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.

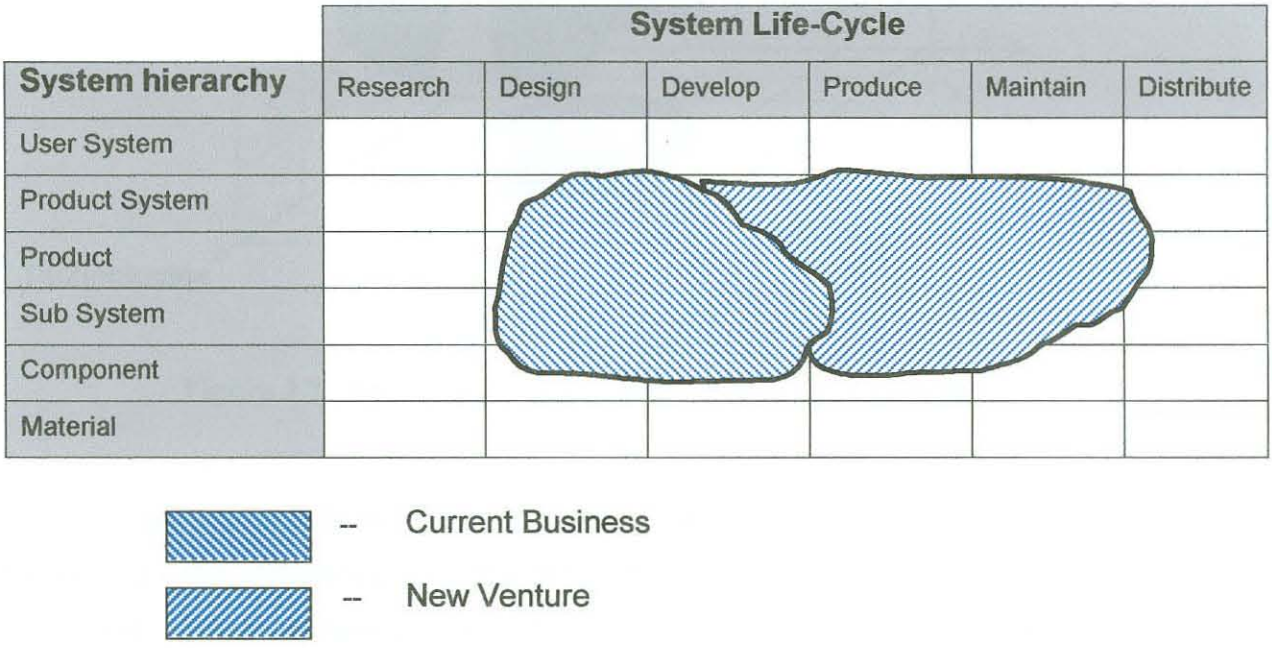


**Figure 2.6: Technology Space Map – Two dimensional**
(Adapted from: G. De Wet[7])

## 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.

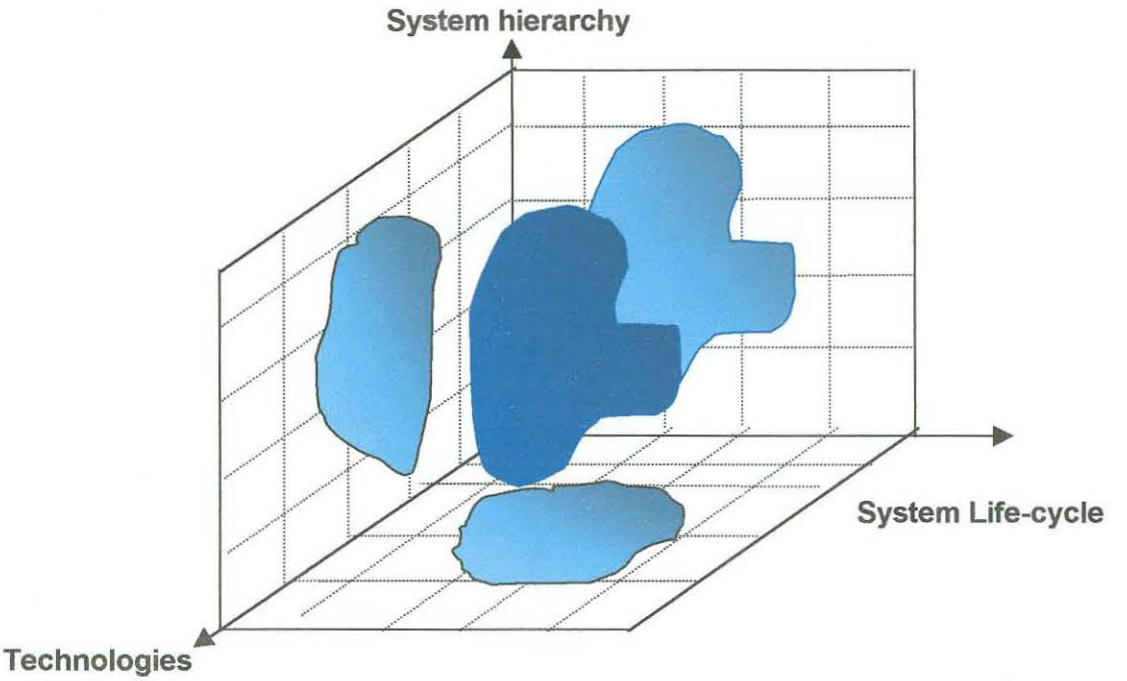


**Figure 2.7: Technology Space Map – Three dimensional**

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