification of the vendor.

If we view the situation from a different perspective, airlines will farm out maintenance services to vendors who will give them the best service at the lowest cost. As airlines move their maintenance units to operate separate from them they will also have the options to look at other vendors for services that are better and cheaper than their 'own'. It is a case of sticking with your core business. If there is some aspect in the maintenance function that you are good at, concentrate on it and strive to develop this aspect to become world class. Therefore vendors will exist that specialise in certain aspects of maintenance and your 'own' vendor will specialise in something else.

The Emirates group has recently joined in the world-wide trend of third party maintenance. They have opened a state-of-the-art facility at the Dubai International airport. They are currently performing line maintenance for 26 airlines operating from the Dubai International Airport. The new facility gives the maintenance base capacity well beyond its own needs and therefore they will have the capacity to perform third party work[28].

4.4 Industry developments

Section 4.4 introduces recent developments in products and/or services in the aviation industry. The aim of this section is to identify some of the diverse technologies that can be applied in the aviation industry.

Delta Airlines are tapping into new technology to bolster their finance. They are looking at new information-technology applications to help cut their operating costs. These efforts saw the birth of their new Operations Control Centre. This centre is now the home of Delta's flight control, maintenance

and equipment control, radio crew routing and meteorology units. Representatives of these units work with colloquies from flight operations, in flight services, airport customer services, reservations and marketing. The 'bridge' as it is also known, manage more than 100 000 'irregular' operations - like flights delayed by either, unscheduled maintenance or any other problem. Delta's officials estimate the centre's greater control capabilities will cut the cost of managing operations by $45 million a year[29].

Three separate projects enable the centre to manage the maintenance function electronically. The first project called the Maintenance Information Retrieval System (MIRS) is an effort to integrate reliability, regulatory - compliance and cost data in a single system that tracks, monitors and schedules maintenance. Implementation required every component on each of Delta's more than 540 aircraft to be entered into the control and tracking system.

The second project involves line maintenance. This system is intended to track the condition of each of Delta's Aircraft and monitor its routing. This would alert maintenance managers, for instance, that they should alter the routing of an aircraft with an identified problem so that maintenance can be performed at a station that is equipped to do so.
The third project involves converting all of Delta's technical manuals to digital format. Delta may eventually market the maintenance aids generated by these projects to outside customers.

Japan Airlines, (JAL) is developing an automated computer-linked maintenance system to speed up aircraft turn around times during maintenance. The automation of the inspection and cleaning procedures allows JAL to recover and repair more parts in a shorter time. The labour saving potential of robots are also impressive[30].

The airline has introduced an automated fluorescent penetration inspection system in their engine maintenance plant. This system can accommodate 95% of parts for the Pratt & Whitney JT9D engine.

They also developed more sophisticated systems, but they are not yet operational. These include a fan blade recovery process, which uses three very sophisticated robots to automatically perform the following functions. The first robot is responsible for the machining away of worn fan blades' leading edges. The second robot fits titanium bars as replacement and secures them with an electron beam weld. The final robot, machines the repaired blades to within acceptable tolerances. Each fan blade recovered in this process, rather than being scrapped, saves the airline $1100. If kept in mind that for JAL the cost of new parts represents 65% of the engine maintenance budget, this new process can translate into huge savings for the airline.

Computer-based aids are being introduced to help maintenance personnel perform their functions more efficiently. Boeing has developed such a device called the Portable Maintenance Aid or PMA. These aids are designed to be used in conjunction with onboard computers of aircraft like the Boeing 777 and the 747-400. These aids would allow mechanics on the ramp or hanger floor to quickly access manual data and technical tips for performing an inspection, substitution or repair of a component. Other data like maintenance performed, time spent etc. can be logged and at the end of the day and/or shift this data can be downloaded on the mainframe and introduced to the general information system used. All work performed will therefore be logged for future reference.

Another development by Boeing is a new method of measuring aircraft dependability that more accurately reflects cost. This computerised method, called *Dependability Cost* could change the way carriers perform aircraft maintenance and help improve dispatch reliability. *Dependability Cost* assigns a cost for each repair that includes related schedule interruptions expenses, spares and spare holding costs, repair time, training shop material

and associated expenses. Values are assigned based on statistics and market research. Airline-unique charges can be added to any individual database to measure cost of a specific operation[31].

One of this programmes advantages is that it can identify small items or procedures that cost the airline a lot of money. In an experiment conducted using this system, 3000 items were included in the *Dependability Cost* database for the Boeing 737, 250 (8.3%) were found to be responsible for 85% of the cost. Many of these are simple items that can be upgraded for longer service life. Boeing is offering this software and documentation free to airlines. This program can run on any PC-based system.

In another development by Boeing they have put together a detailed catalogue of their maintenance training services and world-wide course schedules. This is available as a hard or soft copy and will be mailed to all their clients. It is also available on the Internet. In addition to the world-wide courses offered by Boeing, they also plan to vigorously apply new technology to produce an almost "just in time" instruction medium. For example information and/or technical tips can be downloaded via the Internet, before the aircraft arrives at its destination. The company is also looking at developing desktop simulators that are easy to move from location to location[32].

United Airlines has recently switched to an integrated highly-automated operations maintenance monitoring system to increase flight reliability and safety. The payback period for this multimillion-dollar intelligent workstation network is estimated to take about a year, through savings from reduced flight delays and cancellations.

Portions of the system architecture, software and interface philosophies can be adapted for other departments in the airline. United's chairman, Stephan M. Wolf is seeking to increase airline efficiency to better compete with low

cost operators. The implementation of this system is a step towards realising this goal.

The system makes use of advanced telephone technology. This allows a flight crew on route or a line mechanic calling *United's System Aircraft Maintenance Control* (SAMC), to automatically reach the maintenance expert on duty, for that specific aircraft type. As the maintenance expert answers the phone, individual maintenance data and related information will be displayed on his PC screen. The SAMC monitors the progress of 550 transports in United's fleet on a 24-hour world-wide basis. The system's main function is to co-ordinate unscheduled maintenance activities and help pilots and mechanics diagnose equipment problems on all their aircraft. Early and correct notification of part and tool requirements, aid mechanics in completing repairs during aircraft stopovers or turn-arounds. During peak flight periods each SAMC controller can receive up to 40 calls an hour requesting help to solve aircraft maintenance problems. The SAMC system also allows for fast access to relevant information, with minimum keystrokes. In addition the system also allows for telephone conferencing with other maintenance experts. Safety and consistency is believed to increase by providing more information for the controllers decision-making process. The new system also helps maintenance controllers better manage the workload. Departure critical repairs can be prioritised and colour coded on the controller's screen. Chronic aircraft problems can be more easily identified by the system. Secondary benefits of the system includes the ability of managers to focus on flights with a history of being delayed and the performance of high yield popular flights can be monitored[33].

United Airlines also recently installed a Sony electronic photography system that enables its top engineers to identify maintenance problems and provide expert design solutions for repairs, right from their offices to mechanics in the field. This system was installed in 1992. A logical upgrade of this system will be to go digital and send the images via e-mail. The benefit of a system like this is that experts, who are not near the physical location, can do 'visual

inspections'. This means that an airline can best utilise its knowledge on a specific topic, no matter where in the world the fleet operates. The system can also be used with a borescope camera (instrument able to look inside engine) for fast engine inspections. The benefit of the system is that one receives instant undistorted information, without sending a team to gather it[34].

United said that the system paid for itself in the first few weeks when one of their aircraft was damaged. A structural engineer designed and completed a sheet metal patch from the information he received from the photographs. It saved United a trip to Japan and two days out of service costs.

Continental Airlines is using cockpit resource management (CRM) techniques in a training program for its technical and maintenance personnel. CRM encourages teamwork and effective problem solving skills. The aim of the program, which Continental calls Crew Co-ordination Concepts (CCC), is to improve safety and efficiency. The CCC program attempts to increase communication between team members, whether they are mechanics or pilots and teach them how to identify the essential problem of a given situation and stick to solving the problem. Human factors specialists often describe this kind of program as one that brings forth 'work environment related cultural changes'. The executives at Continental rather think of the program as one that sets a different environment. With this program they try to involve more of the people in the decision-making process[35].

Boeing has assembled a suite of advanced training courses to match its new high technology 777 transport aircraft. The 777 maintenance training takes advantage of the latest educational media and computer advances. Students now spend about 50% of their time in on-hands training. Boeing now trains the students to identify problems and trouble shoot systems, rather than theoretically teaching them the systems. In the classrooms students can practice their new skills after class on computer-based simulators in the classroom. The set-up is exactly the same as they would find in the 777's maintenance access panel of the on-board computer. There are also 13 real

simulator sessions where the students are provided with a lifelike environment in which to practice troubleshooting. With the introduction of the new technology, the training period has shrunk from 75 days to 45 days[32].

Flight technicians may be able to cut aircraft troubleshooting time substantially through the assistance of new personal computer-based maintenance systems, also known as the 'Virtual Maintainer' (VM), featuring a video teleconferencing capability, digitised technical library and comprehensive system database[36].

In use, a maintenance technician would carry a VM to the flight line and plug it into the aircraft. Fault codes are read directly from the aircraft and interpreted by the VM. This enables the technician to find the problem and identify it. Once the fault is isolated, the system displays the most likely cause and information about the procedures to rectify the problem. The video-conferencing function allows experts to be contacted and consulted on the problem on hand. The video feed also allows a remote viewer to comment on the condition of the actual parts. The system also allows for a borescope camera to be connected and photos or video clips can be sent to the main shop or to any person in consultation. The system will hold information on procedures and even video clips and images on how to perform certain maintenance operations.

4.5 Conclusion

The first four chapters served as an introduction to the field of technology and the transfer of technology. Some of the most important aspects were highlighted in the technology transfer process and the reader was introduced to the aviation industry, and in particular, the maintenance function. The reader was also introduced to some new developments in the aviation industry in order to show what technologies are employed in the industry, especially in the maintenance function.

Apart from serving as an introduction, the first four chapters also laid the foundation for the research. The preceding chapters set a theoretical standard, with which aspects concerned with the transfer of technology in practice, can be compared with. It must be said that the theory must be seen as the 'perfect world', while industry must be seen as the 'real world'. These two worlds differ due to the fact that in theory, certain assumptions are made which are not possible in the real situation, to mention only one difference.

Chapter 1 shows the important role technology can play in the modern enterprise. Research into the South African aviation industry will establish whether the industry feels that technology can play a significant role in this industry. Chapter 2 highlighted the important aspects involved in the transfer of technology. Research into the South African industry will show whether it is familiar with these aspects, which concepts they use, and if so which are better than other. Research will also show if technology is transferred in industry, what mechanisms are used and what the greatest barriers to the transfer of technology are.

Chapter 5 - Research

5.1 Introduction

Chapter 2 through to Chapter 4 highlights the theory behind technology transfer. In order to compare the South African Aviation industry to the theory concerning technology transfer, research was undertaken in the industry. Chapter 5 forms part of the research that was done based on the theory in the preceding chapters. Chapter 5 will cover the research methodology, results of the research and a discussion on the results of the research.

The main aim of the research is to investigate the technology transfer activities, with reference to the transfer mechanisms used in the South African aviation industry. The feeling is that not enough emphasis is placed on technology, and the role technology can play in creating a competitive advantage in the market. The research will therefore also aim to focus the attention of role-players in the South African aviation industry on technology. In order to obtain the most appropriate technology it must be transferred and the focus of the research will be on transfer of technology from an originator to a user of the technology. The research will further focus on technologies used in the aviation maintenance function.

The results of the research will also be used to test the following hypotheses:

1. Do South African companies transfer technology?
   Hypothesis: Yes, technology is being developed outside the companies and therefore appropriate technologies are being transferred to the companies.

2. How effective is the transfer process?
   Hypothesis: Not very effective, due to the years of isolation.

3. Is there a gap between the current technology used and the technology available?

   Hypothesis: Yes, due to the years of isolation and the lack of knowledge concerning the technology available to the companies.

4. Are there dedicated people and programmes looking into technology and the managing thereof?

   Hypothesis: No, technology is not seen as an important enough aspect to have dedicated people managing it. This may be due to the fact that the industry is not dependent on in-house technology development. It may also be because the industry is technology followers, or technology is not seen as a factor for competitiveness.

5. Do barriers influence the effective transfer of technology?

   Hypothesis: True, there are many barriers to the transfer process like cost, red tape, ignorance, etc.

6. Is current technology fully exploited by the organisations?

   Hypothesis: No, due to insufficient training and scepticism around the technology being used, etc.

5.2 Research Methodology

The main research was done by means of a questionnaire consisting of 24 questions. Role players in the South African Aviation industry were contacted and asked to participate in the research project. The questionnaire was completed during a short interview with the relevant persons. The questionnaire was designed so that people throughout the hierarchy, could participate in the research. The questionnaires were completed anonymously. The questionnaire consisted of five sections. The sections will now be discussed in more detail.

Section A

Section A consists of a short introduction explaining what is required of the participant and the approximate duration of the questionnaire.

Section B

Section B consists of definitions in order to define certain terms used in the questionnaire. The purpose of this section is to create a mutual framework of understanding for all participants and to minimise the chances of confusion.

Section C

Section C gathers biographical information of the participant. The purpose of this section is to determine the position of the participant in the hierarchy of the organisation. This is relevant to the fact that the transfer can occur from outside sources or from within, and the emphasis will vary at different levels in the organisation.

Section D

Section D's questions focus on the technology transfer from outside the company and concentrate on the higher levels in the hierarchy. This is essentially a 'top-down' view of technology transfer in the organisation.

Section E

Section E's questions focus on the internal technology transfer of the company. This will involve more levels in the organisation and may be seen as a 'bottom-up' view of the organisation.

The general methodology followed in both the external and internal part (Section D & Section E) of the questionnaire is first, to determine if transfer of technology takes place that is relevant to the participant. If the answer is 'yes' the likely sources of the technology are identified and also the effectiveness according to the participants perception. Following this, the likely mechanisms of transfer are identified and also the effectiveness of the mechanisms, again

according to the perception of the participant. The questionnaire then aims to identify possible barriers to transfer of technology and finally it determines the appropriateness of the technology transferred. A copy of the questionnaire can be seen in Appendix A.

5.3 Results and discussion

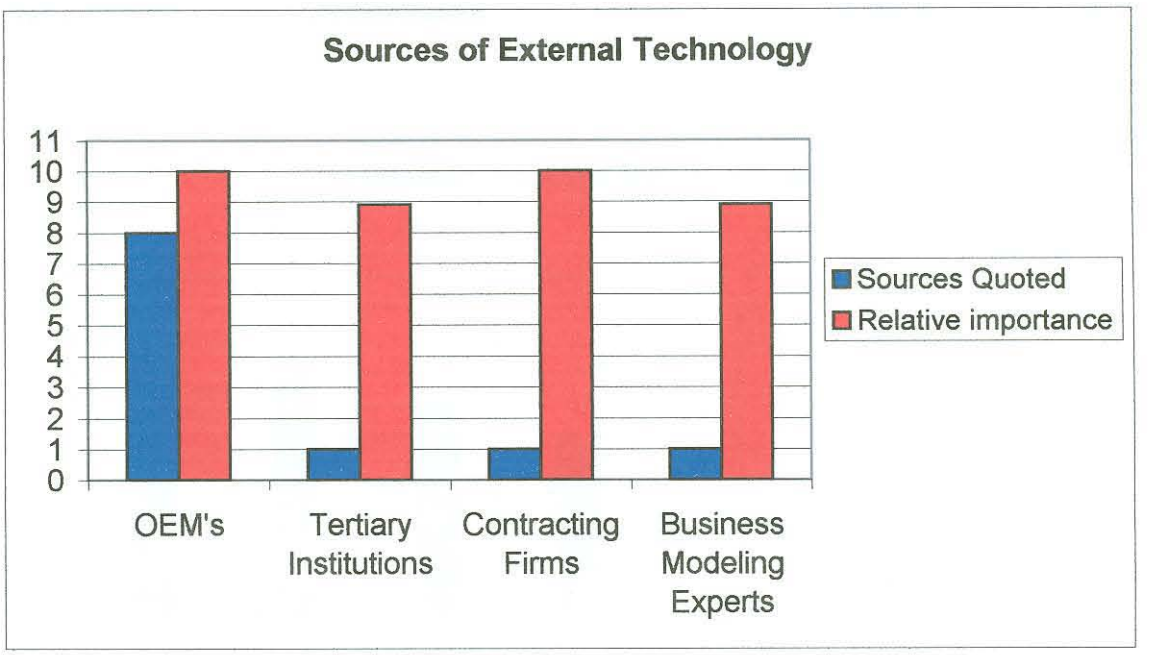
In this section the results of the research will be discussed. This includes both the results from the questionnaires as well as the results of the interviews. First the results of the questionnaire will be discussed under the headings: biographical information, internal technology transfer and external technology transfer. Thereafter a short discussion on the interviews will follow.

5.3.1 Biographical information

Ten people were interviewed and at this time a questionnaire was completed. Six people were interviewed from the civil industry and four from the military industry. Of the ten people interviewed, five were from middle management level and five were on a supervisor level or below. Eight people were in possession of a technical certificate or diploma, while one person had attended university up to a Bachelors – level and one up to Honours level. The age of the respondents varied between 20 and 49 years of age, with one respondent being older than 50.

5.3.2 External Technology Transfer

All the respondents replied 'yes' to the question whether their companies utilise opportunities to transfer technology from outside sources. The average rating for the effectiveness of these transfer projects were 80%. Under the main sources utilised, OEM's were quoted 8 times, tertiary institutions once, contracting firms once and business modelling experts once. The average weights (out of ten) depicting the importance of the sources to the company can be seen in graph 5.1.



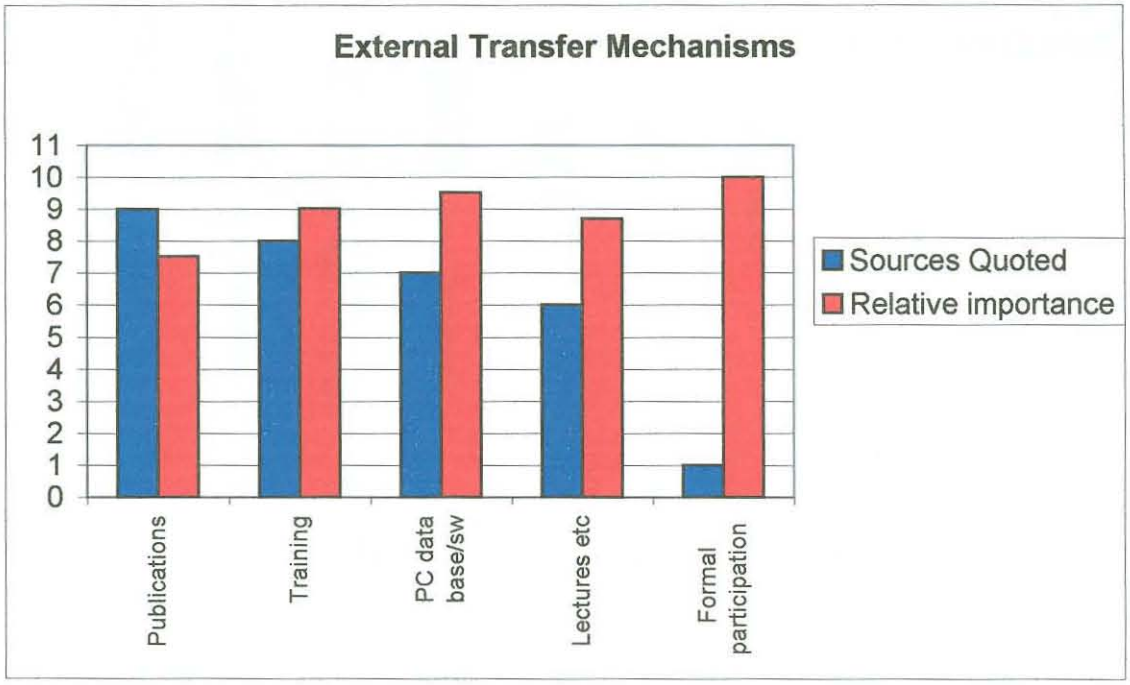
Graph 5.1: External Technology Sources

In the response to the question whether transferred technology enhanced the level of maintenance operations, eight respondents responded 'yes', while two responded 'no'.

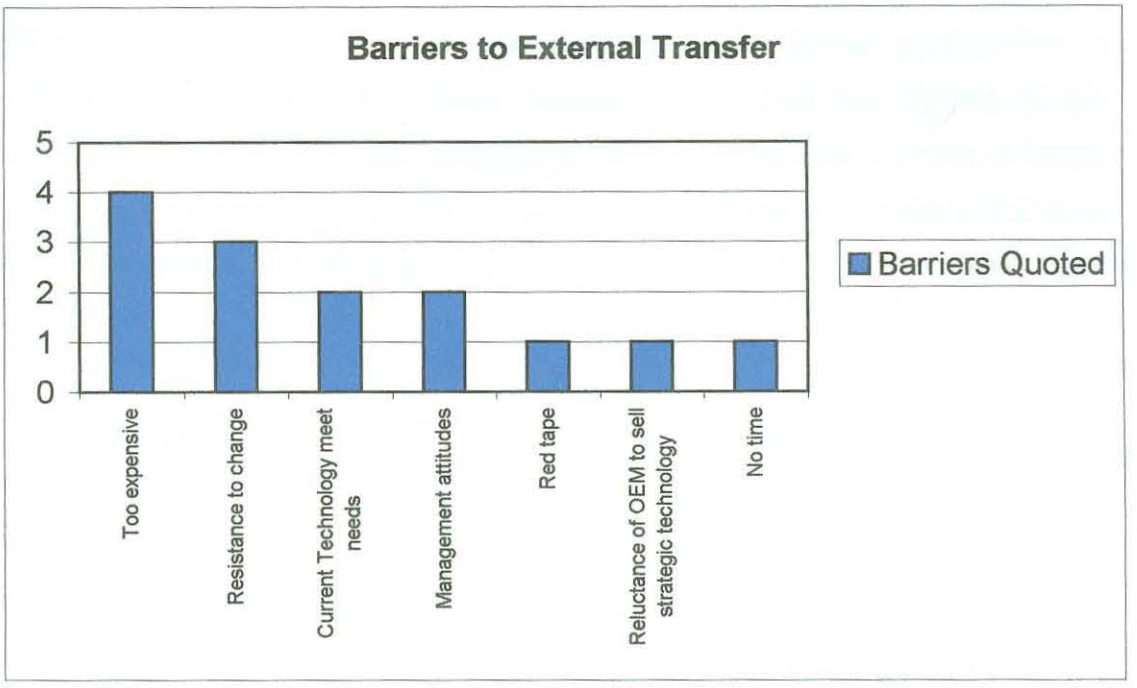
Six respondents felt that there is a gap between the technology utilised by their organisation and the technology that is available to the industry. Three respondents felt that there was no gap, while one respondent replied 'don't know'. The severity of the gap was indicated to be 5.9 out of ten with one indicating a severe gap and ten indicating an insignificant gap.

On the question whether there is a formal technology transfer programme present in the respective companies, seven respondents were not sure, while two respondents replied 'yes' and one responded 'no'.

Graph 5.2 indicates the mechanisms used in the transfer of technology. Graph 5.3 indicates the possible barriers to transfer as indicated by the respondents in the questionnaire.



Graph 5.2: Mechanisms of External Technology Transfer



Graph 5.3: Barriers to External Technology Transfer

Nine respondents felt that their companies invested in appropriate technology while one believed his/her company did not invest in the most appropriate technology.

Discussion on external technology transfer

Out of the research done it is clear that the main external source of technology is Original Equipment Manufacturers (OEMs). The needs of the aviation industry are therefore satisfied mainly by equipment supplied by OEMs. A certain level of skill and knowledge is needed in order to properly use the equipment and therefore all three aspects of technology are present. The research also indicates that there is a gap between the technology that is used in the industry and the technology that is available. The severity of the gap translates into being restrictive. There are therefore needs that cannot be satisfied by the current technology.

The mechanisms used to transfer the technology can be seen in graph 5.2. It is interesting to see that publications, mainly in the form of manuals, are the

most widely used, while their relative importance is rated as the lowest of the mechanisms used. On the other end of the scale, formal participation is utilised the least and its relative importance is rated the highest of the mechanisms used. This may be because of the fact that the concept of formal participation during an acquisition programme, is a newer concept to the local aviation industry and although it is seen to be important, it is not widely used yet.

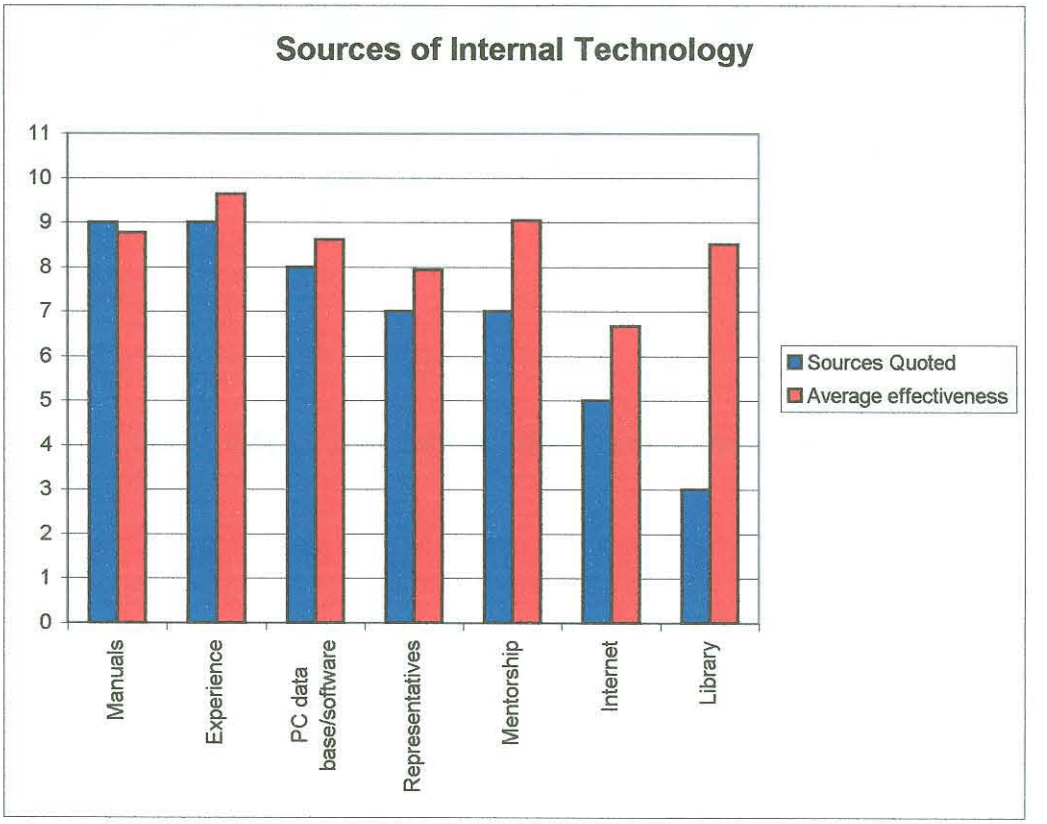
The biggest barrier to external technology transfer is the cost of the technology. This point was also raised in the interviews. It seems that the individual companies just do not have enough money to buy the most appropriate technology. This may be the main reason for the gap between available and current technologies. A solution to this problem may lie in the nature of the relationship between the supplier of the technology and the user. It might be considered to enter into collaborative agreements, where the traditional supplier – user relation makes way for a more mutually beneficial agreement in which both parties gain, in terms of technology. In short, pay for technology with technology. This might be a very important point to consider. Another important aspect is that there are not dedicated personnel looking after technology transfer aspects in the respective companies. Most of the respondents were unsure if there were dedicated transfer policies or programmes in their companies. If a section identifies a need, they are responsible for transferring the appropriate technology. This can work but is not the most effective strategy. Personnel often do not have the appropriate skills to manage these types of projects. A dedicated team will have the appropriate skills and they will be exposed to various transfer projects, thereby gaining valuable experience in this field.

Most respondents felt that their companies do transfer appropriate technology. During the interviews however, people complained about the fact that not all the parties concerned are consulted when new technology is considered for the companies. Poor communication was cited as a major problem in this regard.

5.3.3 Internal Technology Transfer

Eight respondents indicated that their companies have training programs with the aim of transferring technology internally, while two respondents indicated that there are no such programmes.

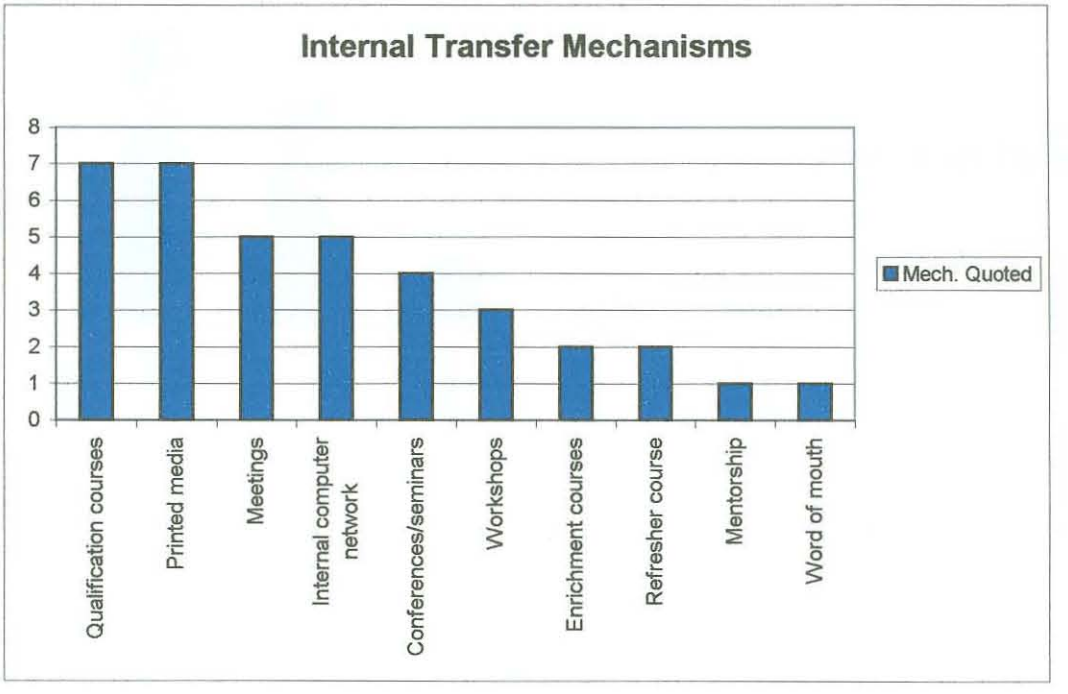
The sources used for technology and their perceived effectiveness (measured on a scale out of ten) is summarised by graph 5.4.



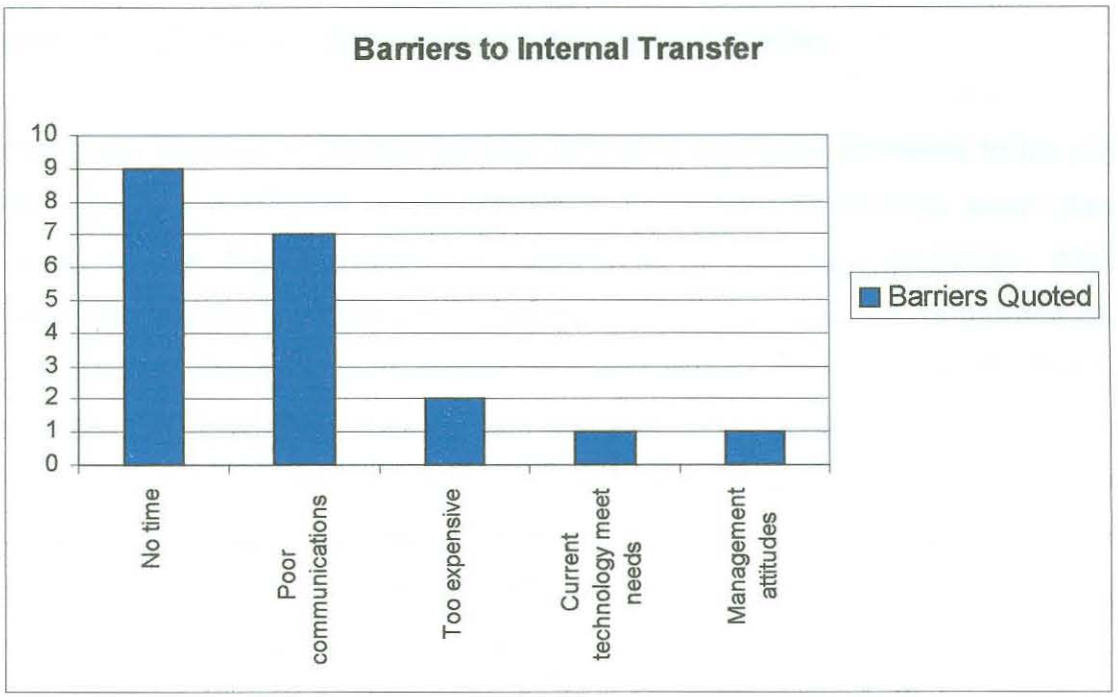
Graph 5.4: Sources of Internal Technology Utilised

Graph 5.5 indicates the mechanisms used to transfer technology internally. Seven respondents indicated that direct assistance is the most effective of the mechanisms used.

The barriers to internal transfer is illustrated in graph 5.6



Graph 5.5: Mechanisms used in Internal Technology Transfer



Graph 5.6: Barriers to Internal Technology Transfer

Only two respondents indicated that they believed that the technologies available in their companies are fully exploited and five indicated that the technologies utilised in the companies are appropriate.

Discussion on internal technology transfer.

Graph 5.4 describes the sources of technology utilised in the companies. Manuals together with experience were identified as the most often used sources. The companies should therefore look at this source of knowledge and skills and make sure that the attributes these personnel possess, are fully exploited and that they are rewarded for their effort. Structures should also be in place to ensure that the skills and knowledge are transferred from the experienced personnel to the rest of the company's people.

The main mechanisms used to transfer technology, or part of it internally, are qualification courses, direct assistance and printed media. Direct assistance is used the most. This may be the result of experience being one of the main

sources of technology. Experienced people assist less experienced people and therefore it is one of the main mechanisms of transfer.

The main barriers to internal transfer of technology were identified to be not enough time and poor communications. Poor communications were also mentioned in the interviews as being one of the main obstacles. Also mentioned is the fact that personnel have work that must be completed on time and that they do not have time for anything else except their work. Again, people that look after the transfer process may be the answer. This is however, a bit difficult, because internal transfer has mostly to do with the broadening of the individuals knowledge and skills base. In order to realise this, individuals will have to attend courses, training sessions, etc. In the interviews it was indicated that there simply is not enough time to do this.

5.3.4 Discussion of Hypotheses

The research supports the first of the hypotheses. All the respondents acknowledged the fact that they do transfer technology and that most technology is developed outside their organisations.

The research didn't support the second hypothesis. The transfer process as used in the respective companies is perceived to be effective. It seems that the years of isolation did not have the negative impact that it was thought to have had. The effectiveness of the transfer projects may also be the result of the culture of 'we can make anything work', an attitude which is the result of the fact that the industry had to be self-sufficient.

The research supports the third hypothesis. The research indicates that there is a gap between the technologies used in the companies and the technologies available to the companies. The severity of the gap was indicated to be restricting. The gap may be the result of the barriers to the transfer of technology especially factors like cost.

The research supports the fourth hypothesis. There are no dedicated people concerned with managing technology and the transfer thereof. During the interviews there was great uncertainty as to whether there are formal strategies or programmes for the transfer of technology. The transfer projects are done in an informal way with the individual sections responsible for the transfer of the technology.

The research also supports the fifth hypothesis. The barriers to the transfer process are indicated in graphs 5.3 and 5.6. As can be seen in these graphs the barriers to transfer are not the same between the external and the internal transfer environments. This is due to the fact that these two environments are subjected to different difficulties, which eventually forms barriers to the smooth transfer of technology.

The final hypothesis was also supported by the research. The majority (80%) of the respondents indicated that the technologies used in their organisations, are not fully exploited. This may be due to the fact that the knowledge component in the transfer process is not sufficiently transferred. In short, workers may not be sufficiently trained in order to exploit the transferred technology fully.

5.4 Conclusion

During the research, most respondents indicated that their respective companies utilise the opportunity to transfer technology, if the need arises. Most respondents however, also indicated that their respective companies do not have formal technology transfer strategies or programmes in place. This means that there are not dedicated people looking after transfer projects. At this moment transfer projects are therefore overseen by 'non-specialists'. The section, to which the technology is transferred, is therefore also responsible for the management of the project. The positive side of this situation is that the people involved in the transfer process are very knowledgeable on the

technical aspects of the project, but are they competent in the management of the project? By having dedicated people specialising in the management of the project in the project team, the efficiency of the total project will be improved. Due to the fact that most respondents indicated that their respective companies do not have formal technology transfer strategies in place, a model is proposed to assist in establishing a formal strategy. The model also aims to introduce the basic aspects involved in a transfer project and show the difference in the activities associated with the transfer phase and the operating phase. Not only can the model be used in the early planning stages of a project, but it can also be used during the project as a guide to measure the progress and output of the project. The model will be discussed in Chapter 6.

Chapter 6 – Transfer Model

6.1 Newly Proposed Model

The aim of the model described in this chapter is to introduce the basic activities involved in a technology transfer project. The model can be used in a formal technology transfer strategy from the early planning stages through the measuring of progress and output of the project, to the post review of the project.

The following model is proposed for describing the process, from need identification to using the technology. For the purpose of the model the following step are identified:

1. Identifying the need
2. Searching/Developing the technology
3. Evaluating the technology
4. Transferring the technology
5. Customise technology
6. Implement technology
7. Manage technology

These steps are indicated by the following flow diagram:

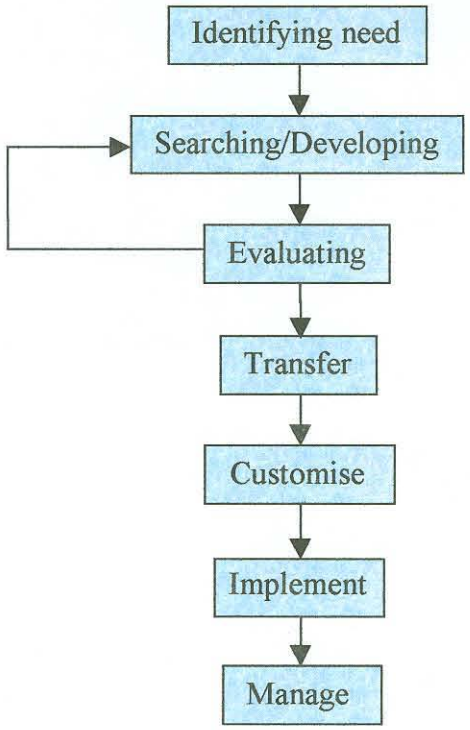


Diagram 6.1: Transfer process

Figure 6.1 depict, the technology transfer process as it moves through the individual stages of the project. The form of the graph is assumed and determining the exact form of the graph may be the subject for further study. The blue line in figure 6.1 indicates the cumulative progress of the transfer process over time. The blue dotted lines indicate the progress of individuals or groups. There is a certain element of noise involved in the transfer process as illustrated by the magnified portion of the blue line in figure 1. The noise consists of external factors, which have an effect on the process. This includes factors like company culture that is not geared towards change, poor information flow and poor communication.

The first step of the transfer process is the identification of the need. With the identification of the need one actually defines the desired output of the system. The system in this case will represent a technology or technologies

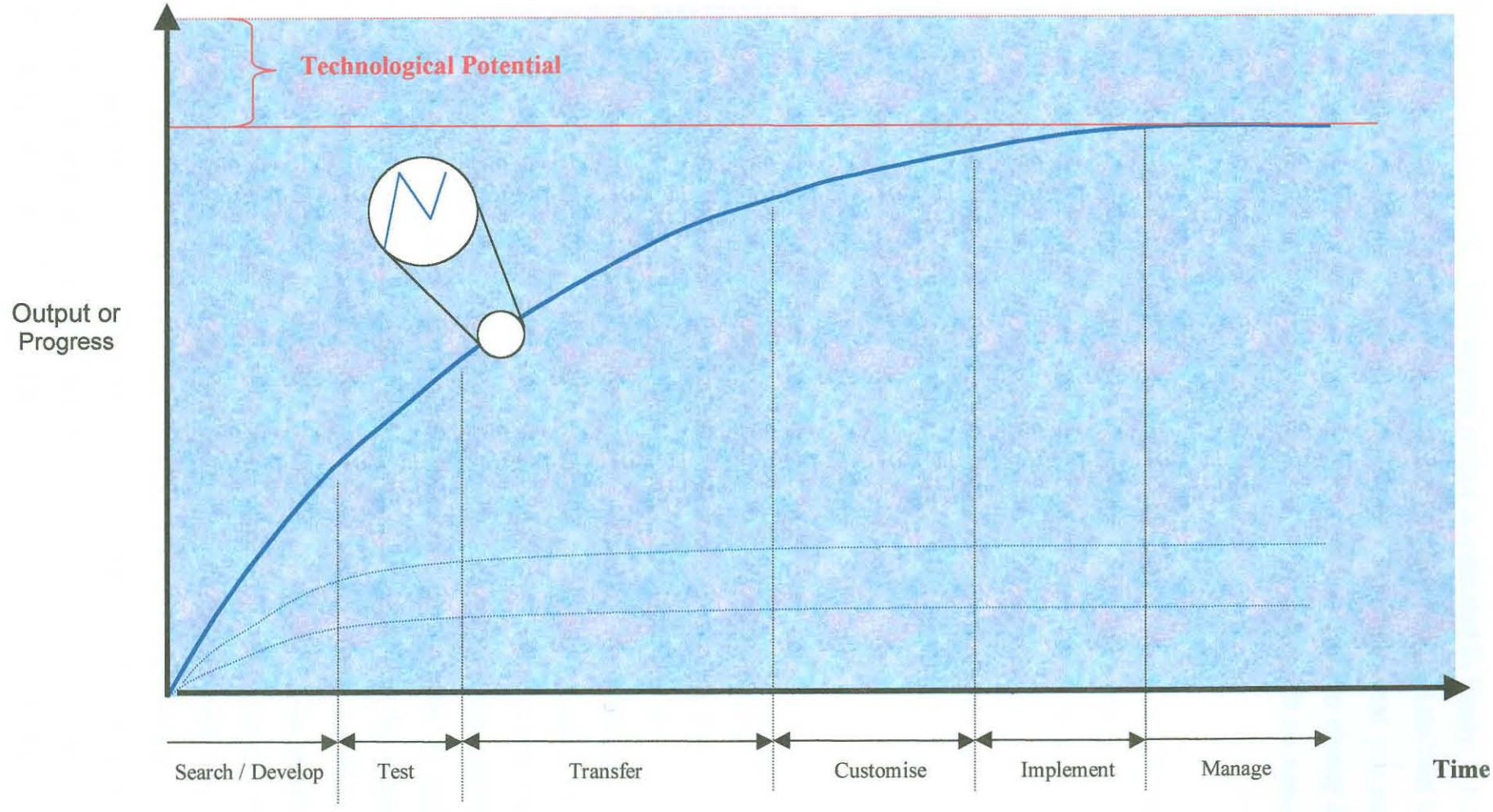


Figure 6.1: Technology Transfer Model

that will satisfy the need. The desired output is indicated in Figure 6.1 with a red line. The main aim of the system will be to reach this goal defined by the desired output as fast as possible. The red line indicates what you want to do, what need you want to solve. In this step it is important to clearly define the objectives and specifications, because the whole effort will be measured against it.

The first effort in the process of identifying the need is searching and identifying potentially appropriate technologies that will satisfy the need effectively. These technologies may be found internally or external to the company. Any of the sources mentioned earlier in this paper should be used, in order to find the most appropriate technology. The company may also opt to develop the technology themselves, if they have access to the relevant resources like a R&D laboratory.

The third step is evaluating candidate technologies. The candidate technologies should be evaluated according to the clearly defined objectives and specifications defined in the first step. It is now clear why this was such an important step, defining the objectives and specifications of the system. As illustrated in the flow diagram, this step has a feedback to the search/develop step. This is due to the fact that this is an evaluation step and the technology may not be suited to the application. Therefore one must go back and do a further search for more applicable technology. It is important to note that if you have to go and search for technology in order to satisfy a need, the need is probably unique and a technology will not be developed specifically with your application of it in mind. In short you will look for a technology with the best fit, one that would satisfy most of your needs, and one that is flexible enough in order to be customised to one's specific needs. The evaluators of the technology must keep in mind that the technology itself is dynamic and there might be future developments in the technology. There is thus a potential for improvements in the technology. This may have an effect on the application of the technology. For this reason the potential technological development is indicated in figure 6.1 by the red dotted line.

The red line that indicates the technology level that would satisfy the need may even be a sloping line with positive gradient due to the fast development in the technology. The personal computer (PC) industry is a good example. If you want to develop a programme for a PC application, do you develop it for the current state in PC performance, or do you develop it for the performance in a year's time. The most important point is selecting a technology in which the potential development will benefit the application of the technology.

The fourth step is getting the technology into the company i.e. transferring it. This can be done via several mechanisms already discussed. The transfer can be in the passive mode or active mode, the active mode being the mode where a third party is involved in helping with the transfer process between the developer and the user. In this step, not only do the physical (hardware) components of the technology enter the user domain, but the training of the resources commences.

In the fifth step the technology is customised to the users specifications and liking. The technology is tweaked in order to satisfy very specific needs of the user defined in the first step of the transfer process.

During the sixth step the final implementation is completed. In this step all the resources that will be using the technology are introduced at their respective levels. This is also the step where the new technology is being used for its intended purpose. If the technology replaces older technology it often runs parallel to the older technology while its operations are scaled down. The training is completed during this step and any initial problems are solved.

The seventh and final step lasts for the rest of the life of the technology. In this step the technology is managed over the rest of its life. Not only is the technology managed, but also the resources using it. Several aspects that are looked at from a management's perspective include:

- Incorporating improvements in the technology
- Monitoring competing technologies
- Monitoring the fitness of the technology

Management of the new technology should include the monitoring of improvements in the technology and the incorporation of any improvements, if it is beneficial and relevant to the application. Any improvements identified by the users of the technology should also be considered. These improvements are very often incremental as opposed to the drastic changes during the implementation phases.

The second point is the monitoring of competing technologies. Because technology can give a company the competitive edge, competing technologies may pose a threat. Such technologies should then be considered to succeed current technology. The last point is the fitness of current technology. The question should be asked whether the current technology is still able to deliver what is expected of it.

The final managerial task, after implementing the new technology, is to assess the success of the transfer process. In order to do this the project should be evaluated according to the objectives and specifications defined in the first step of the model.

It is clear that in this final step, which lasts for the rest of the life of the technology, different management principles are used as opposed to the first five steps in the process. In the final step, general management principles are used to manage the technology from day to day. In this phase the technology is used, while in the previous steps the technology was being implemented.

6.2 Conclusion

This model serves as a starting point to the introduction of a formal technology transfer project. The model can easily be customised according to each project's needs. It also serves as a handy management tool to people involved in technology transfer projects. It is important to note the difference in the managerial aspects during first six steps and the last step. In the first six steps project management principles are used while in the final step general management principles are used.

Chapter 7 - The Future

7.1 The Future

What will the future hold for maintenance in the aviation industry? If this question can be answered companies can identify technologies that can help them in the future to streamline their operations. Unfortunately no one can answer this question, but certain trends in the industry can be identified. If these trends are expected to continue one can identify technologies that may be used to further support these trends. These technologies may provide a competitive edge. The aim of this chapter is therefore to identify trends that are believed to continue in the industry and if the trends are identified, companies can identify technologies that may support these trends in the future. Companies can then decide whether or not to invest in such technologies.

A major trend is for established maintenance functions of larger airlines to move outside the airline and function as a separate independent business. This trend is expected to continue in future, due to the fact that airlines want to focus on their core business function of providing a service of transporting passengers and cargo between destinations. Airlines feel that major maintenance is not part of their core business and therefore they are moving this business function outside the airline. These newly formed maintenance companies compete for maintenance work and even compete for work from their old allies. These companies will not only compete on the quality of work, but will also compete on turn around time. To my mind this will become the most important aspect in the competition between independent maintenance houses. Time is a very important aspect to the airlines, because an aircraft standing on the ground is not earning revenue and it is therefore very important to minimise the time aircraft spend on the ground. It is so important that even acceleration clauses in the maintenance contracts may be an important economical consideration. This boils down to a situation where an airline is prepared to pay more for the maintenance of their aircraft if the

maintenance can be done in a shorter period of time. In future we will see that most of the maintenance work in the aviation industry will be done by independent maintenance houses. We will also see the trend that these houses will specialise in a certain aspect of maintenance due to the competition in the industry. The industry will also see a growing trend in outsourcing because, in certain specialised maintenance tasks, the market is not big enough to warrant the training and employment of resources for such specialised tasks. Therefore larger maintenance companies will outsource maintenance work of this kind. This is especially true for the South African aviation industry.

Another trend that is thought to continue is the repair of components. Airlines have achieved big saving by repairing components and not replacing them with new components. There are very significant developments in technology in repairing components. The South African industry should seriously consider this market, for it is geared to repair most components. This is because of the fact that they were forced in the past to be self-sufficient and they did not have access to new parts and were therefore forced to repair parts.

Maintenance, especially that of components, will therefore move outside the airlines and will be performed by separate companies. We will see a fragmented industry with many small companies, each specialising in an aspect of maintenance. These companies will each stick to their core business and will be very competitive. These companies will compete on time and cost. Their performance will be scrutinised by governing bodies like the FAA, and the feeling is that the quality of work will be of a uniform high standard.

Line maintenance is expected to stay within the airlines. Line maintenance includes the monitoring and co-ordinating of all technical aspects concerning the operations of a fleet of aircraft. It also include functions like visual inspections, replacement of consumables like oil, the monitoring of the

condition of components and the replacement of faulty components. It does not include the repair of components. Airlines will therefore assume the responsibility of co-ordinating the maintenance function and perform routine tasks without getting involved in the physical repair of the components.

This function is expected to be performed from a central location, which will be called the brain of the operation or, as one airline described it, as the 'bridge of command'. Employing some innovative technology it will be possible for the brain to perform its duties over the globe, where-ever aircraft belonging to the airline might be. The brain will have access to all relevant information necessary to perform its duties, from spare part listings to relevant information on each individual aircraft. In the brain, highly qualified, competent people will monitor the progress of their fleet all over the world. All technical problems will be communicated to the brain, where decision-makers will recommend corrective action after considering all relevant information. The information the brain receives will either be directly from the onboard computer of the aircraft, or it will be from a technician on the ground servicing the aircraft. Not only will the technicians of the future be equipped with the traditional toolbox, but he will also be equipped with technology that will directly connect him visually with the brain. A small camera will allow co-ordinators in the brain to exactly see what the technician is doing. Tasks like visual inspections will 'physically' be performed by the technician but 'mentally' by the co-ordinator. The skills will therefore reside with the technician and the knowledge with the co-ordinator. In the case where a component must be replaced, the co-ordinator will guide the technician through the process on how to perform the task. The procedure will be monitored by the co-ordinator, because he is in visual contact and the co-ordinator can at any time consult the procedure manual, because he has instant access to it. The technician will therefore act as remote robot, 'controlled' by the co-ordinator. The co-ordinator will act as the brain and the technician as the hand. The brain will possess all the knowledge, know-how and decision-making capabilities, while the technician will possess the skills of performing the required actions.

The line maintenance system is shown in Figure 7.1, which approximates the physiological system of the human body. The whole system is considered to be a technology and this might be the way line-maintenance technologies are headed in the future.

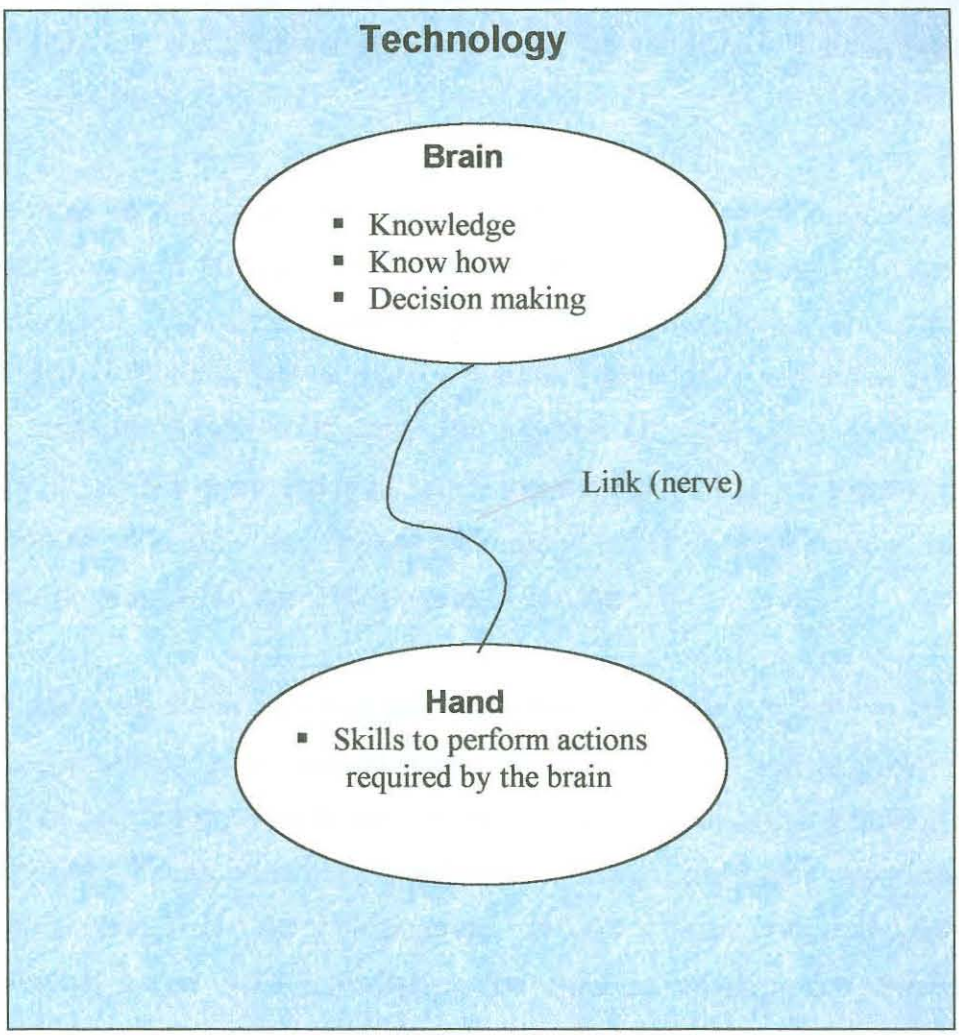


Figure 7.1: Line maintenance system

Chapter 8 – Conclusions and Recommendations

The fact that technology plays an increasingly important role in the modern organisation cannot be denied. Organisations around the globe invest in the research and development of new technology, because of the great potential new innovative technologies may hold. These organisations not only invest in new technology, but also spend a great deal on the proper management of current technology.

Herein may lie the greatest stumbling block for South African companies, especially those in the aviation industry. It takes money to make money and this is a luxury that South African companies do not have. The research indicated that the greatest barrier for external transfer of technology, is the lack of sufficient funds. A strategy that may be considered, is entering into mutually beneficial partnerships, where new state of the art technology is exchanged for locally developed technology. This is due to the unique circumstances experienced in the years of isolation.

The research also indicated that the respective companies do not have formal technology transfer strategies in place. Being a special kind of project, the transfer of technology should be handled by people with the relevant skills and expertise. It has become a specialised function and many organisations are appointing Technology Managers, with the task of managing all technological issues. This is a strategy that may be considered by the South African industry. There may be several advantages in employing dedicated people to look after the technological position of a company. These people will have extensive knowledge on the technology used by their company, the technology that is available to their company and the technologies used by their main competitors. They will also know the technological potential of the current technology and will therefore be able to advise on the maximal exploitation of the current technology. This is very important in any

competitive market, where organisations strive to do the most with the technology available to them.

The model presented as a result of this study may be used as a starting point for organisations that want to manage a very important 'resource' in the form of technology and then specifically the transfer of technology. Various parts of the model can however be researched in greater detail. The exact form of the graph depicting the progress throughout the transfer process is, at this stage, an assumption. Further research into this aspect of the model may bring forth answers to common problems in a transfer project. The problems encountered may be present in a specific stage of the project and some problems may even be industry specific. Another aspect that may be investigated is at what point in time the complete transfer of technology has taken place. Research of this nature will answer questions like "when is a technology established in an organisation"?

This study succeeded in its aims to investigate the technology transfer activities in the South African aviation industry and to introduce the reader to the major aspects involved in the technology transfer process. It also succeeded in its aim to provide a model, which summarise the most important aspects involved in a technology transfer program.

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Appendix A

QUESTIONNAIRE

Section A

Instructions

The questionnaire consists of 24 questions. The following three types of questions are presented :

a) Questions where it is expected of you to formulate an answer.
b) Questions which are formulated in such a way that you can indicate your selection with a X.
c) Questions which should be answered by rating the options. Please indicate your rating with a X. or a value with the scale indicated at the relevant questions.

The questionnaire will take approximately 15 minutes to complete.

Section B

Definitions

For the purpose of the current research the following terms will be defined as follow :

Technology - Technology refers to special knowledge or a defined tool which is applied to achieve practical goal. An example is maintenance. Maintenance is used to assure the availability of an aircraft. Within maintenance there are different technologies in use like computers networks, special tools, maintenance schedules, special equipment etc.

Technology Transfer - Technology transfer is the movement and adoption of a technology from a originator to a user. Transfer does not only mean the movement but also includes the use of technology. Technology transfer also takes place inside an organization. The adopted new technology must be taught to the people inside the organization. A good example is a computer data network which is created by a specialist and the transferred (bought) to your organization.

Transfer Mechanism - This is the method by which the technology is transferred. An example may be a maintenance manual where a lot of knowledge are stored or a course where new knowledge and skills are attained.

OEM - Original Equipment Manufacturer. This is the manufacturer of the equipment you use in your organization..

Section C

Biographical Information

1. Please state the organization to which you belong. _____

2. Post/Position held in the organization. _____

2.1 How does your company categorize the post/position mentioned in (2) ?

2.1.1 Supervisor or below ☐

2.1.2 Middle management ☐

2.1.3 Senior management ☐

2.1.4 Executive management ☐

3. Indicate your highest level of qualification

3.1 Non university training:

3.1.1 Technical certificate/diploma ☐

3.2 University training:

3.2.1 B - level ☐

3.2.2 Honours - level ☐

3.2.3 M - level ☐

3.2.4 D - level ☐

4. Please indicate your age group.

4.1 under 20 ☐

4.2 20 - 29 ☐

4.3 30 - 39 ☐

4.4 40 - 49 ☐

4.5 50 - 59 ☐

4.6 over 60 ☐

Section D

Technology transfer from external environment

5.1 Does your company utilize the opportunities to transfer technology from outside sources?

Yes	No	Don't Know

5.1.1 If yes, how effective would you rate the transfer.

1	2	3	4	5	6	7	8	9
low			average			high		

5.1.2 If yes, please rank (1,2,3…) the main sources utilized by your company. (1 indicating the most important source)

5.1.2.1 Original Equipment Manufacturers (OEMs) (like Boeing) ☐
5.1.2.2 Tertiary training institutes (like universities) ☐
5.1.2.3 Research institutions (like the CSIR) ☐
5.1.2.4 Name any other sources your company utilize

_____ ☐
_____ ☐
_____ ☐

5.2 Does the transfer of technology from **outside** sources enhance the level of maintenance operations in your organization?

Yes	No

5.3 Is there a gap between the technology available in your company compared to what is available in the market with special reference to maintenance operations?

Yes	No	Don't Know

5.3.1 If yes, how serious is this gap to your mind?

1	2	3	4	5	6	7	8	9
severe			restricting			insignificant		

5.4 Is there a formal **external** technology transfer strategy in your company?

Yes	No	Don't Know

5.5 Please rank (1,2,3…) the mechanisms of technology transfer from **outside**, used in your organization. (1 indicating the most important transfer mechanism)

5.5.1 Publications (technical magazines, manuals etc.) ☐

5.5.2 Computerized data base/software ☐

5.5.3 Lectures/conferences and seminars based on knowledge transfer. ☐

5.5.4 Training based on skills development ☐

5.5.5 Name any other mechanisms that come to mind

_____ ☐

_____ ☐

_____ ☐

5.6 Please indicate the possible barriers to the transfer of technology from **outside** sources.

5.6.1 No time ☐

5.6.2 Too expensive ☐

5.6.3 Current product/procedures meet the needs ☐

5.6.4 Too much red tape ☐

5.6.5 Management attitudes ☐

5.6.6 Resistance to change ☐

5.6.7 Name any other barriers that come to mind ☐

_____

_____

_____

5.7 Does your organization invest in appropriate technology?

Yes	No	Don't Know

Section E

Internal technology transfer

6.1 Does your organization have a formal training program to transfer knowledge and skills with reference to the maintenance function?

Yes	No	Don't Know

6.2 Please rank (1,2,3....) the sources of information according to effectiveness. (1 indicating the most effective source)

6.2.1 Manuals ☐

6.2.2 Computer data base/software ☐

6.2.3 Internet ☐

6.2.4 Library ☐

6.2.5 Mentorship ☐

6.2.6 Experience ☐

6.2.7 Representatives (ex. from OEMs) ☐

6.2.8 Please indicate any other sources

_____ ☐

_____ ☐

_____ ☐

6.3 What mechanisms do your company utilize to transfer skills and knowledge **within** the company?

6.3.1 Qualification courses ☐

6.3.2 Enrichment courses ☐

6.3.3 Refreshment courses ☐

6.3.4 Workshops ☐

6.3.5 Direct assistance ☐

6.3.6 Conferences/seminars ☐

6.3.7 Printed media (manuals, news letters etc.) ☐

6.3.8 Internal computer network ☐

6.3.9 Meetings ☐

6.3.10 Please indicate any other mechanisms used

_____

_____

6.4 From the above mentioned list (6.3) please select the most effective mechanism in your opinion.

_____

6.5 Please indicate the possible barriers to the transfer of knowledge and skills **in** your organization.

6.5.1 No time ☐

6.5.2 Too expensive ☐

6.5.3 Knowledge and skills adequate ☐

6.5.4 Too much red tape ☐

6.5.5 Management attitudes ☐

6.5.6 Subordinate's resistance to change ☐

6.5.7 Poor communication ☐

6.5.8 Name any other barriers that come to mind

_____

_____

_____

_____

6.6 Do technical personnel fully exploit current technologies available **in** your organization?

Yes	No	Don't Know

6.7 Are the available technologies **in** your company appropriate?

Yes	No	Don't Know